Engineered High Energy Crop (EHEC) Programs

# Final Programmatic Environmental Impact Statement (PEIS)

DOE/EIS-0481

JULY 2015

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# Engineered High Energy Crop Programs

# Final Programmatic Environmental Impact Statement

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**Responsible Federal Agency:**

U.S. Department of Energy, Advanced Research Projects Agency-Energy

**Cooperating Agencies:**

U.S. Department of Agriculture, Animal and Plant Health Inspection Service;
U.S. Department of Agriculture, Forest Service

**Title:** Engineered High Energy Crop Programs Final Programmatic Environmental Impact Statement (DOE/EIS-0481)

**Location:** Southeastern United States, specifically Alabama, Florida (excluding the Everglades/Southern Florida coastal plain ecoregion), Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

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**Abstract:**

The U.S. Department of Energy (DOE) Advanced Research Projects Agency-Energy (ARPA–E) prepared this Final Programmatic Environmental Impact Statement (PEIS)[1] to evaluate the potential environmental impacts of the Proposed Action to develop and implement one or more programs to catalyze the research, development, and demonstration of engineered high energy crops (EHECs) in the Southeastern United States. EHECs are agriculturally-viable photosynthetic species containing genetic material that have been intentionally introduced through biotechnology, interspecific hybridization, or other engineering processes (excluding processes that occur in nature without human intervention), and specifically engineered to increase energy production independent of increasing the amount of biomass by producing fuel molecules that can be introduced easily into existing energy infrastructure. EHECs present a promising renewable energy source that, by virtue of biological carbon capture, has a reduced carbon life-cycle, thereby may decrease the production of greenhouse gasses, and allow for domestic production of renewable fuels. A main component of the proposed EHEC Programs would be DOE or other Federal or state agencies providing financial assistance for confined field trials to evaluate the performance of EHECs that will facilitate the commercial development and deployment of biofuels. Confined field trials may range in size and could include development scale (up to 5 acres), pilot scale (up to 250 acres), or demonstration scale (up to 15,000 acres). The field trials would demonstrate the EHEC's biological and economic viability and further DOE ARPA-E's mission.

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[1] Vertical change bars in the margins of this Final PEIS indicate revisions or new information added since the Draft PEIS was issued in January 2015. Editorial changes are not marked.

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# Summary

## S-1 Introduction

The Department of Energy (DOE) Advanced Research Projects Agency-Energy (ARPA-E) is considering a proposed action (Proposed Action) to implement one or more programs to catalyze the development and demonstration of engineered high energy crops (EHECs) through confined field trials in the Southeastern United States. DOE has elected to prepare a Programmatic Environmental Impact Statement (PEIS) to provide a broad view of the potential environmental impacts and issues to be considered in future proposals to implement EHEC programs. Thus, this Final PEIS addresses environmental impacts and issues at a broad, program level, identifies a geographical area within which future proposed field trials may occur, and identifies best management practices (BMPs) that can be considered in future, tiered NEPA reviews for possible implementation during field trials. The geographic scope for this PEIS is limited to existing croplands, pasturelands, and forested areas in the states of Alabama, Florida (excluding the Everglades/Southern Florida coastal plain ecoregion), Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

DOE has prepared this Final PEIS in compliance with the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500–1508) and DOE's NEPA regulations (10 CFR Part 1021), and other applicable regulations (Appendix A). The preparation of a PEIS includes formal opportunities for public input during the scoping period and the Draft PEIS comment period. On June 21, 2013, DOE issued in the *Federal Register* (FR) a Notice of Intent (NOI) to prepare a PEIS for the Proposed Action (78 FR 37593) and to conduct public scoping with in-person and web-based meetings. DOE published the Draft PEIS Notice of Availability in the *Federal Register* on January 16, 2015. That initiated a 60-day public review and Draft PEIS comment period (80 FR 2404). The Draft PEIS comment period closed on March 17, 2015; DOE reviewed all of the comments received on the Draft PEIS. Appendix B includes copies of the comments and DOE comment responses identifying corresponding revisions in the Final PEIS, as appropriate. Section S-1.3, Public Participation and Agency Coordination, provides a summary of the public and agency coordination conducted for this PEIS. Additional details on this topic can be found in Section 1.6.

This Final PEIS provides information for Federal, state, and local, agencies; non-government organizations; research institutions; and the general public on the potential environmental impacts of the proposed DOE EHEC Programs. For this Final PEIS, the focus is on the development of biofuels resulting from future EHEC Programs funded by DOE or other Federal agencies. This environmental information could be used by decision-makers, researchers, and other Federal agencies in identifying potential concerns for consideration in future site-specific environmental reviews. Such site-specific environmental reviews may tier off of this Final PEIS, as appropriate, in accordance with 40 CFR 1508.28. This Final PEIS could be used by the public to better understand the potential impacts associated with the various EHEC technologies and activities.

### S-1.1 Background

Renewable energy sources comprise a variety of technology classes to supply thermal energy, electricity, and mechanical energy, as well as to produce fuels for assorted energy service needs. Biomass, the biological matter derived from living or recently living organisms such as plants, is a type of renewable energy source that can be converted into liquid fuels (commonly known as biofuels) or combusted directly for its energy content to generate electricity or heat. The two most common types of biofuels are ethanol and biodiesel. In the United States, ethanol, an alcohol made primarily from corn starch, is most commonly used as an additive for petroleum-based fuels to reduce toxic air emissions and increase octane (U.S. Department of Agriculture -- Economic Research Service, 2012). In 2009, the transportation sector used about 0.6 quadrillion Btu of biofuels (Oak Ridge National Laboratory, 2009).

### S-1.1.1 Energy Crops

Energy crops are crops grown specifically for their biomass or fuel value. Biomass includes cellulose (a carbohydrate that is the principal component of wood and linked to lignin molecules that strengthen plant cell walls) as its main combustible component; biomass can be converted into biofuels (such as ethanol or biodiesel) or combusted directly for its energy content to generate electricity or heat. Non-food energy crops usually produce more usable energy than food energy crops that have higher nutritional value. Both non-food and food crops have the potential as energy crops to become EHECs.

There are three broad classes of energy crops—perennial herbaceous, annual herbaceous, and woody crops. Perennial herbaceous plants are plants that re-grow from their root-stock; these plants grow and bloom over the spring and summer, die in the autumn/winter, and return in the spring (from their root-stock). Annual herbaceous plants die at the end of their growing season and must be replanted each year. Woody crops are plants, such as trees or shrubs, that produce wood as their structural tissue; short-rotation woody crops are fast-growing species, such as Populus and Eucalyptus, that can be harvested year-round and continue growing year after year. Table S-1 identifies some examples of energy crops that have the potential to be EHECs (recognizing there are other possible species); this list does not represent the entire range of possible EHECs.

**Table S-1: Examples of Plants with the Potential to Be EHECs**

| Perennial Herbaceous | Annual Herbaceous | Woody Crops |
|---|---|---|
| Agave | Camelina | Eucalyptus |
| Giant Cane | Energy Beet | Pine |
| Basin Wildrye | Maize | Poplar |
| Bull Rush | Sorghum | Spruce |
| Energy Cane | Tobacco | Willow |
| Guayule | | |
| Jatropha | | |
| Miscane | | |
| Miscanthus | | |
| Napiergrass | | |
| Reed Canarygrass | | |
| Sainfoin | | |
| Salicornia | | |
| Sugarcane | | |
| Switchgrass | | |

Both non-food and food crops can be engineered to become EHECs. Molecularly engineered organisms are those whose genetic material has been modified by genetic material from one or more organism(s); the receiving organism has new traits or characteristics (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). This technology has been used extensively in creating genetically modified agricultural crops; the most widely adopted bioengineered crops have been those with herbicide-tolerant traits or insect resistant traits such as in bioengineered soybeans and corn. Three crops (corn, cotton, and soybeans) make up the bulk of the acres planted to genetically-engineered (GE) crops. U.S. farmers planted about 169 million acres of these GE crops in 2013, or about half of the total land used to grow crops (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014).

### S-1.1.2 EHECs

Scientists are identifying crop species that produce large quantities of biomass with minimal inputs. They are also developing other approaches for increasing the amount of energy produced per acre without increasing the amount of biomass (e.g., improving the photosynthetic process). These approaches are referred to in this PEIS as approaches "independent of increasing the amount of biomass." This Final PEIS focuses on the development of biofuels from EHECs; EHECs could be specifically engineered to increase energy production independent of increasing the amount of biomass. These EHECs would be agriculturally-viable plant species containing genetic material that has been intentionally introduced through biotechnology, interspecific hybridization, or other engineering processes. Engineered processes exclude processes that occur in nature without human intervention. Thus, specifically engineered EHECs could produce more useful energy per acre. EHECs present a promising renewable energy source that, by virtue of biological carbon capture, has a reduced carbon life-cycle, and thereby may decrease the production of greenhouse gasses (GHGs) and allow for domestic production of renewable fuels. The existing DOE ARPA-E Plants Engineered to Replace Oil (PETRO) Program is an example of a Program that would produce biofuels from sources that are considered EHECs.

DOE's Proposed Action is the development and implementation of EHEC Programs to catalyze the deployment of EHECs through research, development, and demonstration activities involving the planting and harvesting of EHECs in the Southeastern United States. A main element of the Proposed Action would be providing Federal financial assistance, from DOE or other Federal agencies, to recipients, such as commercial entities, independent contract growers, or research institutions, for confined field trials to evaluate the performance of EHECs. A confined field trial is an experiment conducted under stringent terms and conditions to confine a crop while it is grown outside of a greenhouse.

## S-1.2 Purpose and Need for Agency Action

Present day production of biofuels is limited by the inefficient capture of solar energy and carbon dioxide ($CO_2$) that occurs during plant photosynthesis, and conversion of these inputs into a ready-to-use energy source (i.e., fuel). Increasing photosynthesis, improving bioenergy crop yield, creating or adding molecules found in petroleum-based fuels, and redirecting carbon capture to more useful molecules are some of the ways to modify plants to increase carbon sequestration and to improve biofuels. These modifications may be interlinked; for example, modifying a plant to grow more roots to improve nutrient uptake may take away aboveground biomass production. Research for these modifications is preliminary. Existing research programs are experimenting with a variety of engineering approaches to increase carbon sequestration and biofuel improvements.

Energy crop research programs are trying to fill an agency research gap by experimenting with a variety of plants that are non-cellulose sources to produce more efficiently grown and easily extracted agricultural-based biofuels in many regions of the United States; however, research for these modifications is preliminary. EHECs could include those plant species being modified under the ARPA-E PETRO Program or other current and future research programs engineered to increase energy production independent of increasing the amount of biomass. Successful EHEC Programs may advance the environmentally responsible deployment of biofuels produced by, or through the processing of, EHECs to provide substitute biofuels that are cost-competitive with petroleum, large-scale (deployment), and renewable.

Programs that catalyze the deployment of EHECs to market, including development and demonstration confined field trials, would further the mission and strategic goals of DOE. DOE aims to catalyze the timely, material, and efficient transformation of our nation's energy system and to secure our nation's leadership in clean energy technologies. The technologies being investigated under the ARPA-E PETRO program are working to address DOE's and ARPA-E's goals by increasing energy density per acre; reducing agricultural input requirements; promoting plant production of materials or molecules that require less processing prior to introduction into existing infrastructure; or thereby allowing the United States to lead in the development of new biofuel technology.

In the absence of DOE or other Federal agency funding and support for EHEC Programs, scientific understanding and innovation in the responsible growth of EHECs and, ultimately, commercial deployment of EHECs would develop more slowly or not at all. Accordingly, DOE needs to take action to catalyze the development and deployment of EHECs.

## S-1.3 Agency Coordination and Public Participation

### S-1.3.1 Agency Coordination

DOE is the lead Federal agency proposing to carry out the Proposed Action. Cooperating agencies, as defined by the CEQ may include any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in proposed legislation, a proposed action, or reasonable alternative (40 CFR §1508.5). DOE sent invitations to various Federal agencies to be cooperating agencies for this PEIS; Appendix D provides a list of the invited cooperating agencies. Of these, the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) and the U.S. Forest Service (USFS) agreed to be cooperating agencies for this PEIS. The USDA APHIS Bureau of Regulatory Services (BRS) provided expertise related to agriculture concerns from pests and diseases, and the USFS provided knowledge of forestry concerns.

### S-1.3.2 Public Participation - Scoping

DOE issued a public Request for Information (RFI) on April 12, 2013, soliciting input regarding concerns about and barriers to the development of EHECs, including potential environmental impacts (U.S. Department of Energy, 2013). DOE considered the comments received from the RFI in developing the Notice of Intent (NOI) for the PEIS. DOE's "Notice of Intent to Prepare a Programmatic Environmental Impact Statement (PEIS) for Engineered High Energy Crop Programs" was published in the *Federal Register* on June 21, 2013 (78 FR 37593).

DOE provided opportunities for public participation in compliance with CEQ regulations and DOE's NEPA regulations and implementing procedures through in-person and web-based scoping meetings held in July 2013.

DOE held in-person scoping meetings in Lexington, Kentucky; Jackson, Mississippi; and Raleigh, North Carolina. In addition, DOE hosted a web-based meeting to receive comments. DOE contacted more than 150 organizations to gather input during scoping, including approximately 30 state and local government officials, and members of Congress. In meetings and submitted comments, commenters expressed concern *inter alia* about the potential invasiveness of EHECs, possible indirect impacts to natural resources, the potential for EHECs to displace land used for food production; and additional technologies for consideration related to the conversion of plants into fuels. Major concerns identified in the public scoping comments included:

- Invasiveness;
- Indirect impacts to natural resources;
- Potential for EHECs to displace land used for food production; and
- Prospective technologies associated with the conversion of plants into fuels.

Section 1.6 of the Draft PEIS provides information on public participation and the main comment themes. Comments received during scoping are available online at the DOE EHEC PEIS project website (http://engineeredhighenergycropspeis.com/library). DOE considered these comments during the preparation of the Draft PEIS. Appendix B of the Draft PEIS included agency and public scoping information, including public notices and scoping meeting materials.

### S-1.3.2 Draft PEIS Public Review and Comment Period

The publication of the Notice of Availability in the *Federal Register* on January 16, 2015 for the Draft PEIS initiated a 60-day public review and comment period, during which DOE hosted an in-person public hearing and two web-based meetings. DOE held an in-person hearing in Washington, D.C. on February 17, 2015. In addition, DOE hosted two web-based hearings on February 24 and February 26, 2015 to solicit comments. DOE provided electronic notifications to those individuals and parties who submitted scoping comments, and to interested members of the public, members of Congress, and applicable Federal, state, and local agencies about the availability and public comment period for the Draft PEIS. The Draft PEIS was available on the DOE EHEC PEIS project website (http://engineeredhighenergycropsPEIS.com/library) and DOE NEPA Website (http://www.energy.gov/nepa) (and will continue to be available). DOE considered all comments received on the Draft PEIS in preparing and revising this Final PEIS. Appendix B provides the Draft PEIS comments received and DOE comment responses. Concerns focused on the potential invasiveness of EHECs, potential indirect impacts to protected species, scope of the alternatives considered, and additional crops or technologies for consideration. Section 1.6 of this Final PEIS provides information on public participation and the main comment themes. Appendix C provides the Draft PEIS public involvement materials, including public notices and hearing materials.

### S-1.3.3 Changes from Draft PEIS to Final PEIS

Based on public and agency comments, several changes occurred from the Draft PEIS to the Final EIS. Changes were incorporated to improve accuracy, clarity, consistency, and additional analysis based on public comment and internal review. For a more detailed description of the comments received on the Draft PEIS and DOE's responses to those comments, see Appendix B: Response to Draft PEIS Comments and DOE Responses.

- Clarification of the permitting process and governing agency;

- Consistency in describing future site- and plant-specific environmental compliance (NEPA) reviews and tailored BMPs; and
- Changes to the potential impacts for invasiveness.

## S-2 Description of the Proposed Action and Alternatives

DOE's Proposed Action is to facilitate the deployment of EHECs through DOE (or other Federal agency) funding for programs that support research, development, and demonstration phases of EHECs up to commercial scale. Under the Proposed Action, DOE would develop and implement one or more EHEC Programs to catalyze the deployment of EHECs through research, development, and demonstration activities involving the planting and harvesting of these crops in the Southeastern United States. A main element of the proposed EHEC Programs would be providing financial assistance to funding recipients for confined field trials to evaluate the performance of EHECs. For this Final PEIS, development of genetically engineered biofuels resulting from future EHEC Programs would be funded by DOE or other Federal agencies.

For this Final PEIS, DOE identified three scaled alternatives, in addition to the No Action Alternative, to help frame the discussion for the affected environment and potential impacts. NEPA requires that any Federal agency proposing a major Federal action (as defined in 40 CFR Part 1508.18) must consider reasonable alternatives to the Proposed Action. This Final PEIS analyses the alternatives at a programmatic level. The scaled alternatives are illustrative, intended to provide environmental information regarding the range of potential impacts of the reasonable alternatives, and thus inform future consideration of EHEC Programs; DOE does not necessarily intend to choose from among the scaled alternatives.

As this is a programmatic evaluation, site- and EHEC-specific issues are not assessed. The production of EHECs could utilize agricultural practices that are similar to those used in traditional crop agriculture with some variations in equipment and techniques. Production operations and multi-year characteristics for each EHEC could vary. Therefore, this Final PEIS discusses the three broad classes of energy crops (perennial herbaceous, annual herbaceous and woody crops) and identifies the range of possible impacts on resources present in the nine-state project area for the Proposed Action and Alternatives, including the No Action Alternative. Site- and EHEC-specific concerns would be assessed by DOE or another Federal agency in future project-specific environmental compliance reviews, to include NEPA reviews, once a crop and locations are proposed.

### S-2.1 Alternative 1 – Development-scale Confined Field Trials (up to 5 acres)

Alternative 1 includes small scale, up to 5 acres or less, confined field trials. These small-sized confined field trials are the first step in testing whether an EHEC will grow under agricultural conditions. Under this alternative, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that could be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%.[2] Although confined field trials would be limited to these types of agricultural land, the trials could result in that land being

[2] For all of proposed alternatives, these percentages are the same restraints proposed in the *Billion Ton Update* report to "simulate the relative inelastic nature of agriculture in the near-term" meaning growers do not swap out crops quickly (U.S. Department of Energy, 2011).

switched to a different agricultural use (e.g., cropland could be converted to forested land for the purpose of the field trial). The development-scale confined field trials would follow the same protocols as typical confined field trials, including required APHIS permits and notifications.

### S-2.2 Alternative 2 – Pilot-scale Confined Field Trials (up to 250 acres)

Alternative 2 is a pilot-scale field trial to begin experimenting with the EHEC in a larger sized area (up to 250 acres). Pilot-scale field trials could involve multiple growers at multiple smaller non-contiguous locations as a means to determine if the EHEC could grow beyond the development-scale with similar results. Under this alternative, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%. Although confined field trials would be limited to these types of agricultural land, the trials could result in that land being switched to a different agricultural use (e.g., cropland could be converted to forested land for the purpose of the field trial). The pilot-scale confined field trials would follow the same protocols as typical confined field trials, including required APHIS permits and notifications.

### S-2.3 Alternative 3 – Demonstration-scale Confined Field Trials (up to 15,000 acres)

The largest scale of the alternatives is Alternative 3, the demonstration-scale field trial, to test whether an EHEC is commercially viable. The demonstration-scale size (up to 15,000 acres) was estimated to be the acreage of EHECs needed to produce biomass for a hypothetical, small-scale, commercial ethanol plant.[3] Under Alternative 3, demonstration-scale field trials could involve multiple growers at multiple smaller non-contiguous locations. Under this alternative, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%. Although confined field trials would be limited to these types of agricultural land, the trials could result in that land being switched to a different agricultural use (e.g., cropland could be converted to forested land for the purpose of the field trial). Similar to Alternatives 1 and 2, the demonstration-scale confined field trials would follow the same protocols as typical confined field trials, including required APHIS permits and notifications.

### S-2.4 No Action Alternative

The No Action Alternative is carried forward in this Final PEIS in accordance with 40 CFR 1502.14(d) to represent the environmental baseline against which to compare the other alternatives. Under this alternative, DOE (or other Federal agencies) would not provide financial assistance for the development and implementation of EHEC Programs. Although some private-sector field trials involving EHECs might be undertaken under permits issued by USDA APHIS, for purposes of this no action analysis, DOE assumes that development of EHECs would occur slowly or in an uncoordinated fashion.

[3] DOE estimated that to supply a 10 million gallon/year corn ethanol plant (the smallest commercial scale plant) would take approximately 30,000 acres of corn. One goal of the ARPA-E Program is to develop biofuels that produce twice as much energy per acre as corn; therefore, the demonstration-scale alternative was calculated to be half that amount of acreage or 15,000 acres.

## S-3 Summary of Potential Environmental Impacts

Direct, indirect, and cumulative environmental impacts were examined in this Final PEIS for the following nine resource areas: land use, water resources, geology and soils, biological resources, socioeconomics and environmental justice, wildfires, air quality, safety and human health, and climate change and greenhouse gases. Table S-2 provides an overview of the potential impacts anticipated under each of the alternatives considered by resource area. The potential environmental impacts are presented in more detail within Chapter 4; potential cumulative impacts are presented in Chapter 5.

Best management practices are identified in several places in the Final PEIS within Chapter 4. Future site- and plant-specific environmental compliance documentation, including NEPA documentation, would identify specific BMPs that may be required as a condition of receipt of funding or permits from a Federal agency. As identified in Table S-2, implementation of BMPs should be considered to avoid or minimize the potential environmental impacts to that specific resource area.

**Table S-2: Summary of Anticipated Environmental Impacts by Alternative**

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Meets Purpose & Need | Yes | Yes | Yes | No | N/A |
| **Resource Areas** | | | | | |
| Land Use<br>* Potential economic impacts of converting land use from traditional crops to EHECs is in the Socioeconomics section. | No direct or indirect impacts are anticipated since a relatively small amount of vegetation could be converted from traditional crops to EHECs. | No direct or indirect impacts are anticipated to convert traditional crops to EHECs. | No direct or indirect impacts are anticipated to convert traditional crops to EHECs. | No impacts are anticipated. | None. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Water Resources | No direct impacts are anticipated. Minor indirect beneficial impacts on surface water could occur from perennial herbaceous and woody EHECs, and negligible indirect adverse impacts to surface water quality could occur from annual and perennial EHECs.<br><br>Minor beneficial impacts are anticipated from herbaceous EHECs on groundwater, whereas negligible adverse impacts on groundwater and water use and availability could occur from woody EHECs. | Potential minor adverse indirect impacts on surface water and groundwater quality could occur at the planting stage. The intensity would vary by crop type and location. Minor beneficial indirect impacts could occur from perennial and woody crop EHECs.<br><br>Higher water inputs to increase biomass or yield could cause potential minor adverse impacts on water use; impacts not anticipated from annual crops.<br><br>Additional environmental compliance reviews may be necessary to determine site- and plant-specific impacts to groundwater for woody EHECs.<br><br>Potential impacts could be mitigated through BMPs. | Impacts would be similar to Alternative 2.<br><br>Additional environmental compliance reviews may be necessary to determine site- and plant-specific impacts to groundwater for woody EHECs.<br><br>Potential impacts could be mitigated through BMPs. | No impacts are expected since there would be no change in water quality or quantity used for irrigation purposes from existing conditions under this alternative. | BMPs would be identified on a project-specific basis.<br><br>BMPs could include:<br><br>-Evaluate water needs for an EHEC on a site-specific basis and reduce the agrochemical amount applied, application timing, and delivery method.<br><br>-To reduce sedimentation, apply cover crops, practice conservation tillage, and leave plant residue on the soil surface.<br><br>-Avoid discharging herbicide, pesticides, and nutrients into waters of the United States when possible. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Geology and Soils | Potential direct and indirect impacts on geology and soils vary depending on the EHEC.<br><br>No impacts or minor adverse impacts are anticipated from subsidence, minor adverse to beneficial impacts of erosion. No impacts to prime and unique farmlands would occur. | Potential minor adverse impacts from annual herbaceous EHECs include soil nutrient depletion, contamination from over-application of pesticides, and increased risk of erosion following crop harvest.<br><br>Beneficial impacts are anticipated on subsidence and erosion from perennial herbaceous and woody EHECs.<br><br>Application of BMPs could lessen any potential impacts.<br><br>No impacts to prime and unique farmlands would occur. | Potential wind and water erosion impacts from annual herbaceous EHECs would be similar to those under Alternatives 1 and 2 but likely higher because of the increase in program acreage.<br><br>Beneficial impacts are anticipated on subsidence and erosion from perennial herbaceous and woody EHECs.<br><br>Applying BMPs could lessen any potential impacts.<br><br>No impacts to prime and unique farmlands would occur. | No impacts are expected since there would be no change from existing conditions. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs could include:<br><br>-Employ standard best agricultural practices to keep soil contamination and erosion to a minimum such as cover crops to reduce erosion; broad-based dips, cross-drains, water bars to control runoff in forested areas; and silt fences, brush barriers, sediment traps, straw bales to capture sediment. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Biological Resources | Minor impacts to vegetation could be expected.<br><br>Negligible to minor adverse impacts on wildlife and non-native species may occur depending on the site and species.<br><br>Negligible to no impacts are anticipated from the introduction or establishment of invasive species with proper BMPs in place.<br><br>Potential indirect impacts to life-cycles may require EHEC-specific environmental compliance reviews to determine impacts, particularly potential toxicity to wildlife at a field trial location and population dynamics.<br><br>Impacts to protected species, critical habitats, or migratory birds would be identified through future site- and plant-specific NEPA reviews and may require consultation with USFWS / NMFS, if appropriate. | Impacts would be similar to Alternative 1 but on a larger scale.<br><br>Minor impacts to vegetation are anticipated.<br><br>Minor adverse impacts to wildlife and non-native species could occur; future site- and plant-specific NEPA reviews would need to be conducted.<br><br>Minor adverse impacts may result if invasive species are introduced or established; BMPs would be identified in future site- and plant-specific NEPA reviews to mitigate impacts.<br><br>Potential adverse indirect impacts to life-cycles may require EHEC-specific NEPA reviews to determine impacts, particularly potential toxicity to wildlife at a field trial location and population dynamics.<br><br>Impacts to protected species, critical habitats, or migratory birds would be identified in future site- and plant-specific NEPA reviews and may require consultation with USFWS / NMFS, if appropriate. | Impacts would be similar to Alternative 2 but on a larger scale.<br><br>Minor impacts to vegetation could be expected.<br><br>Minor adverse impacts to wildlife and non-native species could occur; future site- and plant-specific NEPA reviews would need to be conducted.<br><br>Major short- or long-term adverse impacts could occur resulting in the introduction or establishment of invasive species; BMPs would be identified in future site- and plant-specific NEPA reviews.<br><br>Potential adverse indirect impacts to life-cycles may require EHEC-specific NEPA reviews to determine impacts, particularly potential toxicity to wildlife at a field trial location and population dynamics.<br><br>Impacts to protected species, critical habitats, or migratory birds would be identified in future site- and plant-specific NEPA reviews and may require consultation with USFWS / NMFS, if appropriate. | No impacts are anticipated from the No Action Alternative. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs could include:<br><br>-Evaluate field trial locations for proximity to protected species, critical habitats, or migratory birds to ensure that potential impacts are minimized or avoided.<br><br>-To minimize the inadvertent spread of EHECs, BMPs could include: plant weed-free seed; manage propagules (flowering / seed production) including manual removal of flowers; and maintain field borders.<br><br>-Avoid and minimize the use of herbicides and pesticides to the extent practicable. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Socioeconomics and Environmental Justice | Negligible short-term to no impacts, possibly some beneficial impacts, due to economic, demographic, or social effects are anticipated.<br>Net costs to an EHEC Program participant might be greater than the costs of producing commercial crops that the EHEC replaces.<br>Impacts to low income populations or minority populations are not anticipated at a programmatic level, but site-specific analysis would be required. | Minor to negligible impacts, possibly some beneficial impacts, due to economic, demographic, or social effects are anticipated.<br>No impacts to low income populations or minority populations are anticipated at a programmatic level, but site-specific analysis would be required. | Minor adverse to beneficial impacts due to economic, demographic, or social effects are anticipated.<br>No impacts to low income populations or minority populations are anticipated at a programmatic level, but site-specific analysis would be required. | No impacts are anticipated since there would be no change from existing conditions. | None. |
| Wildfires | Negligible short-term impacts could occur for perennial or annual EHECs with added or increased terpene storage potential.<br>Increased terpene storage potential and production capacity in EHECs may increase the likelihood for wildfire potential; however, it is not clear that an EHEC woody crop would present a greater fire hazard than existing pine plantations found in the project area. | Because of the increased size of the field trials, which could increase the potential for wildfires, major or long-term mitigable to minor adverse impacts could occur under this Alternative.<br>Implementation of BMPs would be identified in future project-specific environmental documentation to reduce wildfire potential. | Major or long-term mitigable to minor adverse impacts could occur under this Alternative due to the increased size of the field trials, which could increase the potential for wildfires.<br>Given the increased size of the field trials, BMPs would be identified in future project-specific environmental documentation to reduce wildfire potential. | No impacts would be expected since there would be no change from existing conditions. | BMPs would be identified on a project-specific basis.<br>Recommended BMPs to reduce wildfire potential could include:<br>-use of defined fuel breaks around field trial site;<br>-incorporate defensible space; maintain irrigation; implement fuel reduction programs; and<br>-weekly reviews of Southern Area fire maps. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Air Quality | Overall, negligible impacts on air quality and current pollutant state levels are anticipated. Similar to existing conditions, normal agricultural practices (tilling and equipment use) may lead to decreased air quality from increased air particulates and exhaust from farm equipment.<br><br>Depending on the EHEC, long-term minor beneficial impacts on air quality at the regional and state levels for particulate matter emissions could be expected.<br><br>Minor adverse impacts from plant off-gassing may occur. | Similar to Alternative 2, negligible impacts on air quality would be expected.<br><br>Depending on the EHEC, long-term minor beneficial impacts on air quality at the regional and state levels for particulate matter emissions could be expected.<br><br>Minor adverse impacts from plant off-gassing may occur. | Despite the increased scale, potential impacts to air quality would be negligible.<br><br>A potential adverse impact could result from the increase in woody crops and the resulting volatile organic carbon concentrations. However, this is dependent on the EHEC species.<br><br>Depending on the EHEC, long-term minor beneficial impacts on air quality at the regional and state levels for particulate matter emissions could be expected.<br><br>Minor adverse impacts from plant off-gassing may occur. | No impacts are anticipated since impacts on air quality would be the same as those seen with conventional crops. | None. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Safety & Human Health | No direct or indirect impacts on worker health or public safety are anticipated.<br><br>Consequences of intentional destructive acts to an EHEC field trial would be limited and should not result in injury or harm to the public or workers. | No direct or indirect impacts on worker health or public safety would be expected.<br><br>Due to the larger size of the confined field trials, there could be a slightly greater opportunity for intentional destructive acts to occur.<br><br>Consequences of intentional destructive acts to an EHEC field trial would be limited and should not result in injury or harm to the public or workers.<br><br>BMPs could prevent or minimize impacts from intentional destructive acts. | No direct or indirect impacts on worker or public health and safety would be expected.<br><br>Similar to Alternative 2, the larger size of the confined field trials may provide a slightly greater opportunity for intentional destructive acts to occur.<br><br>Consequences of intentional destructive acts to an EHEC field trial would be limited and should not result in injury or harm to the public or workers.<br><br>BMPs could prevent or minimize impacts from intentional destructive acts. | No impacts are expected since there would be no change from existing conditions. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs to reduce the potential for intentional destructive acts would include:<br><br>-Limit access to the field trial locations,<br><br>-Do not make site locations public knowledge, and<br><br>-When choosing locations, avoid major inland ports, container terminals, nuclear power plants, or national defense infrastructure. |
| Climate Change and Greenhouse Gas Emissions (GHG) | Negligible impacts to GHG emissions or climate would be expected.<br><br>Emissions from vehicles and farm equipment would remain the same.<br><br>A range of potential GHG emissions from soils, with a maximum of 0.21 tons $CO_2e$/year emitted from the soils and a minimum of 1.78 tons $CO_2e$/year sequestered in the soils would result with EHECs. | Similar to Alternative 1, negligible impacts to GHG emissions or climate would be expected and emissions from vehicles and farm equipment would remain the same.<br><br>A maximum of 10.42 tons $CO_2e$/year emitted from soils and a minimum of 89.0 tons $CO_2e$/year sequestered in the soils. | Minor adverse impacts to GHG emissions or climate could be expected. Emissions from vehicles and farm equipment would remain the same.<br><br>A range from of 642.9 tons $CO_2e$/year emitted from the soils to 5,340.7 tons $CO_2e$/year sequestered in the soils.<br><br>Successful demonstration and deployment of EHECs could help reduce GHG emission and result in net benefits in the long-term. | No impacts would be expected since there would be no change from existing conditions.<br><br>Potential GHG reductions through EHEC deployment would not be catalyzed and would occur more slowly or not at all. | None |

### S-3.1 Issues to be Resolved and Conclusions

The potential for environmental impacts varies by EHEC species, the modifications to the EHECs, field trial location, and the size of the field trial. However, the development of EHECs may have potential benefits once EHECs are commercially viable (after completion of the field trials); such benefits may include decreased greenhouse gas emissions due to the reduced need for and use of fossil fuels as an energy source. The potential concerns from EHECs can be generalized as follows:

- Perennial herbaceous EHECs would have the smallest potential for environmental impacts across the resource areas, and may result in potential benefits. For example, the decreased use of fertilizers and pesticides to grow perennial herbaceous EHECs in comparison to corn production (or other existing agricultural crops) could cause reduced nitrate and pesticide leaching into groundwater and providing long-term beneficial impacts.
- Given the size of the pilot-scale (up to 250 acres) and the deployment-scale (up to 15,000 acres), the potential for invasiveness is a concern to be mitigated. Invasive species are plants or animals that are not native to an ecosystem and which cause, or are likely to cause, economic or environmental harm or harm to human health. Field trials must follow all USDA APHIS permit requirements.
- Concerns related to the potential for wildfire impacts resulting from woody crop EHECs with increased terpene content can be mitigated with a variety of BMPs to deter the spread of a wildfire and reduce wildfire hazards.

Many commenters raised concerns about the potential for EHECs to increase the risk of invasiveness. DOE also agrees with these concerns related to the potential for invasiveness and the recommendations for rigorous screening protocols and monitoring, best management practices and mitigation, and establishing eradication protocols for all field trials to manage potential risk. The potential impacts for future EHEC Programs would be plant- and site-dependent; the type of crop and location for planting are variables that need to be reviewed at a project-specific level. For future EHEC Programs, the implementing agency (DOE or other Federal agency) would be responsible for preparing environmental compliance reviews, to include NEPA reviews, to identify EHEC plant- and site-specific potential environmental impacts that may result for future project-specific actions. Although beneficial impacts may result, potential adverse impacts could be avoided or minimized through the use of BMPs for plant- and site-specific actions. DOE or another Federal agency may require a recipient to implement appropriate BMPs as a condition of receiving funding or permits for a specific project.

## S-4 Preferred Alternative

DOE's preferred alternative is Alternative 3 (demonstration-scale up to 15,000 acres) allowing DOE (or other Federal agency) to facilitate the deployment of EHECs by funding programs that support commercial demonstration of EHECs in the Southeastern United States. Under Alternative 3, demonstration-scale size field trials could involve multiple growers at multiple smaller non-contiguous locations. Demonstration-scale confined field trials would follow the same protocols as typical confined field trials, including required APHIS permits and notifications.

Under Alternative 3, development of genetically engineered biofuels resulting from future EHEC Programs would be funded by DOE or other Federal agencies. In addition, under this alternative, every proposed EHEC Program and associated EHEC action would undergo the appropriate level of environmental review under NEPA, would follow USDA APHIS BRS permitting requirements, and would comply with any other legal requirements

## S-5 Structure of the Final PEIS

This Final PEIS is arranged by a Summary, 10 chapters including a reference list, and 5 appendices:

- The Summary covers the contents of the Final PEIS. In accordance with 40 CFR 1502.12, the Summary stresses the major conclusions and areas of controversy (including issues raised by agencies and the public).
- Chapter 1, Introduction, provides background information on EHECs, an overview of the NEPA process, the purpose and need for agency action, and information on public and agency coordination.
- Chapter 2, Proposed Action and Alternatives, describes the Proposed Action, the three Alternatives, and the No Action Alternative. The chapter includes a summary of potential environmental impacts associated with the proposed EHECs. The chapter concludes with a brief overview of required BMPs for confined field trials and BMPs to mitigate potential resource area concerns.
- Chapter 3, Affected Environment, provides the existing conditions for the nine-state project area for the potentially affected environmental resource areas. The chapter provides an overview of these resource areas following EPA's Level II ecoregions. The resource areas addressed in Chapter 3 include:
    - *Land Use* – Land use and land ownership information.
    - *Water Resources* – Surface water and groundwater features, water quality, and water availability.
    - *Geology and Soils* – Geologic characteristics of the project area, including the kinds and quality of soils.
    - *Biological Resources* – Flora and fauna of the project area, and the occurrence and protection of threatened and endangered species.
    - *Socioeconomics and Environmental Justice* – Population, housing, public services, and personal income and racial composition in the project area.
    - *Wildfires* – Wildfire vegetation concerns, recent wildfires in the project area, and fire protection management.
    - *Safety and Human Health* – Industrial health and safety (focusing on occupational and worker hazards), public health and safety (review of hazards), and intentional destructive acts.
    - *Air Quality* – Ambient air quality and criteria pollutants.
    - *Climate and Greenhouse Gas Emissions* – Climatic conditions such as temperature and precipitation, ambient air quality, and greenhouse gas emissions.
- Chapter 4, Environmental Consequences, provides the potential environmental impact analyses for each environmental resource area. The analyses are based on the potential programmatic-level impacts for each Alternative. BMPs are identified for specific resource areas, as applicable.
- Chapter 5, Cumulative Impacts, describes the past, present, and reasonably foreseeable projects and the cumulative impacts for particular resource areas discussed in Chapters 3 and 4.
- Chapter 6, Other Required Analyses, provides an overview of the irreversible and irretrievable resources, the relationship between short-term and long-term productivity, and any unavoidable adverse impacts.
- Chapter 7, References

- Chapter 8, Reviewers, Cooperating Agencies, and Preparers, identifies DOE and cooperating agencies reviewers, and list of preparers.
- Chapter 9, Abbreviations and Acronyms
- Chapter 10, Glossary of Terms
- Appendix A, Environmental Laws and Regulations, summarizes the environmental laws and regulations relevant to the PEIS.
- Appendix B, Draft PEIS Comments Received and DOE Responses.
- Appendix C, Draft PEIS Public Hearing Materials.

  Appendix D, Federal Agencies Invited as Cooperating Agencies, identifies the Federal agencies invited to participate as cooperating agencies for this PEIS.
- Appendix E, Federally-listed Threatened and Endangered Species and Critical Habitat, lists protected species that may be present in the project area and attempts to identify possible species distribution based on the location for the Southeastern project area.

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[4] Differences in page numbers between Draft PEIS and Final PEIS are editorial changes.

**LIST OF TABLES**

**LIST OF FIGURES**

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# 1 Introduction

The U.S. Department of Energy (DOE), Advanced Research Projects Agency-Energy (ARPA-E) is considering funding actions to catalyze the commercial development and demonstration of engineered high energy crops (EHECs) in the Southeastern United States. The geographic scope for this PEIS is limited to existing croplands, pasturelands, and forested areas in the states of Alabama, Florida (excluding the Everglades/Southern Florida coastal plain ecoregion), Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

A "Notice of Intent to Prepare a Programmatic Environmental Impact Statement (PEIS) for Engineered High Energy Crop Programs" (NOI) was published in the Federal Register (FR) on June 21, 2013 (78 FR 37593). The Draft PEIS evaluated the potential environmental effects of the Proposed Action and alternatives in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA; 42 United States Code [U.S.C.] 4321 et seq.), the Council on Environmental Quality's (CEQ) NEPA implementing regulations (40 Code of Federal Regulations [CFR] Parts 1500–1508), and DOE's NEPA Implementing Procedures (10 CFR Part 1021). Programmatic NEPA analyses are broadly scoped analyses that assess the potential environmental impacts of proposed Federal actions, such as programs that vary based on geographic regions, facility types, or multiple projects.

The sections in this Chapter provide background information on the Proposed Action; the purpose and need for the Proposed Action; and an overview of the NEPA process, cooperating agencies, and public involvement activities for the PEIS.

## 1.1 Background

Renewable energy sources comprise a variety of technology classes to supply thermal energy, electricity, and mechanical energy, as well as to produce fuels for assorted energy service needs. The energy output of these technologies and the size and scale are variable. Renewable energy sources are generally classified as biofuels, direct solar energy, hydropower, geothermal energy, ocean energy, and wind energy. Biomass, the biological matter derived from living or recently living organisms such as plants, is a type of renewable energy source that can be converted into liquid fuels (commonly known as biofuels) or combusted directly for its energy content to generate electricity or heat. The two most common types of biofuels are ethanol and biodiesel. Today, roughly half of the gasoline sold in the United States includes 5% to 10% ethanol (U.S. Department of Agriculture -- Economic Research Service, 2012). In the United States, ethanol, an alcohol made primarily from corn starch, is most commonly used as an additive for petroleum-based fuels to reduce toxic air emissions and increase octane.

### 1.1.1 Biofuels and Biofuel Engineering

Cellulosic ethanol is produced from sources other than starch in corn grain, such as woody biomass, corn stover, or switchgrass. Ethanol is available as an alternative fuel blend called E-85 containing 83% ethanol in the summer and 70% ethanol in the winter. In January 2012, there were 2,770 stations selling E-85 across 1,786 cities in the United States. The availability of E-85 has increased to 3,330 E-85 fueling stations located in 2,131 cities in the United States as of June 2014 (E85prices, 2014). Biodiesel refers to an animal-fat or vegetable oil-based fuel made of long-chain alkyl (such as methyl, ethyl, or propyl) esters in a process called trans-esterification. Used in standard compression-ignition, or diesel engines, biodiesel can be used alone, or blended with petrodiesel in any proportions (U.S. Department of Agriculture -- Economic Research Service, 2012). In 2009, the transportation sector used about 0.6 quadrillion Btu of biofuels (such as ethanol and biodiesel) (Oak Ridge National Laboratory, 2009).

Biofuel engineering seeks to breed or genetically modify plants to produce fuels or fuel-like precursors that can be blended into existing fuels or extracted directly from the plants as a ready-to-use resource. Biofuel engineering utilizes novel processes or alternative pathways to optimize the plants for energy capture and conversion, thus allowing more energy (fuels or fuel precursors) to be stored, absorbed, converted, and extracted. The biofuel engineering for EHECs could include:

- Redesigning the carbon fixation pathway of plants using an alternative biochemical pathway that uses less energy;
- Redesigning the sugar production of a plant to produce a fuel-like precursor;
- Incorporating genetic traits to increase a plants' natural ability to produce and store oils or energy-dense fuel molecules, such as triglyceride oils;
- Designing drought-resistant, cold-tolerant variant of oilseed crops;
- Designing a plant that produces and stores non-triglyceride-oil hydrocarbons (in plants that would not otherwise produce such hydrocarbons), such as long-chain alkanes and alkenes, aromatic terpenes, etc.;
- Designing a plant variant that absorbs higher levels of $CO_2$ to enhance photosynthesis and fuel conversion through, for example, improved light capture and use or more efficient metabolism;
- Designing a plant that produces and stores triglyceride oil in its leaves and stems, instead of only in seeds; and
- Increasing the amount of energy-dense fuel molecules in a pine tree species.

By increasing the per-acre fuel production by these plants, biofuel engineering would enhance the productivity of existing energy croplands, thereby supporting the EISA 2007 mandates for the United States to manufacture 36 billion gallons of biofuels by 2022 and the requirements for advanced biofuels under RFS.

### 1.1.2 Energy Crops

Energy crops are crops grown specifically for their biomass or fuel value. Biomass includes cellulose (a carbohydrate that is the principal component of wood and linked to lignin molecules that strengthen plant cell walls) as its main combustible component; biomass can be converted into biofuels (such as ethanol or biodiesel) or combusted directly for its energy content to generate electricity or heat. Non-food energy crops usually produce more usable energy than food energy crops that have higher nutritional value. Both non-food and food crops have the potential as energy crops to become EHECs.

There are three broad classes of energy crops—perennial herbaceous, annual herbaceous, and woody crops. Perennial herbaceous plants are plants that re-grow from their root-stock; these plants grow and bloom over the spring and summer, die in the autumn/winter, and return in the spring (from their root-stock). Annual herbaceous plants die at the end of their growing season and must be replanted each year. Woody crops are plants, such as trees or shrubs, that produces wood as its structural tissue; short-rotation woody crops are fast-growing species, such as Populus and Eucalyptus, that can be harvested year-round and continue growing year after year. Table 1.1-1 identifies some examples of energy crops that have the potential to be EHECs (recognizing there are other possible species); this list does not represent the entire range of possible EHECs.

**Table 1.1-1: Examples of Plants with the Potential to be EHECs**

| Perennial Herbaceous | Annual Herbaceous | Woody Crops |
|---|---|---|
| Agave<br>Giant Cane<br>Basin Wildrye<br>Bull Rush<br>Energy Cane<br>Guayule<br>Jatropha<br>Miscane<br>Miscanthus<br>Napiergrass<br>Reed Canarygrass<br>Sainfoin<br>Salicornia<br>Sugarcane<br>Switchgrass | Camelina<br>Energy Beet<br>Maize<br>Sorghum<br>Tobacco | Eucalyptus<br>Pine<br>Poplar<br>Spruce<br>Willow |

Both non-food and food crops can be engineered to increase the potential to become EHECs. Molecularly engineered organisms are those whose genetic material has been modified by genetic material from one or more organism(s); the receiving organism has new traits or characteristics (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). This technology has been used extensively in creating genetically modified (GM) agricultural crops; the most widely adopted bioengineered crops have been those with herbicide-tolerant traits or insect resistant traits such as in bioengineered soybeans and corn. Three crops (corn, cotton, and soybeans) make up the bulk of the acres planted to GE crops. U.S. farmers planted about 169 million acres of these GE crops in 2013, or about half of total land used to grow crops (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014).

Table 1.1-2 lists many of the GE crops and their associated traits that are currently available or in development in the United States within the past five years (2009-2014). These modified, traditional agricultural crops have been grown with extensive oversight, regulation, and review by USDA's APHIS, the Food and Drug Administration (FDA), or the EPA. APHIS regulates the environmental release of certain GE organisms that are, or have the potential to be, plant pests.

**Table 1.1-2: GE Crops Available and in Development in the United States (2009-2014)[5]**

| Crop | Herbicide Tolerance | Insect Resistance | Viral/Fungal Resistance | Agronomic/ Energy Property |
|---|---|---|---|---|
| **Corn** | • Glyphosate<br>• Imidazolinone<br>• Tissue-selective Glyphosate<br>• 2,4-D and –ACCase-inhibitor | • Lepidopteran<br>• Rootworm<br>• Insect Resistant<br>• Rootworm and Glyphosate | | • Fertility restored<br>• Male sterile<br>• Drought Tolerant |
| **Soybeans** | • Glyphosate and Isoxaflutole<br>• Imidazolinone<br>• HPPD and Glufosinate<br>• Glufosinate<br>• 2,4-D, Glyphosate, and Glufosinate<br>• Dicamba<br>• 2,4-D and Glufosinate | • Lepidopteran<br>• Insect resistant | | • Increased Yield<br>• High Oleic Acid<br>• Improved Fatty Acid Profile<br>• Altered Fatty Acid Profile<br>• Stearidonic Acid Produced |
| **Cotton** | • Glyphosate<br>• 2 4-D and Glufosinate<br>• Dicamba and Glufosinate | • Lepidopteran | | |
| **Beet** | Glyphosate | | | |
| **Canola** | Glyphosate | | | |
| **Papaya** | | | Papaya ringspot virus[6] | |
| **Alfalfa** | Glyphosate | | | Reduced Lignin |
| **Eucalyptus** | | | | Freeze Tolerant |
| **Creeping Bentgrass** | Glyphosate | | | |
| **Potatoes** | | | | • Low Acrylamide Potential<br>• Reduced Black Spot Bruise |

*Italics*=petition for nonregulation is pending; Normal=approved (currently available, as of 2014)

*Source:* (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014)

These organisms are referred to as 'regulated articles.' Introduction includes interstate movement, or release into the environment that is outside an area of physical containment (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). USDA biotechnology regulations require any GE organism with the potential to be a plant pest to be regulated until it has undergone extensive review to demonstrate that it does not pose a plant pest risk.

Many of the crops identified in Table 1.1-2 have been deregulated by APHIS and have also completed reviews from the EPA (and the FDA[7]), as warranted by the nature of the GE trait (U.S. Department of

[5] Only includes crops available or in development within the past five years (2009-2014).

[6] Responding to a devastating papaya virus epidemic in the mid-1990s, researchers at Cornell University and at the University of Hawaii developed two virus-resistant varieties of GE papaya. First commercial plantings were made in 1998. The new varieties are no longer susceptible to infection (even when the virus is widespread); the GE papaya were planted on more than 30% of Hawaii's papaya acreage in 1999.

[7] FDA review is not required and has been done voluntarily.

Agriculture -- Animal and Plant Health Inspection Service, 2006). The effects of genetic engineering technology can be highly variable, and risks and benefits must be considered on a case-by-case basis (Chapman & Burke, 2006).

### 1.1.3 Engineered High Energy Crops (EHECs)

Scientists are not only identifying crop species that produce large quantities of biomass with minimal inputs, but they are also developing other approaches that do not rely on biomass. EHECs could be specifically engineered to increase energy production independent of increasing the amount of biomass. These EHECs would be agriculturally-viable photosynthetic species containing genetic material that has been intentionally introduced through biotechnology, interspecific hybridization or other engineering processes such as optimized agronomic practices. Engineering processes exclude processes that occur in nature without human intervention. Thus, specifically engineered EHECs could produce more useful energy per acre. EHECs present a promising renewable energy source that, by virtue of biological carbon capture, has a reduced carbon life-cycle, decreasing the production of GHGs and allowing for domestic production of renewable fuels.

Desirable production traits for EHECs include:

- Growth on land not currently used for food production;
- Reduced input requirements (land, water, fertilizer, pesticides);
- Improved tolerance to environmental and biotic stress;
- Produce high energy fuel molecules that are readily extractable from the plant;
- Efficient methods for stable genetic modification;
- Facile establishment and control (e.g., through seeds, vegetation propagation, and sterile traits);
- Ability to harvest with existing equipment; and
- Perennial with good longevity or annual that can be included in crop rotations.

The processing traits for an ideal EHEC can include:

- High total dry matter yield (low water content at harvest);
- High energy density biological feedstock that can be easily converted into fuel;
- Can be easily transported and stored without loss of energy after harvest;
- Low mineral (ash) content at harvest;
- Low volatile organic carbon (VOC) emissions during harvest; and
- Compatibility with established production, harvesting, distribution, and storage infrastructure.

There are several preferred environmental traits for a crop to be used as an EHEC. These traits include, but are not limited to:

- Favorable as wildlife habitat and a positive contributor to biodiversity;
- Non-invasive with low risk of gene flow to wild relatives;
- Manageable fire hazard risk; and
- Low cost through limited use of high-value agricultural inputs such as land, fertilizer, or irrigation.

This Final PEIS is focusing only EHECs that are not food crops. Eligible crops in the proposed EHEC Programs could include any plants of renewable biomass. Crops that may be used in confined field trials as part of the EHEC Programs include, but are not limited to, crops currently being investigated under ARPA-E's PETRO program. Table 1.1-1 does not represent the entire range of possible EHECs.

### 1.1.4 Regulatory Requirements for Biotechnology Products

The United States adapted existing laws to create a complex set of rules under the 1986 Coordinated Framework for Regulation of Biotechnology (51 FR 23302), using the existing regulatory authority and Federal oversight shared by three agencies involved in regulating GE plants: the USDA-APHIS, the EPA, and the FDA. In the case of EHECs, under the Coordinated Framework review, USDA-APHIS would review the plant, EPA would register the use of the pesticides in EHEC production (as applicable), and FDA would consider the safety and regulatory status of food and feed derived from the plant (as applicable). EPA would also establish a tolerance for allowable pesticide residues on harvested EHECs (as applicable). The USDA-APHIS, EPA, and FDA update their regulations as needed to address new trends and issues of the future. The proposed EHEC Programs would follow the Coordinated Framework approach, as appropriate.

#### 1.1.4.1 APHIS Reviews

APHIS approves and monitors introductions of regulated GE crops—specifically, movements into and through the United States and field tests. APHIS regulates the import, transportation, and field testing of agricultural biotechnology products (such as transgenic seeds and plants) through notification and permitting procedures. These agricultural biotechnology products are considered "regulated articles." APHIS issues authorizations for field releases of those GE organisms (mostly GE plants) that are categorized as "regulated articles" under its regulations, to allow technology providers to pursue field testing.

Before conducting a confined field trial of a new GE crop, developers must apply for APHIS approval through notification or permit. The specific protocols and types of information required to conduct confined field trials are based on the biology of the plant as it relates to the environment it is released into and what is known about the trait and gene. In the United States, a tiered system is available, where a *Notification* can be used when introducing genetic material into crops that is well characterized. A *Permit* is required when the trait is novel or less information is known about the crop or crop/trait combination.

*Notification*: GE plants that meet six specific criteria described in the regulations undergo an administratively streamlined process, known as a notification. Specifically, to qualify for introduction under a notification, the plant must not:

- Be listed as a noxious weed;
- Be transformed with genetic material that has not been stably integrated into the plant genome;
- Contain genes of unknown function;
- Cause the production of an infectious entity, be toxic or be intended for pharmaceutical use;
- Pose a significant risk of creating any new plant virus; and
- Contain genetic material from animal or human pathogens.

To obtain a notification, an applicant must submit design protocols and meet certain eligibility and performance standards. The eligibility standards (7 CFR §340.3(b)(1-6)) describe the requirements of GE plants for field testing. The performance standards (7 CFR §340.3(c)(1-6)) outline general expectations for conducting the field trial such as preventing the crop from persisting in the environment, maintaining the identity of the crop, preventing regulated materials from mixing with non-regulated plant materials, keeping the regulated material from being disseminated during transit, destroying regulated materials when they are no longer in use, and managing volunteers to keep them from persisting in the environment. The actual conditions for meeting the performance standards are not specified; applicants submit design protocols specifying what methods will be used to meet the performance standards.

Under the Federal Plant Pest Act, APHIS' Biotechnology Regulatory Services (BRS) must determine whether an engineered plant variety is likely to become a pest. In addition, APHIS BRS expects regulated entities to comply with all design protocols and performance standards that may include observing isolation distances, confinement measures, harvesting procedures, and devitalization and disposal.

*Permit*: For GE plants that do not meet the criteria for a notification, an APHIS permit is required. This process involves a more comprehensive review. To obtain a permit, an applicant must submit its proposed field test for review and approval by APHIS on a case-by-case basis. There are no eligibility requirements and no performance standards in the regulations for GE plants grown under permits. In addition to the data required for notification, permit applicants must describe how they will perform the test, including specific measures to reduce the risk of harm to other plants, so the tested organisms remain confined and do not persist after completion of the field test. Applicants for notifications and permits must develop protocols specifying how they will conduct the confined field trial to meet the performance standards.

After field testing under the APHIS permit, an applicant may petition APHIS for a determination of non-regulated status in order to facilitate commercialization. If, after comprehensive review, APHIS determines that the GE organism is unlikely to pose a plant pest risk, APHIS makes a "determination of non-regulated status." If the GE organism received approval, the GE organism is no longer subject to the regulatory requirements of 7 CFR Part 340 and no longer requires permits; the GE organism can be moved and planted without APHIS oversight (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2012).

#### 1.1.4.2 EPA Reviews

If a plant is engineered to produce a new substance that "prevents, destroys, repels, or mitigates a pest," it is considered a pesticide and is subject to regulation by EPA (Federal Register, 1994). Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA regulates plants with genes that provide protection against any form of pest, but only if breeding employs GE methods. The introduction of novel compounds, or changes to the levels of innate pest-protective compounds by way of conventional hybridization, mutagenesis, cloning, and other breeding methods, in both native and exotic species, remains unregulated.

#### 1.1.4.3 FDA Reviews

The FDA regulates all food applications of crops, including those crops that are developed through the use of biotechnology, to ensure that foods derived from new plant varieties are safe to eat. FDA has authority to regulate food under the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.) and the Public Health Service Act. To help developers of foods and feeds derived from GE plants comply with their obligation to market safe food in accordance with FDA statutory and regulatory requirements, FDA encourages developers to participate in a voluntary FDA consultation process prior to commercialization. In that process, developers submit data and information to FDA to determine if a food from a GE crop complies with FDA statutory and regulatory requirements. (U.S. Food and Drug Administration, 1992)

The FDA has published recommendations for voluntary food safety evaluations for new non-pesticidal proteins produced by new plant varieties intended to be used as food, including GE plants. Early food safety evaluations help ensure that potential food safety issues related to a new protein in a new plant variety are addressed early in development. These evaluations are not intended as a replacement for a biotechnology consultation with FDA, but the information may be used later in the biotechnology consultation. (U.S. Food and Drug Administration, 2006)

### 1.1.5 U.S. Renewable Energy Goals and Implementing Legislation

In the past decade, several pieces of legislation, combined with executive actions, were enacted to support the development of renewable energy programs, including cellulosic biofuels derived from biomass such as the Farm Bill and the Energy and Independence Security Act. The Agricultural Act of 2014 (Public Law [Pub.L.] 113–79), known also as the 2014 Farm Bill, continued funding several renewable energy programs from the 2008 Farm Bill including the Rural Energy for America Program (REAP) and associated energy audits and renewable energy development assistance, the Biomass Crop Assistance Program (BCAP), and the Repowering Assistance program to advance low carbon advanced biofuels. Of note, through BCAP, the 2014 Farm Bill makes incentives available for biomass production. BCAP provides two categories of financial assistance: (1) annual and establishment payments that share in the cost of establishing and maintaining production of eligible biomass crops; and (2) matching payments that share in the cost of the collection, harvest, storage, and transportation of biomass to an eligible biomass conversion facility. BCAP has mandatory funding of $25 million per year for 2014–2018; no discretionary funding is authorized. However, the 2014 Farm Bill reduced the funding commitment from the 2008 Farm Bill and consolidated the initial 23 programs down to 13 programs.

The enactment of the Energy Independence and Security Act of 2007 (Pub. L. 110-140), referred to as EISA 2007, contains provisions to increase energy efficiency and the availability and use of renewable energy. One key provision of EISA 2007 is the establishment of a revised Renewable Fuel Standard (RFS) to 36 billion gallons per year (BGY) of annual renewable fuel use by 2022 and a requirement that 60% of the revised RFS (16 BGY) be met by advanced biofuels, including cellulosic ethanol. Other components in EISA 2007 included 14 BGY met by advanced biofuels, 1 BGY by biomass based biodiesel, and 15 BGY by conventional biofuels, such as corn-starch based ethanol. EISA 2007 also established new definitions for renewable fuels (e.g., greenhouse gas reduction thresholds) and renewable biomass used for fuel production.

Other agencies and programs are trying to address Federal and agency renewable energy goals through a variety of projects and investments including:

- Biomass research such as projects funded by DOE's Bioenergy Technologies Office (BTO)
- Use of microorganisms – In April 2010, ARPA-E announced $40 million in funding for projects selected under its electrofuels technology development program to use microorganisms to create liquid transportation fuels in a way that could be up to 10 times more energy-efficient than current biofuel production methods;
- Fuel subsidies for ethanol production from corn starch;
- Development of infrastructure (e.g., DOE BTO/U.S. Department of Agriculture [USDA] refinery funding); and
- Other biofuel investments and goals:
    - In 2009, the U.S. Air Force Energy Plan established a goal of obtaining 50% of its contiguous United States aviation fuel via a synthetic blend utilizing domestic feedstocks produced in the United States by 2016.
    - In October 2009, the U.S. Navy established a goal of obtaining 50% of its total energy consumption from alternative sources (e.g., biofuels) by 2020
    - In March 2011, President Obama directed DOE, USDA and the Navy to partner with private industry to spur development of advanced drop-in biofuels requiring each agency to invest its core competencies as well as funding toward this Defense Protection Act (DPA) Advanced Biofuels Production Project; this partnership includes an investment up to $510 million over three years to produce advanced, drop-in biofuels for military and commercial transportation.
    - In December 2011, USDA and the Navy announced that the Defense Logistics Agency (DLA) had signed a contract to purchase 450,000 gallons of advanced, drop-in biofuels.
    - In January 2013, President Obama signed the National Defense Authorization Act (NDAA) allowing DoD to develop alternative sources of energy and to invest in the construction of biofuel refineries.
    - In 2013, the USDA and Navy announced a joint "Farm-to-Fleet" venture to incorporate biofuel blends into regular, operational fuel purchase and use by the military as part of domestic solicitations for jet engine and marine diesel fuels. As part of this joint venture, the Navy aims to purchase JP-5 and F-76 advanced drop-in biofuels blended from 10% to 50% with conventional fuels. The USDA's Commodity Credit Corporation (CCC) will provide funding to assist with the initiative.
    - In May 2013, four companies were competitively selected under Phase I of the DPA Advanced Biofuels Production Project. These companies, if successful in Phases I and II, would deliver up to 170 million gallons of military-compatible fuel annually starting in 2016 and with at least 50% lower life-cycle GHG emissions than conventional fuel and at a cost of less than $4 per gallon.

DOE and the USDA identified actions needed to ensure development of viable alternatives to petroleum-based fuels (Biomass Research and Development Board, 2008). The resulting document, National Biofuels Action Plan, discusses the need to achieve improvements in the near- and long-term production of first- and second-generation feedstocks to sustain growth in the biofuels industry. First-generation feedstocks include, for example, corn for the production of ethanol and soybeans for the production of biodiesel. Although production of these crops has been increasing, DOE and USDA also recognize the need to avoid disrupting the production of crops for human and animal consumption (Biomass Research and Development Board, 2008).

### 1.1.6 DOE ARPA-E's Mission

DOE's mission and strategic goals include promoting energy security in the United States by providing reliable, clean, and affordable energy and strengthening the nation's technological leadership and economic competitiveness through advancements in science and technology. DOE's ARPA-E was created by the America COMPETES Act (Pub. L. 110-69), and signed into law by President Bush on August 9, 2007 in response to a recommendation by the National Academies in the *Rising above the Gathering Storm* report to create an agency patterned on the Defense Advanced Research Projects Agency (DARPA). As described in the *ARPA-E Strategic Vision 2013* (U.S. Department of Energy -- Advanced Research Projects Agency, 2013a), ARPA-E "catalyzes transformational energy technologies that could create a more secure and affordable American future by advancing high-potential, high-impact energy technologies that are too early for private sector or other DOE applied research and development investment." The focus of ARPA-E is on energy technologies that can be meaningfully advanced with a small investment over a specified time period.

ARPA-E was established to fund the development and deployment of transformational energy technologies in the United States. ARPA-E's mission is to reduce foreign energy imports and energy-related emissions including greenhouse gases (GHGs), to improve efficiency across the energy spectrum through the development of advanced energy technologies, and to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies (U.S. Department of Energy -- Advanced Research Projects Agency, 2013c). Since 2009, ARPA-E has funded 360 projects for potentially transformational energy technology projects, intended to explore creative "outside-the-box" technologies or research in the areas of energy generation, storage, and utilization. Several of these projects have already demonstrated early indicators of technical success, such as engineered microbes that use hydrogen and carbon dioxide to make liquid transportation fuel or development of a 1 megawatt silicon carbide transistor the size of a fingernail (U.S. Department of Energy -- Advanced Research Projects Agency, 2013b).

In September 2011, ARPA-E announced $36 million in funding for the Plants Engineered To Replace Oil (PETRO) Program to develop non-food crops that can more easily produce transportation fuel, such as fuels that can be extracted directly from the plants (U.S. Department of Energy -- Advanced Research Projects Agency, 2011). The goal is to produce crops that can help supply the transportation sector with biofuels that are cost-competitive with petroleum and do not affect the Nation's food supply. PETRO aims to redirect the processes for energy and carbon dioxide ($CO_2$) capture in plants toward fuel production, thereby creating biofuel crops that deliver more energy per acre with less processing prior to the pump, and represent a price-competitive, domestically-produced alternative to petroleum-based fuels.

## 1.2 Proposed Action

The Proposed Action is the development and implementation of future EHEC Programs to catalyze the deployment of EHECs through research, development, and demonstration activities using confined field trials of EHECs in the Southeastern United States. Funding EHEC Programs that facilitate the development and implementation of the commercialization of EHECs is directly in line with ARPA-E's mission. These EHECs would be agriculturally-viable photosynthetic species containing genetic material that has been intentionally introduced through biotechnology, interspecific hybridization, or other engineering processes to produce more useful energy per acre. EHECs could be specifically engineered to increase energy production independent of increasing the amount of biomass and present a promising renewable energy source that, by virtue of biological carbon capture, has a reduced carbon life-cycle, decreasing the production of GHGs, and allowing for domestic production of renewable fuels. With Federal assistance, from DOE or other Federal agencies, commercial entities, independent contract growers, or research institutions, would be able to conduct confined field trials to evaluate the performance of EHECs.

Confined field trials would be a key component to demonstrate the biological and economic viability of EHECs—critical to bringing these crops to market—and to further ARPA-E's mission. A confined field trial is an experiment conducted under stringent terms and conditions to confine a crop while it is grown outside of a greenhouse. The confined field trials may range in size and could include development-scale (up to 5 acres), pilot-scale (up to 250 acres), or demonstration-scale (up to 15,000 acres). All necessary permits, such as permits from the USDA Animal and Plant Health Inspection Service (APHIS), would be obtained before initiating confined field trials. Section 2.2.5 provides additional information on confined field trials.

Based, in part, on the analyses in the PEIS, DOE will decide whether to provide funding to support the development and deployment of EHECs through development-scale (Alternative 1), pilot-scale (Alternative 2), demonstration-scale field trials (Alternative 3), or not to provide funding (No Action Alternative). Funding for the Proposed Action or Alternatives would be contingent on the completion of plant- and site-specific environmental reviews, in compliance with laws such as NEPA, by DOE or another Federal agency. Additionally, DOE or another Federal agency may require the grantee or permittee to implement best management practices (BMPs) to avoid, minimize, or mitigate any potential environmental impacts as a condition of receiving funding or a permit. If DOE, following site-specific environmental reviews, issues a Record of Decision (ROD), that ROD could require implementation of BMPs.

## 1.3 Purpose and Need for Agency Action

Despite the success of converting corn starch into ethanol as a biofuel, this technology alone does not satisfy the challenge set by the Federal government. As described in Section 1.1.5, a variety of agencies and scientists are expanding their research to other bioenergy and biomass resources to comply with the revised RFS. Present day production of biofuels is limited by the inefficient capture of solar energy and carbon dioxide ($CO_2$) that occurs during plant photosynthesis, and conversion of these inputs into a ready-to-use energy source (i.e., fuel). Increasing photosynthesis, improving bioenergy crop yield, creating or adding molecules found in petroleum-based fuels, and redirecting carbon capture to more useful molecules are some of the ways to modify plants to increase carbon sequestration and to improve biofuels. These modifications may be interlinked; for example, modifying a plant to grow more roots to improve nutrient uptake may take away aboveground biomass production.

Energy crop research programs are trying to fill an agency research gap by experimenting with a variety of plants that are non-cellulose sources to produce more efficiently grown and easily extracted agricultural-based biofuels in many regions of the United States; however, research for these modifications is preliminary. Existing research programs are experimenting with a variety of engineering approaches to increase carbon sequestration and biofuel improvements. EHECs could include those plant species being modified under the ARPA-E PETRO Program or other current and future research programs engineered to increase energy production independent of increasing the amount of biomass. Successful EHEC Programs may advance the environmentally responsible deployment of biofuels produced by, or through the processing of, EHECs to provide substitute biofuels that are cost-competitive with petroleum, large-scale (deployment), and renewable.

Programs that catalyze the deployment of EHECs to market, including development and demonstration field trials, would further the mission and strategic goals of DOE. DOE aims to catalyze the timely, material, and efficient transformation of our nation's energy system and to secure our nation's leadership in clean energy technologies. The technologies being investigated under the ARPA-E PETRO program are working to address DOE's and ARPA-E's goals by increasing energy density per acre; reducing agricultural input requirements; promoting plant production of materials or molecules that require less processing prior to introduction into existing infrastructure; or thereby allowing the United States to lead in the development of new biofuel technology.

There is a need for DOE or other Federal agency funding and support for EHEC Programs, without which scientific understanding and innovation in the responsible use of EHECs and, ultimately, commercial deployment of EHECs would develop more slowly or not at all. Accordingly, the purpose for agency action is for DOE to take action to catalyze the development and deployment of EHECs.

## 1.4 NEPA Process

DOE is voluntarily developing this PEIS in accordance with NEPA, CEQ NEPA implementing regulations, and DOE's NEPA implementing procedures. This Final PEIS examines the potential impacts associated with the proposed development and implementation of EHEC Programs, in particular the potential impacts of confined field trials and harvesting of EHECs in the Southeastern United States. It does not eliminate the need for environmental compliance review of site- and plant-specific individual projects that might be eligible for funding or other forms of support by DOE or other Federal agencies. Rather, to the extent that DOE proposes to fund or undertake particular projects that may fall within the scope of this Final PEIS, project-specific environmental compliance reviews for such projects and activities are expected to build on, or tier from, this Final PEIS and to be more effective and efficient. Moreover, any such projects and activities would be subject to compliance with obligations under other environmental laws such as the Endangered Species Act of 1973 (16 U.S.C. §§ 1531-1544 et seq.) and the National Historic Preservation Act of 1966 (16 U.S.C. §§ 470 et seq.). This Final PEIS does not cover post-harvest activities for the EHECs, such as transportation to the refinery, refining into biofuels, and tail-pipe emissions. DOE or another Federal agency would conduct environmental reviews in compliance with law to identify potential impacts resulting from post-harvest activities and energy conversion on a plant- and site-specific basis.

DOE's purpose in preparing this voluntary Final PEIS is to inform Federal and state agencies, decision makers, and the public of the potential environmental impacts of the Proposed Action and its alternatives. An interdisciplinary team of plant geneticists, biologists, hydrogeologists, air quality specialists, environmental scientists, planners, engineers, archaeologists and historians, hazardous waste specialists, and biofuel experts have prepared this Final PEIS. DOE has received public input on the issues to be analyzed during the public involvement process for this project (see Section 1.7).

The breadth of subject matter in this NEPA document and the nature of the environmental resources potentially affected require that DOE consider many laws, regulations, and executive orders (EOs) related to environmental protection. These authorities are addressed in various sections of this document where they are relevant to particular environmental resources and conditions. Some regulations prescribe standards for compliance, whereas others require specific planning and management actions to protect environmental attributes potentially affected by DOE actions. Appendix A provides a list of the applicable laws and regulations considered in development of this Final PEIS.

### 1.4.1 Programmatic Analysis

The NEPA Task Force reported that "Programmatic NEPA analyses and tiering can reduce or eliminate redundant and duplicative analyses and effectively address cumulative effects" (Council on Environmental Quality, 2003). A programmatic environmental document, such as this Final PEIS, may be prepared when an agency is proposing to carry out a broad action, program, or policy. DOE has determined that development and implementation of the EHEC Programs is a broad action with wide ranging effects and has voluntarily prepared this Final PEIS.

As reported in recently finalized guidance, "Effective Use of Programmatic NEPA Reviews," CEQ notes that "programmatic analyses have value by setting out the broad view of environmental impacts and benefits for a proposed decision" (Council of Environmental Quality, 2014). A programmatic approach can create a comprehensive, analytical framework that supports subsequent analyses of specific actions at site- and ecoregion-specific locations within the nation. Programmatic analysis can save resources by effectively providing a starting point for the analysis of cumulative and indirect impacts, allowing subsequent NEPA analyses to be more narrowly focused on specific activities at specific locations. This approach avoids the need for repetitive broad analyses in subsequent tiered NEPA reviews and provides a more comprehensive picture of the consequences of possible actions. Site- or plant-specific impact assessment of the EHEC Programs is not practicable at the program development level because specific sites, ecoregions, and EHECs are unknown at this time.

### 1.4.2 Tiering

Tiering (40 CFR §1502.20) is a staged approach to NEPA described in CEQ's NEPA Implementing Regulations. It is the process by which broader "programmatic" environmental analyses are applied to site-specific actions and impacts in subsequent NEPA ("tiered") studies. The purpose of tiering subsequent Environmental Impact Statements (EIS) and Environmental Assessments (EA) is to eliminate repetitive discussions of the same issues previously addressed in the PEIS and to focus on the actual issues ripe for decision. The subsequent environmental analyses would need to summarize the issues discussed in the PEIS and incorporate by reference discussions from that PEIS. Any future environmental analyses would concentrate on the issues specific to the proposed sites and EHEC species. The geographic region for this PEIS is limited to the Southeastern United States (see Section 2.2.2). This voluntary PEIS by DOE is a first-tier environmental review. DOE anticipates tiering subsequent NEPA documents for site-specific projects involving technologies developed under the proposed EHEC Programs from this PEIS.

## 1.5 Cooperating Agencies

DOE is the lead Federal agency proposing to carry out the Proposed Action. Cooperating agencies, as defined by the CEQ, include any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in proposed legislation, a Proposed Action, or reasonable alternative (40 CFR §1508.5). A cooperating agency assists the lead Federal agency by participating in the NEPA process and typically has some responsibilities for the review of impacts related to its jurisdiction or special expertise. Invited cooperating agencies for this Final PEIS include the USDA's APHIS and Forest Service (USFS). APHIS formally accepted to serve as a cooperating agency, and USFS informally accepted. Appendix D provides a list of the invited cooperating agencies for this Final PEIS.

### 1.5.1 USDA Animal and Plant Health Inspection Service (APHIS)

The USDA APHIS is responsible for protecting United States' agriculture from pests and diseases under the authority of the Plant Protection Act (PPA), Title IV of the Agricultural Risk Protection Act of 2000. Under the PPA, the Secretary of Agriculture has delegated authority to APHIS to prohibit or restrict the import, export, and interstate movement of plants, plant products, certain biological control organisms, noxious weeds, and plant pests. APHIS issues permits for the import, interstate movement, or environmental release of identified genetically engineered (GE) plants. The APHIS permit applications require information about the nature of the GE organism to be introduced and the measures undertaken to prevent its spread or establishment in the environment. APHIS technical experts review each permit application. Based on the review of the permit application, APHIS may issue the permit for the introduction of GE organisms (including plants, insects, or microbes) that may pose a plant pest risk. DOE met with and extended a cooperating agency request to APHIS for this PEIS due to their specialized expertise with and authority over GE plants and their potential environmental impacts. Any confined field trials under the proposed EHEC Programs will need a permit for review and approval by APHIS. APHIS signed a Memorandum of Understanding with DOE to serve as a cooperating agency and to provide technical review of the PEIS.

### 1.5.2 USDA Forest Service

Established in 1905, the USFS, an agency within the USDA, manages public lands in national forests and grasslands. National forests and grasslands encompass 193 million acres of land throughout the United States. DOE extended a cooperating agency request to the USFS for this PEIS due to the potential for woody biomass to be used as a crop type. The USFS is informally providing special expertise related to all aspects of forest health, forest economics, and potential environmental issues in the review of the PEIS.

## 1.6 Public Participation

DOE determined the issues to be addressed in the PEIS by involving the public. Public involvement allows for full and fair discussion of potential environmental impacts. DOE provided opportunities for public participation in compliance with CEQ regulations and DOE's NEPA implementing procedures (40 CFR §1506.6). The purpose of public involvement under NEPA is to provide open communication between DOE and the public resulting in better decision making.

Several opportunities were provided for public involvement during the preparation of this PEIS. This section provides an overview of scoping and Draft PEIS public involvement. DOE contacted more than 500 Federal, state, and local agency and government officials, members of Congress, non-governmental organizations, and the public for the Draft PEIS. In addition, DOE developed a project website to disseminate information to the public; the project website can be accessed at http://engineeredhighenergycropspeis.com. The project website will remain accessible throughout the NEPA process.

### 1.6.1 Request for Information

DOE issued a public Request for Information (RFI) on April 12, 2013 soliciting input regarding concerns about and barriers to the development of EHECs (including potential environmental impacts), such as those crops being investigated under the ARPA-E PETRO program and potential future DOE programs (U.S. Department of Energy, 2013). DOE considered the comments received from the RFI in developing the NOI.

### 1.6.2 Notice of Intent

The NOI to prepare this PEIS was published in the *Federal Register* on June 21, 2013 to initiate the scoping process under NEPA (78 FR 37593). To ensure that all issues related to the Proposed Action were considered, DOE requested comments to further delineate the scope of the environmental analysis, including alternatives and potential environmental issues. Included in the NOI publication was an announcement of public scoping meetings.

DOE also published meeting notices in the following newspapers:

- July 2, 2013 in the *Lexington Herald Leader*, Lexington, Kentucky;
- July 2-3, 2013 in *The Clarion Ledger*, Jackson, Mississippi; and
- July 3, 2013 in the *News & Observer*, Raleigh, North Carolina.

### 1.6.3 Scoping Meetings: In-person and Web-based Meetings

DOE conducted in-person and web-based scoping meetings to solicit input on the issues, concerns, and alternatives of the PEIS. DOE accepted comments during the scoping meetings and by mail, by e-mail, and electronically through an online comment form on the project website. DOE conducted in-person scoping meetings over a three-day period in July 2013:

- July 9, 2013 at the Lexington Convention Center, 430 West Vine Street, Lexington, Kentucky;

- July 10, 2013 at the Mississippi e-Center at Jackson State University (Convention Hall), 1230 Raymond Road, Jackson, Mississippi; and
- July 11, 2013 at the Raleigh Convention Center, 500 S. Salisbury Street, Raleigh, North Carolina.

Each scoping meeting included a poster session for the public to view exhibits related to the project and to talk with subject matter experts, followed by an open forum to provide verbal comments. The open forum began with a presentation providing an overview of the project and the NEPA process before the formal commenting session. All verbal comments were transcribed by a court reporter to ensure they would be available to DOE and the public for consideration during preparation of the Draft PEIS. A total of 52 people attended the in-person scoping meetings with 11 individuals providing oral comments for DOE's consideration.

DOE hosted one web-based meeting on July 17, 2013 providing an overview of the project and the NEPA process and soliciting comments from the public. A total of 25 people registered for this two-hour meeting; 3 individuals provided oral comments.

### 1.6.4 Notice of Availability

The publication of the Draft PEIS Notice of Availability in the *Federal Register* by the U.S. Environmental Protection Agency (EPA) on January 16, 2015 initiated a 60-day public review and comment period (80 FR 2404). The NOA publication also included an announcement of the Draft PEIS in-person and web-based public hearings. DOE published a meeting notice in the *Washington Post* on February 16, 2015 and in the *Washington Post Express* on February 17, 2015 (see Appendix C).

### 1.6.5 Draft PEIS Public Hearings: In-person and Web-based Meetings

DOE conducted in-person and web-based public hearings to solicit input on the Draft PEIS. DOE accepted comments during these meetings and by mail, by e-mail, and electronically through an online comment form on the project website. DOE held an in-person Draft PEIS public hearing on February 17, 2015 at the Washington Capitol, 550 C Street Southwest, Washington, DC 20024. The hearing included a poster session for the public to view exhibits related to the Draft PEIS and to talk with subject matter experts, followed by an open forum to provide verbal comments. The open forum began with a presentation providing an overview of the project and the NEPA process before the formal commenting session. All verbal comments were transcribed by a court reporter to ensure they would be available to DOE and the public for consideration during preparation of the Final PEIS. Only one person attended the in-person public hearing; she provided oral comments on the Draft PEIS for DOE's consideration.

DOE hosted two web-based meetings on February 24 and February 26, 2015 providing an overview of the project and the NEPA process and soliciting comments on the Draft PEIS. A total of 29 people participated in the two-hour web-based meetings; 3 individuals provided oral comments. Appendix C includes the Draft PEIS public involvement materials including the Federal Register notice, newspaper advertisements, and public hearing materials.

### 1.6.6 Agency and Public Draft PEIS Concerns

DOE received 25 individual written comments from Federal and state agencies, organizations, and individuals on the Draft PEIS. DOE reviewed and considered these comments for the Final PEIS. Major concerns are presented below:

- Invasiveness: Concerns were raised that EHECs may increase the risk of invasiveness. Agencies and interested groups recommended that rigorous screening protocols and monitoring, mitigation, and eradication protocols be established for all field trials to manage potential risk.

- Best Management Practices: Several comments recommended DOE identify specific BMP requirements and mitigation measures for field trials to prevent invasiveness, that is, the spread of proposed EHECs that are not native to an ecosystem and which may cause, or are likely to cause, economic or environmental harm or harm to human health.

- Indirect impacts to natural resources: Concerns related to the potential indirect impacts on water quality, wetlands, aquatic and biological resources, protected species, and habitat protection.

- Potential for EHECs to displace land used for food production: The potential to displace annual row crops such as corn, which serves several purposes including human consumption and livestock feed, and the displacement of pasture and hay land were concerns.

- Prospective technologies associated with the conversion of plants into fuels: Other technologies discussed and recommended as potential biotechnology tools associated with EHEC included algae, natural gas, renewable coal alternative, leaching, and a new cropping system.

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# 2 Proposed Action and Alternatives

## 2.1 Introduction

As part of the NEPA process, DOE must consider the range of reasonable alternatives to the Proposed Action. Reasonable alternatives include those that are practical or feasible from a technical and economic standpoint, and support the underlying purpose and need for agency action. The Final PEIS identifies the potential environmental impacts resulting from development of EHECs and considers the potential impacts of alternatives for development and implementation of EHEC Programs. Project alternatives that do not meet any of the criteria of feasibility are not required to be and were not analyzed further. DOE identified the following alternatives to evaluate—development-scale confined field trials (up to 5 acres), pilot-scale confined field trials (up to 250 acres), demonstration-scale confined field trials (up to 15,000 acres), and the No Action Alternative. The use of these scaled alternatives is intended to help frame the discussion for potential impacts.

## 2.2 Proposed Action

The Proposed Action is the development and implementation of EHEC Programs to catalyze the deployment of EHECs for fuel production through research, development, and demonstration activities involving the planting and harvesting of EHECs in the Southeastern United States. These EHECs could be specifically engineered to increase energy production independent of increasing the amount of biomass and present a promising renewable energy source that could result in decreased GHGs and the domestic production of renewable fuels. With financial assistance from DOE, commercial entities, independent contract growers, or research institutions, would be able to conduct confined field trials to evaluate the performance of EHECs. The use of confined field trials to grow EHECs would occur only after obtaining any regulatory permits that identify procedures to minimize the unintentional spread and establishment of the crop. Examples of EHECs include, but are not limited to, crops currently being investigated under ARPA-E's PETRO Program, such as engineered varieties of camelina, loblolly pine, tobacco, giant cane, energy beet, sugarcane, miscanthus, sorghum, and switchgrass.

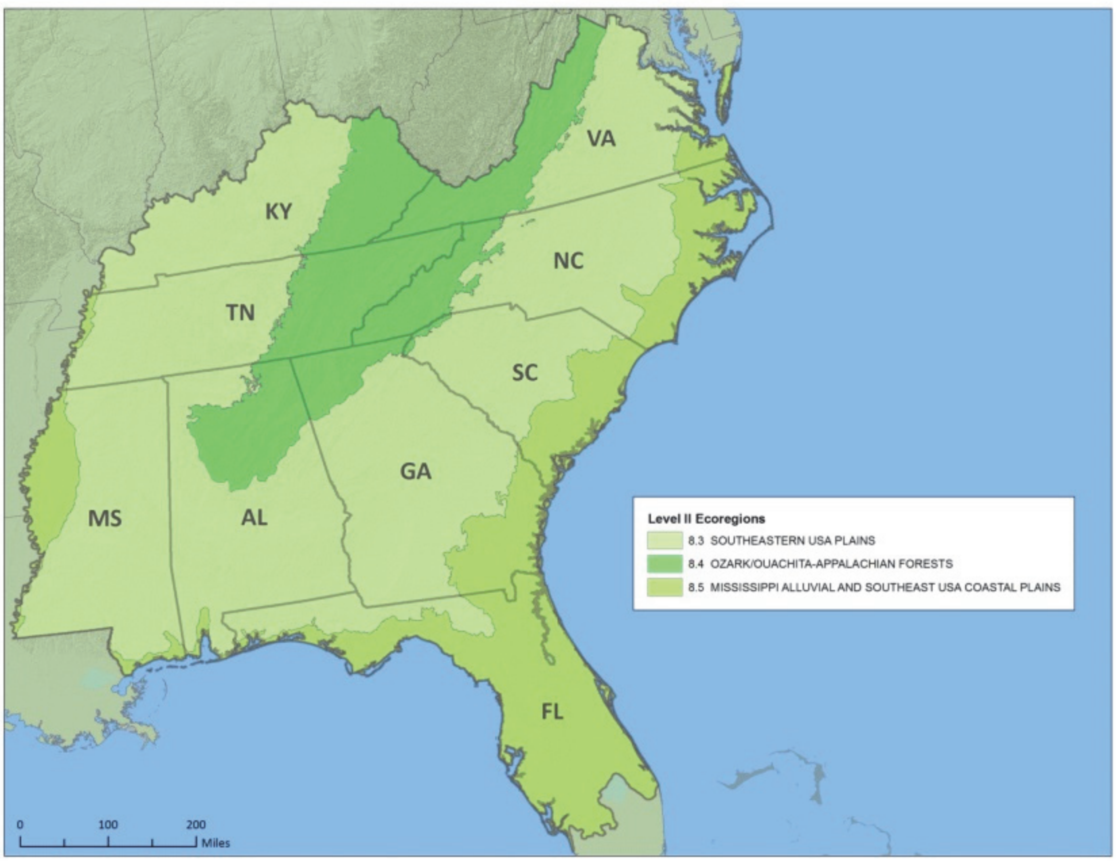
This Final PEIS is focusing only on EHECs that are not food crops. Eligible crops in the proposed EHEC Programs could include any plants of renewable biomass. Crops that may be used in confined field trials as part of the EHEC Programs include, but are not limited to, crops currently being investigated under ARPA-E's PETRO program. Table 1.1-1 does not represent the entire range of possible EHECs.

This Final PEIS focuses on the potential impacts associated with crop production and harvesting related to confined field trials for the proposed EHEC Programs, and not the potential impacts associated with post-harvest activities, such as transportation to the refinery, refining into biofuels, and tail-pipe emissions. Given the programmatic nature of the Proposed Action and large geographic area, further site- and plant-specific environmental compliance reviews would need to be conducted to identify potential impacts of the EHEC at proposed field trial locations and from post-harvest activities and energy conversion activities tied to a specific EHEC project. For future projects, the Federal agency proposing to implement an EHEC Program (e.g., DOE or another Federal agency) would conduct site- and plant-specific environmental reviews in compliance with law, such as NEPA, to identify potential environmental impacts. Additionally, DOE or another Federal agency may require BMPs specific to the proposed EHEC project as a condition for the grantee or permittee to receive funding or a permit.

### 2.2.1 Geographic Scope

This Final PEIS assesses the potential environmental impacts of alternatives for development and implementation of EHEC Programs. The geographic scope for this Final PEIS is the Southeastern United States—Alabama, Florida (excluding the Everglades and Southern Florida coastal plain ecoregion), Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia (Figure 2.2-1). DOE, in its discretion, is limiting the geographic scope of the EHEC Programs to these states due to favorable climate and growing conditions for EHECs, and therefore DOE does not need to analyze impacts in other regions. These states offer climate and growing conditions that favor EHECs. If experience in these states indicates expansion of the EHEC Programs is warranted, additional states may be assessed in subsequent environmental compliance reviews.

**Figure 2.2-1: Geographic Scope of EHEC PEIS by Level II Ecoregion**




To provide general descriptions for the project area, this Final PEIS uses EPA's Level II ecoregions (also known as "ecological regions"). Ecoregions are geographic areas grouped by the common presence or absence of common flora, fauna, and non-living ecosystems characteristics. For some resource areas, additional research may include watersheds or state boundaries as helpful means to assess the existing environment.

### 2.2.2 General Plant Characteristics

Table 2.2-1 identifies the plant characteristics considered in this Final PEIS to determine potential impacts, where appropriate. Many of these characteristics may not change from the non-engineered crop to an EHEC. Descriptions of each plant characteristic are provided below.

**Table 2.2-1: Plant Characteristics**

| Characteristic | Range of Analysis |
|---|---|
| Existence of sexually-compatible relatives | Yes or No |
| Methods of pollination | Self – Wind – Insect – Combination |
| Level of domestication | Low → High |
| Weediness/Competitiveness | Low → High |
| Toxicity | Low → High |
| Alternative commercial uses | Yes or No |
| Water use requirements | Low → High |
| Nativity | Yes or No |
| Land use requirements (planting cycle) | Annual – 2 to 5 years – over 5 years |
| Agricultural input requirements (fertilizer, irrigation) | Low → High |
| Growing range/suitable habitat | Very limited → Broad |
| Fire hazard potential | Low → High |

#### 2.2.2.1 Existence of Sexually-compatible Relatives

Development of engineered crops must consider the potential for gene flow to other crop plants or wild relatives. This process can occur between sexually-compatible plants and wild relatives if the appropriate conditions are met. If there are no sexually-compatible plants within close proximity, then “pollen mediated” gene flow cannot occur.

#### 2.2.2.2 Methods of Pollination

Pollination is an important process in plant reproduction involving the transfer of plant pollen, thus enabling fertilization and sexual reproduction. Methods of pollination for energy crops include self-pollination, or pollination by insects, animals, wind, or a combination of these. Self-pollination is a form of pollination that can occur when a flowering plant has both a stamen and a carpel (pistil) and the plant species is self-fertile. Few plants self-pollinate. Insect pollination, or entomophily, is a form of pollination occurring where plants have evolved with colored petals or a strong scent to attract insects, such as honeybees, bumblebees, butterflies, moths, wasps, ants, flies, and beetles; these insects carry or move pollen grains from the anther of one plant to the carpel (pistil) of another plant. Wind pollination, or anemophily, is a form of pollination where the pollen grains, often light and not sticky, are distributed by the air currents. Wind-pollinating plants tend to have exposed stamens that produce large quantities of pollen relative to insect-pollinated plants and feathery stigma to trap airborne pollen grains.

EHECs may be designed as sterile variants to prevent pollination, pollen formation, and reduce the risk of invasiveness. This can be achieved through several different means, one of which is to alter the fertility of the plants through genetic modification. In the case of GM eucalyptus, for example, scientists splice in a gene known as the "Barnase gene" to limit the ability of the trees to reproduce; eucalyptus trees with the Barnase gene produce flowers without viable pollen (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2010). Other times, entities rely on using hybrids between two different species. Hybrids between two different plant species in the same family are often sterile, but not always. In fact, there have been a number of cases where the species that were thought to be sexually sterile have nonetheless produced viable seed and become significant invaders (Barney & DiTomaso, 2008). Sterility can, in fact, break down and a small number of viable seeds could be formed (Ramsey & Schemske, 1998) (Ainouche, 2009). Even if this percentage is small, the chance of reproduction may become substantial when considering the fact that these species may be planted on a large scale. However, strategies have been developed to prevent gene flow from plantations to natural forests to mitigate escape (Haggman, 2013).

If a plant is unable to create viable seeds, it may be capable of vegetative propagation by other means, such as underground rhizomes. For example, giant reed plants do not produce viable seeds but they propagate vegetatively (a form of asexual reproduction in which a new plant can grow from a part of the parent plant) from even small stem fragments, a trait that enhances invasiveness (DiTomaso, Barney, & Fox, 2007).

### 2.2.2.3 Level of Domestication

Domestication involves the alteration of genetic material through selective breeding in order to hand-pick specific traits, such as appearance or life-cycle that will enhance energy production in these crops. The level of domestication can vary related to species diversity.

### 2.2.2.4 Weediness/Competitiveness

Weediness can be defined as a plant's ability to successfully colonize and proliferate in disturbed habitats. Plants with weediness traits have the ability to adapt to new environments and thrive unaided. These plants have the potential to become invasive, disrupting ecosystems, and inhibiting crop yields. There is concern that altered plants may pose a risk to the native ecosystems where they reside, if the modified version is not properly controlled or constructed and can outcompete or displace native species. Research on the potential impacts of modified species that become established outside of target areas is still in its infancy; globally, there are several known cases of "escape" where GM plants spread into the environment, some permanently as wild populations. These "escapes" include GM crops of bentgrass (in Oregon and Idaho), cotton and maize (in Mexico), and oilseed rape (in North Dakota and California). However, considerable uncertainty remains about the risks that these species may pose relative to native species as it is challenging to predict which GM plants will persist or become invasive. (Bauer-Panskus, Hamberger, & Then, 2010)

Just as non-native species are not all necessarily invasive, modified plants do not all necessarily pose a risk to native ecosystems. The risk depends on the specific characteristics of the plant, where it is being cultivated, and whether wild relatives of the plant grow in the region, among other considerations. One study of the use of GM poplars as a biofuel feedstock suggests that the scope of the ecological issues expected form their use is likely no greater than for "conventional plantation culture" (Strauss, 2001). Other studies indicate that the risks are likely much greater in cases where non-native species are modified to improve their adaptability in areas where they might otherwise not be able to survive (Hails, 2001) (Sheppard, 2011).

### 2.2.2.5 Toxicity

Some plants protect themselves using chemical compounds that deter predators (such as herbivorous animals). These chemicals can be toxic to animals and humans, such as deadly nightshade, a perennial herbaceous plant with toxic leaves and berries. Toxicity in plants can potentially cause an adverse reaction to organisms that comes into contact with it. The level of toxicity varies from species to species, and within species.

### 2.2.2.6 Alternative Commercial Uses

An EHEC may have an alternative or secondary commercial use when produced at a larger scale providing additional economic value. These products can have a wide range of application and be introduced to various markets. For example, EHEC woody trees may have their fuel extracted as a primary use, with pulp as a byproduct as a secondary commercial use.

### 2.2.2.7 Water Use Requirements

Plant water use, also known as evapotranspiration, is the water used by plants for growth. Lack of water can lead to stress on a crop reducing yield and quality of the plants. Crop water use is weather-or irrigation-dependent; in addition, soil type and structure, water, and the type of plant and its growth stage are also factors in crop water use.

### 2.2.2.8 Nativity

Nativity refers to the plants found naturally (endemic) in an area. In North America, the term "native plant" is a plant that was present before colonization (prior to European contact). Non-native species can significantly impact native species and communities through competition. Some ecosystem impacts may be long-term or even irreversible, such as altered erosion and sedimentation rates in soils, changes in soil chemistry, or as a physical barrier to native species (Gordon, 1998).

### 2.2.2.9 Land Use Requirements

Planting cycles of the EHECs were considered in order to determine growth rate of the EHECs and to estimate the amount of time land will be in use during production. The planting cycle is typically classified into one of three categories: annual, two to five years, or greater than five years.

### 2.2.2.10 Agricultural Input Requirements

Specific agricultural input requirements are identified to ensure each crop is grown in an environment that allows for maximum productivity. Inputs such as irrigation, fertilizer, and pesticides vary for each crop.

#### 2.2.2.11 Growing Range/Suitable Habitat

Range is considered to determine the ideal habitat for optimum growth and identify any limitations in the ability of the plants to thrive and adapt to various environments.

#### 2.2.2.12 Fire Hazard Potential

The fire hazard potential assesses the level of risk associated with combustibility and fire spread potential of the plants. The geographic scope of this Final PEIS (Southeastern region of the United States) includes land prone to drought, and thus vulnerable to fires.

### 2.2.3 Confined Field Trials

A major component of the proposed EHEC Programs would be to facilitate financial assistance to recipients to conduct confined field trials to test the effectiveness of the crops. Confined field trials are experiments to evaluate the performance of a crop that are conducted under stringent terms and conditions designed to confine the experimental crop. Confined field trials are essential to test the viability of EHECs under real field conditions in local environments.

Confined field trials are necessary to collect the agronomic and ecological data required to complete the environmental safety assessment of the GE plant. These types of studies may include: field surveys designed to assess the potential impacts on non-target, beneficial, and endangered organisms; evaluation of the environmental fate of novel plant expressed proteins, particularly pest control proteins; and assessment of morphological characteristics that could signal any changes to plant or soil impacts. For regulatory authorities, there is the opportunity to build public confidence in the biosafety regulatory system by demonstrating the safe conduct of confined field trials, including the monitoring and enforcement of regulatory standards. For farmers, these field trials provide an opportunity to appreciate first-hand the potential risks and benefits that may be afforded by the cultivation of these new crops.

Confined field trials are essential to the scientific, political, and social success of any biosafety system, and are a necessary prerequisite to the unconfined (general) environmental release of GE plants. For the plant breeder, confined field trials provide the first opportunity to evaluate the agronomic potential of novel plant-trait combinations in the open environment. In this regard, confined field trials serve the same purpose as conventional breeders' trials. The outcome of the site after completion of the field trial, including potential for invasiveness and spread, would be analyzed in future site- and plant-specific environmental analyses.

Regulated confined field trials are the initial environmental releases of engineered crops and are regulated by the USDA with the intent to minimize environmental impact of this introduction while evaluating the efficacy of the new traits within confined field trials. A field trial is conducted under conditions known to limit the pollen- or seed-mediated dissemination of new genes into the environment, to limit the persistence in the environment of the GE plant or its progeny, and to limit the introduction of the GE plant or plant products into the human food or livestock feed pathways. The intent of a confined field trial is reproductive isolation, but depending on circumstances, may also include some degree of physical isolation.

Following 7 CFR Part 340 (*Introduction of Organisms and Products Altered or Produced Through Genetic Engineering*), the following processes, procedures, safeguards, and protocols may be implemented as USDA APHIS BRS permit requirements for the proposed EHEC confined field trials:

- Training of personnel in the necessary growing and handling procedures for transgenic plants;
- Fencing and gating of the research site;
- Planting a border around the transgenic plant plots using a non-transgenic variety of the same plant;
- Leaving alleys between the planted blocks for placement of weed and harvest residues, and treating these residues through dessication or pesticide application;
- Creating a fallow area (in this case 30 feet wide) around the entire field trial site, and suppressing all plants within this area with pesticide or mechanical treatment;
- Weekly monitoring of the field plots for weeds, emergence of seed heads, or other developments requiring further action;
- Hand removal of any emergent seed heads;
- Ongoing evaluation of the study crop for establishment, growth characteristics, etc.;
- Following the field trial, destruction of above and below-ground biomass through chopping, root-raking, exposure to freezing temperatures, dessication, decomposition, and eventual incorporation into the soil;
- Cleaning all equipment, tools, and instruments on-site with pressurized air and bleach;
- Repeated application of Roundup® or other broad-spectrum pesticide and monitoring of the site for one year following destruction of the study crop for the presence of volunteer plants of the study species;
- Volunteer monitoring for regrowth of the GE crop on the field test site following the field trial; and
- Extension of the monitoring period if needed to eradicate the study crop.

## 2.3 Alternatives

This Final PEIS evaluates the range of reasonable implementation alternatives.  DOE considered a range of confined field trial sizes (in acreage) to progress from the lab to demonstration size allowing for commercial production of an EHEC.  The scale alternatives are illustrative, intended to provide environmental information regarding the range of potential impacts of the reasonable alternatives, and thus inform future consideration of EHEC Programs.  DOE expects that the EHEC Programs will be at a scale covered by one or more of the alternatives in this Final PEIS; however, DOE is not limited to selecting a single alternative at the precise scale identified in this document.  Below is a brief description of the Alternatives considered within this Final PEIS.

### 2.3.1 Alternative 1 – Development-scale Confined Field Trials (up to 5 acres)

Alternative 1 includes small scale, up to 5 acres or less, confined field trials. These small-sized field trials are the first step in testing whether an EHEC will grow under agricultural conditions. Under this alternative, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%.[8] These development-scale confined field trials would follow the same protocols as typical field trials, including required APHIS permits and notifications.

### 2.3.2 Alternative 2 – Pilot-scale Confined Field Trials (up to 250 acres)

Alternative 2 is a pilot-scale field trial to begin experimenting with the EHEC in a larger sized area. Pilot-scale field trials could involve multiple growers at multiple smaller non-contiguous locations as a means to determine if the EHEC could grow beyond the development-scale with similar results. Under this alternative, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%. These field trials would follow the same protocols as typical field trials, including required APHIS permits and notifications.

### 2.3.3 Alternative 3 – Demonstration-scale Confined Field Trials (up to 15,000 acres)

The largest scale of the alternatives is Alternative 3, the demonstration-scale field trial, to test whether an EHEC is commercially viable. DOE estimated that to supply a 10 million gallon/year corn ethanol plant (the smallest commercial plant) would require approximately 30,000 acres of corn. One goal of the ARPA-E PETRO Program is for the development of biofuels that are twice the output of corn. Using this as an assumption, the deployment-scale alternative was calculated to be half that amount of acreage, or 15,000 acres. Therefore, the demonstration-scale size of up to 15,000 acres was estimated to be the acreage of EHECs needed to produce biomass for a hypothetical, small-scale, commercial ethanol plant. Under Alternative 3, demonstration-scale field trials could involve multiple growers at multiple smaller non-contiguous locations. Under this alternative, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%. Similar to Alternative 1 and Alternative 2, these field trials would follow the same protocols as typical field trials, including required APHIS permits and notifications.

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[8] For all alternatives, these percentages are the same restraints proposed in the Billion Ton Update report to "simulate the relative inelastic nature of agriculture in the near-term" meaning growers do not swap out crops quickly (U.S. Department of Energy, 2011).

### 2.3.4 No Action Alternative

The No Action Alternative is carried forward in this Final PEIS in accordance with 40 CFR §1502.14(d) to represent the environmental baseline against which to compare the other alternatives. Under this alternative, DOE would not provide financial assistance for the development and implementation of EHEC Programs. Although some private-sector field trials involving EHECs might be undertaken under permits issued by APHIS and dedicated energy crops may be grown, for purposes of this no action analysis, DOE assumes that development of EHECs would occur slowly or in an uncoordinated fashion.

## 2.4 Best Management Practices

Best Management Practices, or BMPs, are defined as "a practice or usually a combination of practices that are determined by a state to be the most effective and practicable means… of controlling point and non-point source pollution at levels compatible with environmental quality goals" (Ice, Schilling, & Vowell, 2010). BMPs can be a method, measure, or practice designed for a project- or site-specific condition to provide environmentally sound, economically feasible, and effective management of an action while mitigating any potential impacts. For environmental management, BMPs include, but are not limited to, structural and nonstructural controls, operations, and maintenance procedures. This Final PEIS identifies BMPs that could be implemented to help mitigate potential adverse impacts. The BMPs are not required through this Final PEIS but would be considered and recommended, as appropriate, during future site- and plant-specific environmental reviews conducted in compliance with law, such as NEPA. Section 2.2.3 identifies several processes, procedures, safeguards, and protocols that may be considered as BMPs for future project-specific EHECs, as identified by USDA APHIS.

## 2.5 Comparison of Alternatives

Table 2.5-1 includes a summary of the potential environmental impacts associated with selection of the Alternatives evaluated in this Final PEIS. The potential environmental impacts are presented with more detail within Chapter 4; in addition, BMPs that could minimize or avoid common impacts of the resource area are identified, where appropriate. Cumulative impacts are presented in Chapter 5.

## 2.6 Preferred Alternative

DOE's preferred alternative is Alternative 3 (demonstration-scale up to 15,000 acres) allowing DOE (or other Federal agency) to facilitate the deployment of EHECs by funding programs that support commercial demonstration of EHECs in the Southeastern United States. Under Alternative 3, demonstration-scale size field trials could involve multiple growers at multiple smaller non-contiguous locations. Demonstration-scale confined field trials would follow the same protocols as typical confined field trials, including required APHIS permits and notifications.

Under Alternative 3, development of genetically engineered biofuels resulting from future EHEC Programs would be funded by DOE or other Federal agencies. In addition, under this alternative, every proposed EHEC Program and associated EHEC action would undergo the appropriate level of environmental review under NEPA, would follow USDA APHIS BRS permitting requirements, and would comply with any other legal requirements.

**Table 2.6-1: Summary of Potential Environmental Impacts by Alternative**

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Meets Purpose & Need | Yes | Yes | Yes | No | |
| **Resource Areas** | | | | | |
| Land Use<br><br>* Potential economic impacts of converting land use from traditional crops to EHECs is discussed in the Socioeconomics section of this table. | No direct or indirect impacts are anticipated since a relatively small amount of vegetation could be converted from traditional crops to EHECs. | No direct or indirect impacts are anticipated to convert traditional crops to EHECs. | No direct or indirect impacts are anticipated to convert traditional crops to EHECs. | No impacts are anticipated. | None. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Water Resources | No direct impacts are anticipated. Minor indirect beneficial impacts on surface water could occur from perennial herbaceous and woody EHECs, and negligible indirect adverse impacts to surface water quality could occur from annual perennial EHECs.<br><br>Minor beneficial impacts are anticipated from herbaceous EHECs on groundwater, whereas negligible adverse impacts on groundwater and water use and availability could occur from woody EHECs. | Potential minor adverse indirect impacts on surface water and groundwater quality could occur at the planting stage. The intensity would vary by crop type and location. Minor beneficial indirect impacts could occur from perennial and woody crop EHECs.<br><br>Higher water inputs to increase biomass or yield could cause potential minor adverse impacts on water use; impacts are not anticipated from annual crops.<br><br>Additional environmental compliance reviews may be necessary to determine site- and plant-specific impacts to groundwater for woody EHECs.<br><br>Potential impacts could be mitigated through BMPs. | Impacts would be similar to Alternative 2.<br><br>Additional environmental compliance reviews may be necessary to determine site- and plant-specific impacts to groundwater for woody EHECs.<br><br>Potential impacts could be mitigated through the BMPs. | No impacts are expected since there would be no change in water quality or quantity used for irrigation purposes from existing conditions under this alternative. | BMPs would be identified on a project-specific basis.<br><br>BMPs could include:<br><br>-Evaluate water needs for an EHEC on a site-specific basis and reduce the agrochemical amount applied, application timing, and delivery method.<br><br>-To reduce sedimentation, apply cover crops, practice conservation tillage, and leave plant residue on the soil surface.<br><br>-Avoid discharging herbicide, pesticides, and nutrients into waters of the United States when possible. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Geology and Soils | Potential direct and indirect impacts on geology and soils vary depending on the EHEC.<br><br>No impacts or minor adverse impacts are anticipated from subsidence, minor adverse to beneficial impacts to erosion. No impacts to prime and unique farmlands would occur. | Potential minor adverse impacts from annual herbaceous EHECs include soil nutrient depletion, contamination from over-application of pesticides, and increased risk of erosion following crop harvest.<br><br>Beneficial impacts are anticipated on subsidence and erosion from perennial herbaceous and woody EHECs.<br><br>Application of BMPs could lessen any potential impacts.<br><br>No impacts to prime and unique farmlands would occur. | Potential wind and water erosion impacts from annual herbaceous EHECs would be similar to those under Alternatives 1 and 2 but likely higher because of the increase in program acreage.<br><br>Beneficial impacts are anticipated on subsidence and erosion from perennial herbaceous and woody EHECs.<br><br>Applying BMPs could lessen any potential impacts.<br><br>No impacts to prime and unique farmlands would occur. | No impacts are expected since there would be no change from existing conditions. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs could include:<br><br>-Employ standard best agricultural practices to keep soil contamination and erosion to a minimum such as cover crops to reduce erosion; broad-based dips, cross-drains, water bars to control runoff in forested areas; and silt fences, brush barriers, sediment traps, straw bales to capture sediment. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Biological Resources | Minor impacts to vegetation could be expected.<br><br>Negligible to minor adverse impacts on wildlife and non-native species may occur depending on the site and species.<br><br>Negligible to no impacts are anticipated from the introduction or establishment of invasive species with proper BMPs in place.<br><br>Potential indirect impacts to life-cycles may require EHEC-specific environmental compliance reviews to determine impacts, particularly potential toxicity to wildlife at a field trial location and population dynamics.<br><br>Impacts to protected species, critical habitats, or migratory birds would be identified through future site- and plant-specific NEPA reviews and may require consultation with USFWS / NMFS, if appropriate. | Impacts would be similar to Alternative 1 but on a larger scale.<br><br>Minor impacts to vegetation are anticipated.<br><br>Minor adverse impacts to wildlife and non-native species could occur; future site- and plant-specific NEPA reviews would need to be conducted.<br><br>Minor adverse impacts may result if invasive species are introduced or established; BMPs would be identified in future site- and plant-specific NEPA reviews to mitigate impacts.<br><br>Potential adverse indirect impacts to life-cycles may require EHEC-specific NEPA reviews to determine impacts, particularly potential toxicity to wildlife at a field trial location and population dynamics.<br><br>Impacts to protected species, critical habitats, or migratory birds would be identified in future site- and plant-specific NEPA reviews and may require consultation with USFWS / NMFS, if appropriate. | Impacts would be similar to Alternative 2 but on a larger scale.<br><br>Minor impacts to vegetation could be expected.<br><br>Minor adverse impacts to wildlife and non-native species could occur; future site- and plant-specific NEPA reviews would need to be conducted.<br><br>Major short- or long-term adverse impacts could occur resulting in the introduction or establishment of invasive species; BMPs would be identified in future site- and plant-specific NEPA reviews.<br><br>Potential adverse indirect impacts to life-cycles may require EHEC-specific NEPA reviews to determine impacts, particularly potential toxicity to wildlife at a field trial location and population dynamics.<br><br>Impacts to protected species, critical habitats, or migratory birds would be identified in future site- and plant-specific NEPA reviews and may require consultation with USFWS / NMFS, if appropriate. | No impacts are anticipated from the No Action Alternative. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs could include:<br><br>-Evaluate field trial locations for proximity to protected species, critical habitats, or migratory birds to ensure that potential impacts are minimized or avoided.<br><br>-To minimize the inadvertent spread of EHECs, BMPs could include: plant weed-free seed; manage propagules (flowering / seed production) including manual removal of flowers; and maintain field borders.<br><br>-Avoid and minimize the use of herbicides and pesticides to the extent practicable. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Socioeconomics and Environmental Justice | Negligible short-term to no impacts, possibly some beneficial impacts, due to economic, demographic, or social effects are anticipated.<br><br>Net costs to an EHEC Program participant might be greater than the costs of producing commercial crops that the EHEC replaces.<br><br>Impacts to low income populations or minority populations are not anticipated at a programmatic level, but site-specific analysis would be required. | Minor to negligible impacts, possibly some beneficial impacts, due to economic, demographic, or social effects are anticipated.<br><br>No impacts to low income populations or minority populations are anticipated at a programmatic level, but site-specific analysis would be required. | Minor adverse to beneficial impacts due to economic, demographic, or social effects are anticipated.<br><br>No impacts to low income populations or minority populations are anticipated at a programmatic level, but site-specific analysis would be required. | No impacts are anticipated since there would be no change from existing conditions. | None. |
| Wildfires | Negligible short-term impacts could occur for perennial or annual EHECs with added or increased terpene storage potential.<br><br>Increased terpene storage potential and production capacity in EHECs may increase the likelihood for wildfire potential; however, it is not clear that an EHEC woody crop would present a greater fire hazard than existing pine plantations found in the project area. | Because of the increased size of the field trials, which could increase the potential for wildfires, major or long-term mitigable to minor adverse impacts could occur under this Alternative.<br><br>Implementation of BMPs would be identified in future project-specific environmental documentation to reduce wildfire potential. | Major or long-term mitigable to minor adverse impacts could occur under this Alternative due to the increased size of the field trials, which could increase the potential for wildfires.<br><br>Given the increased size of the field trials, BMPs would be identified in future project-specific environmental documentation to reduce wildfire potential. | No impacts would be expected since there would be no change from existing conditions. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs to reduce wildfire potential could include:<br><br>-use of defined fuel breaks around field trial site;<br>-incorporate defensible space; maintain irrigation; implement fuel reduction programs; and<br>-weekly reviews of Southern Area fire maps. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Air Quality | Overall, negligible impacts on air quality and current pollutant state levels are anticipated. Similar to existing conditions, normal agricultural practices (tilling and equipment use) may lead to decreased air quality from increased air particulates and exhaust from farm equipment.<br><br>Depending on the EHEC, long-term minor beneficial impacts on air quality at the regional and state levels for particulate matter emissions could be expected.<br><br>Minor adverse impacts from plant off-gassing may occur. | Similar to Alternative 2, negligible impacts on air quality would be expected.<br><br>Depending on the EHEC, long-term minor beneficial impacts on air quality at the regional and state levels for particulate matter emissions could be expected.<br><br>Minor adverse impacts from plant off-gassing may occur. | Despite the increased scale, potential impacts to air quality would be negligible.<br><br>A potential adverse impact could result from the increase in woody crops and the resulting volatile organic carbon concentrations. However, this is dependent on the EHEC species.<br><br>Depending on the EHEC, long-term minor beneficial impacts on air quality at the regional and state levels for particulate matter emissions could be expected.<br><br>Minor adverse impacts from plant off-gassing may occur. | No impacts are anticipated since impacts on air quality would be the same as those seen with conventional crops. | None. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Safety & Human Health | No direct or indirect impacts on worker health or public safety are anticipated.<br><br>Consequences of intentional destructive acts to an EHEC field trial would be limited and should not result in injury or harm to the public or workers. | No direct or indirect impacts on worker health or public safety would be expected.<br><br>Due to the larger size of the confined field trials, there could be a slightly greater opportunity for intentional destructive acts to occur.<br><br>Consequences of intentional destructive acts to an EHEC field trial would be limited and should not result in injury or harm to the public or workers.<br><br>BMPs could prevent or minimize impacts from intentional destructive acts. | No direct or indirect impacts on worker or public health and safety would be expected.<br><br>Similar to Alternative 2, the larger size of the confined field trials may provide a slightly greater opportunity for intentional destructive acts to occur.<br><br>Consequences of intentional destructive acts to an EHEC field trial would be limited and should not result in injury or harm to the public or workers.<br><br>BMPs could prevent or minimize impacts from intentional destructive acts. | No impacts are expected since there would be no change from existing conditions. | BMPs would be identified on a project-specific basis.<br><br>Recommended BMPs to reduce the potential for intentional destructive acts would include:<br><br>-Limit access to the field trial locations,<br><br>-Do not make site locations public knowledge, and<br><br>-When choosing locations, avoid major inland ports, container terminals, nuclear power plants, or national defense infrastructure. |

| Attribute | Alternative 1: Deployment-scale | Alternative 2: Pilot-scale | Alternative 3: Development-scale | No Action Alternative | BMPs |
|---|---|---|---|---|---|
| Climate Change and Greenhouse Gas Emissions (GHG) | Negligible impacts to GHG emissions or climate would be expected.  Emissions from vehicles and farm equipment would remain the same.<br><br>A range of potential GHG emissions from soils, with a maximum of 0.21 tons $CO_2e$/year emitted from the soils and a minimum of 1.78 tons $CO_2e$/year sequestered in the soils would result with EHECs. | Similar to Alternative 1, negligible impacts to GHG emissions or climate would be expected and emissions from vehicles and farm equipment would remain the same.<br><br>A maximum of 10.42 tons $CO_2e$/year emitted from soils and a minimum of 89.0 tons $CO_2e$/year sequestered in the soils. | Minor adverse impacts to GHG emissions or climate could be expected. Emissions from vehicles and farm equipment would remain the same.<br><br>A range from of 642.9 tons $CO_2e$/year emitted from the soils to 5,340.7 tons $CO_2e$/year sequestered in the soils.<br><br>Successful demonstration and deployment of EHECs could help reduce GHG emission and result in net benefits in the long-term. | No impacts would be expected since there would be no change from existing conditions.<br><br>Potential GHG reductions through EHEC deployment would not be catalyzed and would occur more slowly or not at all. | None |

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# 3 Affected Environment

## 3.1 Introduction

Based on the land area and complexity of the resources within the nine-state project area, this Final PEIS describes the resource areas, where possible, at the ecoregion level. The EPA describes an ecoregion as an area composed of similar ecosystems and characterized by the spatial patterning and composition of biotic (living) and abiotic (non-living) features, including vegetation, wildlife, geology, physiography (patterns of terrain or landforms), climate, soils, land use, and hydrology. As a result, within an ecoregion, there is a similarity in the type, quality, and quantity of environmental resources. Ecoregions are effective for describing national and regional "state of the environment" reports, assessing environmental resource inventories, setting regional resource management goals, determining carrying capacity, and developing biological criteria.

North America has a hierarchy of four levels of ecoregions, with Level I being the broadest classification. Each level consists of subdivisions of the previous (next highest) level. Level I ecoregions divide North America into 15 broad ecoregions highlighting major ecological areas of the continent. Level II ecoregions provide a more detailed description of the large ecological areas nested within the Level I ecoregions. This Final PEIS describes the existing environment at the Level II ecoregion level.

The entire project area (268,125,312 acres) for this Final PEIS is encompassed within the Level I ecoregion known as the Eastern Temperate Forests (637,145,164 acres). There are three Level II ecoregions for the project area within this Final PEIS:

- Level II 8.3: Southeastern USA Plains,
- Level II 8.4: Ozark/Ouachita-Appalachian Forests, and
- Level II 8.5: Mississippi Alluvial and Southeast USA Coastal Plains.

Figure 3.1-1 illustrates the three Level II ecoregions in the project area. Table 3.1-1 identifies the basic characteristics of each of these Level II ecoregions.

**Figure 3.1-1: Level II Ecoregions in the Project Area**

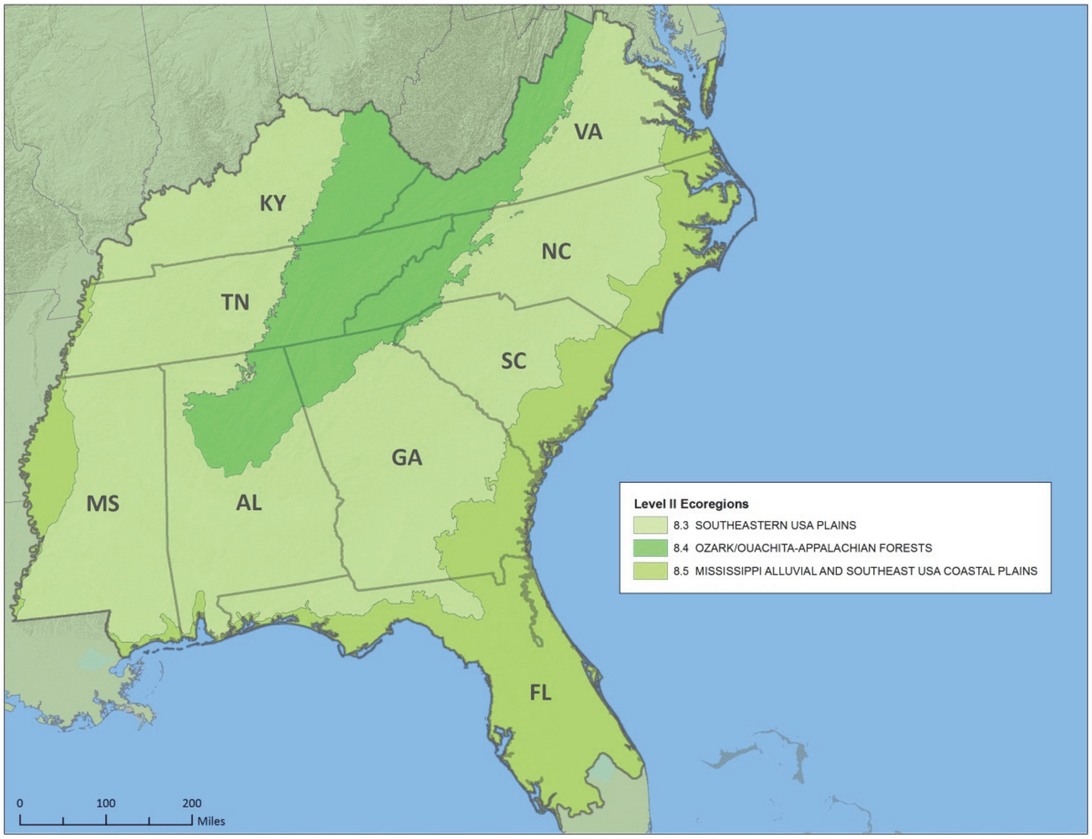



**Table 3.1-1: Descriptions of the Level II Ecoregions Reviewed in this Final PEIS for Land and Water, Climate, and Human Activities**

| Level II<br>Surface (acres) | Landforms;<br>Waterbodies | Climate<br>(mean annual temperature; mean annual precipitation) | Human Activities |
|---|---|---|---|
| **8.3 Southeastern USA Plains (233,951,962)** | irregular plains, low hills | 55.4 – 66.2°F;<br>39.37 – 62.99 in | forestry; agriculture (tobacco, hogs, cotton); urban areas |
| **8.4 Ozark/Ouachita-Appalachian Forests (128,171,090)** | hills and low mountains, some wild valleys | 62.6 – 64.4°F; 39.37 – 78.74 in | forestry; coal mining; some local agriculture; tourism |
| **8.5 Mississippi Alluvial and Southeast USA Coastal Plains (95,560,593)** | flat plains; many wetlands | 55.4 – 80.6°F; 43.31 – 70.87 in | forestry and agriculture (citrus, soybeans, cotton); tourism; fishing |

*Source:* (Commission for Environmental Cooperation, 2008)

# 3.2 Land Use

## 3.2.1 Definition of the Resource

Land use is defined as "the arrangements, activities and inputs people undertake in a certain land cover type to produce, change, or maintain it" (Di Gregorio & Jansen, 1998), with land cover referring to the observed physical cover as seen from the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, roads, etc.) that cover the earth's surface (Food and Agriculture Organization of the United Nations, 1997).

Further, a given land use may take place on one, or more than one, piece of land and several land uses may occur on the same piece of land (Food and Agriculture Organization of the United Nations, 1997). Defining land use in this way provides a basis for precise and quantitative economic and environmental impact analysis and permits precise distinctions between land uses, if required. Land use analysis addresses how different land uses currently interact and if there would be conflict between new and existing land uses. Land use within this document is described as the acreage within cropland, permanent pasture, or forest land, since any of these lands uses could be converted into EHEC land use with some special land use restrictions (i.e., native sod). (Food and Agriculture Organization of the United Nations, 1997)

In the context of this analysis, land use shifts indicate the changes in what is planted in a particular area of cropland, pastureland or forested land. For example, if crop "b" replaces crop "a" in a particular acre or group of acres, then a land use shift from "a" to "b" has occurred. Land use shifts occur as farmers make production decisions based on the economic use of the land taking into account agricultural policy and environmental considerations. The same analysis would apply for a particular area of pastureland or forested land.

The primary unit of analysis for this resource area is by individual states because data availability for land use, croplands, and forest lands is greater using state boundaries. Figure 3.1-1 shows state boundaries overlain with the Level II ecoregion boundaries for the project area.

## 3.2.2 Existing Conditions – Agricultural Land Use

### 3.2.2.1 Available Cropland

Available agricultural land includes cropland, pastureland, and other lands that food, fiber, or other agricultural products are produced or capable of being produced. The 2007 Agricultural Census estimates the amount of land in agricultural land uses in the United States (U.S. Department of Agriculture, 2009). Table 3.2-1 illustrates the agricultural lands uses in the project area by state and the total within the Southeastern United States.

### 3.2.2.2 EHECs

As described in Chapter 2, there are a number of species of perennial and annual herbaceous crops that have the potential for development as EHECs. Currently, under DOE's ARPA-E PETRO program, EHECs are being developed using the following crop species: camelina, giant cane bamboo, energy beets, miscane, miscanthus, sorghum, sugarcane, switchgrass, loblolly pine, and tobacco. The USDA reports sorghum, sugarcane, and tobacco in their annual crop production in their summaries (U.S. Department of Agriculture -- National Agricultural Statistics Service, 2013). Research and development is occurring for all of these species listed, but commercial uses are currently limited for some species whereas others are considered weeds. Experimental field research is occurring and is not included in the annual reported crop production summary. Table 3.2-2 shows acres harvested by state for the three species (sorghum, sugar cane, and tobacco) accounted for by the USDA in their crop production summaries.

**Table 3.2-1: Agricultural Land Use (in acres) in the Project Area by State**

| State | 2007 | | | | | |
|---|---|---|---|---|---|---|
| | Total Farmland (acres) | Cropland (acres) | Woodland (acres) | Pastureland (acres) | House lots (acres) | Farmland in Conservation (acres) |
| **Alabama** | 9,033,537 | 3,142,958 | 3,375,438 | 2,017,079 | 498,062 | 494,441 |
| **Florida** | 9,231,570 | 2,953,340 | 2,330,336 | 3,221,202 | 726,692 | 224,867 |
| **Georgia** | 10,150,539 | 4,478,168 | 3,712,672 | 1,341,985 | 617,714 | 331,166 |
| **Kentucky** | 13,993,121 | 7,278,098 | 3,107,137 | 2,912,424 | 695,462 | 375,049 |
| **Mississippi** | 11,456,241 | 5,530,825 | 3,610,991 | 1,639,243 | 675,182 | 1,107,406 |
| **North Carolina** | 8,474,671 | 4,895,204 | 2,201,609 | 941,609 | 436,249 | 163,676 |
| **South Carolina** | 4,889,339 | 2,151,219 | 1,827,191 | 617,136 | 293,793 | 264,950 |
| **Tennessee** | 10,969,789 | 6,047,348 | 2,042,868 | 2,545,047 | 334,535 | 289,200 |
| **Virginia** | 8,103,925 | 3,274,137 | 2,319,491 | 2,150,933 | 359,364 | 70,112 |
| **Southeastern US** | **86,302,732** | **39,751,297** | **24,527,733** | **17,386,658** | **4,637,053** | **3,320,867** |

*Source:* (U.S. Department of Agriculture -- Economic Research Service, 2014)

**Table 3.2-2: Sorghum, Sugarcane, and Tobacco Harvested by State**

| State | Area Harvested (1,000 acres) | | | Area Harvested (1,000 acres) | | | Area Harvested (1,000 acres) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2002 | | | 2007 | | | 2012 | | |
| | Sorghum | Sugarcane | Tobacco | Sorghum | Sugarcane | Tobacco | Sorghum | Sugarcane | Tobacco |
| **Alabama** | 10.0 | 0 | 0 | 12.0 | 0 | 0 | 0 | 0 | 0 |
| **Florida** | 0 | 461.0 | 4.6 | 0 | 393.0 | 0 | 0 | 410.0 | 0 |
| **Georgia** | 55.0 | 0 | 26.5 | 65.0 | 0 | 18.5 | 50.0 | 0 | 10.0 |
| **Kentucky** | 12.0 | 0 | 111.1 | 15.0 | 0 | 89.2 | 0 | 0 | 87.2 |
| **Mississippi** | 80.0 | 0 | 0.0 | 145.0 | 0 | 0 | 60.0 | 0 | 0 |
| **North Carolina** | 0 | 0 | 168.3 | 12.0 | 0 | 170.0 | 0 | 0 | 166.1 |
| **South Carolina** | 7.0 | 0 | 30.5 | 9.0 | 0 | 20.5 | 0 | 0 | 12.0 |
| **Tennessee** | 30.0 | 0 | 34.9 | 18.0 | 0 | 19.9 | 0 | 0 | 23.9 |
| **Virginia** | 8.0 | 0 | 30.0 | 0 | 0 | 20.6 | 0 | 0 | 23.1 |

*Source:* (U.S. Department of Agriculture -- National Agricultural Statistics Service, 2013; U.S. Department of Agriculture -- National Agricultural Statistics Service, 2010; U.S. Department of Agriculture -- National Agricultural Statistics Service, 2005)

The amount of available land suitable for agriculture crops is a critical factor in determining biofuel production capacity. In order to maximize productivity on available land, EHECs may be engineered to have higher yields than their wild or natural varieties. Although maximizing yields in EHEC varieties can increase overall production of EHECs, changes to land use management may be required to successfully grow sufficient acreage. In its *U.S. Billion-Ton Update, Biomass Supply for a Bioenergy and Bioproducts Industry*, DOE estimated that energy crops could displace as many as 40 to 60 million acres of cropland and pasture and produce 150 to nearly 380 million dry tons of biomass sustainably, provided average annual yields of 5 to 8 dry tons per acre could be attained. Demands for food, feed, and exports would still be met under the Billion-Ton Study scenarios because of projected yield growth and other technological advances in U.S. agriculture (U.S. Department of Energy, 2011).

In addition, each climatic region of the United States would need to develop region-specific crop management guidelines. Furthermore, an energy crop strategy should include rotational cropping systems that combine varieties of high-tonnage crops with year-round cultivation and harvest in order to maintain a steady supply of raw materials (McCutchen, Avant Jr., & Baltensperger, 2008). Table 3.2-3 and Table 3.2-4 show current estimates for biodiesel and cellulosic production capacity in the project area by state.

**Table 3.2-3: Biodiesel Production Capacity**

| State | Biodiesel Production Capacity | |
|---|---|---|
| | Number of Plants | Production (Million Gal Per Year) |
| **Alabama** | 2 | 46 |
| **Florida** | 1 | 2 |
| **Georgia** | 3 | 16 |
| **Kentucky** | 4 | 50 |
| **Mississippi** | 3 | 105 |
| **North Carolina** | 4 | 10 |
| **South Carolina** | 2 | 40 |
| **Tennessee** | 1 | 2 |
| **Virginia** | 3 | 9 |
| **Total** | 23 | 280 |

*Source:* (U.S. Department of Agriculture -- Economic Research Service, 2013)

There have been several bills introduced in more than 16 states calling for a moratoria or outright bans on GE crops (Organic Consumers Association, n.d.). Although none have been proposed within the project area, the passage of such laws has the potential to reduce the amount of land that may be used to produce future EHECs.

**Table 3.2-4: Cellulosic (Fuel Ethanol) Production Facilities Capacity and Utilization Rates, by State, January 2014**

| States | Nameplate capacity[9] | Operating capacity[10] | Under-construction / expansion capacity | Capacity utilization rates[11] |
|---|---|---|---|---|
| | **Million gallons per year** | | | |
| **Georgia** | 100 | 100 | 0 | 1.00 |
| **Kentucky** | 35 | 35 | 0 | 1.01 |
| **Mississippi** | 54 | 0 | 0 | 0.00 |
| **Tennessee** | 225 | 225 | 0 | 1.00 |
| **Virginia** | 65 | 0 | 0 | 0.00 |
| **Total** | 479 | 360 | 0 | |

*Source:* (Renewable Fuels Association, 2014)

## 3.2.3 Existing Conditions – Forest Land Use

The USFS defines a forested area as "forest land" if it is at least one acre in size and at least 10% occupied by forest trees of any size, or formerly had such tree cover and is not currently developed for

[9] Rated volume of plant under normal operating conditions

[10] Volume of ethanol produced. Can exceed rated volume if normal operating hours are exceeded

[11] Calculated by dividing ethanol production by nameplate capacity

non-forest use. Examples of non-forest uses include areas for crops, improved pasture, and residential areas. Forest land includes transition zones, such as areas between heavily forested and non-forested lands that are at least 10% stocked with forest trees, and forest areas adjacent to urban and built-up lands (U.S. Forest Service, 2009). Timberlands are defined as forest lands used for the production of commercial wood products. Commercial timberlands are used for repeated growing and harvesting of trees (Environmental Protection Agency, 2014a).

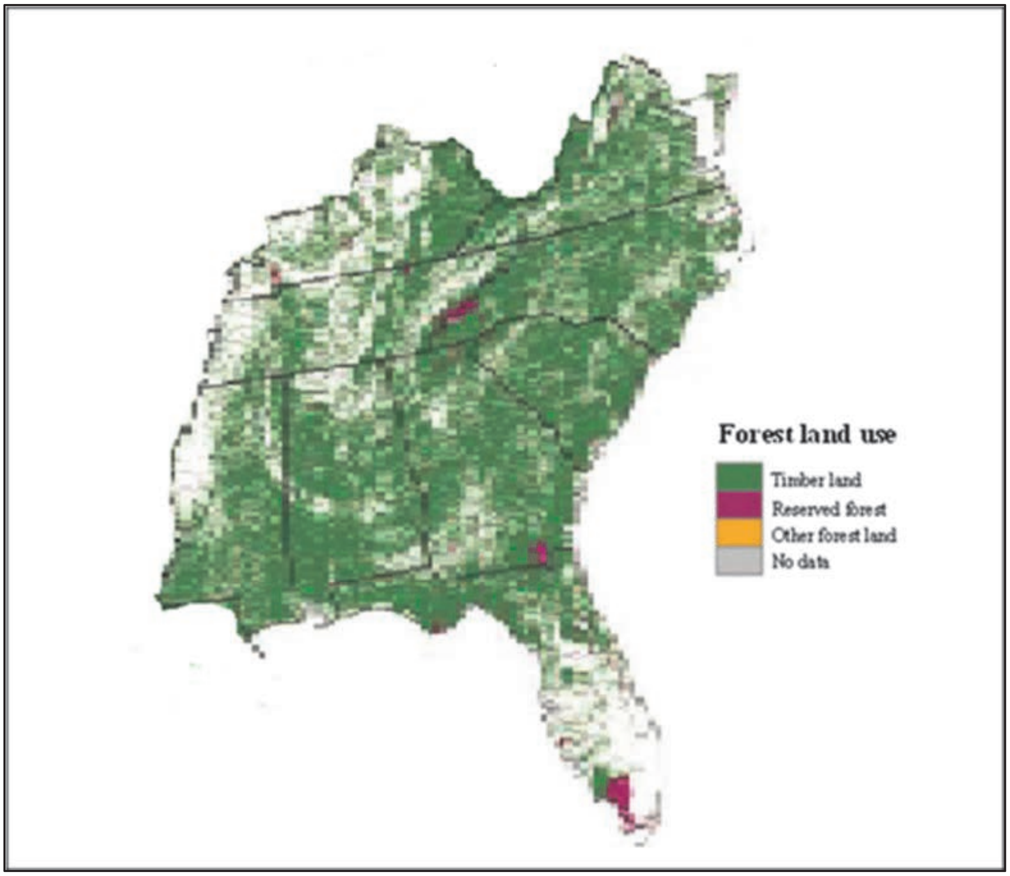
Figure 3.2-1 depicts the timberland, reserved forest, and other forest land in the project area. Table 3.2-5 provides acreage for the forest land resources of the project area as described in the *Forest Resources of the United States 2007, A Technical Document Supporting the Forest Service 2010 RPA Assessment* (U.S. Forest Service, 2009), in addition to total land area and other land. The project area encompasses 262.4 million acres of total land with 59% considered timberland. In 2007, Southern forests accounted for 58% of the total timber volume harvested in the United States (Hoyle, 2012). The continued management of forest species in the Southeastern United States is important on both a local and national scale. Although these forests in the region comprise only 2% of global forest cover, they produce 25% of the world's pulpwood for paper and 18% of its industrial timber (Southern Forests for the Future, 2013). This area produces more timber than any country in the world (Stanturf, Kellison, Broerman, & Jones, 2003).

**Table 3.2-5: Forestry Resources within the Project Area by State**

| State | Total land area (1,000 acres) | Forest Resources within the United States (1,000 acres) | | | | | | Other Land (1,000 acres) |
|---|---|---|---|---|---|---|---|---|
| | | Total Forest | Timberland | | | Reserved Forest | Other Forest | |
| | | | Total | Planted | Natural Origin | | | |
| **Alabama** | 32,435 | 22,903 | 22838 | 7,181 | 15,658 | 64 | 1 | 9,467 |
| **Florida** | 35,026 | 17,461 | 15,916 | 4,967 | 10,950 | 1,124 | 421 | 16,020 |
| **Georgia** | 37,114 | 24,752 | 24,324 | 7,745 | 16,579 | 427 | 1 | 11,934 |
| **Kentucky** | 25,426 | 12,472 | 12,347 | 61 | 12,286 | 97 | 28 | 12,829 |
| **Mississippi** | 30,026 | 19,487 | 19,450 | 5,812 | 13,638 | 22 | 15 | 10,502 |
| **North Carolina** | 31,128 | 18,621 | 18,121 | 3,223 | 14,898 | 380 | 120 | 12,007 |
| **South Carolina** | 19,207 | 13,060 | 12,972 | 3,314 | 9,658 | 68 | 20 | 6,059 |
| **Tennessee** | 26,390 | 13,941 | 13,517 | 716 | 12,801 | 416 | 8 | 12,025 |
| **Virginia** | 25,626 | 15,883 | 15,285 | 2,600 | 12,685 | 555 | 43 | 9,145 |
| **Total** | **262,378** | **158,580** | **154,770** | **35,619** | **119,153** | **3,153** | **657** | **99,988** |

*Source:* (U.S. Forest Service, 2012a)

**Figure 3.2-1: Timberland, Reserved Forest, and other Forest Land in the Project Area as Designated by the U.S. Forest Service**




*Source:* (U.S. Forest Service, 2012a)

Table 3.2-6 further defines forest lands by ownership class. Forests in the project area span 158.6 million acres, accounting for 60.4% of the total land area in the project area. Federal forest lands account for approximately 15.3 million acres (9.6% of total forest land) with 3.2 million acres (2.0% of total forest land) reserved. Reserved forest land is defined as those forested areas that are withdrawn from wood production by legal statute. The majority holders of these areas include national parks, National Forest System wilderness areas, and state parks (Azuma, Menlove, & Gray, 2007). The National Forest System provides 9.1 million acres or 38.3% of Federally-owned forest in the region, and the Bureau of Land Management (BLM) provides management on 6,000 acres of forest land. State and local government owned forests total approximately 8.4 million acres (35.4% of total publically-owned forest land). Reserved forest lands (Federal or state-owned lands) are considered to be ineligible lands for EHEC production. Land considered ineligible also includes native sod and land that is already enrolled in Conservation Reserve Program, Wetlands Reserve Program, or Grassland Reserve Program. Native sod is land that the plant cover is composed principally of native grasses, grass like plants, forbs, or shrubs suitable for grazing and browsing; and that has never been tilled for the production of an annual crops. Total private forest land accounts for approximately 85% of the total forest land with the Southeastern United States (U.S. Forest Service, 2012a).

**Table 3.2-6: Forest Ownership by State**

| State | All ownership (1,000 acres) | Public (1,000 acres) | | | | | | | Total Private (1,000 acres) |
|---|---|---|---|---|---|---|---|---|---|
| | | Total Public | Federal | | | | State | County and Municipal | |
| | | | Total Federal | National Forest System | BLM | Other Federal | | | |
| **Alabama** | 22,903 | 1,525 | 1,025 | 745 | 0 | 280 | 349 | 151 | 21,378 |
| **Florida** | 17,461 | 6,055 | 2,626 | 1,180 | 6 | 1,446 | 2,900 | 515 | 11,406 |
| **Georgia** | 24,752 | 2,542 | 1,781 | 824 | 0 | 957 | 436 | 325 | 22,210 |
| **Kentucky** | 12,472 | 1,423 | 1,176 | 714 | 0 | 461 | 162 | 73 | 11,049 |
| **Mississippi** | 19,487 | 2,329 | 1,848 | 1,340 | 0 | 509 | 233 | 241 | 17,158 |
| **North Carolina** | 18,621 | 3,141 | 2,144 | 1,287 | 0 | 858 | 726 | 271 | 15,480 |
| **South Carolina** | 13,060 | 1,584 | 1,028 | 596 | 0 | 432 | 379 | 176 | 11,477 |
| **Tennessee** | 13,941 | 2,269 | 1,391 | 660 | 0 | 731 | 768 | 104 | 11,672 |
| **Virginia** | 15,883 | 2,867 | 2,270 | 1,750 | 0 | 520 | 349 | 247 | 13,017 |
| **Total** | 158,580 | 23,735 | 15,289 | 9,096 | 6 | 6,194 | 6,302 | 2,103 | 134,847 |

*Source:* (U.S. Forest Service, 2012a)

### 3.2.3.1 Forested Lands

As previously mentioned, woody crops with the potential for use as potential EHECs include eucalyptus, loblolly pine, poplar, spruce, and willow. Currently, DOE's ARPA-E PETRO Program is investigating the potential of loblolly pine. Loblolly pine is one of the leading commercial timber species in the Southeastern United States (Baker & Langdon, 1990; Mississippi Foresty Commission, 2010) and accounts for 25.7% of total timberland acreage in that region (U.S. Forest Service, 2012a). Loblolly pine contributes substantially to the timber and pulpwood industry, and to other areas such as pine straw production.

The natural range of loblolly pine extends throughout the region. The species can thrive in low-nutrient soils, meaning that land suitable for use in growing loblolly pine may have few other similarly productive commercial agricultural uses. Overgrown fields that are of marginal use for crop agriculture may be ideal sites for loblolly plantations (Clatterbuck & Ganus, 1999). Growth of loblolly pine for biofuel could utilize underused agricultural land and would not necessarily require a trade-off between land used for food crops and land used for EHECs. As with non-woody crops, optimal land management practices for EHECs may differ from those used for timber growth in loblolly pine. The frequency of thinning and the rotation age (final harvest age) would be dependent on the intended use of the crop, and are different for timber versus pulpwood (used for biofuels) (Henderson & Munn, 2012).

## 3.2.4 Expiring Conservation Reserve Program Acres

The USDA's Conservation Reserve Program (CRP) is a voluntary conservation program available to agricultural producers to help assist them in enhancing environmentally sensitive lands. Producers enrolled in the CRP plant long-term, resource-conserving covers such as native grasses or trees to improve the quality of water, control soil erosion, and enhance wildlife habitat.

In return, the USDA Farm Service Agency (FSA) provides participants with rental payments and cost-share assistance for 10 to 15 years. From FY 2014 to FY 2018, more than 940,000 acres will expire from CRP contracts throughout the Southeastern United States. This averages approximately 188,000 acres per year. Overall, Mississippi (330,600 acres) and Georgia (145,700 acres), account for approximately 50.5% of the expiring acres. Table 3.2-7 provides information on expiring CRP acres by FY and by state.

Different study methodologies have been conducted with different year ranges of expiring CRP acres to determine the extent of CRP acres returning to active crop production. One report characterizes these studies as of three types: (1) prior land use; (2) CRP contract holder surveys of intended use if CRP were not an option; and (3) data from acres leaving CRP from 1992 to 1997. The prior land use scenario indicates that approximately 93% of CRP lands would return to active crop and hay production. Survey data from CRP contract holders indicate that if CRP were no longer an option that 63% of acres would return to crop production, 23% would retain cover for hay and forage, and 10% would be kept in grass and tree cover for forest products and wildlife The data from 1992 to 1997 indicated that approximately 58% of expired acres returned to crop production, at least in the short term (Hansen, 2007). Overall, the data seems to indicate that the majority of acres expiring from CRP would return to crop production if they are not re-enroll into CRP; however, this would be highly dependent on current and anticipated crop prices, land prices, and other external factors that influence land use decisions.

**Table 3.2-7: Expiring CRP Acres by Fiscal Year 2014-2018**

| State | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| **Alabama** | 34,065 | 27,450 | 14,100.1 | 32,494.5 | 15,491 |
| **Florida** | 6,827.6 | 5,042.6 | 693.4 | 5,700.8 | 2,497.1 |
| **Georgia** | 62,777.7 | 41,894.2 | 3,523.7 | 14,695.3 | 22,860.1 |
| **Kentucky** | 20,047.7 | 25,215.8 | 14,327 | 25,136.3 | 36,556.3 |
| **Mississippi** | 45,420.8 | 63,821.2 | 40,725.8 | 124,418.3 | 56,218.9 |
| **North Carolina** | 12,494 | 14,967.9 | 9,400.6 | 8,725.3 | 9,225.2 |
| **South Carolina** | 18,846.9 | 18,522 | 3,162.7 | 16,181.3 | 2,676.7 |
| **Tennessee** | 9,257.2 | 13,509.7 | 8,983.4 | 13,453.1 | 5,376.7 |
| **Virginia** | 2,304.70 | 8,092.50 | 8,592.50 | 9,820.00 | 5,639.80 |
| **Southeastern US** | 212,041.6 | 218,515.9 | 103,509.2 | 250,624.9 | 156,541.8 |

*Source:* (U.S. Department of Agriculture -- Farm Service Agency, 2014)

# 3.3 Water Resources

## 3.3.1 Definition of the Resource

Water resources are streams, lakes, rivers, and other aquatic habitats in an area and include surface water, groundwater, wetlands, floodplains, coastal resources, and wild and scenic rivers. Water resources—such as lakes, rivers, streams, canals, and drainage ditches—make up the surface hydrology of a given watershed (an area of land where all of the water that falls in it and drains off goes to the same place). The term "waters of the United States" applies only to surface waters—including rivers, lakes, estuaries, coastal waters, and wetlands—used for commerce, recreation, industry, sources of fishing, and other purposes such as irrigation. The Clean Water Act, administered by EPA, uses state-established water quality standards and technology-based effluent limitations to protect and restore surface water quality. Water quality standards consist of a designated beneficial use of a waterbody (e.g., contact recreation, fishing, water supply), and the numerical or quantitative statement that identifies at what point the waterbody does not meet its designated use. Given the programmatic nature of the Proposed Action, water resources are described by Level II Ecoregion; state-level water quality standards are not expressly considered in this section.

### 3.3.1.1 Surface Water

Surface water resources consist of lakes, rivers, streams, estuaries, and coastal waters. Surface water is important for its contributions to the economic, ecological, recreational, and human health of a community or locale. Surface water can be freshwater or estuarine.

Freshwater streams and rivers are dynamic interconnected systems of moving water. Streams can be perennial (flow year-round), intermittent (flow during storm events or snowmelt) or interrupted (perennial flows that travel underground in karst terrain). Smaller streams join to form larger streams, and the coming together of streams eventually forms rivers (American Rivers, n.d.). Ultimately, rivers flow into lakes or estuaries. Reservoirs are rivers that have been dammed for human uses (e.g., water supply, power generation, recreation). There are few naturally occurring lakes in the Southeastern United States.

Estuaries (including bays and tidal rivers) are water bodies that provide transition zones between freshwater and ocean (salt or saline) water. These coastal waterbodies are among the most biologically productive places on earth (Environmental Protection Agency, n.d.). Many habitats within the region that are important to wildlife species are completely dependent upon the influence of salt water and direct management action, such as coastal impoundments (Environmental Protection Agency, n.d.). Much of this area is rich in natural resources, contains major tourist destinations, and continues to experience population growth.

Surface water quality is described in terms of the ability for the waterbody to support particular uses (e.g., for public water supply; protection of fish, shellfish, and wildlife habitat or consumption; and recreational, agricultural, industrial, and navigational purposes) and whether water quality standards are met for pollutants, nutrients, pathogens, and physical measurements (e.g., pH and turbidity). Pollutants are introduced through either point (i.e., discharged directly from a pipe into surface waters) or non-point (i.e., does not have a single point of origin such as sediment, or human-made, such as chemicals and toxics) sources.

Water quality is assessed by impact to specific constituents that include microbial pathogens; nutrients; total dissolved solids (TDS, salinity, and hardness); metals; pesticides; suspended solids; dissolved oxygen; pH; and other contaminants. These constituents have direct impacts on aquatic ecosystems and public health that form the basis of the water quality standards set for these compounds. Microbial pathogens can cause disease to humans via both ingestion and dermal contact and are frequently cited as the cause of beach closures and other recreational water hazards in lakes and estuaries. Nutrient over-enrichment can promote a cascade of events in waterbodies from algal blooms to decreases in dissolved oxygen and associated fish kills.

Agricultural practices have the potential to affect water quality due to the vast amount of acreage devoted to farming nationwide and the physical and chemical demands that agricultural use has on the land. The most common types of agricultural pollutants include excess sediment, fertilizers, animal manure, and pesticides (Environmental Protection Agency, 2013d). A pesticide (as used in this Final PEIS) is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Therefore, in this Final PEIS, herbicides, insecticides, and fungicides are termed pesticides. Fertilizers[12] and pesticides have been found to be in excess in many waterbodies in the United States (Environmental Protection Agency, 2013e). The amount of fertilizers applied varies greatly with the type and location of the crop. Certain pesticides may pose a threat to the health of both people and wildlife. (Section 3.9 provides additional information on pesticides from a safety and human health perspective.)

Nutrients are essential for plant and animal growth but in elevated concentrations can degrade water quality. For most crops, it is standard agricultural practice to apply fertilizers such as nitrogen (N) and phosphorus (P), as well as pesticides. Nitrogen in forms such as nitrate ($NO_3$) is highly soluble, and along with some pesticides infiltrates downwards toward the water table. More than 100,000 miles of rivers and streams, close to 2.5 million acres of lakes, reservoirs, and ponds, and more than 800 square miles of bays and estuaries in the United States have poor water quality related to nitrogen and phosphorus pollution. Over 166 dead zones have been documented nationwide, affecting waterbodies like the Chesapeake Bay and the Gulf of Mexico (Environmental Protection Agency, 2013e). These dead zones are areas of hypoxic (low-oxygen) caused by "excessive nutrient pollution from human activities coupled with other factors that deplete the oxygen required to support most marine life in bottom and near-bottom water" (National Oceanic and Atmospheric Administration, 2012). The Gulf of Mexico dead zone is the largest in the United States, measured to be 5,840 $mi^2$ in 2013, and occurs every summer because of nutrient pollution from the Mississippi River Basin, an area that drains 31 upstream states (Environmental Protection Agency, 2013e).

Sediments from soil erosion associated with agriculture can impair water quality. Cropland erosion accounts for one half of the sediment that reaches the nation's waterways each year (Environmental Protection Agency, 2013d). The amount of sediment eroding from agricultural areas is directly related to land use—the more intensive the use, the greater the erosion. For example, more sediment erodes from

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[12] Plants require at least 16 elements for normal growth and for completion of their life-cycle. Those used in the largest amounts—carbon, hydrogen and oxygen—are non-mineral elements supplied by air and water. The other 13 elements are taken up by plants only in mineral form from the soil either from naturally occurring amounts or from minerals added in fertilizers.

row crop fields than from pastures or woodlands. Fine sediment has been identified as a source of stream impairment in much of the Southeast's stream basins.

### 3.3.1.2 Groundwater

Groundwater is the water beneath the land surface that fills the spaces in rock and sediment. It is an essential resource often used for potable water consumption, agricultural irrigation, and industrial applications. Replenished by precipitation, under natural conditions, much of that recharge returns to the atmosphere by evapotranspiration (loss of soil water to the atmosphere through evaporation and plant transpiration) from plants and trees or discharges to surface waters. Groundwater discharge to surface waters allows streams to flow beyond rain and snowmelt periods and sustains lake levels during dry spells.

Groundwater provinces are areas with similar geologic and hydrologic characteristics such as rock materials, topography, surface drainage, and availability of groundwater. An aquifer is the geologic layer that transmits groundwater. It may be a layer of gravel or sand, a layer of sandstone or cavernous limestone, a rubbly top or base of lava flows, or even a large body of massive rock, such as fractured granite, that has sizable openings. Aquifers can be unconfined (no layer to restrict the vertical movement of groundwater) or confined (bounded by clays or nonporous bedrock). A principal aquifer is a regionally extensive aquifer or aquifer system that can be used as a source of potable water (U.S. Geological Survey, 1999b). Sole source aquifers are defined by the EPA as an aquifer that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. These areas may have no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend on the aquifer for drinking water. EPA has designated three sole source aquifers that are entirely or partially within the project area: Biscayne, Floridan, and Southern Hills aquifers. This designation protects the area's groundwater resources by requiring EPA review prior to area projects receiving Federal funds (Environmental Protection Agency, 2013f).

Water quality parameters and sources of contamination are similar for surface and groundwater. Streams receive a percentage of their base flow from groundwater, so the same factors that affect surface water affect groundwater, and vice versa. Most aquifers are more protected than surface water from quick contamination, because as water migrates down through soil and rock layers, many chemicals and solid particles become trapped before entering an aquifer by forming attractive bonds with soil particles. Some confined aquifers, such as carbonate aquifers, are inherently more susceptible to contamination because they consist of open channels that allow water to move quickly and unimpeded. Naturally occurring contaminants are present in the rocks and sediments. As groundwater flows through sediments, metals such as iron and manganese dissolve and may later be found in high concentrations in the water. (U.S. Geological Survey, 1999a)

Fertilizers can increase the concentration of nitrate in groundwater wells, especially shallow wells (less than 200 feet deep) (Environmental Protection Agency, 2012a). Nitrate concentrations in shallow wells are elevated within the Southeastern United States, particularly in agricultural areas associated with some of the most intense applications of fertilizer and manure (Winrock International, 2009). Natural features related to geology, hydrology, and soils, and natural processes can affect the transport of nitrate over the land and into the ground, making some aquifers more vulnerable to contamination than others (U.S. Geological Survey, 2010).

Contamination of coastal groundwater by nutrients may result from wastewater disposal from septic systems, agricultural and urban uses of fertilizer, and agricultural use of manure. Nutrients carried by groundwater can be discharged to coastal waters or to drinking water supply wells. Often, water quality concerns for coastal ecosystems have focused on surface water sources of nutrients and other contaminants. Because groundwater moves slowly, the flushing of nutrient-contaminated groundwater from an aquifer can take many years, even several decades. (U.S. Geological Survey, 2010)

Another common groundwater contaminant from agricultural practices is pesticides (see Section 3.9.2.2). Pesticides can reach water-bearing aquifers below ground from applications onto crop fields, seepage of contaminated surface water, accidental spills and leaks, improper disposal, and even through injection waste material into wells. Pesticides in shallow groundwater aquifers are of concern because in some areas the groundwater is used for drinking water and groundwater contamination is difficult to reverse once it occurs. A persistent pesticide can remain in groundwater long after its use is discontinued because of the slow rates of groundwater flow and the resulting long residence time of water and the pesticide (U.S. Geological Survey, 2014a). Many communities obtain their drinking water from aquifers. Water suppliers drill wells through soil and rock into aquifers to reach the groundwater and supply the public with drinking water. Many homes also have their own private wells drilled on their property to tap this water supply. Unfortunately, groundwater can become contaminated by human activity. Chemicals can enter the soil and rock, polluting the aquifer, and groundwater (Environmental Protection Agency, 2012b).

### 3.3.1.3 Water Use and Availability

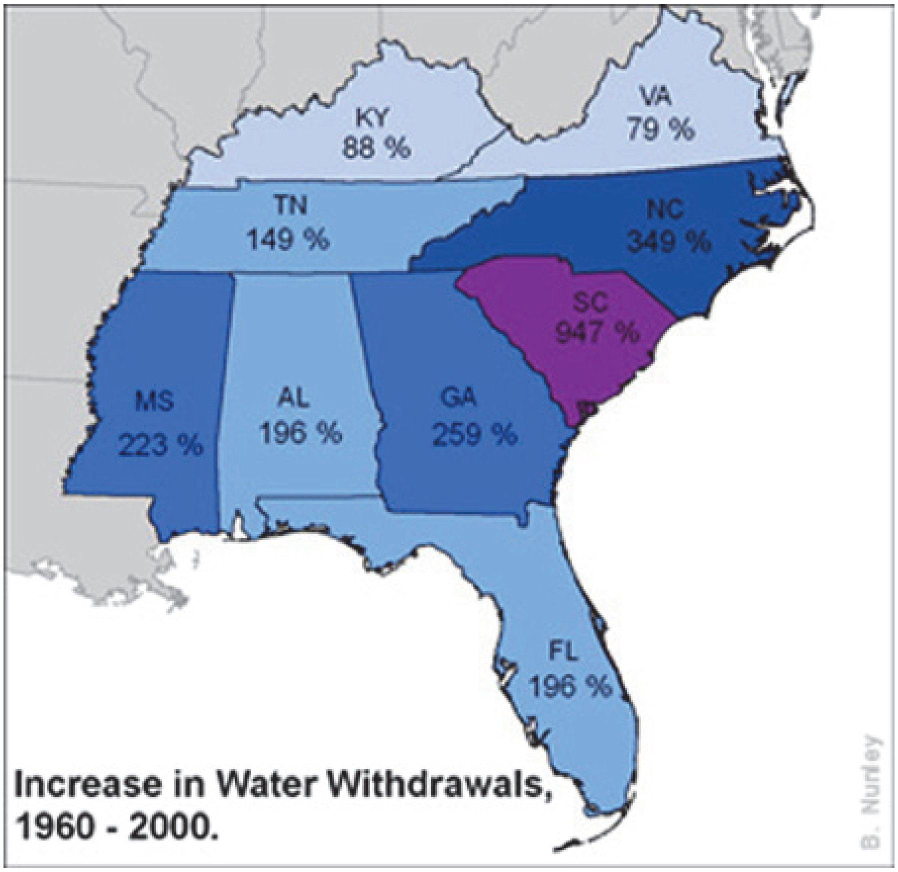
An adequate supply of water is essential for human health and economic wellbeing. Historically, rainfall in the Southeastern United States has been adequate to maintain water resources, and the region relies on a balanced mix of groundwater and surface water sources. However, several factors have contributed to growing water scarcity (Environmental Protection Agency, 2012a)

- Populations, particularly in urban areas of Florida and Georgia, have grown rapidly in recent years. The population of Georgia rose from 5.4 million in 1980 to 9.8 million in 2011; the population of Florida rose from 9.7 million to 19.1 million during this same period.
- Agriculture, especially extensive operations in the Lower Mississippi River basin, requires large supplies of irrigation water.
- The climate in the southeast appears to be warming and becoming increasingly prone to drought. Since 1970, the average temperature in the region has increased 1.6 degrees Fahrenheit (ºF) and precipitation has decreased by 7.7%.

***Population.*** Over the past five decades, population growth and development in the Southeast region has brought an increasing demand for water. The Southeast population has doubled since 1960, with an additional 23 million people expected to call it home by 2030. The region had an 89% increase in population from 1960 to 2000. Fifty-eight of the 100 fastest growing counties in the nation are in the project area (National Wildlife Federation, 2008).

Abundant supplies of fresh water for residences, agriculture, industry, and power plant cooling contributed to the rapid development in the Southeast; however, the area might have grown too quickly for the water supply. In 1960, the public water supply used just 447 million gallons per day (Mgal/day) in the nine-state project area (as cited in (National Wildlife Federation, 2008)). By 2000, the water usage had jumped to 8,529 Mgal/day, a nearly 20-fold increase (as shown in Figure 3.3-1). Concurrently, water use for irrigation increased 5.6-fold (National Wildlife Federation, 2008).

**Figure 3.3-1: Percent Increases in Water Withdrawals in the Project Area from 1960-2000**




*Source: (National Wildlife Federation, 2008)*

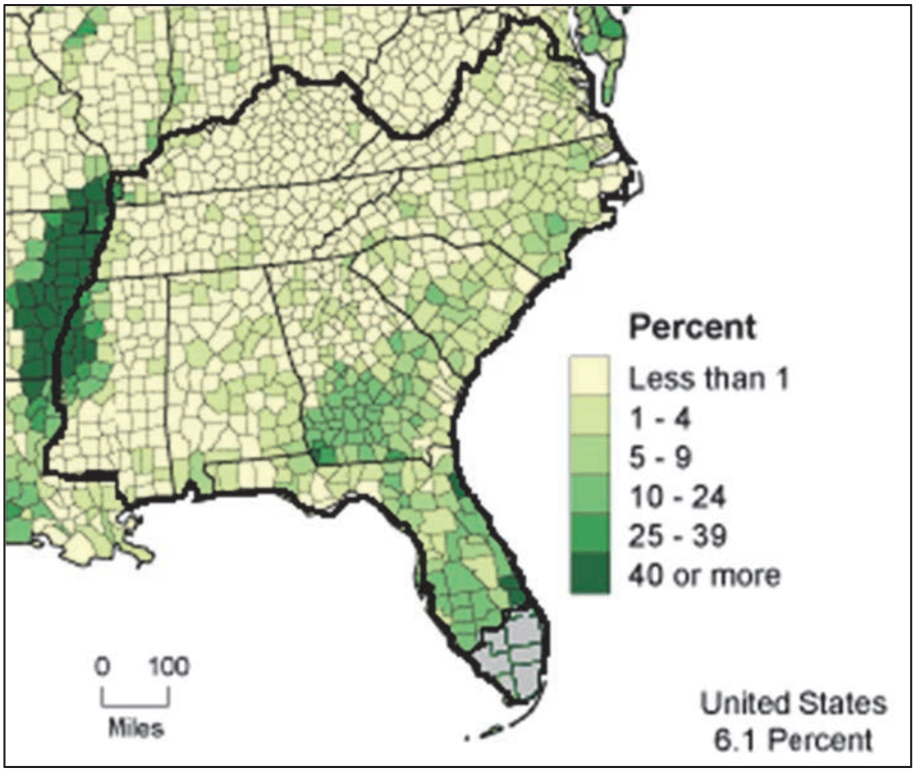
***Irrigation.*** The primary concern with regard to water availability and biofuel crop production is how much irrigation will be required—either new or reallocated—that might compete with water used for other purposes. Crops can be either rainfed or irrigated. Irrigation water can come from groundwater or surface water. Some of the applied water is incorporated into the crop, but most of it leaves the fields as evaporation from the soil and transpiration from plants during photosynthesis as evapotranspiration, runoff to rivers and streams (sometimes called "return flow"), and infiltration to the surficial aquifer (Committee on Water Implications of Biofuels Production in the United States, 2008).

Understanding evapotranspiration is important to estimating a crop's water demands (e.g., whether or not to irrigate). Transpiration occurs when water entering the plant roots is carried to stems and leaves for building plant tissue via photosynthesis[13] and then passed through the leaves into the atmosphere. Evaporation is water evaporating from soil, water surfaces, or plant leaf surfaces holding water droplets from rain, irrigation, or dew. Wind, temperature, humidity, plant type, and water availability are a few components that affect evapotranspiration. Under rainfed or deficit irrigation, the plant leaf stomata close when the soil cannot supply water at a sufficient rate, or the root system is not extensive and efficient enough to withdraw water from the soil system to meet the atmospheric demand. Rainfed crops usually have deeper and more extensive root systems than irrigated crops and can withdraw water from deeper soil layers. However, in the absence of rain, when the available soil water is depleted, rainfed plants experience wilting and evapotranspiration reduction. Beyond a certain water stress threshold, crop yield will decrease. Under rainfed conditions, seasonal evapotranspiration of a crop usually will be close or equal to the sum of the available water in the soil profile and rainfall. (Irmak, 2009)

Irrigation accounts for the majority of the nation's consumptive use of water. Estimates of the total quantity of water used for irrigation on farms in the United States vary, depending on year and data source. The USDA estimates that 91.2 million acre-feet were used for irrigation in 2008, with 53% supplied from groundwater, 32% from surface water of off-farm suppliers (e.g., irrigation districts), and 15% surface water "self-supply" (U.S. Department of Agriculture -- National Agricultural Statistics Service, 2009). Figure 3.3–2 shows the areas where irrigation is most intensively used in the project area; the darkest areas are those where more than 40% of farmed acreage is irrigated. Figure 3.3–2 also depicts the percentage of all farmland in the Southeastern United States that is irrigated, organized by county to provide a more detailed level of geographic resolution.

[13] Photosynthesis uses less than 1% of the total water absorbed by plants, and the rest is lost through transpiration. Since water makes up 90% of the weight of most crops, the consumption of less than 1% of water may seem unexpected, but plants use their water for other purposes such as transpiration to build green biomass and grain. (Irmak, 2009)

**Figure 3.3-2: Acres of Irrigated Land as Percent of Land in Farms Acreage in 2007 in the Project Area**




*Source:* modified from (U.S. Department of Agriculture -- National Agricultural Statistics Service, 2009)

***Drought.*** Increased use of water resources and the effects of drought have led to concerns about the future availability of surface and groundwater to meet domestic, agricultural, industrial, and environmental needs. The Southeastern United States operated under unusually good water availability conditions for about 40 years prior to noteworthy droughts of the past several years. However, historic records show that regular droughts are becoming more typical for the Southeast (National Wildlife Federation, 2008). Recent droughts illustrate the Southeast's vulnerability. Crop losses due to the 2007 drought are estimated at more than $1.3 billion from corn, wheat, soybeans, cotton, and hay (National Wildlife Federation, 2008). At the same time, warming-induced sea-level rise, along with increased groundwater pumping, may increase the risk of saltwater intrusion into important groundwater aquifers (Reilly, Dennehy, Alley, & Cunningham, 2008).

## 3.3.2 Existing Conditions

This section describes the water resources in the project area using Level II ecoregions (as described earlier) within the Southeastern United States. The section includes a general description of the ecoregion's impaired waterbodies, as well as a general discussion of the various types of water resources found in the project area, including major lakes, rivers, streams, channels, ponds, and other water features near agricultural areas.

#### 3.3.2.1 Southeastern USA Plains

The Southeastern USA Plains is the largest of the three ecoregions in the project area, covering land area in all nine states (majority of Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Tennessee, and Kentucky, and the northern part of Florida), as shown in Figure 3.1-1Figure 3.1-1.

**Surface Water**

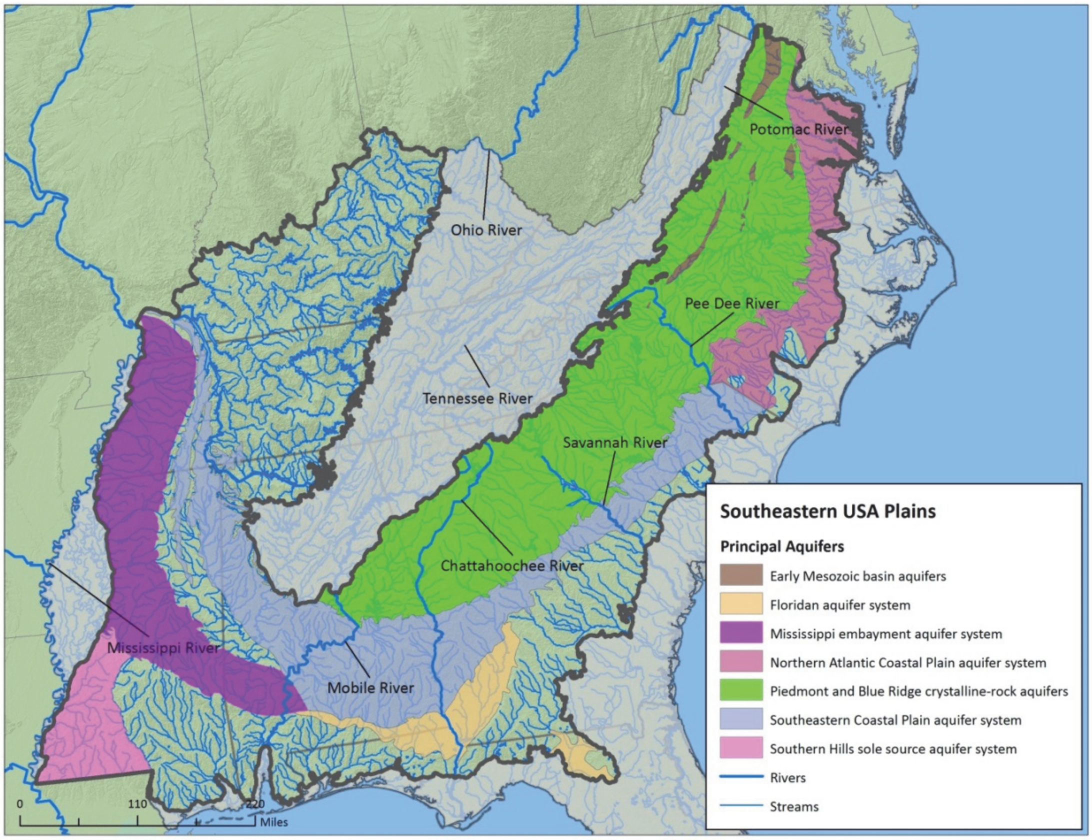
***Freshwater.*** The Ohio River, which runs along the northern border of Kentucky, drains most of the northern part of the ecoregion. Other large rivers in this ecoregion include: the Potomac, Chattahoochee, Mobile, Pee Dee, Savannah, Mississippi, and Tennessee rivers (as shown in Figure 3.3-3). Stream morphology in this ecoregion is highly variable and both high gradient streams with boulder or cobble substrates and low gradient streams with sand or gravel bottoms occur (Omernik, 2002). Silt and sand dominate lowland channels while upland streams are rockier. Virtually all of the major stream systems have been channelized to some degree (Kentucky Department of Fish and Wildlife Resources, 2013). Perennial streams in the Southeastern USA Plains ecoregion are relatively low gradient and sandy-bottomed (Omernik, 2002). There are few naturally occurring lakes in this region; most are reservoirs sited in the valleys (Environmental Protection Agency, 2013c).

Dams have an important impact on aquatic resources within the ecoregion. With more than 1,000 dams impounding 550 miles of streams, the Southeastern USA Plains ecoregion has the most dams of the three ecoregions in the project area (South Carolina Department of Natural Resources, 2005) (Georgia Department of Natural Resources, 2005); (Kentucky Department of Fish and Wildlife Resources, 2013). Dams result in a loss of connectivity and can negatively affect aquatic biota both above and below the impoundment. Additionally, impoundments often negatively affect un-impounded downstream reaches by altering hydrologic and thermal regimes, modifying stream channel morphology, increasing erosion and sedimentation and ultimately reducing suitable habitat for native aquatic fauna (South Carolina Department of Natural Resources, 2005).

***Estuarine Water.*** There are no estuaries in this ecoregion.

***Surface Water Quality.*** Urbanization, farming, channelization, diversion, mining, and dam-building have altered many rivers and streams in this ecoregion (Omernik, 2002). Nonpoint source discharges from agricultural operations can negatively affect water quality. The Southeastern USA Plains ecoregion has the second highest density of permitted discharges and the highest density of Concentrated Animal Feeding Operations, with approximately 6.5 operations per 100 $mi^2$ within South Carolina (South Carolina Department of Natural Resources, 2005). Excessive concentrations of nitrogen and phosphorus are in a larger proportion of streams in this ecoregion than in the southeast as a whole, possibly related to the large concentration of animal feeding operations (Tennessee Department of Environment and Conservation, 2012). Point source discharges from industrial, municipal, and commercial sources add a variety of chemical pollutants to the receiving streams, rivers, and lakes (South Carolina Department of Natural Resources, 2005). Point-source discharges into streams in this region include wastewater industrial facilities, and municipal treatment facilities.

**Figure 3.3-3: Water Resources of the Southeastern USA Plains Ecoregion**




Forest clearing, soil tilling, and channelization near streams in the Southeastern USA Plains ecoregion have resulted in streams that are heavily silted. Stream bank erosion due to loss of riparian areas, livestock grazing, and altered hydrology also contribute to sedimentation in streams. During the past century, many streams in the Southeastern plains were channelized to improve drainage of croplands; leading to increased erosion of cropland and increased sedimentation of the receiving streams. This also resulted in changing many streams into straight shallow ditches with severely depressed populations of aquatic fauna (Smith, et al., 2002).

Water quantity is also a problem for streams situated in the Southeastern USA Plains. Water withdrawal for irrigation is a common practice in the ecoregion. During summer months, some streams are completely dewatered due to uncontrolled irrigation of croplands (Georgia Department of Natural Resources, 2005). Furthermore, many pond-owners close their drain structures during dry periods in an attempt to maintain clear water, thereby dewatering the stream below (South Carolina Department of Natural Resources, 2005).

**Groundwater**

***Sole Source Aquifers.*** The Southern Hills Regional Aquifer System is a sole source aquifer consisting of 13 interdependent aquifers in eastern Louisiana and southwestern Mississippi. Although several streams are available as alternatives for water supply, local officials have not accepted them because of the additional water treatment that would be necessary and the extensive distribution system needed to deliver water to areas not near a source stream. (Environmental Protection Agency, 2013f)

***Principal Aquifers.*** As shown in Figure 3.3-3, there are seven principal aquifer systems within the Southeastern USA Plains ecoregion: Piedmont and Blue Ridge Province, which in this ecoregion includes the Early Mesozoic basins, and the Piedmont and Blue Ridge crystalline-rock aquifers; the Mississippi embayment aquifer; and the Atlantic Coastal Plain. The Atlantic Coastal Plain can be differentiated from the Piedmont on the west by the Fall Line, a zone of rapids or waterfalls that marks the position where streams flow from the consolidated rocks of the Piedmont onto semi-consolidated to unconsolidated rocks of the Atlantic Coastal Plain. Within the project area, there are three main regional aquifers within the Atlantic Coastal Plain: the North Atlantic Coastal Plain (NACP) aquifer, Southeastern Coastal Plain Aquifer, and the Floridan aquifer, as shown in Figure 3.3-3.

Natural water quality within the Piedmont and Blue Ridge aquifers is generally satisfactory, but locally, dissolved iron concentrations may be high (greater than 0.3 parts per million). Some crystalline rocks and some sedimentary rocks in early Mesozoic basins contain minerals that, when weathered, can contribute iron and manganese to groundwater, particularly if the water is slightly acidic (Barber & Maupin, 2005).

Carbonate aquifers contain numerous springs and sinkholes, which allow relatively rapid transport of water and contaminants and may enhance its vulnerability to contamination. In some areas, water in the Floridan aquifer is not suitable for drinking without some type of chemical treatment because it contains various minerals or salts. Salt water, which is heavier than freshwater, can seep into drinking water wells making the water too salty to drink (U.S. Geological Survey, 2011). Land-use practices affect the water quality of the Floridan aquifer system (Marella & Berndt, 2005). The aquifer system is unconfined in many areas and sinkholes and sinking streams commonly provide a direct pathway for land-surface contaminants to enter the groundwater system. Nitrate, herbicides, and pesticides from agricultural activities have been detected in many of the springs and wells in northern Florida. Herbicides also have been detected in trace concentrations in nine of 15 springs discharging from the Upper Floridan aquifer in South Georgia (Marella & Berndt, 2005).

### Water Use and Availability

Freshwater aquifers along the Atlantic coastal zone are among the most productive in the United States, supplying drinking water to an estimated 30 million people from Maine to Florida. Directly below recharge areas, the water is fresh, but seaward and with depth, the water becomes saline. The location of the zone of diffusion (where fresh and salt water mix) depends on the volume of freshwater entering the aquifer from recharge or leakage. One of the most common problems in the Atlantic Coastal Plain aquifers is saltwater intrusion. The position of the freshwater-saltwater boundary depends on the amount of inflow into the aquifer and the amount of freshwater discharging from the aquifer. Because freshwater has a lower concentration of dissolved solids than does saltwater, it is less dense than saltwater and tends to flow on top of surrounding or underlying saltwater (Masterson, Pope, Monti Jr, & Nardi, 2011). Groundwater use in 2000 for the principal aquifers in the Southeastern USA Plains ecoregion is listed in Table 3.3-1Table 3.3-1.

**Table 3.3-1: Water Use Estimates for Principal Aquifers within the Southeastern USA Plains Ecoregion in 2000**

| Regional Principal Aquifer | Total Water Use | Public Supply | Irrigation | Self-Supplied Industrial |
|---|---|---|---|---|
| | Million gallons per day | | | |
| Piedmont and Blue Ridge Crystalline Rock | 146 | 92.1 | 29.9 | 23.6 |
| Mississippi Embayment | 946 | 576 | 195 | 175 |
| Northern Atlantic Coastal Plain | 1,035 | 793 | 70 | 172 |
| Southeastern Coastal Plain | 860 | 340 | 382 | 138 |
| Floridan | 3,465 | 1,330 | 1,930 | 385 |

*Source:* (Reilly, Dennehy, Alley, & Cunningham, 2008)

There is no numerical information on the Piedmont and Blue Ridge early Mesozoic principal aquifer water use.

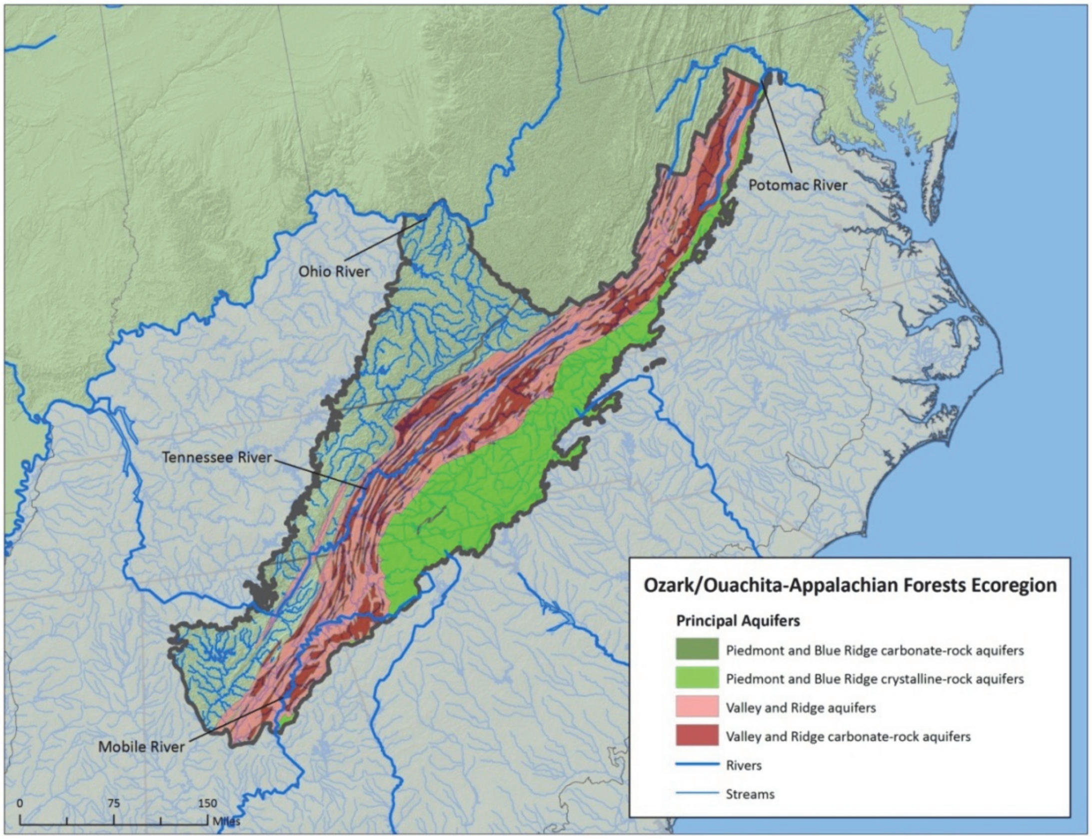
### 3.3.2.2 Ozark and Ouachita-Appalachian Forests

**Surface Water**

***Freshwater.*** The Ozark and Ouachita-Appalachian Forests ecoregion is home to the headwaters of six major freshwater drainage systems that are rich in species diversity: the Ohio, Tennessee, Mobile, and the Appalachicola Rivers, South Atlantic, and Pamlico-Ablemarle Sound (as shown in Figure 3.3-4) (The Nature Conservancy and Southern Appalachian Forest Coalition, 2000). Rivers in the Ozark and Ouachita-Appalachian Forests ecoregion flow mostly over bedrock and other resistant rock types, with steep channels and short meander lengths (Smith, et al., 2002). There is a high density of perennial, moderate- and high-gradient streams with bedrock and boulder substrates (Omernik, 2002). Major streams flow down the axes of many of the valleys, and tributary streams commonly join the major streams at nearly right angles. Natural lakes are scarce across this ecoregion. Many of the lakes in this area are human-made lakes or reservoirs from dammed rivers (Environmental Protection Agency, 2013c).

***Estuarine Water.*** There are no estuaries in this ecoregion.

**Figure 3.3-4: Water Resources of the Ozark and Ouachita-Appalachian Forests Ecoregion**




***Surface Water Quality.*** The Ozark and Ouachita-Appalachian Forests ecoregion has the second highest percentage of monitored stream miles not supporting designated uses in the project area, surpassed only be the Southeastern Coastal Plains. Point-source discharges into streams in this ecoregion include effluent from industrial facilities and treated wastewater from municipal treatment facilities. Other water quality stressors include sedimentation from roads, cultivated fields, and pastures (Smith, et al., 2002). More than half of the streams and rivers are in poor condition, with high levels of phosphorus, riparian vegetative cover, riparian disturbance, nitrogen, and streambed sediments (Georgia Department of Natural Resources, 2005). Acidic drainage from mines and industrial pollution has led to stream habitat degradation and the loss of fish species in the Ohio and Allegheny River systems (Omernik, 2002). In addition, non-point source pollution from agricultural and silvicultural (forestry) practices, development, road construction and mining activities are also large components (Environmental Protection Agency, 2013c).

Hydroelectric power impoundments and the invasion of exotic species, such as the zebra mussel, have affected aquatic diversity in this ecoregion (Environmental Protection Agency, 2005). The stresses include increased nutrient loadings, altered sediment loadings, toxic contamination from pesticides, effluents, and acid drainage as well as habitat loss and alteration to hydraulic regimes (Kentucky Department of Fish and Wildlife Resources, 2013).

Because of poor water quality, eight watersheds within this ecoregion are considered U.S. watershed hotspots—defined as USGS hydrologic units or sub-basins with 10 or more at-risk freshwater fish and mussel species (The Nature Conservancy and Southern Appalachian Forest Coalition, 2000). One watershed within this ecoregion, the Conasauga Watershed, is at the top of this list—8th out of 87 watersheds in the United States with 21 at-risk aquatic species. Six of the estimated 327 critical watersheds necessary to conserve populations of all at-risk aquatic species in the United States occur in this ecoregion (The Nature Conservancy and Southern Appalachian Forest Coalition, 2000). Additionally, valleys and river bottoms have been employed for a wide variety of agricultural uses, including row crops, pasture, and hay fields (The Nature Conservancy and Southern Appalachian Forest Coalition, 2000). In some watersheds, vegetated stream buffers are too narrow to provide adequate erosion control, and in some areas, livestock have unrestricted access to streams. These practices have resulted in general degradation of water quality and habitat for aquatic species.

**Groundwater**

Groundwater withdrawals for industrial, municipal, and residential uses as well as contamination of groundwater represent potential impacts to sensitive environments such as the caves formed in karst areas (Kentucky Department of Fish and Wildlife Resources, 2013). This ecoregion contains the majority of caves (800+) in the project area (Georgia Department of Natural Resources, 2005).

***Sole Source Aquifers.*** There are no sole source aquifers within this ecoregion (Environmental Protection Agency, 2013f).

***Principal Aquifers.*** As shown in Figure 3.3-4, there are two principal aquifer systems within the Ozark and Ouachita-Appalachian Forests ecoregion: (1) the Piedmont and Blue Ridge Province, which in this ecoregion includes the Piedmont and Blue Ridge crystalline-rock aquifer and carbonate-rock aquifer and the Valley and Ridge limestone aquifers; and (2) the Valley and Ridge carbonate-rock aquifers. The Piedmont and Blue Ridge crystalline-rock aquifer is discussed earlier in Section 3.2.3.1, Southeastern USA Plains Groundwater.

Limestone, dolomite, and marble of Paleozoic and Precambrian age form the carbonate-rock aquifers that extend over about 3% of the Piedmont and the Blue Ridge Provinces. Although these carbonate rocks are of small extent, they are major sources of local water and are the most productive Piedmont and Blue Ridge aquifers (Barber & Maupin, 2005).

The Valley and Ridge aquifers are contiguous fractured-bedrock aquifers located in the eastern United States. The groundwater flow system is different where these rocks are folded and where they are not. Soluble carbonate rocks and easily eroded shales underlie the valleys in the province, and more erosion-resistant siltstone, sandstone, and some cherty dolomite underlie ridges (U.S. Geological Survey, 1990).

***Groundwater Quality.*** The groundwater within the Ozark and Ouachita-Appalachian Forests ecoregion is generally good; the TDS value is usually low and pH usually ranges from 6.0 to 8.0 in the Piedmont aquifer (Barber & Maupin, 2005). The quality of the water in the Valley and Ridge aquifers is somewhat variable, but generally is satisfactory for municipal supplies and other purposes (U.S. Geological Survey, 1990). Most of the water in the upper parts of the aquifers is suitable for most uses without treatment. In some coal-mining areas, the groundwater is mixed with acidic mine water, which can contain large concentrations of iron, manganese, sulfate, and dissolved solids (Barber & Maupin, 2005). Waters from the carbonate-rock aquifers have dissolved-solids concentrations that average 330 mg/L and hardness values of 280 mg/L, (very hard) (U.S. Geological Survey, 1990).

**Water Use and Availability**

The Valley and Ridge carbonate-rock aquifers can yield up to 400 gallons per minute (gpm). These high flow rates are due to large interconnecting solution channels in the limestone and dolomite rock formations. Although high well yields are possible, yields are often unpredictable in new wells and dry holes are common. In general, sandstone and limestone formations are the most productive aquifers. Yields vary from less than 1 gpm to 400 gpm, but most wells produce only enough water for domestic, light commercial and some agricultural uses (Reilly, Dennehy, Alley, & Cunningham, 2008). Groundwater use in 2000 for the principal aquifers in the Ozark and Ouachita-Appalachian Forests ecoregion is listed in Table 3.3–2.

**Table 3.3-2: Water Use Estimates for Principal Aquifers within the Ozark and Ouachita-Appalachian Forests Ecoregion in 2000**

| Regional Principal Aquifer | Total Water Use | Public Supply | Irrigation | Self-Supplied Industrial |
|---|---|---|---|---|
| | Million gallons per day | | | |
| **Valley and Ridge carbonate-rock** | **363** | **226** | **7** | **130** |
| **Piedmont and Blue Ridge carbonate-rock** | **29.9** | **17.8** | **0.35** | **11.8** |

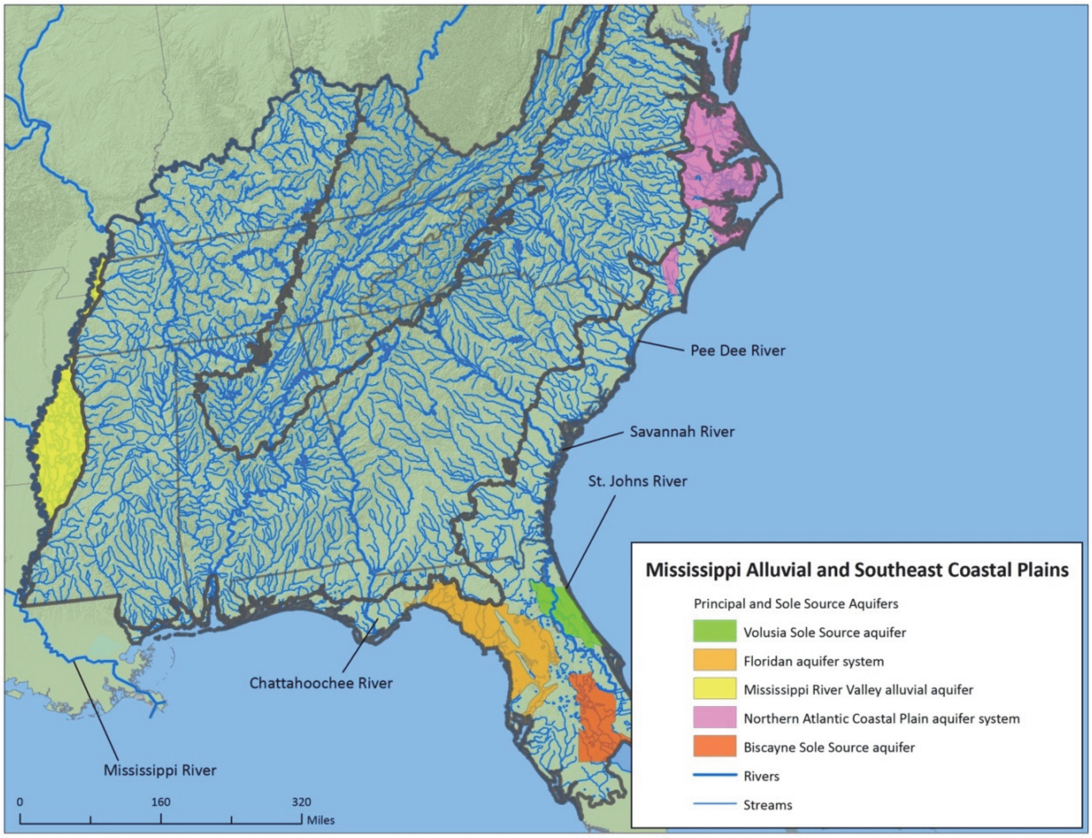
*Source:* (Reilly, Dennehy, Alley, & Cunningham, 2008)

No information is available for water use from the Valley and Ridge limestone principal aquifers.

### 3.3.2.3 Mississippi Alluvial and Southeast USA Coastal Plains

The Mississippi Alluvial Plain extends from southern Illinois, at the confluence of the Ohio River with the Mississippi River, south to the Gulf of Mexico. The Southeast Coastal Plain is an area of low relief along the East coast of the United States that extends 2,200 miles from the New York Bight southward to a Georgia/Florida section of the Eastern Continental Divide. Within this project area, the ecoregion stretches along the eastern border of Virginia, North Carolina, South Carolina, Georgia, Mississippi, Alabama, most of Florida, and a portion of western Mississippi along the Mississippi River, as shown in Figure 3.3-5.

**Figure 3.3-5: Water Resources of the Mississippi Alluvial and Southeast USA Coastal Plains Ecoregion**




## Surface Water

***Freshwater.*** The Mississippi Alluvial and Southeast USA Coastal Plains ecoregion is generally wet, including many rivers, marsh, and swampland. The Mississippi Alluvial Plain section of the ecoregion consists of a low floodplain and delta system formed by the Mississippi River. Although the Mississippi River is the principal river of the Mississippi Alluvial Plain section, the Tensas, the Sunflower, and the Yazoo Rivers are among several others whose drainage basins are contained within the alluvial plain (Roy, 2012). Other river systems within or intersecting the ecoregion include the Suwannee, Savannah, Potomac, Delaware, Susquehanna, James, Sabine, Brazos, St. Johns, Apalachicola, and Guadalupe Rivers (Georgia Department of Natural Resources, 2005), as shown in Figure 3.3-5. Most of these rivers are alluvial, or sediment carrying (Omernik, 2002). In general, rivers in this ecoregion meander broadly across flat plains created by river deposition and form complex wetland topographies, with natural levees, back swamps, and oxbow lakes (Omernik, 2002).

The rivers can be categorized into three main groups: brownwater (with headwaters north of the ecoregion and carrying substantial inorganic loads), blackwater (with headwaters in the Coastal Plain and with "coffee-colored" waters dominated by organic acids), and spring-fed (with headwaters in limestone karst). These systems typically drain acidic flatwoods or swamps. Each of these groups has unique biodiversity resources. Many aquatic animals are endemic to the ecoregion, and many are restricted to a single river system and its tributaries (The Nature Conservancy, 2001).

Before human modification, the Mississippi Alluvial and Southeast USA Coastal Plains were largely comprised of forests, oxbow ("U"-shaped) lakes, and bayous. Many of the lakes, bayous, and wetlands were intermittent, dependent upon the floodwaters of the Mississippi River (Houston Advanced Research Center, n.d.). The landscape in the Mississippi Alluvial Valley has changed dramatically during the last 200 years, with the most rapid change occurring within the last 75 years with the construction of more than 30 major reservoirs for flood control, power generation, municipal water supply, and navigation (Winrock International, 2009).

***Estuarine and Coastal Water.*** The Southeastern Coastal Plains section of the ecoregion contains a wealth of resources, including barrier islands such as North Carolina's Outer Banks; busy shipping ports in Miami and Jacksonville, FL, Savannah, GA, and Charleston, SC; quiet coastal wetlands that provide a habitat for migratory birds and other animals; and important commercial and recreational fishery resources. Six estuaries in the Southeast have been designated as possessing national significance and are part of EPA's National Estuary Program, as established under Section 320 of the Clean Water Act; these are located in North Carolina (Albemarle-Pamlico Sounds); Florida (Charlotte Harbor, Indian River Lagoon, Sarasota Bay, and Tampa Bay); and Alabama (Mobile Bay) (Environmental Protection Agency, 2011a). North Carolina's Albemarle-Pamlico Estuarine System is one of the largest and most productive aquatic systems in North America. The Albemarle-Pamlico system represents North Carolina's key resource base for commercial fishing, recreational fishing, and tourism (Environmental Protection Agency, 2012c).

***Water Quality.*** Changes in water quality and quantity, caused by hydrologic alterations (impoundments, groundwater withdrawal and ditching) and point and nonpoint pollution, are threatening the aquatic systems in this ecoregion. The Apalachicola, Ocklawaha, Ochlocknee, Hillsborough, and Withlacoochee (Citrus County) Rivers have dams that alter their natural hydrology. The Ocklawaha River was altered by damming to create the Cross-Florida Barge Canal and channelizing of the Kissimmee River (Florida Department of Environmental Protection, 2012). Dams often affect un-impounded downstream reaches by altering hydrologic and thermal regimes, modifying stream channel morphology, increasing erosion and sedimentation and ultimately reducing suitable habitat for native aquatic fauna (South Carolina Department of Natural Resources, 2005).

Urban runoff, air pollution, sedimentation, and the introduction of non-native species have affected habitats in riparian zones (land areas along rivers or streams) and native aquatic fauna (Houston Advanced Research Center, n.d.). Industrial, residential, and agricultural land uses have affected surface water and groundwater quality throughout the ecoregion. Agriculture is the largest land use in this ecoregion, and surface water quality has been affected by sediment generated from agriculture (Florida Department of Environmental Protection, 2012).

The influence from agricultural land use, especially in the Mississippi Alluvial Plains section of this ecoregion, with additional contributions from urban areas, has resulted in streams that often have high turbidities, mixtures of pesticides, and degraded riparian habitat. Biological communities in the streams commonly are stressed (Renken, Arkansas, Louisiana, Mississippi Regional Summary, HA 730-F, 1988). Pesticides were detected in streams draining agricultural or mixed land-use basins and in over 60% of samples collected from these streams exceeded aquatic-life guidelines. Pesticides frequently were detected in samples from urban streams; diazinon and chlorpyrifos were detected in every sample, usually in concentrations above aquatic-life guidelines. Although the pesticide dichlorodiphenyltrichloroethane, otherwise known as DDT, was discontinued in 1972, DDT and its metabolites (chemicals resulting from the breakdown of DDT) were found to be widespread within the Mississippi Alluvial Plains ecoregion (Chapman, et al., 2004). DDT, or its metabolites, was found in all fish tissue samples collected and 67% of the streambed-sediment samples. Detectable levels of a metabolite of DDT were measured in 14% of surface-water samples (Houston Advanced Research Center, n.d.).

Nonalluvial (blackwater) rivers and streams are vulnerable to nutrient loadings and hydrologic disruptions from groundwater and surface water withdrawals, draining of adjacent wetlands, insufficient stream buffers, and other factors. Impacts on these systems from human activities include increased flow variability, reduced dissolved oxygen, and increased silt loads (Chapman, et al., 2004).

The primary impacts on biological diversity in the Southeast USA Coastal Plains section of the ecoregion are intensive silvicultural practices, including conversion of natural forests to managed pine monocultures and the clear-cutting of bottomland hardwood forests for lumber. There are also a large proportion of stream miles with non-native fish species present (Florida Department of Environmental Protection, 2012). Development is a growing threat, especially in coastal areas. Agricultural conversion, fire regime alteration, and the introduction of non-native species are additional threats to the ecoregion's diversity (Chapman, et al., 2004).

Pathogens and mercury are pollutants of concern in many Southeastern Coastal Plains watersheds (Roy, 2012). In 2006, 100% of the Southeast coast shoreline miles were under fish consumption advisories. Most fish advisories were issued, at least in part, due to mercury contamination. In addition, many of the ecoregion's monitored beaches were closed or under advisory for some period during 2006. Elevated bacteria levels in the region's coastal waters were primarily responsible for the beach closures and advisories (Environmental Protection Agency, 2012c).

**Groundwater**

***Sole Source Aquifers.*** There are two sole source aquifers that are entirely or partially within this ecoregion the Biscayne Aquifer in south Florida and Volusia Aquifer in east-central Florida. The Volusia Aquifer is a carbonate aquifer containing numerous springs and sinkholes, which allow relatively rapid transport of water and contaminants and enhances its vulnerability to contamination. The Biscayne Aquifer is the primary source of fresh water for the South Florida metropolitan area. An unconfined aquifer of highly permeable limestone, Biscayne Aquifer is vulnerable to surface contamination. Only the northern part of the sole source aquifer, above Lake Okeechobee, is within the project area. (Environmental Protection Agency, 2013f)

***Principal Aquifers.*** There are three principal aquifers within the Mississippi Alluvial and Southeast USA Coastal Plains ecoregion: the Mississippi River Valley alluvial aquifer, NACP, and the Floridan aquifer. The NACP and Floridan aquifers are described in Section 3.2.3.1, Southeastern USA Plains Groundwater. The eastern part of the Coastal Plain Province in this ecoregion is characterized by a coastal plain of low hills, low ridges, and gentle lowlands. Fine-grained strata of clay, chalk, and mudstone underlie the low-lying areas; coarse sand and gravel underlie low ridges and hills. The western part of the province is a southward-facing plain of low, rolling, slightly hilly terrain that becomes a flat plain to the south. A broad marshy zone is located near the coast (Renken, Arkansas, Louisiana, Mississippi Regional Summary, HA 730-F, 1988).

The highly productive Mississippi River Valley alluvial aquifer is part of a surficial aquifer system found throughout this ecoregion. The Mississippi River Valley alluvial aquifer underlies a 33,000 square mile area and is located mostly within Arkansas, Louisiana, Mississippi, and Missouri, and to a much lesser extent in Illinois, Kentucky, and Tennessee. It is composed of highly permeable layers of Quaternary-age (within the last 2.6 million years) deposits of sand, gravel, silt, and some clay (Reilly, Dennehy, Alley, & Cunningham, 2008).

Groundwater quality in the alluvial aquifer is generally suitable for most uses. Land use practices have affected groundwater quality; pesticides, such as atrazine, simazine, and metolachlor, were detected throughout the aquifer (Renken, Arkansas, Louisiana, Mississippi Regional Summary, HA 730-F, 1988).

**Water Use and Availability**

Groundwater use in the Mississippi River Valley alluvium, the coastal lowlands, and surficial aquifer systems has been fundamental to the region's agriculture, industry, and some municipalities. Groundwater use in 2000 for the principal aquifers in the Mississippi Alluvial and Southeastern USA Plains ecoregion is listed in Table 3.3-3.

**Table 3.3-3: Water Use Estimates for Principal Aquifers within Mississippi Alluvial and Coastal Plains Ecoregion in 2000**

| Regional Principal Aquifer | Total Water Use | Public Supply | Irrigation | Self-Supplied Industrial |
|---|---|---|---|---|
| | Million gallons per day | | | |
| **Mississippi River Valley Alluvial** | 9,290 | 70 | 9,150 | 70 |

*Source:* (Reilly, Dennehy, Alley, & Cunningham, 2008)

The total withdrawals for the Mississippi River Valley Alluvial aquifer rank third in the Nation for groundwater use and account for approximately 12% of the nation's water use (Reilly, Dennehy, Alley, & Cunningham, 2008).

Withdrawals of large quantities of water from Coastal Plain aquifer systems during the last 90 years have lowered water levels, decreased the saturated thickness of several aquifers, caused encroachment of salt water, and even altered patterns of regional groundwater flow. Before development of the Coastal Plain aquifers, recharge entered the regional flow system in the upland, interstream areas between major rivers. Groundwater was discharged in the valleys of the major rivers or along the coast. Recent regional investigations have shown that large, long-term withdrawals have caused an increase in the rate of recharge in some upland areas and that most of the major rivers no longer represent sites of regional groundwater discharge. Because of extensive irrigation and the lowering of groundwater levels due to pumpage near the rivers, most of the major river valleys have become recharge areas that provide water to the underlying Coastal Plain aquifers (Renken, Arkansas, Louisiana, Mississippi Regional Summary, HA 730-F, 1988).

# 3.4 Geology and Soils

## 3.4.1 Definition of the Resource

Geological resources are described as the geology, soils, and other geophysical features that characterize an area. This section contains a brief overview of what constitutes geology, soils, and geologic hazards, such as land subsidence and erosion. This section addresses geological and soil factors relevant to agricultural practices. In its traditional meaning, soil is the natural medium for the growth of land plants, whether or not it has discernible soil horizons. A soil horizon is a layer of soil, approximately parallel to the soil surface with distinct characteristics produced by soil-forming processes. Soil, comprised of mineral matter, organic matter, water, and air, covers the earth's surface as a continuum, except on bare rock, or in areas of perpetual frost or deep water. The upper limit of soil is the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose. For purposes of classification, the lower boundary of soil is arbitrarily set at 200 centimeters (cm) (U.S. Department of Agriculture -- Natural Resources Conservation Service, 1999; University of Idaho, n.d.; Brady, 1974).

The following sections describe soil formation and the classification system on the highest level (i.e., Soil Order). Based on factors such fertility, depth of root zones and climate, there are designations of prime and unique farmland that are agriculturally well suited for crop production and forest land.

### 3.4.1.1 Soil Formation and Classification

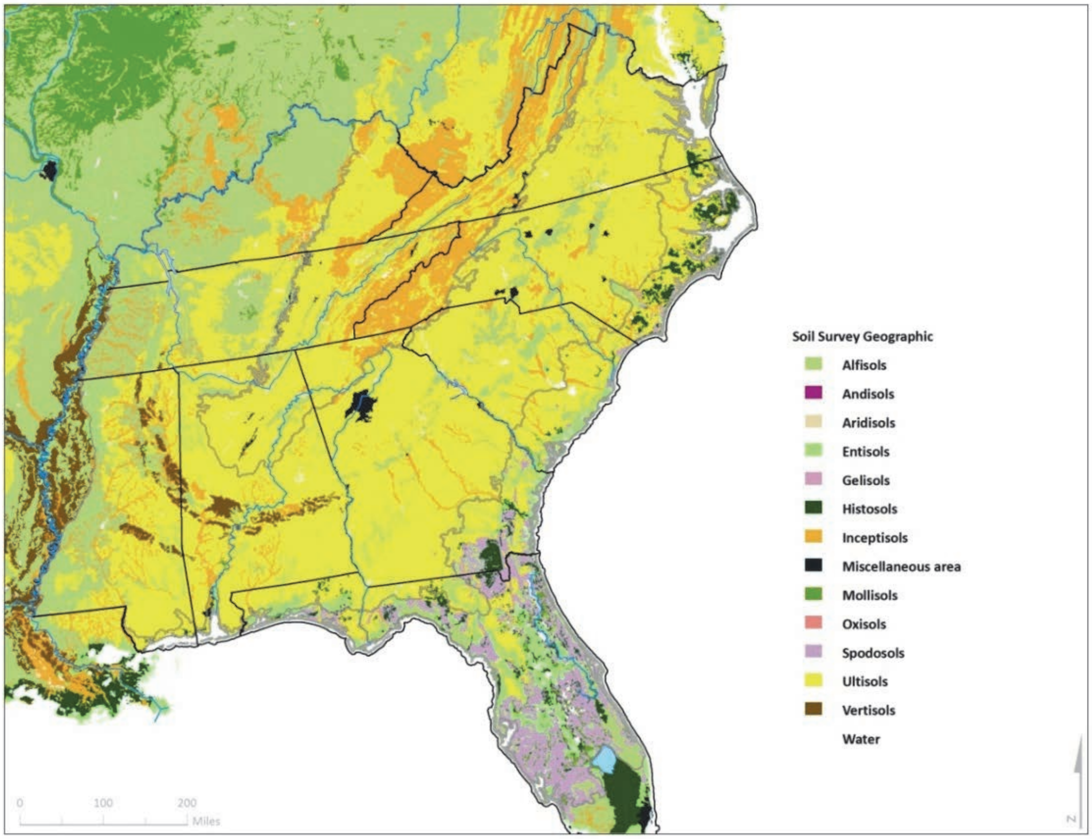
Soils are classified through a methodology referred to as soil survey. Groupings are largely based on component materials or diagnostic horizons (layers), which are a function of parent material, climate, and presence of organisms.

There are 10 primary soil orders in the United States and eight are found in the project area. The soil orders are discussed in the subsections that follow (Brady, 1974). A generalized map of each soil order's coverage throughout the project area is included in Figure 3.4-1.

***Alfisols*** are soils that develop from weathering processes that remove clays and other minerals out of the surface layer and are extensive in the United States. The surface layer of soil, usually light gray or brown, predominantly contains aluminum and iron. Alfisols typically form in humid environments under forested lands; they are highly productive for agricultural use. They have high fertility in which clays often accumulate below the surface. Alfisols do not develop on steep slopes, alluvial floodplains, or poorly drained depressions (University of Wisconsin, n.d.).

***Entisols*** describe soils that have formed recently. The central concept is that the soils have little or no evidence of development of soil forming horizons. Many Entisols are sandy and shallow and typically develop from sediments from unconsolidated parent materials. The soils are typically found in locations such as river bottoms and steep rocky settings. Entisols provide cropland and habitat in many locations worldwide and are prominent in many floodplains (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

**Figure 3.4-1: Soil Orders in the Project Area**




*Source:* (ESRI, 2010)

***Histosols*** are highly organic, contain 20-30% organic materials (i.e., carbon) by volume, and are most common in Florida and along coastal areas where poor drainage creates conditions of slow decomposition and peat accumulates. Histosols typically form in wetland environments from dead plant materials. These soils are referred to as peats, bogs, or mucks. While Histosols are not productive for agriculture, they are productive for the mining of fuels (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

***Inceptisols*** are noted for displaying a lack of horizon (i.e., layer) development. They are widely distributed across a range of ecological and geographic settings, including steep slopes and recently exposed parent materials. These soils occur in cool to warm humid and subhumid regions and have altered horizons where basic compounds or iron and aluminum have leached from the soil, yet retain some weatherable minerals that are important for plant growth and health. The largest area is one that includes the Appalachian Mountains in the project area (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

***Mollisols*** are soft soils that are typically found in grassland ecosystems and are extensive in the Great Plains of the Midwest, but also found in Florida and rare spots in Tennessee, Alabama, and Kentucky. They are noted for having a dark surface horizon that is highly organic. The high organic content of Mollisols provides the added benefit of limiting groundwater contamination by herbicide applications.

Mollisols are notably productive for agricultural purposes because of a fertile, organic-rich surface layer. Most of these soils have supported grass vegetation at some time, although many apparently have been forested at one time or are currently forested. Mollisols are used mainly as cropland. Generally, grains and sorghum are grown in the drier regions and maize (corn) and soybeans in the warmer, humid regions (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

***Spodosols*** form from weathering processes that strip aluminum and organic matter from the surface layer and deposit them in the lower horizon resulting in aluminum and iron oxides layers. These soils are amorphous mixtures of organic matter and aluminum, with or without iron, which have accumulated within the soil profile. In undisturbed soils there is normally an overlying horizon, generally gray to light gray in color, which has the color of uncoated quartz. The particle size class is mostly sandy, course-loamy, loamy-skeletal or course silty. Spodosols do not support agricultural uses. They are common in coniferous forests in cool, moist climates. There are most extensive in areas of cool, humid or per humid climates in the Northeastern states and other parts of the United States. They are naturally infertile soils that can be highly responsive to good management. Spodosols are noted for their bright red horizon immediately underlying the white colored leached horizon (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

***Ultisols*** form from weathering and leeching processes that result in a clay-enriched subsoil dominated by minerals such as quartz, kaolinite, and iron oxides, yet is calcium deficient. Due to the removal of organic materials from surface layers, Ultisols have minimal agricultural fertility; they generally contain a reddish subsurface clay layer. They are found in humid temperate and tropical areas of the world. Because of the climates in which they are found, Ultisols typically support productive forests (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

***Vertisols*** are clay soils that shrink and swell with changes in moisture. During dry periods, Vertisols shrink and large cracks form. They shrink when dry and swell when they become wetter and the soils expand. The changing nature of these soils prevents the formation of distinct horizons (University of Wisconsin, n.d.) (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(a)).

### 3.4.1.2 Prime and Unique Farmland

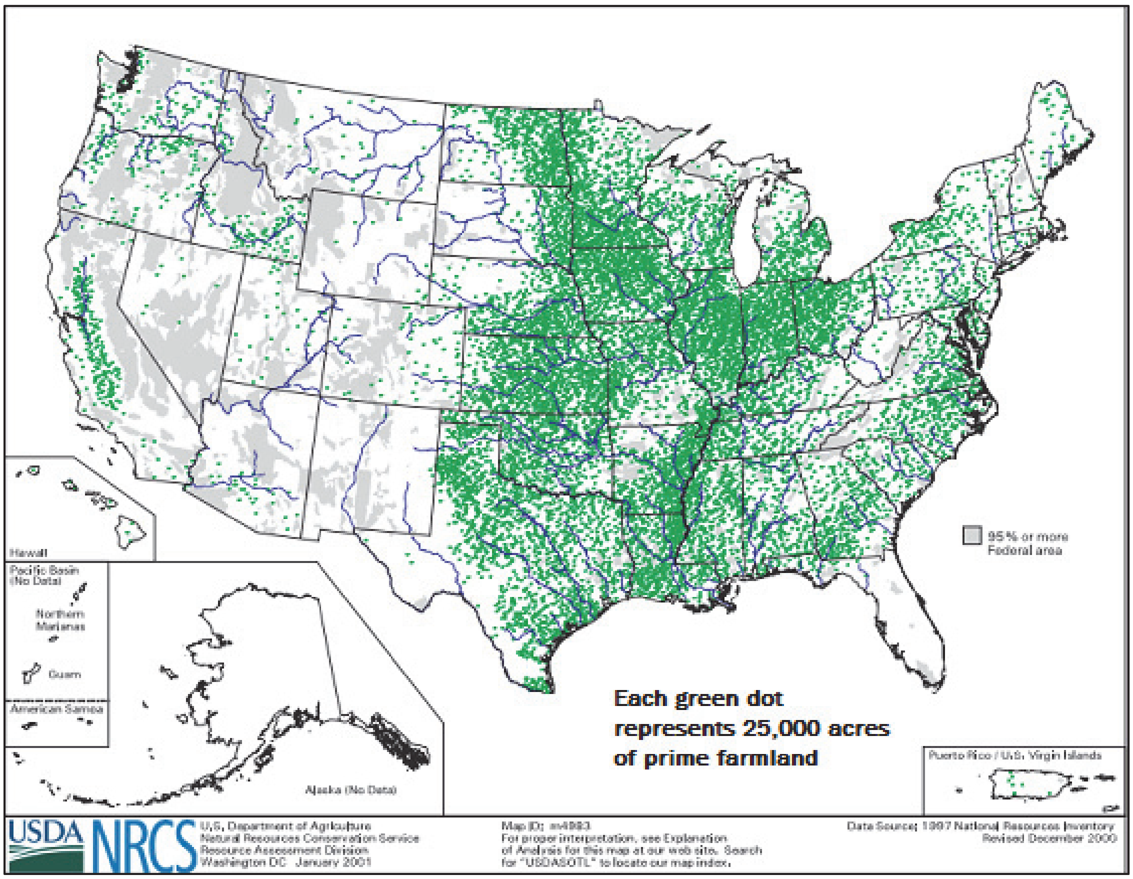
Prime farmland includes land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed[14] crops and that is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. In general, prime farmland has an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, an acceptable level of acidity or alkalinity, an acceptable content of salt or sodium, and few or no rocks. Its soils are permeable to water and air. Prime farmland is not excessively eroded or saturated with water for long periods, and it either does not flood

[14] Oilseed Crops are grown primarily for the oil contained in the seeds. The oil content of small grains (e.g., wheat) is only 1-2%; that of oilseeds ranges from about 20% for soybeans to over 40% for sunflowers and rapeseed (canola). (The Canadian Encyclopedia, 2014)

frequently during the growing season or is protected from flooding (U.S. Department of Agriculture -- Natural Resources Conservation Service, n.d.(b)). Prime farmland is most prominent in the Coastal Plain, Great Plains, and Interior Lowlands physiographic provinces.

Data collection on the reduction of prime farmland since 1982 indicates that acreage in all regions of the United States has decreased since 1982. There is concern that agricultural land is being removed from the cropland use and converted to other uses (U.S. Department of Agriculture -- Natural Resources Conservation Service, 2000b). According to the *Farmland Protection Policy Act, Annual Report for 2012*, Alabama is one of the top 10 states in the United States requesting conversion of prime farmland to other uses (U.S. Department of Agriculture -- Natural Resources Conservation Service, 2013). Figure 3.4-2Figure 3.4-2 shows the prime farmland distribution as determined in 1997.

**Figure 3.4-2: Prime Farmland Distribution (as of 1997)**




*Source:* (U.S. Department of Agriculture -- Natural Resources Conservation Service, 2000a)

### 3.4.1.3 Forest Land Soils

Soil erosion in an undisturbed forest is low, generally under 0.5 tons per acre per year (tons/acre/year). Disturbances, including from timber harvesting, however, can dramatically increase soil erosion to levels exceeding 50 tons/acre/year. Absent the incorporation of Best Management Practices (BMPs), the decrease in the number of trees would result in a decrease in evapotranspiration, which contributes to increased subsurface flow, stream flow, and channel erosion. Field research has found that timber harvesting tends to compact the soil. Compaction increases soil erosion and adversely impacts forest productivity. Accelerated erosion caused by timber harvesting may result in deterioration of soil physical properties, nutrient loss, and degraded stream water quality from sediment, herbicides, and plant nutrients. Forestry agencies in the southern states have continued to develop BMP implementation monitoring methods to improve consistency and usage throughout the region. Usage of BMPs can dramatically reduce impacts from forest management activities, including erosion and delivery of pollutants to streams. (Ice, Schilling, & Vowell, 2010)

For this project area, former and current forest land exists with major lumber industrial operations in existence. Forest land is discussed under Land Use (Section 3.1.6) (Elliot, Page-Dumroese, & Robichaud, n.d.).

### 3.4.1.4 Erosion

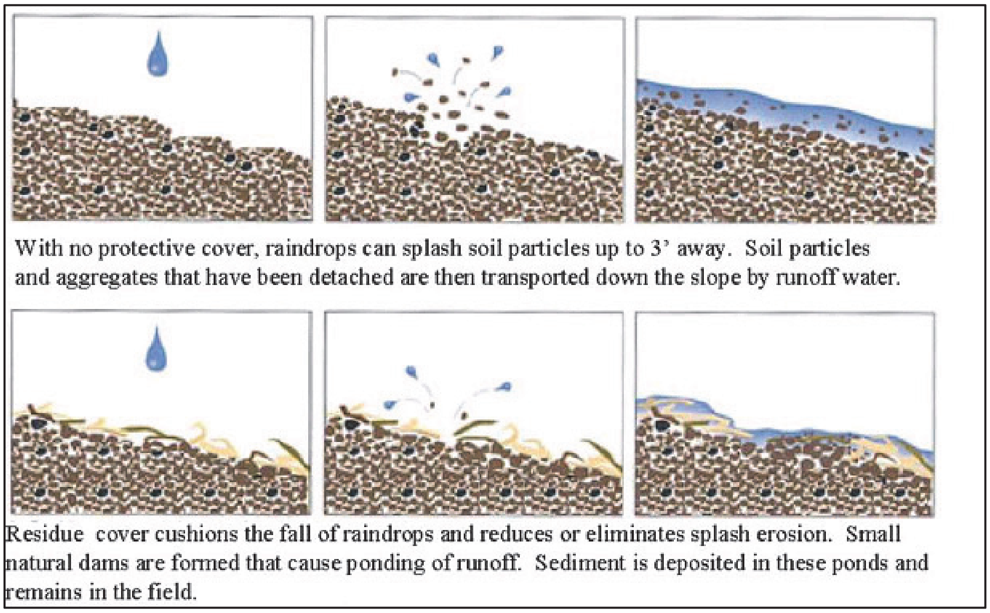
Erosion can be either detrimental or beneficial to agricultural practices. Soils can be formed by erosion of material from higher elevations to lower elevations, thus creating deeper and potentially more fertile matrix for plant growth and sustainability. Erosion can also remove soil from otherwise fertile or marginal land thereby reducing the volume and acreage of soil and land available for crop systems.

Erosion is the act in which earth is removed from a particular location by water, wind, or ice. The process of erosion moves bits of rock or soil from one place to another. While erosion can wear down mountains and fill in valleys over thousands or millions of years, erosion takes place on a daily basis at the granular level. The forces of water, wind, or ice (usually in the form of a glacier) carry rocks and soil from the locations where they were weathered. When wind or water slows down sufficiently, or when a glacier melts, any sediment carried by those forces will be deposited (National Geographic, n.d.).

Moving water, in various forms, is a major erosive force. Rain carries away bits of soil and slowly washes away rock fragments. Rushing streams and rivers wear away their banks, creating larger and larger valleys (National Geographic, n.d.). Likewise, waves constitute a major force in shaping coastal environments by repeatedly crashing into shorelines and breaking sediment grains into successively smaller pieces. In many cases, wave action and offshore currents may cause shoreline migration (U.S. Geological Survey, 2007). Cropland soils are prone to degradation from repeated disturbances and exposure of the soil surface due to tillage and soil management practices (Veseth, 1986).

The most effective way to control erosion is to maintain a permanent cover on the soil surface. Plant residue management constitutes one way of controlling soil erosion on agricultural lands; biomass residues intercept raindrops, thereby reducing surface runoff and protecting surface particle detachment by raindrop impact (Figure 3.4-3). Plant residue also improves soil water intake by preventing soil surface sealing due to raindrop impact, and consequently, reducing surface runoff (Al-Kaisi, 2000). In addition, plant residue slows surface runoff, allowing improved moisture infiltration. Not only does the aboveground growth provide surface soil protection, but also the root system helps stabilize the soil by infiltrating the profile and holding it in place. Furthermore, plant residues reduce pollution by preventing runoff of nutrients and pesticides into surface water (Penn State College of Agricultural Sciences, 2014).

**Figure 3.4-3: Effects of Ground Cover on Reducing Erosion**




*Source:* (Plant and Soil Sciences eLibrary, 2014)

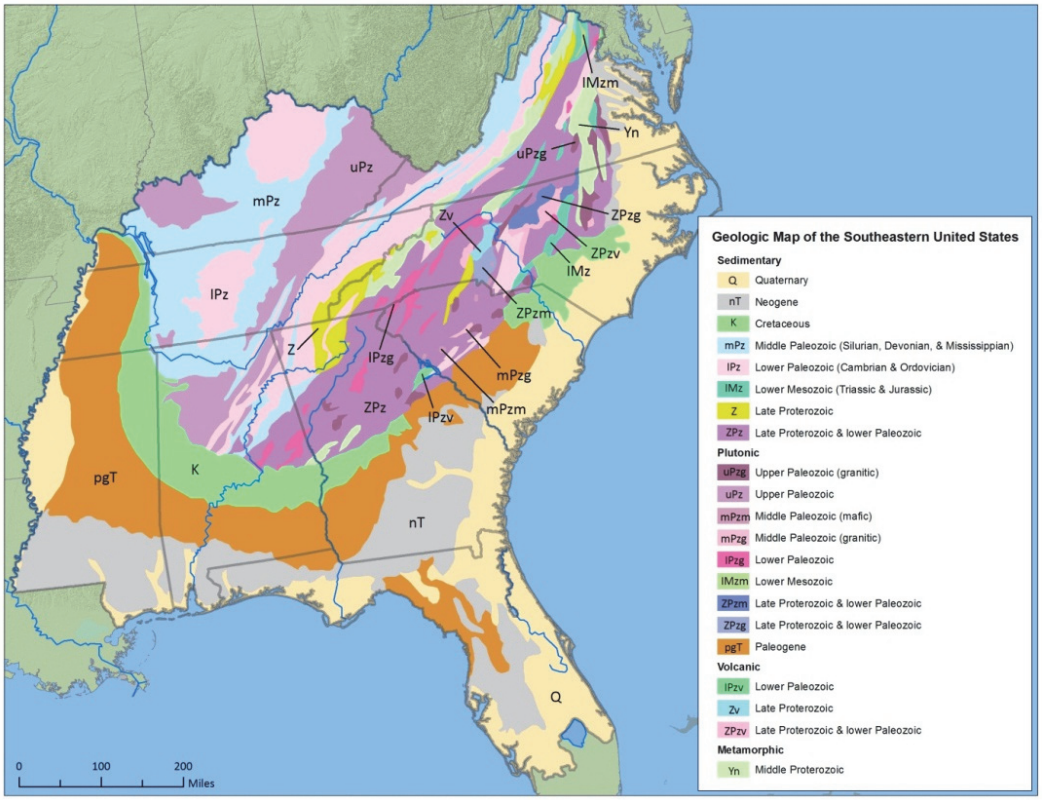
Wind is also a major force of erosion, carrying dust, sand, and volcanic ash from one place to another. Wind erosion occurs when sediment grains blow against rock with sufficient force to cause little pieces of the rock to break (National Geographic, n.d.).

## 3.4.2 Existing Conditions – Physiographic Regions

Geology and soils are inherently site-specific resources, and as such, existing conditions cannot be described in detail on the scale for this project area. Physiographic conditions for site-specific projects would be addressed, as required, in future environmental compliance reviews. However, it is possible to describe the general geologic composition of the project area with a discussion of USGS physiographic divisions.

Figure 3.4-4Figure 3.4-4 shows the generalized geology of the project area. Much of the Southeastern United States is dominated by the Appalachian Mountains. Rocks exposed in today's Appalachian Mountains reveals elongated belts of folded and thrust faulted marine sedimentary rocks, volcanic rocks, and slivers of ancient ocean floor. Strong evidence suggests that these rocks were deformed during plate collision. The birth of the Appalachian ranges, some 480 million years ago, marks the first of several mountain building plate collisions that culminated in the construction of the supercontinent Pangea with the Appalachians near the center. By the end of the Mesozoic Era (66 million years ago), the Appalachian Mountains had been eroded to an almost flat plain. It was not until the region was uplifted during the Cenozoic Era (ongoing era beginning 65 million years ago) that the distinctive topography of the present formed (U.S. Geological Survey, 2004).

**Figure 3.4-4: Generalized Geology of the Project Area**

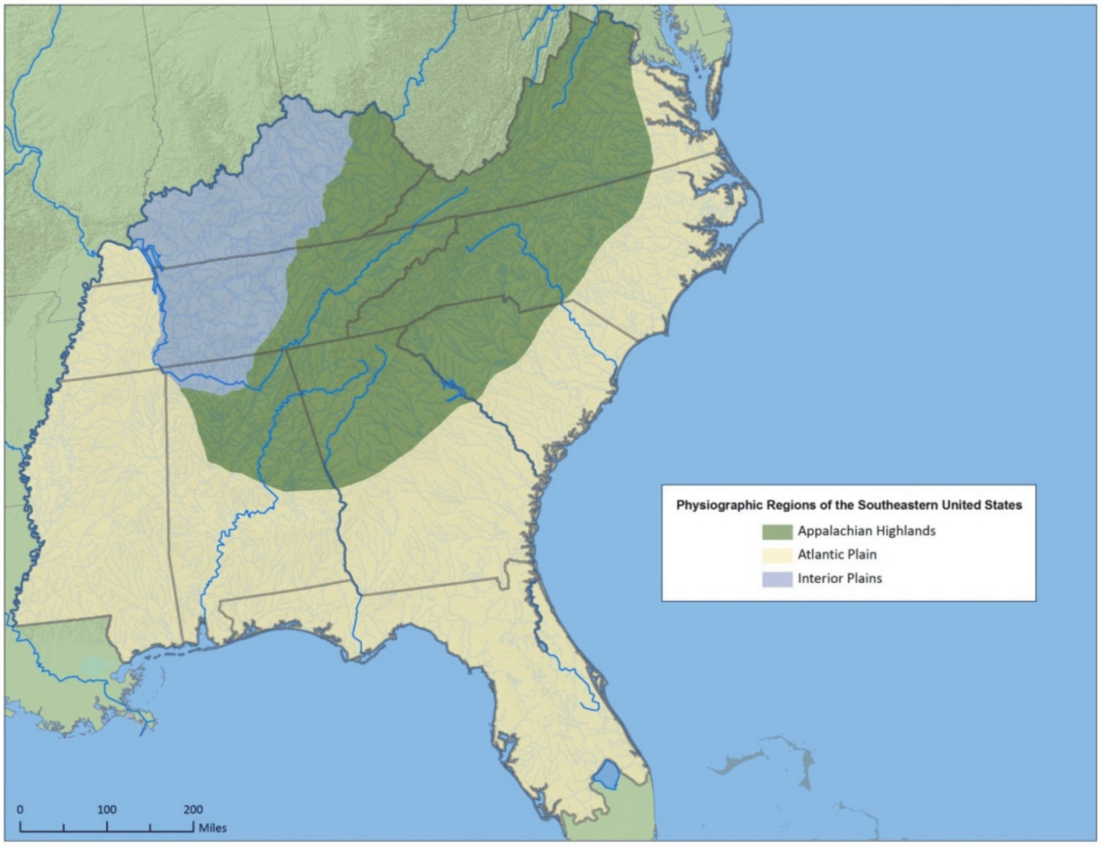



*Source:* (Reed & Bush, 2005)

Physiographic divisions are broad-scale regions established by common geomorphology, rock type, and geologic structure and history. Geologic, topographic, and soil characteristics may impose limitations on potential uses for a particular site. Areas characterized by seismic activity, structural instability, excessive erodibility, steep slopes, or the presence of prime or unique farmlands may completely preclude the implementation of a project at a particular site, require the use of certain engineering technology, or require consultation with state or Federal agencies.

The project area is divided into three distinct physiographic regions: the Atlantic Plain, Appalachian Highlands, and Interior Plains (Fenneman, 1917; U.S. Geological Survey, 2003). Generally, the Atlantic Plain occupies the largest geographical area and acreage of the project area. Physiographic divisions are similar to ecoregions in that they are based on broad common physical similarities, whereas ecoregions also take into account common flora and fauna found in an area. For this section, the characteristics of each physiographic region are reviewed; Figure 3.4-5 depicts the Physiographic Regions in the project area.

**Figure 3.4-5: Physiographic Regions of the Project Area**




*Source:* (U.S. Geological Survey, 2003)

### 3.4.2.1 Atlantic Plain

The Atlantic Plain includes the Continental Shelf and the Gulf and Atlantic Coast plains stretching from New Jersey to Texas. Within the project area, portions of Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and southern Tennessee are within the Atlantic Plain. Food crop production and livestock grazing take up approximately 20% of the region while 60% is covered by forests (Conservation Effects Assessment Project, 2011).

The Atlantic Plain is geologically one of the youngest regions of North America. This region was slowly built up as the Rocky Mountains began to rise 70 million years ago and sediment washed out from the Appalachian Highlands and the Interior Plains. The area is characterized by a gentle topography and a transition zone between land and sea that often has marshes, lagoons, swamps, sand bars, and reefs. Deposits of coastal marine life over millions of years form the basis for rich fossil fuel reserves in the region. The Atlantic Plains contain prime and unique farmlands (U.S. Geological Survey, 2003).

***Soils.*** Many Atlantic Plain soils are formed from marine sediments, laid down when the sea once covered the region. Sediment eroded from the Appalachian Mountains, and peat soils formed by vegetation decaying over thousands years, also cover large areas. Diverse soil types and water resources allow many plant communities to flourish. The Atlantic Plain region may be further subdivided into the areas[15] (U.S. Forest Service, 1994) (Brady, 1974):

- Mid Atlantic Plain – Ultisols and Entisols
- Middle Coastal Zones – Ultisols and Alfisols
- Coast Plains – Ultisols, Inceptisols, Alfisols, Entisols, and Spodosols
- Atlantic Coastal Flatlands – Ultisols, Spodosols, and Histosols
- Florida Coastal Flatlands – Ultisols, Inceptisols, Histosols, Spodosols, and Entisols
- Coastal Plains and Flatwoods and Western Gulf – Ultisols, Alfisols, Entisols, Alfisols
- Florida Coastal Lowlands (Erosion) – Ultisols, Histosols, Inceptisols, Spodosols, Entisols

***Erosion.*** Erosion can be either detrimental or beneficial to agricultural practices. Soils in the Atlantic Plain can be impacted by soil loss in the event of heavy rainfall and flooding if the soil remains bare lacking cover crop after tilling. Crop residues incorporated into the soil followed by reseeding can reduce erosion and soil loss. Erosion can also remove soil from otherwise fertile or marginal land thereby reducing the volume and acreage of soil and land available for crop systems. Benefits of erosion include the redeposition of mineral and organic soil components onto the land.

Erosion also is a major force along coastlines. In Florida, over 485 miles, or approximately 59% of the state's beaches, are experiencing erosion. While some of this erosion is due to natural forces, a large amount of coastal erosion in Florida is directly attributable to the construction and maintenance of navigation inlets.

### 3.4.2.2 Appalachian Highlands

The Appalachian Mountain Range extends 900 miles from New York to Alabama. Within the project area, this includes portions of Virginia, North Carolina, South Carolina, Georgia, Tennessee, and Kentucky. The Appalachian Highlands are composed of layers of intensely folded sedimentary rock created when North America first collided with Europe and Africa more than 500 million years ago during the Paleozoic Era. Once the height of the present-day Rocky Mountains, the sedimentary rock of the Appalachian Highlands has eroded considerably, with most of the peaks now less than 5,000 feet in elevation. The valley areas of the region are characterized by prime and unique farmlands and are rich in mineral resources. Although deposits of copper and iron ore have been largely exhausted, coal deposits remain abundant (U.S. Geological Survey, 2003).

Within the Appalachian Highlands, the Piedmont Province, which includes parts of Georgia, South Carolina, North Carolina, and Virginia, consists of generally rolling ridges with a few hundred feet of elevation difference between the hills and valleys (Medina, Reid, & Carpenter, 2004). The Piedmont's combination of igneous and metamorphic rocks starkly contrasts with the sedimentary formations found in the adjacent Atlantic Plain Province. Piedmont ridges and plateaus are differentiated in their degrees of metamorphosis. Because highly metamorphosed rocks are more resistant to weathering, the Piedmont Province ranges from steeply sloped ridges with highly eroded valleys in the northern sections, to rolling

[15] For more details on soil characteristics, refer to Section 3.4.1.1.

hills and broad plateaus in the southern sections (Georgia Department of Natural Resources, The Nature Conservancy, Jordan, Jones & Goulding, Inc., 2000).

***Soils.*** The Appalachian Highlands regional topography ranges from steep and mountainous to relatively flat and fertile valleys. Agricultural lands, typically in small farms with row crops and livestock, occupy 23% of the total land cover. About 17% of the 4.2 million acres of wetlands in this region occur in agricultural settings (U.S. Department of Agriculture -- Natural Resources Conservation Service, 2011). The dominant soil orders in the Appalachian Highlands are Inceptisols and Ultisols. The basement rock of the region is composed of hard igneous and metamorphic rock that is resistant to weathering and, in addition to the steep slopes and frequent rainfall, soils do not have the opportunity to form or build up over time. There are pockets of fertile soil formed from ancient volcanic activity to support agricultural practices (Kahle, Undated).

***Erosion.*** Erosion of the Appalachian Mountains has been occurring since their formation during a series of mountain building events that took place between 480 and 300 million years ago. The primary processes contributing to the erosion of the Appalachians are dominated by ice; geologists at the College of William and Mary believe that erosion of the Appalachians initiates when water seeps into cracks or pore spaces within rocks. When the water freezes into ice, it expands and further perpetuates the cracks or open spaces within the rock. It is estimated that these processes are eroding the peaks of the Appalachians at a rate of roughly 6 meters per million years. However, because rivers in the region are actually carving valleys faster than the summits are eroding, incising into the Appalachians at a rate from 30 to 100 meters per million years, the topography of the Appalachians is currently getting more, rather than less, dramatic (Geotimes, 2007). A different study conducted in North Carolina estimates a much faster rate of Appalachian hill-slope erosion at between 0.051 and 0.111 meters per year (Hales, Scharer, & Wooten, 2011).

#### 3.4.2.3 Interior Plains

The Interior Plains, which include the Great Plains, were formed as a result of erosion from the Rocky Mountains during the Cenozoic Era (i.e., within the last 65 million years) and are underlain by sedimentary rock. The eastern edge of the Great Plains includes portions of western Tennessee and Kentucky. The region has relatively low topographic relief. Almost the entire Interior Plains region is drained by either the Mississippi or Missouri Rivers (U.S. Geological Survey, 2003).

***Soils.*** The soils of the Interior Plains are extensive as they are part of the Great Plains Region. However, only the western most portions of Kentucky and Tennessee of the project area are within this physiographic region. Alfisols, Ultisols, and Vertisols are the most common followed by Entisols and Inceptisols. In Kentucky, one of the most fertile Alfisols along the Mississippi River alluvial plain is extensive, making up about 500,000 acres in Kentucky and occurring in 35 counties in the state. Most areas are used for crops or pasture. Corn, small grain, soybeans, tobacco, and hay are the main crops. These soils are highly productive. Many acres of these soils are prime farmland.

In Tennessee, one of the most predominant Ultisol soils (Dickson series) consists of deep, moderately well drained soils that formed in a silty mantle two to four feet thick and in the underlying limestone bedrock. These soils occur on more than 400,000 acres. Corn and soybeans are the principal row crops.

Pastures support tall fescue and white clover (U.S. Department of Agriculture -- Natural Resources Conservation Service, 2000b).

***Erosion.*** Erosion in the Interior Plains physiographic province has been, and continues to be, a major issue in agricultural areas of the region. Specifically, portions of western Kentucky have experienced, and attempted to mitigate the impacts from erosion for nearly a century (Pratt, 2013). During the 1930s, the Jackson Purchase[16] area practically washed away during the Dust Bowl Era; the area's silty loess soils are highly conducive to windblown erosion. Researchers at the University of Kentucky, College of Agriculture, developed the KY-31 tall fescue grass to help stabilize soils and reduce erosion. Throughout the 1950s and 1960s, soil tillage would cause soil loss from agricultural lands and deliver soils to roadside ditches and, eventually, the roads themselves. Since that time, Kentucky has been a national leader in developing no tillage technologies; today, about 70% of the state's wheat acreage, 50% of the corn acreage, and 80% of soybean acreage is no-till (UKAgNews, 2012).

## 3.5 Biological Resources

### 3.5.1 Definition of the Resource

This section describes the flora (plants) and fauna (animals) often referred to as biological resources and the habitats that occur in the project area. Biological resources include those that are limited in number or habitat or restricted in movement (e.g., plants and small mammals), and those that are more mobile and can travel greater distances (e.g., birds and terrestrial mammals).

Biological resources are divided into three categories: vegetation, wildlife, and non-native species. Protected species are reviewed on a state-specific basis for wildlife and vegetation. For the purposes of this Final PEIS, protected species include migratory birds and listed or candidate species under Federal and state laws within the project area. In addition, this section provides an overview on non-native species related to agriculture.

### 3.5.2 Existing Conditions

As described earlier, the project area includes three Level II ecoregions (Figure 3.1-1Figure 3.1-1 and Table 3.1-1). Table 3.5-1 provides a general summary of vegetation and wildlife for each of these Level II ecoregions. Additional details about the ecoregions are provided in Table 3.1-1 in Section 3.1, Land Use.

[16] The Jackson Purchase Area of western Kentucky is bounded by the Mississippi River to the west, Ohio River to the north and Tennessee River to the east.

**Table 3.5-1: Descriptions of the Level II Ecoregions Reviewed in this Final PEIS for Vegetation and Wildlife**

| Level II | Vegetation | Wildlife |
|---|---|---|
| **8.3 Southeastern USA Plains** | oak, hickory, loblolly and shortleaf pine | white-tailed deer, gray squirrel, armadillo, wild turkey, northern cardinal, mockingbird |
| **8.4 Ozark/Ouachita-Appalachian Forests** | mixed oaks with hickory, also white pine, birch, beech, maple, hemlock | black bear, white-tailed deer, chipmunk, wild turkey |
| **8.5 Mississippi Alluvial and Southeastern USA Coastal Plains** | bottomland forests (ash, oak, tupelo, bald cypress); southern mixed forests (beech, sweet gum, magnolias, oaks, pine, saw palmetto) | white-tailed deer, opossum, armadillo, American alligator, mockingbird, egret |

*Source*: (Commission for Environmental Cooperation, 2008)

Biological resources are "… organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity." The variability among living organisms and the ecological complexes of which they are a part of is known as biological diversity, and includes diversity within and between species and ecosystems (Convention on Biological Diversity, 2013). The following descriptions provide a general overview of the biological resources present within the project area:

- **Vegetation** refers to the plants of a specific region. This analysis focuses on the wild vegetation (e.g., non-agricultural vegetation) of the project area. Crops, or agricultural vegetation, within the project area are discussed in Section 3.1, Land Use. The natural vegetation of the Southeastern United States is diverse as result of the wide variation in geological conditions. Plant communities vary by region, as each is unique, with its own characteristic species composition, diversity, and structure. This diversity is due to several environmental factors, including climate, elevation, location, precipitation, and soil type. The types of plants vary with the land cover.

- **Wildlife** refers to the animal species that characterize a region. Wildlife includes vertebrates (mammals, amphibians, reptiles, birds, and fish) and invertebrates (inserts, spiders, crustaceans, worms, mollusks, and coral). Native species are often described as endemic, indigenous, or naturalized. This analysis focuses on the non-domesticated wildlife, with limited information on aquatic species, given the nature of the Proposed Action within the project area. Major contributors to declining biodiversity in the project area include urbanization, agricultural expansion, land degradation, deforestation, land and water pollution, invasive species, and climate change. The most widespread threats to biodiversity from agricultural activities are the expansion of crops and grazing into wildlife habitats, overgrazing riparian areas, and agricultural activities that contaminate aquatic habitats. Protected species are reviewed in Section 3.4.3, Protected Habitats and Species.

- **Non-native species** are species that are not native to a specific area (also referred to as non-indigenous species). As defined by EO 13112, an invasive species is "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (White House, 1999). Many invasive species have resulted from human activities introducing non-native species into the United States. EO 13112 protects the U.S. from invasive species, unless benefits clearly outweigh potential harms. In addition, the PPA, which became law in June 2000 as part of the Agricultural Risk Protection Act, consolidated all or part of 10 existing laws, applicable to USDA activities, into one comprehensive law, including the authority to regulate plants, plant products, certain biological control organisms, noxious weeds, and plant pests (Corn, L.M.; Johnson, R., 2013). Non-native species are often introduced from other regions or countries accidentally, intentionally, or through habitat change induced by humans or nature. Often these non-native species have no natural controls in the area where they are released, allowing their populations to increase rapidly. A non-native species becomes invasive when it out-competes native species and replaces native species in natural plant communities. Some species have a particularly high potential for damage because, once introduced, they lack natural enemies and their populations can increase and spread to levels that are difficult and costly to eradicate (Invasive Species Advisory Committee, 2006).

The following sections provide summaries of the vegetation, wildlife, and non-native species for the three ecoregions within the project area.

### 3.5.2.1 Southeastern USA Plains

***Vegetation.*** The Southeastern Plains is an interior coastal plain that stretches from Virginia in the north, west to Kentucky and Mississippi, south to the Florida panhandle, and east almost to the Atlantic Coast. Although mostly tree-covered, these irregular plains have a mosaic of cropland, pasture, woodland, and forest land cover. The predominant vegetation type in the Southeastern Plains is found from Virginia south to Alabama and consists of longleaf pine, with smaller areas of oak-hickory-pine forest stands. In the southern part of the ecoregion, the vegetation also includes some southern mixed forest with beech, sweetgum, southern magnolia, laurel, live oaks, and various pines. Floodplains include bottomland oaks, red maple, green ash, sweetgum, and American elm, as well as areas of bald cypress, pond cypress, and water tupelo (Wiken, Nava, & Griffith, 2011).

Of the total cropland of the Southeastern Plains (Table 3.2-1), large proportions are actively used to cultivate commodity crops such as corn, sorghum, and soybeans. Additional major crops include cotton, peanuts, and tobacco in Virginia and North Carolina. A large proportion of cropland in Florida is devoted to sugarcane and citrus fruit. More than half of Georgia's vegetable, fruit, and nut production acreage is devoted to pecan orchards; Georgia is the largest pecan-producing state in the United States (University of Georgia, 2014). In addition to pecans, Georgia is one of the top four states in peach production with almost 20,000 tons produced in 2013 (U.S. Department of Agriculture -- National Agricultural Statistics Service, 2014).

The vegetation in central Kentucky and Tennessee, as well as in northern Alabama, is further categorized as an interior plateau. The natural vegetation of this ecosystem is primarily an oak-hickory forest, with some areas of bluestem prairie, cedar glades, and mixed mesophytic forest. White oak, northern red oak, black oak, hickories, yellow poplar, red maple, and eastern red cedar are typically found in the area (Wiken, Nava, & Griffith, 2011).

The transitional area between the mountains to the coastal plain is known as the Piedmont region and runs southward from Virginia to Alabama. The Piedmont ecosystem is comprised of historic oak-hickory-pine forest that is dominated by white oak, southern red oak, post oak, and hickory, with some shortleaf pine and loblolly pine (Wiken, Nava, & Griffith, 2011). The area has extensive forestry and agriculture (e.g., tobacco, hogs, and cotton) interspersed with urban areas (Commission for Environmental Cooperation, 2008). Loblolly pine is one of the leading commercial timber species in the Southeastern United States (Baker & Langdon, 1990).

***Wildlife.*** The Southeastern Plains ecoregion provides habitat for a wide variety of animals. The whitetail deer is the only large indigenous mammal, with the exception of a few isolated areas where black bear or the endangered Florida panther are found in small numbers. Common small mammals include raccoons, opossums, flying squirrels, cottontail rabbits, and numerous species of ground-dwelling rodents. Forest snakes include cottonmouth moccasin, copperhead, rough green snake, rat snake, and coachwhip (Bailey, 231 Southern Mixed Forest Province, 1995a).

Widespread bird species in this ecoregion include the eastern wild turkey, bobwhite, and mourning dove. Other common birds include the pine warbler, cardinal, summer tanager, Carolina wren, ruby-throated hummingbird, blue jay, hooded warbler, eastern towhee, and the tufted titmouse (Bailey, 231 Southern Mixed Forest Province, 1995a).

Past conversion of forest and woodland habitats to agricultural uses has resulted in the loss of much of the natural upland vegetation in this area. In particular, the more mesic subtypes of longleaf pine-dominated forest/savanna, a predominant vegetation type in pre-settlement times, have been greatly reduced in the landscape (U.S. Forest Service, 2012b).

***Non-native Species.*** The increased demand for bioenergy has led to considerable interest in a number of non-native and potentially invasive species that are currently being cultivated for use as bioenergy crops. In fact, some of the characteristics that make a plant particularly useful as a source of biomass (e.g., rapid growth, competiveness, tolerance of a range of climate conditions) are the same characteristics that make a plant a potentially invasive species. Several grass species that are under consideration for use as bioenergy crops, including giant reed, reed canarygrass and miscanthus, are already considered invasive in some areas of the United States (Raghu, 2006).

Throughout the last century large numbers of damaging plants have been introduced into and established in the Southeastern United States. Table 3.5-2 provides a partial list of non-native (invasive) weed species present in the Southeastern United States (with some widespread throughout the United States). While many of these species are relatively benign or serve as pests primarily to crops, lawns, or orchards, a number are capable of invading natural communities and impacting plants and wildlife. Some of these species were deliberately introduced as crop or horticultural plants, livestock, or pets and later escaped from cultivation or domestication (South Carolina Department of Natural Resources, 2005). Some species were introduced to control erosion or provide food for wildlife, whereas others were accidentally introduced by importation of food and other materials (Reichard & White, 2001) (Sun & Norman, 2011). As described in Chapter 1, the focus of the EHEC Programs is on the development of biofuels.

Notable examples of non-native plant species within the Southeastern USA Plains ecoregion include hydrilla, Japanese climbing fern, and cogon grass. Many river floodplains and valleys in the ecoregion are overrun with Chinaberry trees, Japanese honeysuckle, Japanese stiltgrass, and common reed. kudzu, autumn olive (South Carolina Department of Natural Resources, 2005), fairy grass, Oriental Bittersweet, Princess Tree, Tree-of-Heaven, wisteria, and multiflora rose are major components of the understory in many upland forest stands (The Nature Conservancy, 2006).

Feral hogs are a non-native species to this ecoregion causing damage to understory vegetation in mesic upland hardwood forests, where they feed on roots, tubers, fruits, and herbs. Feral hogs are also capable of impacting a wide variety of plant species associated with wet pine savannas and herb bogs (Georgia Department of Natural Resources, 2005).

Insect and animal species causing damage to trees in this ecoregion include the fire ant, gypsy moth, nutria, Hemlock woolly adelgid, and Emerald ashborer (The Nature Conservancy, 2006). Disease outbreaks related to exotic pests have emerged such as dogwood anthracnose and beech bark disease, and native pests such as the southern pine beetle have devastated both natural and planted stands of pine as well (The Nature Conservancy, 2006).

Conversely, some native species have the potential to become invasive if introduced outside their native range. A bio-geographical context must therefore be included when assessing whether a non-native species should be considered an invasive species (National Invasive Species Council, 2008).

Many beneficially introduced species have had long-term economic and environmental costs owing to their invasiveness (Raghu, 2006). Kudzu, Johnsongrass, multiflora rose, and Japanese honeysuckle are examples of non-native, invasive species that were at one time promoted and distributed by the U.S. government for such uses as erosion control, livestock living fences, forage, wildlife habitat, and highway medians. These species were later recognized as invasive and causing harm, invading and impacting natural systems across the U.S.; and have since caused unforeseen ecological damage; incurring long-term economic and environmental costs that are ongoing still (Swearingen, 2010).

#### 3.5.2.2 Ozark/Ouachita-Appalachian Forests

***Vegetation.*** The Ozark/Ouachita-Appalachian Forests ecoregion covers the entire Appalachian Mountain chain, including the mountains of Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. The ridges and valleys of the Appalachian Mountain chain are sandwiched between higher, more rugged mountains, and can be found in Virginia, Tennessee, Georgia, and Alabama. It is one of the most diverse ecoregions, and includes Appalachian oak forests, northern hardwoods, and, at the highest elevations in Tennessee and North Carolina, Southeastern spruce-fir forests. The vegetation in the ridges and valleys consists of Appalachian oak forest in the north and oak-hickory-pine forest stands to the south (Wiken, Nava, & Griffith, North American Terrestrial Ecoregions—Level III, 2011). Typical perennial grass species may include species such as tall fescue, hybrid bermudagrass, timothy, rescuegrass and bluegrass; and annual herbaceous species such as ryes, oats, wheats, barleys, orchardgrass, and triticale. Some of these may be farmer-seeded, while others may be self-seeding. (University of Georgia Cooperative Extension, 2012) (U.S. Department of Agriculture, 1971).

**Table 3.5-2: Partial List of Major Economically and Ecologically Important Non-native (Invasive) Weed Species present in the Southeastern United States**

| Habitat | Scientific name | Common name | Plant Type | Distribution |
|---|---|---|---|---|
| Riparian | *Ailanthus altissima* | tree-of-heaven | Tree | Widespread throughout U.S. |
| | *Albizia julibrissin* | mimosa | Shrub/Small Tree | Expanding range in Southeastern U.S. |
| | *Casuarina equisetifolia* | Australian pine | Tree | Expanding range in FL |
| | *Elaeagnus angustifolia* | Russian olive | Shrub/Small Tree | Sporadic infestations in most of U.S |
| | *Phragmites communis* | common reed | Grass | Widespread in eastern U.S. |
| | *Sapiem sebiferum* | Chinese tallow | Tree | Carolinas to FL |
| Aquatic or Wetlands | *Alternanthera philoxeroides* | alligatorweed | Forb | Widespread in Southeastern U.S. |
| | *Egeria densa* | Brazilian elodea | Forb | Southeastern U.S |
| | *Eichhornia crassipes* | water hyacinth | Forb | Widespread in Southeastern U.S. |
| | *Hydrilla verticillata* | hydrilla | Forb | Widespread in southeast & mid-Atlantic coast to CT |
| | *Melaleuca quinquenervia* | melaleuca | Tree | Widespread in FL |
| | *Myriophyllum aquaticum* | parrotfeather | Forb | Widespread throughout U.S |
| | *Myriophyllum spicatum* | Eurasian watermilfoil | Forb | Widespread throughout U.S. |
| | *Salvinia molesta* | giant salvinia | Forb | New infestations in Southeastern U.S. |
| Rangeland and Wildland | *Acacia auriculiformis* | earleaf acacia | Shrub/Small Tree | Expanding range in Southeastern U.S. |
| | *Acroptilon repens* | Russian knapweed | Forb | Widespread throughout U.S. |
| | *Bromus tectorum* | downy brome | Grass | Widespread throughout U.S. |
| | *Carduus nutans* | musk thistle | Forb | Widespread throughout U.S. |
| | *Centaurea maculosa* | spotted knapweed | Forb | Widespread throughout U.S. |
| | *Cirsium arvense* | Canada thistle | Forb | Widespread throughout U.S. |
| | *Cirsium vulgare* | bull thistle | Forb | Widespread throughout U.S. |
| | *Conium maculatum* | poison hemlock | Forb | Widespread throughout U.S. |
| | *Convolvulus arvensis* | field bindweed | Vine | Widespread throughout U.S. |
| | *Imperata cylindrica* | cogon grass | Grass | Expanding range in Southeastern U.S. |
| | *Lantana camara* | lantana | Shrub | Expanding range in FL |
| | *Leucanthemum vulgare* | oxeye daisy | Forb | Widespread throughout U.S. |
| | *Melia azedarach* | Chinaberry tree | Shrub/Small Tree | Spreading in Southeastern U.S. |
| | *Pueraria lobata* | kudzu | Vine | Widespread in southeast |
| | *Solanum viarum* | tropical soda apple | Shrub | Spreading in Southeastern U.S |
| Cropland | *Abutilon theophrasti* | velvetleaf | Forb | Widespread throughout U.S |
| | *Amaranthus retroflexus* | redroot pigweed | Forb | Widespread throughout U.S. |
| | *Aegilops cylindrica* | jointed goatgrass | Grass | Widespread throughout U.S |
| | *Chenopodium album* | common lambsquarters | Forb | Widespread throughout U.S |
| | *Cirsium arvense* | Canada thistle | Forb | Widespread throughout U.S |
| | *Convolvulus arvensis* | field bindweed | Vine | Widespread throughout U.S |
| | *Cyperus esculentus* | yellow nutsedge | Grass | Widespread throughout U.S |
| | *Cyperus rotundus* | purple nutsedge | Grass | Widespread throughout U.S |
| | *Echinochloa crus-galli* | barnyardgrass | Grass | Widespread throughout U.S |
| | *Elytrigia repens* | quackgrass | Grass | Widespread throughout U.S |
| | *Setaria spp.* | foxtails | Grass | Widespread throughout U.S. |
| | *Sorghum halapense* | Johnsongrass | Grass | Widespread throughout U.S |
| | *Striga asiatica* | witchweed | Forb | Eradicated / close to eradication in NC & SC |

*Source:* (Mullin, 2000)

The Blue Ridge section of the Appalachian Mountains runs from Virginia into northern Georgia and forms one of the richest temperate broadleaf forests in the world with a high diversity of flora. It is mostly comprised of Appalachian oak forest, but a variety of oak, hemlock, cove hardwoods, and pine communities occur within this forest type. The Southern Blue Ridge section of this ecoregion contains

400 rare plant species and over 250 endemic plant species (The Nature Conservancy and Southern Appalachian Forest Coalition, 2000). Much of the forestland was once dominated by the American chestnut, an ecologically and economically important tree; however, the chestnut blight, introduced into the United States around 1904, killed almost all of the chestnut trees by the 1930s. In place of the chestnut, other trees, such as the tulip poplar, chestnut oak, white oak, black locust, red maple, and pine species, have become important canopy dominant species. At higher elevations, northern hardwoods of beech, yellow birch, yellow buckeye, and maples are typically found. At the highest elevations, Southeastern spruce-fir forests of Fraser fir, red spruce, yellow birch, and rhododendron are found (Wiken, Nava, & Griffith, North American Terrestrial Ecoregions—Level III, 2011).

The central Appalachians, which extend from Virginia and Kentucky into northern Tennessee, is an especially rugged section of the mountain chain; it is higher, cooler, steeper, and more densely forested than other parts of the Appalachian Mountains. The vegetation is mostly mixed mesophytic forest, which was once dominated by the American chestnut. The mesophytic forest of this area now contains chestnut oak, red maple, white oak, black oak, beech, yellow-poplar, sugar maple, ash, basswood, buckeye, and hemlock (Wiken, Nava, & Griffith, North American Terrestrial Ecoregions—Level III, 2011).

The southwestern Appalachians occur in Kentucky, Tennessee, Georgia, and Alabama. The vegetation of this area is an upland forest, which is dominated by mixed oaks with shortleaf pine, as well as white oak, southern red oak, and some hickories. Mixed mesophytic forests with maple, buckeye, beech, ash, basswood, sweetgum, and oaks are restricted mostly to the deeper ravines and escarpment slopes (Wiken, Nava, & Griffith, North American Terrestrial Ecoregions—Level III, 2011).

***Wildlife.*** The Ozark/Ouachita-Appalachian Forests ecoregion is rich in biodiversity. Black bear, whitetail deer, wild boar, turkey, grouse, songbirds, many species of amphibians and reptiles, thousands of species of invertebrates, and a variety of small mammals are found within this ecoregion. The Southern Blue Ridge section of this ecoregion has more than 60 species of mammals occurring in a relatively small area of the southern Appalachian Mountains. This region also has a high diversity of amphibians and reptiles. This area is the center of the world's salamander diversity; 27 species of salamanders inhabit the Southern Appalachian ecoregion (Bailey, M221 Central Appalachian Broadleaf Forest--Coniferous Forest--Meadow Province, 1995b).

Many of the resident bird species depend on the Ozark/Ouachita-Appalachian Forests ecoregion's mature forests, such as the Acadian flycatcher, wood thrush, Bachman's sparrow, brown-headed nuthatch, and yellow-throated warbler. The conversion of hardwood and mixed pine/hardwood forest to loblolly pine plantations, residential or commercial developments, or agricultural uses is the main risk factors for birds within this ecoregion. One of the factors impacting habitats and species wildlife diversity in the Ozark/Ouachita-Appalachian Forests ecoregion is an increase in residential and commercial development along major highways and on the outskirts of metropolitan areas. This has resulted in loss of both agricultural and forest land, and in habitat fragmentation as new roads and utility corridors have been constructed (Georgia Department of Natural Resources, 2005).

***Non-native Species.*** Exotic plant species of concern include Nepalese browntop, Japanese honeysuckle, oriental bittersweet, royal paulownia, kudzu, and autumn olive. Table 3.5-2 provides a partial list of other invasive weed species expanding into or found to be widespread in the Southeastern United States (and expanding geographic regions). See Section 3.5.2.1, Non-native Species, for historic concerns about invasive weed species and legislation and regulations in the United States.

A particularly important exotic forest pest is the hemlock wooly adelgid, which has invaded the Blue Ridge of Georgia, sweeping from east to west and causing losses of eastern hemlock. The hemlock wooly adelgid also poses a direct threat to the few populations of Carolina hemlock. In addition to impacts on forest communities, this pest threatens adjacent stream communities by causing loss of streamside vegetation (Georgia Department of Natural Resources, 2005).

The red shiner is an introduced fish suspected of having a serious impact on several native fish in the Coosa River system through competition and hybridization. Other exotic aquatic species of concern include the Asiatic clam and the zebra mussel (The Nature Conservancy and Southern Appalachian Forest Coalition, 2000). Feral hogs are particularly harmful, due to their fecundity and indiscriminant use of habitats.

### 3.5.2.3 Mississippi Alluvial and Southeast USA Coastal Plains

***Vegetation.*** The Mississippi Alluvial and Southeast USA Coastal Plains runs down the Atlantic seaboard to include the coastal areas of Virginia, North Carolina, South Carolina, Georgia, and Florida. This area also includes the interior of northern and central Florida. While there is diversity of vegetation types in this ecoregion, all can still be categorized as coastal.

The mid-Atlantic coastal plain covers the Virginia coast down to the South Carolina/Georgia border. The forest cover in this ecoregion was once dominated by longleaf pine. It is now composed of mostly loblolly and some shortleaf pine, with patches of oak, sweetgum, and cypress near major streams. On southern barrier islands, maritime forests of live oak, sand laurel oak, and loblolly pine are present. In the ecoregion's springs, bogs, Carolina bays, and cypress/gum ponds, and marshes, priority species include the green fly orchid, pondspice, Georgia plume, and Franklinia. Cordgrass, saltgrass, and rushes grow in coastal marshes; beach grass and sea oats grow on dunes (Wiken, Nava, & Griffith, North American Terrestrial Ecoregions—Level III, 2011).

The southern coastal plain extends from South Carolina and Georgia through much of central Florida, and along the Gulf coast lowlands of the Florida Panhandle, Alabama, and Mississippi. Once covered mainly by longleaf pine flatwoods and savannas, this region also had a variety of other vegetation communities that supported slash pine, pond pine, pond cypress, beech, sweetgum, southern magnolia, white oak, and laurel oak forest. The southern floodplain forests contain bald cypress, pond cypress, water tupelo, bottomland oaks, sweetgum, green ash, and water hickory (Wiken, Nava, & Griffith, North American Terrestrial Ecoregions—Level III, 2011). In warmer lowland areas of the coastal plain, pastureland may include perennial grasses, such as common and hybrid bermudagrass, bahiagrass, switchgrass, eastern gamagrass, bluestems, toothachegrass, giant cane, and dallisgrass. Annual grasses include millets and sorghums. (University of Georgia Cooperative Extension, 2012) (U.S. Department of Agriculture, 1971)

***Wildlife.*** Presently, the predominant fauna in the Mississippi Alluvial and Southeastern Coastal Plains ecoregion include white-tailed deer, black bear, bobcat, gray fox, raccoon, cottontail rabbit, gray squirrel, fox squirrel, striped skunk, swamp rabbit, and many small rodents and shrews. The herpetofauna (reptiles and amphibians of a particular region) include the box turtle, common garter snake, and timber rattlesnake (Bailey, Section 234A -- Mississippi Alluvial Basin, 2008).

The Southeastern Coastal Plain is characterized by a number of important natural habitats including sandhills, isolated wetlands, pine flatwoods, barrier island beaches and dunes, and maritime forest (Georgia Department of Natural Resources, 2005). In the ecoregion's springs, bogs, Carolina bays and cypress/gum ponds, and marshes, priority species (or those deemed to have significance to the ecoregion because of their role in the food chain, rarity within the area, or commercial importance) include the swallow-tailed kite, Florida water rat, and Florida sandhill crane.

Vehicle induced mortality is a major problem for several state-listed high priority species in this ecoregion, including the: eastern diamondback rattlesnake, eastern indigo snake, gopher tortoise, diamondback terrapin, Sherman's fox squirrel, and Florida pine snake (Chapman, et al., 2004). Common threats to species throughout the ecoregion are habitat conversion by silvicultural practices, development practices along the coast, water quality and quantity issues, fire exclusion, mining practices and non-native invasive species. One of the primary stressors of wildlife diversity in this ecoregion is the rapid pace of development in the coastal counties. Intense development pressures have resulted in the loss or fragmentation of a number of habitats, including maritime forest, pine flatwoods, coastal bluffs, and forested depression wetlands.

The turkey, bobwhite, and mourning dove are game birds found in various parts of the Mississippi Alluvial and Southeastern Coastal Plains ecoregion. Neotropical migrants and forest interior dwellers include the wood thrush, red-eyed vireo, northern parula, and yellow warbler. Cooper's hawk, red-shouldered hawk, and barred owl are found in the area. Songbirds include the red-eyed vireo, cardinal, tufted titmouse, wood thrush, summer tanager, blue-gray gnatcatcher, hooded warbler, Kentucky warbler, acadian flycatcher, willow flycatcher, woodcock, and Carolina wren (Bailey, Section 234A -- Mississippi Alluvial Basin, 2008). Degradation and destruction of forest and wetland habitats and the construction of navigation and flood control systems have had detrimental effects on many of these bird populations (Omernik, 2002).

***Non-native Species.*** Invasive exotic plants in this ecoregion include Chinese tallow tree, water hyacinth, alligatorweed, parrotfeather, giant reed, tropical soda apple, and coastal bermudagrass. Table 3.5-2 provides a partial list of other invasive weed species expanding into or found to be widespread in the Southeastern U.S. (and expanding geographic regions). See Section 3.5.2.1, Non-native Species, for historic concerns about invasive weed species and legislation and regulations in the United States.

Examples of exotic animals include flathead catfish and feral hogs and horses. The channeled apple snail, a South American species that is a well-known pest in Florida, has been recently found in the Satilla River watershed (U.S. Army Corps of Engineers, 2012).

### 3.5.3 Existing Conditions - Protected Habitats and Species

The Southeastern United States has a variety of diverse and unique habitats, including coastal marshes, bottomland hardwoods, the Appalachian Mountains, caves, and longleaf pine forests. Due to this diversity of habitat types, the region contains a wide variety of native species. However, over the past several decades, populations of wildlife species have declined throughout the country, including in the

Southeast. This decline, in turn, can contribute to the decrease in the region's biodiversity (Sax & Gaines, 2003). Appendix E provides a complete list of the threatened and endangered species, as of October 2014.

### 3.5.3.1 Protected Species

In addition to habitats of concern, there are currently 632 animal species and 864 plant species listed (protected) under the ESA (U.S. Fish & Wildlife Service, 2013). The number of candidate species (species for which the USFWS has enough information to warrant proposing them for listing but is precluded from doing so by higher listing priorities) is 34 species as of October 2014. In addition, bald eagles, which are protected under the Bald and Golden Eagle Protection Act, are also in the region. The distribution of protected species varies greatly between states. Because each state is responsible for the management of wildlife within its borders, all wildlife data in the United States is collected on a state-by-state basis. The USFWS compiles its listed species data at the state level. As a result, wildlife data in this section is not broken down by ecoregion or habitat type, but is shown on a state-specific level. Table 3.5-3 identifies the number of protected species in the project area. Appendix E provides a complete list of the threatened and endangered wildlife species, as of April 2015, for states in the project area.

**Table 3.5-3: Number of Species Listed as Endangered or Threatened, Candidates for Listing, or Proposed for Listing under the ESA by State within the Project Area**

| State | Endangered or Threatened Species | | | | Candidate or Proposed Species |
|---|---|---|---|---|---|
| | Vertebrates | Invertebrates | Plants | Aquatic | |
| **Alabama** | 15 | 81 | 22 | 15 | 7 |
| **Florida** | 30 | 16 | 59 | 4 | 14 |
| **Georgia** | 11 | 23 | 26 | 10 | 7 |
| **Kentucky** | 4 | 26 | 10 | 5 | 10 |
| **Mississippi** | 7 | 13 | 4 | 0 | 6 |
| **North Carolina** | 11 | 9 | 27 | 7 | 7 |
| **South Carolina** | 12 | 1 | 21 | 1 | 4 |
| **Tennessee** | 5 | 49 | 21 | 18 | 13 |
| **Virginia** | 9 | 29 | 18 | 7 | 3 |

*Source:* (U.S. Fish & Wildlife Service, 2015)

### 3.5.3.2 Critical Habitat and Habitat of Special Concern

As defined in the ESA, critical habitat is a specific geographic area(s) that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection. Sometimes, critical habitat may include an area that is not currently occupied by a particular listed species but is an area needed for a species recovery. The U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS) identify designated critical habitats and publish final boundaries of the critical habitat in the Federal Register. Appendix E also identifies those designated critical habitats for Federally listed species.

Habitats of special concern are state-identified areas showing a decline in abundance of species. Table 3.5-4 outlines habitats of special concern in the project area by ecoregion. Each of the identified habitats is important for the survival of the region's vegetation and wildlife.

**Table 3.5-4: Habitats of Special Concern in the Project Area by Ecoregion**

| Ecoregion | Habitats of Special Concern |
|---|---|
| **Southeastern USA Plains** | • Black belt prairie<br>• Cedar glades<br>• Large streams and rivers<br>• Longleaf pine forests<br>• Native prairie, barren, woodland savannahs, and canebrakes<br>• Other wetland systems such as mountain bogs, spring seeps, rivers, streams, flood plains, Carolina bays, and marshes<br>• Piedmont prairies<br>• Riparian forests, including bottomland hardwoods<br>• Rivers, lakes, and streams |
| **Ozark/Ouachita-Appalachian Forests** | • Appalachian watersheds<br>• Karst or cave habitats, including springs and underground caverns<br>• Native grasslands<br>• Oak hickory, American chestnut, and old growth forests<br>• Streams, riparian buffers, and stream banks<br>• Upland hardwoods<br>• Wetlands |
| **Mississippi Alluvial and Southeast USA Coastal Plains** | • Atlantic white cedar swamps<br>• Carolina bays<br>• Coastal dunes and marshes<br>• Forested wetlands such as bottomland hardwoods, non-alluvial swamp forests, and pocosins<br>• Longleaf pine forests and savannahs in the coastal plain<br>• Pitcher plant bogs<br>• River and ocean shoreline<br>• Sandhill scrub habitat<br>• Streams and riparian areas<br>• Wetlands and bottomland hardwoods |

*Source:* (U.S. Fish & Wildlife Service, n.d.), (U.S. Fish & Wildlife Service, 2010)

### 3.5.3.3 Migratory Birds

Migratory birds include all native wild birds found in the United States except the house sparrow, starling, feral pigeon, and resident game birds such as pheasant, grouse, quail, and wild turkeys. In the Ozark/Ouachita-Appalachian Forests ecoregion, grassland-dependent migratory birds (such as the Henslow's sparrow) and species tied to early-successional habitat (such as the golden-winged warbler and field sparrow) have been identified (Kentucky Department of Fish and Wildlife Resources, 2013). However, the Mississippi Alluvial and Southeast USA Coastal Plains ecoregion is a major bird migration corridor used in fall and spring migrations. The Lower Mississippi River Alluvial Plain provides essential winter habitat for waterfowl and is the most important area for wintering mallards in North America (Environmental Protection Agency, 2010c). The region provides important wintering areas for waterfowl populations migrating and wintering habitat on the Atlantic Flyway and Mississippi Flyway (Figure 3.5-1). Based on mid-winter inventory data, Southeastern Virginia and Northeastern North

Carolina often rank first or second for the total index of dabbling ducks within the entire Atlantic Flyway (U.S. Fish & Wildlife Service, 2007). In wetlands, ibises, cormorants, kingfishers, great blue heron, green heron, black-crowned heron, Louisiana waterthrush, American black duck, wood duck, marsh wren, and mallards are common. The endangered whooping crane uses the ecoregion's coastal marshes as their sole wintering ground (Houston Advanced Research Center, n.d.). A reference list of migratory game birds is found in 50 CFR Part 10.

**Figure 3.5-1: Migratory Bird Flyways in the United States**


*Source*: (U.S. Fish & Wildlife Service, 2014)

## 3.5.4 Existing Conditions – Non-native (Invasive) Species

Non-native (invasive) plant species could potentially cause plant diseases, prevent native and agricultural species from reproducing, suppress the growth of neighboring plants, out-compete desirable species for nutrients, light, moisture or other vital resources; and adversely impact erosion rates, hydrologic regimes and soil chemistry such as pH and nutrient availability. Natural wildfire cycles could also be altered; invasions by fire-promoting grasses could alter entire plant communities, eliminating or sharply reducing populations of many native plant species (Mullin, 2000).

Invasive plant species are regulated at all levels of government. Local regulations often include control of invasive plants by county weed districts or a similar entity. Some states have specific control responsibilities, while others have prevention programs in place, such as seed, feed, and quarantine laws. At the national level, Federal land managers have the responsibility to develop weed management programs on their lands in states with active weed programs and laws. The USDA APHIS is responsible for preventing the movement of undesirable plant species into the U.S. and enforcement of the Federal Noxious Weed Act. Many states have a weed law and identified state listed noxious weeds. These laws are designed to best complement the needs of that state and its residents.

## 3.6 Socioeconomics and Environmental Justice

### 3.6.1 Definition of the Resource

Socioeconomics encompasses the social and economic conditions of a region. Key elements include demographics, employment, and personal income, as well as the characteristics of specific sectors of the local economy. Environmental Justice specifically addresses the potential for disproportionately high and adverse impacts on minority and low-income populations, or Native American Tribes that may arise from changes in the natural or physical environment, ecological effects, or from related social or economic effects. Socioeconomic conditions provide important context for evaluating Proposed Actions (for example, the availability of labor or the status of agricultural markets). Socioeconomic conditions may be affected by the Proposed Action (for example, the generation of income from the planting of EHECs).

This section presents basic socioeconomic statistics for the populations and economies of the project area. It provides additional discussion of the economic sectors that could be most directly affected by the Proposed Action, such as the agriculture sector (also known as the farm sector) and the forestry sector.

The socioeconomic project area is based on the region defined earlier in this document (Section 2.2.1) that encompasses parts or all of nine states. However, the socioeconomic study area (or simply, "study area" in the remainder of this section) includes all nine states. States are used in this section as the fundamental units for assessing socioeconomic conditions. There are several reasons for this:

- Socioeconomic data are not readily available according to ecoregion boundaries.
- For states such as Florida that are partially inside and partially outside the ecoregion-based area defined earlier in this Final PEIS, the area boundary within the state does not closely match geographic boundaries commonly used for socioeconomic analysis. Thus, it is difficult to precisely exclude a portion of the state for the purposes of basic socioeconomic descriptive statistics in this chapter.
- Some socioeconomic data are readily available only at the state level (e.g., net farm income).
- To the extent that the Proposed Action could affect certain taxes and other government funds, some of those impacts would occur at the statewide level.
- While many socioeconomic effects of EHEC trials would manifest at the local level, the alternatives for this Final PEIS are not location-specific. Thus only the characterization of socioeconomic conditions at a higher level is possible and appropriate for this Affected Environment section.

While the socioeconomic impacts of a Federal action sometimes extend beyond the area normally addressed for other components of a NEPA analysis, measurable impacts to socioeconomic conditions outside of the identified study area are not expected given the limited magnitude of the Proposed Action. Two possible exceptions are the potential for local impacts outside the project area if field trials are conducted near the boundary of the study area, and impacts to prices or other aspects of energy crop markets that extend beyond the boundaries of the project area. In the first case, such impacts can only be assessed at the implementation level when specific field trial locations are considered. In the second case, based on the limited magnitude of the Proposed Action, the field trials are unlikely to have substantial impacts on regional or national markets.

## 3.6.2 Existing Conditions

This section discusses the following socioeconomic dimensions relevant to the Proposed Action:

- Demographic characteristics such as current population, population growth, racial and ethnic composition of the study area population, average income, and poverty status;
- General economic characteristics such as and economic indicators for housing;
- Sectoral economic characteristics such as employment and earnings by major industrial sectors;
- Additional characteristics of the potentially affected farm sector; and
- Additional characteristics of the potentially affected forestry sector.

This section uses a variety of information sources. Federal Government data are used extensively, including from the Census Bureau, Bureau of Labor Statistics, Bureau of Economic Analysis, and USDA. Additional data are drawn from state government sources and other sources.

### 3.6.2.1 Demographic Characteristics

***Population.*** As of 2012, the most populated state in the project area is Florida, with a total population of 19.3 million (Table 3.6-1). Table 3.6-2 shows projected population growth to 2020 for the project area and the Nation. Florida, Georgia, and North Carolina are projected to have the largest increases in population. These states, along with Tennessee, are also projected to have the highest annual growth rates. In the slower growing states–Alabama, Kentucky, and Mississippi–growth rates are expected to increase when compared with those for 2000–2012.

Florida's population is nearly twice[17] as large as that of the next most populous states, Georgia and North Carolina. Mississippi is the least populous state, with approximately 3 million people. Florida, Georgia, and North Carolina also had the largest increases in population, and the highest annual growth rates from 2000–2010, and from 2010–2012. The lowest growth rates in both periods were in Mississippi, Kentucky, and Alabama. These are also the only states in the project area that had growth rates below the national average. Growth rates decreased in all states from 2010–2012 compared to 2000–2010.

[17] As noted earlier, all of Florida is included in the socioeconomic analysis. If the southern portion of Florida that is not within the ecoregions considered in this Draft PEIS were excluded, the 2010 population of Florida within the ecoregions under consideration would be *roughly* 12.8 million (excludes all of Broward, Collier, Miami-Dade, and Monroe counties). This would still be the largest population within the project area.

**Table 3.6-1: Population Levels and Population Change, 2000–2012**

| Area | 2000 Census | 2010 Census | 2012 (Estimated) | Increase 2000–2010 | Increase 2010–2012 | AARC 2000–2010 | AARC 2010–2012 |
|---|---|---|---|---|---|---|---|
| Alabama | 4,447,100 | 4,779,736 | 4,822,023 | 332,636 | 42,287 | 0.72% | 0.44% |
| Florida | 15,982,378 | 18,801,310 | 19,317,568 | 2,818,932 | 516,258 | 1.64% | 1.36% |
| Georgia | 8,186,453 | 9,687,653 | 9,919,945 | 1,501,200 | 232,292 | 1.70% | 1.19% |
| Kentucky | 4,041,769 | 4,339,367 | 4,380,415 | 297,598 | 41,048 | 0.71% | 0.47% |
| Mississippi | 2,844,658 | 2,967,297 | 2,984,926 | 122,639 | 17,629 | 0.42% | 0.30% |
| North Carolina | 8,049,313 | 9,535,483 | 9,752,073 | 1,486,170 | 216,590 | 1.71% | 1.13% |
| South Carolina | 4,012,012 | 4,625,364 | 4,723,723 | 613,352 | 98,359 | 1.43% | 1.06% |
| Tennessee | 5,689,283 | 6,346,105 | 6,456,243 | 656,822 | 110,138 | 1.10% | 0.86% |
| Virginia | 7,078,515 | 8,001,024 | 8,185,867 | 922,509 | 184,843 | 1.23% | 1.15% |
| Study Area | 60,331,481 | 69,083,339 | 70,542,783 | 8,751,858 | 1,459,444 | 1.36% | 1.05% |
| United States | 281,421,906 | 308,745,538 | 313,914,040 | 27,323,632 | 5,168,502 | 0.93% | 0.83% |

*AARC: Average Annual Rate of Change*

*Sources: 2000 Population* – (U.S. Census Bureau, 2013a). *All other data* – (U.S. Census Bureau, 2013b)

**Table 3.6-2: Projected Population Change, 2010–2020**

| Area | 2010 Census | 2020 Projection | Projected Change 2010–2020 | AARC 2010–2020 | Date of Projection |
|---|---|---|---|---|---|
| Alabama | 4,779,736 | 5,101,172 | 321,436 | 0.65% | Fall 2012 |
| Florida | 18,801,310 | 21,141,318 | 2,340,008 | 1.18% | 2013 |
| Georgia | 9,687,653 | 11,326,787 | 1,639,134 | 1.58% | 2012 |
| Kentucky | 4,339,367 | 4,672,754 | 333,387 | 0.74% | 2011 |
| Mississippi | 2,967,297 | 3,156,054 | 188,757 | 0.62% | February 2012 |
| North Carolina | 9,535,483 | 10,629,051 | 1,093,568 | 1.09% | April 2013 |
| South Carolina | 4,625,364 | 5,020,800 | 395,436 | 0.82% | 2013 |
| Tennessee | 6,346,105 | 7,107,296 | 761,191 | 1.14% | 2013 |
| Virginia | 8,001,024 | 8,811,512 | 810,488 | 0.97% | 2012 |
| Study Area | 69,083,339 | 76,966,744 | 7,883,405 | 1.09% | Not Applicable |
| United States | 308,745,538 | 333,896,000 | 25,150,462 | 0.79% | December 2012 |

*AARC: Average Annual Rate of Change*

*Sources:* 2010 population – (U.S. Census Bureau, 2013b). 2020 United States population projection – (U.S. Census Bureau, 2012). 2020 state population projections are from state government sources – (Alabama Center for Business and Economic Research, 2012); (Florida Office of Economic & Demographic Research, 2012); (Georgia Governor's Office of Planning and Budget, 2012); (Kentucky State Data Center, 2011); (Mississippi Office of Policy Research and Planning, 2012); (North Carolina Office of State Budget and Management, 2013); (South Carolina Office of Research & Statistics, 2013); (Tennessee State Data Center, 2013); (Virginia Employment Commission, 2012).

***Race and Ethnicity.*** Table 3.6-3 shows the racial and ethnic components of the state populations in the project area as percentages of the total population. Hispanic is an ethnic designation, not a race designation; Hispanic populations may include persons of any racial identification. The category "All Minorities" consists of all persons other than Non-Hispanic Whites. As shown in Table 3.6-3, Whites make up the majority of the state populations within the project area. However, all of the states except Florida, Kentucky, and Tennessee have lower percentages of White population than the United States.

The Black population as a percentage of total population is higher in all the states, except in Kentucky, than in the United States. The Hispanic population is considerably lower in all of the states than in the United States, except for Florida. The percentage of All Minorities relative to the percentage of such minorities in the United States is considerably lower in Kentucky and Tennessee; somewhat lower in Alabama, North Carolina, South Carolina, and Virginia; and higher in Florida, Georgia, and Mississippi. Further discussion of minority populations is provided in Section 3.6.2.6.

**Table 3.6-3: Race and Ethnicity, 2011**

| Area | Race (%) | | | | | | | Hispanic | All Minorities |
|---|---|---|---|---|---|---|---|---|---|
| | White | Black/African American | American Indian/ Alaska Native | Asian | Native Hawaiian/ Pacific Islander | Some Other Race | Two or More Races | | |
| Alabama | 69.1% | 26.7% | 0.5% | 1.1% | 0.0% | 1.2% | 1.3% | 3.9% | 33.3% |
| Florida | 76.3% | 16.0% | 0.3% | 2.4% | 0.1% | 2.7% | 2.2% | 22.9% | 42.7% |
| Georgia | 60.7% | 30.8% | 0.3% | 3.3% | 0.1% | 2.9% | 1.9% | 9.0% | 44.6% |
| Kentucky | 87.8% | 8.0% | 0.2% | 1.2% | 0.0% | 1.0% | 1.8% | 3.0% | 13.9% |
| Mississippi | 59.4% | 37.4% | 0.4% | 0.9% | 0.0% | 0.6% | 1.2% | 2.7% | 42.3% |
| North Carolina | 70.1% | 21.7% | 1.2% | 2.2% | 0.0% | 2.7% | 2.1% | 8.6% | 35.1% |
| South Carolina | 67.0% | 27.9% | 0.3% | 1.4% | 0.0% | 1.6% | 1.8% | 5.2% | 36.1% |
| Tennessee | 77.9% | 16.7% | 0.3% | 1.4% | 0.0% | 1.7% | 1.9% | 4.6% | 24.7% |
| Virginia | 69.4% | 19.5% | 0.3% | 5.6% | 0.1% | 2.1% | 3.0% | 8.0% | 35.7% |
| United States | 74.1% | 12.6% | 0.8% | 4.8% | 0.2% | 4.7% | 2.8% | 16.7% | 36.7% |

*Race figures may not add to 100% due to rounding/margins of error for each race category. Hispanic population is an additional designation, not a race designation; Hispanic population includes multiple races. "All Minorities" is defined as all persons other than Non-Hispanic White (i.e., other than "White alone, not Hispanic or Latino").*

*Source:* (U.S. Census Bureau, 2013c)

Table 3.6-4 shows the Alabama, Kentucky, Mississippi, South Carolina, and Tennessee as the least affluent states in the project area as defined by median family income and per capita income. Table 3.6-5 provides the poverty guidelines per the 2011 Census Bureau Poverty Rates.[18] Within the project area, only Virginia has figures for Median Family Income and Per Capita Income that exceed the national figures, and only Virginia has a poverty rate that is lower than the national rate. Of the remaining states in the project area, Georgia, North Carolina, and Florida have the next highest levels of Median Family Income and Per Capita Income. Poverty rates are variable but relatively similar (17.0% to 19.9%) except for Mississippi, which has a poverty rate of 22.6% for all individuals. It is important to note that poverty rates for certain populations can be much higher. For instance, the national poverty rate for families with a female householder, with no husband present, and with related children under 5 years of age, is 47.9%.

**Table 3.6-4: Income and Poverty Status, 2011**

| Area | Median Family Income (2011$) | Per Capita Income (2011$) | Individuals Below the Poverty Level (%) |
|---|---|---|---|
| Alabama | $51,991 | $22,711 | 19.9% |
| Florida | $53,958 | $24,905 | 17.0% |
| Georgia | $55,001 | $23,604 | 19.1% |
| Kentucky | $51,917 | $22,300 | 19.1% |
| Mississippi | $46,304 | $19,583 | 22.6% |
| North Carolina | $54,082 | $24,107 | 17.9% |
| South Carolina | $52,240 | $22,598 | 18.9% |
| Tennessee | $52,273 | $23,320 | 18.3% |
| Virginia | $74,500 | $32,123 | 11.5% |
| United States | $61,455 | $26,708 | 15.9% |

*Source:* (U.S. Census Bureau, 2013d)

[18] Poverty status in Table 3.6–4 is based upon the U.S. Census Bureau's poverty threshold. There are 48 poverty thresholds addressing various combinations of persons in a family unit and the number of related children under 18 years of age. These poverty thresholds are mainly used for statistical purposes. A simpler delineation of poverty, used for many administrative purposes, is the poverty guidelines published by the U.S. Department of Health & Human Services. These guidelines, shown in Table 3.6–5, are roughly speaking a simplified version of the Census Bureau's poverty thresholds.

**Table 3.6-5: Poverty Guidelines Applicable to 2011 Census Bureau Poverty Rates**

| Persons in Family/Household | Poverty Guideline |
|---|---|
| 1 | $11,170 |
| 2 | $15,130 |
| 3 | $19,090 |
| 4 | $23,050 |
| 5 | $27,010 |
| 6 | $30,970 |
| 7 | $34,930 |
| 8* | $38,890 |

**For families/households with more than 8 persons, add $3,960 for each additional pers*
*These are the 2012 Poverty Guidelines for the 48 contiguous states and DC. Poverty guidelines (unlike the poverty thresholds) are designated by the year in which they are issued. For instance, the guidelines issued in January 2012 are designated the 2012 p guidelines. However, the 2012 Health and Human Services (HHS) poverty guidelines c reflect price changes through calendar year 2011; accordingly, they are approximately to the U.S. Census Bureau poverty thresholds for calendar year 2011.*

*Source:* (U.S. Department of Health & Human Services Assistant Secretary for Planning and Evaluation, 2012)

Additional detail regarding income is provided in Section 3.6.2.2 on General Economic Characteristics section below. Poverty is discussed further in Section 3.6.2.6 on Environmental Justice section below.

### 3.6.2.2 General Economic Characteristics

***Unemployment.*** Table 3.6-6 shows average unemployment rates by state from 2000 to mid-2013 (July). Figure 3.6-1Figure 3.6-1 shows the same information in graphical format. All states in the project area have current (as of July 2013) unemployment rates above the national rate (7.4%) except Alabama, Florida, and Virginia. Over the period shown, the unemployment rate in Alabama has generally been below the national rate and the rate in Virginia has been considerably below the national rate. The unemployment rate in Florida was at or below the national rate until the onset of the recession, then was above the national rate until mid-2013. Unemployment in Georgia was below the national rate until 2004, essentially at the national rate until the onset of the recession, and above the national rate since the recession began. Unemployment in the other states has generally been at or above the national rate, sometimes considerably above, throughout the period shown.

***Sources of Personal Income.*** Personal income drives the consumer-focused economy of the United States and each of its states. Total personal income consists of the following basic components:

- *Labor Earnings (or simply, "Earnings")* – Earnings is the sum of wage and salary disbursements, supplements to wages and salaries, and proprietors' income.
- *Dividends, Interest, and Rent* – This includes personal dividend income, personal interest income, and rental income (with capital consumption adjustments), and is sometimes referred to as "investment income" or "property income."
- *Transfer Payments (sometimes called Personal Current Transfer Receipts)* – This component of personal income is payments to persons for which no goods are exchanged or current services are performed. It consists of payments to individuals and to nonprofit institutions by Federal, state, and local governments and by businesses. Government payments to

individuals include retirement and disability insurance benefits, medical benefits (mainly Medicare and Medicaid), income maintenance benefits, unemployment insurance compensation, veterans' benefits, and Federal education and training assistance. Government payments to nonprofit institutions exclude payments by the Federal government for work under research and development contracts. Business payments to persons consist primarily of liability payments for personal injury and of corporate gifts to nonprofit institutions.

Transfer payments together with dividends, interest, and rent are known as "non-labor income." Labor earnings are the primary income source for working-age persons, while non-labor income is the primary source for retired persons (e.g., social security, pensions, investment income).

Table 3.6-7Table 3.6-7 shows the 2011 make-up of total personal income, by the three components described above, for the project area, the region, and the Nation. The components vary across the states as a percentage of total personal income. Labor earnings range from 54.9% of total personal income in Florida to 71.1% in Virginia, with a U.S. average of 65.9%. Dividends, interest, and rent as a percentage of total personal income range from 12.2% in Mississippi to 24.8% in Florida. Transfer payments range from 13.5% in Virginia to 26.0% in Mississippi.

Figure 3.6-2 shows the variations in non-labor income. Much of the variation is explained by the age and affluence profiles of the states. For instance, Florida has the highest rate of non-labor income and by far the highest percentage (17.6%) of residents over the age of 65 (U.S. Census Bureau, 2013c), who receive social security and other transfer payments. In addition, many retired residents of Florida are affluent and have substantial investment income, thus dividends, interest, and rent form a high percentage of total personal income in Florida. Virginia and Georgia have the lowest percentages (12.5% and 11%, respectively) of residents over the age of 65 (U.S. Census Bureau, 2013c) and also have the lowest rates of non-labor income. The highest rates of transfer payments are in Alabama, Kentucky, Mississippi, South Carolina, and Tennessee. These are also the least affluent states in the region, at least as defined by median family income and per capita income. Table 3.6-4 shows the Alabama, Kentucky, Mississippi, South Carolina, and Tennessee as the least affluent states in the project area as defined by median family income and per capita income. Table 3.6-5 provides the poverty guidelines per the 2011 Census Bureau Poverty Rates. Within the project area, only Virginia has figures for Median Family Income and Per Capita Income that exceed the national figures, and only Virginia has a poverty rate that is lower than the national rate. Of the remaining states in the project area, Georgia, North Carolina, and Florida have the next highest levels of Median Family Income and Per Capita Income. Poverty rates are variable but relatively similar (17.0% to 19.9%) except for Mississippi, which has a poverty rate of 22.6% for all individuals. It is important to note that poverty rates for certain populations can be much higher. For instance, the national poverty rate for families with a female householder, with no husband present, and with related children under 5 years of age, is 47.9%. These states generally have high rates of income maintenance benefits and Medicaid as shares of non-labor income (Table 3.6-6).

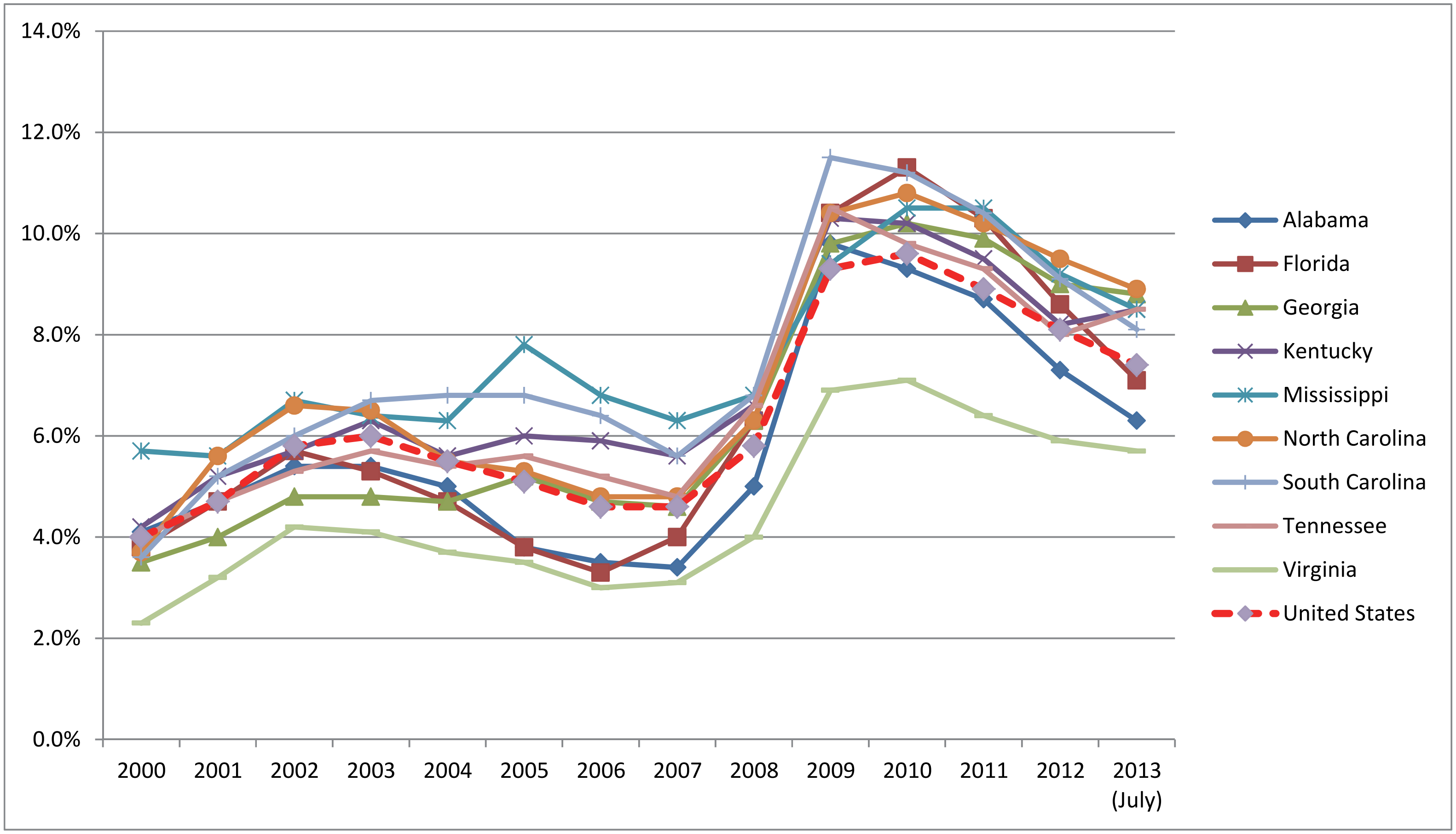
**Table 3.6-6: Annual Average Unemployment Rates (%), 2000–2013**

| Area | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 July* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alabama | 4.1 | 4.7 | 5.4 | 5.4 | 5.0 | 3.8 | 3.5 | 3.4 | 5.0 | 9.8 | 9.3 | 8.7 | 7.3 | 6.3 |
| Florida | 3.8 | 4.7 | 5.7 | 5.3 | 4.7 | 3.8 | 3.3 | 4.0 | 6.3 | 10.4 | 11.3 | 10.3 | 8.6 | 7.1 |
| Georgia | 3.5 | 4.0 | 4.8 | 4.8 | 4.7 | 5.2 | 4.7 | 4.6 | 6.3 | 9.8 | 10.2 | 9.9 | 9.0 | 8.8 |
| Kentucky | 4.2 | 5.2 | 5.7 | 6.3 | 5.6 | 6.0 | 5.9 | 5.6 | 6.6 | 10.3 | 10.2 | 9.5 | 8.2 | 8.5 |
| Mississippi | 5.7 | 5.6 | 6.7 | 6.4 | 6.3 | 7.8 | 6.8 | 6.3 | 6.8 | 9.4 | 10.5 | 10.5 | 9.2 | 8.5 |
| North Carolina | 3.7 | 5.6 | 6.6 | 6.5 | 5.5 | 5.3 | 4.8 | 4.8 | 6.3 | 10.4 | 10.8 | 10.2 | 9.5 | 8.9 |
| South Carolina | 3.6 | 5.2 | 6.0 | 6.7 | 6.8 | 6.8 | 6.4 | 5.6 | 6.8 | 11.5 | 11.2 | 10.4 | 9.1 | 8.1 |
| Tennessee | 4.0 | 4.7 | 5.3 | 5.7 | 5.4 | 5.6 | 5.2 | 4.8 | 6.6 | 10.5 | 9.8 | 9.3 | 8.0 | 8.5 |
| Virginia | 2.3 | 3.2 | 4.2 | 4.1 | 3.7 | 3.5 | 3.0 | 3.1 | 4.0 | 6.9 | 7.1 | 6.4 | 5.9 | 5.7 |
| United States | 4.0 | 4.7 | 5.8 | 6.0 | 5.5 | 5.1 | 4.6 | 4.6 | 5.8 | 9.3 | 9.6 | 8.9 | 8.1 | 7.4 |

* Seasonally adjusted.

*Sources:* (U.S. Bureau of Labor Statistics, 2013a), (U.S. Bureau of Labor Statistics, 2013b), (U.S. Bureau of Labor Statistics, 2013c), (U.S. Bureau of Labor Statistics, 2013d).

**Figure 3.6-1: Annual Average Unemployment Rates, 2000–2013**




*Source:* (U.S. Bureau of Labor Statistics, 2013a), (U.S. Bureau of Labor Statistics, 2013b), (U.S. Bureau of Labor Statistics, 2013c), (U.S. Bureau of Labor Statistics, 2013d).

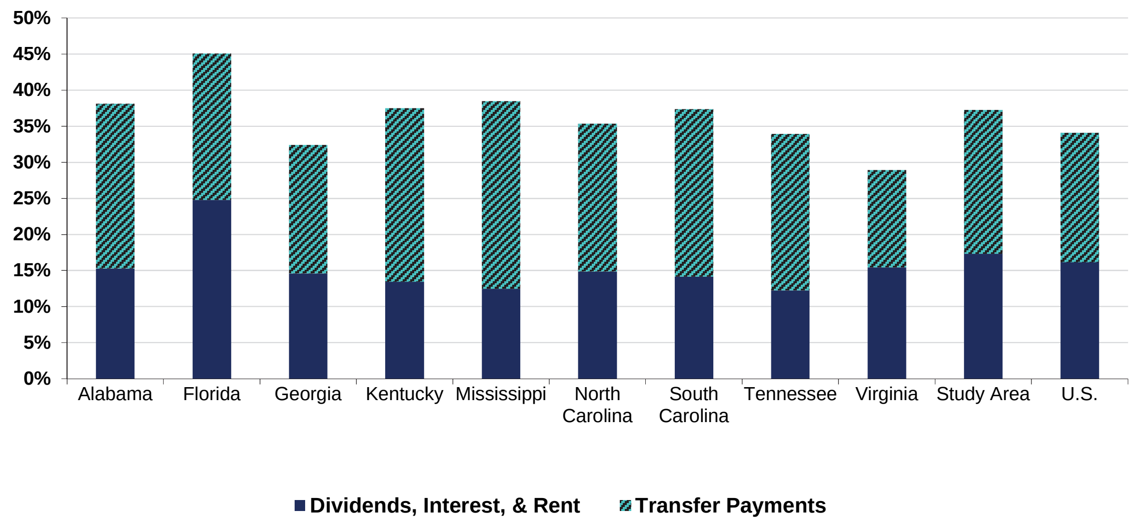
**Table 3.6-7: Sources of Personal Income, 2011 (Billions of 2011 Dollars)**

| | Alabama | Florida | Georgia | Kentucky | Mississippi | North Carolina | South Carolina | Tennessee | Virginia | Study Area | U.S. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Personal Income** | $171.0 | $771.2 | $360.6 | $151.6 | $97.3 | $355.2 | $159.5 | $239.1 | $381.2 | $2,686.7 | $13,221.9 |
| Labor Earnings | $105.8 | $423.5 | $243.7 | $94.8 | $59.9 | $229.7 | $99.9 | $157.9 | $270.9 | $1,686.2 | $8,716.5 |
| Non-Labor Income | $65.2 | $347.7 | $116.9 | $56.8 | $37.4 | $125.5 | $59.6 | $81.2 | $110.2 | $1,000.5 | $4,505.3 |
| Dividends, Interest, & Rent | $26.2 | $191.2 | $52.6 | $20.4 | $12.1 | $52.8 | $22.6 | $29.3 | $58.8 | $465.9 | $2,137.4 |
| Transfer Payments | $39.1 | $156.5 | $64.3 | $36.5 | $25.3 | $72.7 | $37.0 | $51.9 | $51.4 | $534.6 | $2,367.9 |
| **Percent of Total** | | | | | | | | | | | |
| Labor Earnings | 61.9% | 54.9% | 67.6% | 62.5% | 61.5% | 64.7% | 62.6% | 66.1% | 71.1% | 62.8% | 65.9% |
| Non-Labor Income | 38.1% | 45.1% | 32.4% | 37.5% | 38.5% | 35.3% | 37.4% | 33.9% | 28.9% | 37.2% | 34.1% |
| Dividends, Interest, & Rent | 15.3% | 24.8% | 14.6% | 13.4% | 12.5% | 14.9% | 14.1% | 12.2% | 15.4% | 17.3% | 16.2% |
| Transfer Payments | 22.8% | 20.3% | 17.8% | 24.1% | 26.0% | 20.5% | 23.2% | 21.7% | 13.5% | 19.9% | 17.9% |

*Non-labor income and labor earnings may not add to total personal income because of adjustments made by the Bureau of Economic Analysis to account for contributions for social security, cross-county commuting, and other factors.*

*Source:* (Headwaters Institute, 2013).

**Figure 3.6-2: Percentage of Total Personal Income from Non-Labor Sources, 2011**




*Source:* (Headwaters Institute, 2013).

### 3.6.2.3 Sectoral Economic Characteristics

The industrial sectors that could be most directly affected by the Proposed Action are the *Farm* sector, the *Forestry and Logging* sector, and the *Agriculture and Forestry Support Activities* sector. Additional industries may be affected indirectly when the three directly affected sectors purchase supplies or services in support of their EHEC-related operations. Table 3.6-8: Table 3.6-8 shows the shares of total employment represented by each industry for the nine states and the U.S. Table 3.6-8 shows, similarly, the shares of total earnings represented by each industry for the project area and the U.S.

As shown in these tables, the three directly affected sectors make up small portions of both total employment and total earnings in each of the states and the nation. Farm employment ranges from 0.8% of total employment in Florida to 3.7% in Kentucky, and Farm earnings range from 0.2% of total earnings in Tennessee and Virginia to 1.8% in Mississippi. Forestry and Logging employment as a percentage of total employment is highest in Alabama and Mississippi at 0.3%, and this sector's share of total earnings is highest in Mississippi at 0.5%. Agriculture and Forestry Support Activities employment as a percentage of total employment is highest in Florida and Mississippi at 0.5%; for earnings, this sector's share is highest in Florida, Kentucky, and Mississippi at 0.3% (Table 3.6-9).

**Table 3.6-8: Employment by Industry – Shares of Total Full and Part-Time Employment, 2011**

| Industry | Alabama | Florida | Georgia | Kentucky | Mississippi | North Carolina | South Carolina | Tennessee | Virginia | United States |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Employment | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Farm Employment | 2.0% | 0.8% | 1.0% | 3.7% | 3.0% | 1.2% | 1.2% | 2.2% | 1.0% | 1.5% |
| Nonfarm Employment | 98.0% | 99.2% | 99.0% | 96.3% | 97.0% | 98.8% | 98.8% | 97.8% | 99.0% | 98.5% |
| Private Nonfarm Employment | 81.7% | 87.4% | 84.3% | 80.0% | 78.4% | 82.4% | 83.0% | 85.1% | 80.8% | 84.7% |
| Forestry, Fishing, and Related Activities | 0.6% | 0.7% | 0.4% | 0.5% | 0.9% | 0.4% | 0.4% | 0.3% | 0.3% | 0.5% |
| Forestry and Logging | 0.3% | 0.0% | 0.1% | (D) | 0.3% | 0.1% | 0.2% | 0.1% | 0.1% | 0.1% |
| Fishing, Hunting, and Trapping | 0.1% | 0.1% | 0.0% | (D) | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% | 0.1% |
| Agriculture and Forestry Support Activities | 0.3% | 0.5% | 0.3% | 0.4% | 0.5% | 0.3% | 0.2% | 0.2% | 0.1% | 0.4% |
| Mining | 0.5% | 0.3% | 0.2% | 1.3% | 1.0% | 0.2% | 0.2% | 0.3% | 0.3% | 0.8% |
| Utilities | 0.6% | 0.2% | 0.4% | 0.3% | 0.5% | 0.2% | 0.5% | 0.1% | 0.2% | 0.3% |
| Construction | 5.5% | 4.9% | 4.9% | 4.9% | 5.7% | 5.5% | 5.0% | 5.4% | 5.6% | 5.0% |
| Manufacturing | 9.8% | 3.4% | 6.9% | 9.2% | 9.3% | 8.6% | 9.0% | 8.8% | 5.0% | 7.0% |
| Wholesale Trade | 3.2% | 3.5% | 4.0% | 3.3% | 2.6% | 3.5% | 2.9% | 3.6% | 2.6% | 3.5% |
| Retail Trade | 10.9% | 11.1% | 10.1% | 10.3% | 10.8% | 10.2% | 10.9% | 10.7% | 9.9% | 10.1% |
| Transportation and Warehousing | 2.8% | 3.1% | 4.0% | 4.3% | 3.5% | 2.7% | 2.6% | 4.6% | 2.8% | 3.2% |
| Information | 1.1% | 1.7% | 2.2% | 1.3% | 1.0% | 1.6% | 1.3% | 1.5% | 1.8% | 1.8% |
| Finance and Insurance | 4.2% | 5.9% | 4.8% | 4.2% | 3.8% | 4.5% | 4.2% | 4.6% | 4.2% | 5.4% |

**Table 3.6-8: Employment by Industry – Shares of Total Full and Part-Time Employment, 2011 (continued)**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Real Estate and Rental and Leasing | 3.9% | 5.6% | 4.3% | 3.4% | 3.1% | 4.3% | 4.4% | 3.6% | 4.4% | 4.5% |
| Professional, Scientific, & Technical Services | 5.5% | 6.8% | 6.6% | 4.5% | 3.7% | 5.7% | 5.0% | 5.1% | 10.8% | 6.8% |
| Management of Companies and Enterprises | 0.7% | 0.9% | 1.1% | 0.9% | 0.7% | 1.5% | 0.7% | 0.9% | 1.6% | 1.2% |
| Administrative & Waste Management Services | 6.4% | 8.0% | 7.8% | 5.7% | 5.7% | 6.8% | 7.4% | 7.4% | 5.8% | 6.2% |
| Educational Services | 1.6% | 2.1% | 2.1% | 1.7% | 1.7% | 2.2% | 1.6% | 1.9% | 2.1% | 2.4% |
| Health Care and Social Assistance | 9.1% | 11.2% | 9.1% | 10.5% | 9.7% | 10.0% | 8.1% | 10.8% | 9.2% | 11.0% |
| Arts, Entertainment, and Recreation | 1.3% | 3.0% | 1.8% | 1.5% | 1.3% | 2.0% | 1.9% | 2.0% | 2.0% | 2.2% |
| Accommodation and Food Services | 6.6% | 8.2% | 7.0% | 6.8% | 7.8% | 7.0% | 8.0% | 7.2% | 6.7% | 7.0% |
| Other Services, Except Public Administration | 7.4% | 6.9% | 6.6% | 5.3% | 5.5% | 5.5% | 9.1% | 6.3% | 5.6% | 5.7% |
| Government and Government Enterprises | 16.3% | 11.8% | 14.7% | 16.3% | 18.6% | 16.4% | 15.8% | 12.7% | 18.2% | 13.8% |
| Federal, Civilian | 2.3% | 1.3% | 2.0% | 1.7% | 1.7% | 1.3% | 1.3% | 1.4% | 4.0% | 1.7% |
| Military | 1.3% | 1.0% | 1.9% | 2.5% | 2.1% | 2.8% | 2.2% | 0.7% | 3.1% | 1.2% |
| State and Local | 12.7% | 9.5% | 10.8% | 12.0% | 14.8% | 12.3% | 12.3% | 10.6% | 11.1% | 11.0% |

(D) Not shown in the original data source to avoid disclosure of confidential (proprietary) information due to the small number of firms for this industry in this geography, but the estimates for this item are included in the total. Source: (U.S. Bureau of Economic Analysis, 2012)

**Table 3.6-9: Earnings by Industry – Shares of Total Earnings, 2011**

| Industry | Alabama | Florida | Georgia | Kentucky | Mississippi | North Carolina | South Carolina | Tennessee | Virginia | United States |
|---|---|---|---|---|---|---|---|---|---|---|
| Total earnings | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Farm earnings | 0.4% | 0.5% | 0.7% | 1.0% | 1.8% | 0.9% | 0.3% | 0.2% | 0.2% | 1.1% |
| Nonfarm earnings | 99.6% | 99.5% | 99.3% | 99.0% | 98.2% | 99.1% | 99.7% | 99.8% | 99.8% | 98.9% |
| Private nonfarm earnings | 76.7% | 82.1% | 80.2% | 76.2% | 73.2% | 77.2% | 76.9% | 84.9% | 74.3% | 81.3% |
| Forestry, fishing, and related activities | 0.6% | 0.4% | 0.3% | 0.3% | 0.9% | 0.3% | 0.4% | 0.2% | 0.1% | 0.3% |
| Forestry and logging | 0.4% | 0.0% | 0.2% | (D) | 0.5% | 0.1% | 0.2% | 0.1% | 0.1% | 0.1% |
| Fishing, hunting, and trapping | 0.0% | 0.0% | 0.0% | (D) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Agriculture and forestry support activities | 0.2% | 0.3% | 0.1% | 0.3% | 0.3% | 0.2% | 0.1% | 0.1% | 0.0% | 0.2% |
| Mining | 0.7% | 0.1% | 0.2% | 2.1% | 1.4% | 0.1% | 0.1% | 0.2% | 0.4% | 1.2% |
| Utilities | 1.5% | 0.6% | 0.9% | 0.6% | 1.2% | 0.6% | 1.3% | 0.2% | 0.6% | 0.8% |
| Construction | 6.0% | 4.9% | 4.7% | 5.0% | 6.5% | 5.2% | 5.4% | 5.9% | 5.0% | 5.3% |
| Manufacturing | 13.4% | 4.9% | 9.4% | 13.6% | 12.6% | 12.3% | 13.9% | 12.4% | 5.8% | 10.0% |
| Wholesale trade | 4.6% | 5.6% | 6.6% | 4.8% | 3.6% | 5.2% | 4.4% | 5.2% | 3.5% | 5.1% |
| Retail trade | 6.9% | 7.9% | 6.1% | 6.4% | 7.4% | 6.3% | 7.4% | 7.3% | 5.0% | 6.1% |
| Transportation and warehousing | 3.3% | 3.2% | 4.6% | 5.2% | 4.0% | 2.7% | 2.6% | 5.5% | 2.5% | 3.3% |
| Information | 1.4% | 2.8% | 4.4% | 1.6% | 1.1% | 2.4% | 1.8% | 1.8% | 2.9% | 3.3% |
| Finance and insurance | 5.0% | 7.3% | 6.3% | 5.0% | 3.8% | 6.8% | 5.4% | 5.8% | 5.0% | 7.5% |

**Table 3.6-9: Earnings by Industry – Shares of Total Earnings, 2011 (continued)**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Real estate and rental and leasing | 1.3% | 2.5% | 1.9% | 1.1% | 1.1% | 1.3% | 1.5% | 1.6% | 1.6% | 1.8% |
| Professional, scientific, and technical services | 8.2% | 9.2% | 9.4% | 5.4% | 4.5% | 7.3% | 6.8% | 7.0% | 17.9% | 9.8% |
| Management of companies and enterprises | 1.3% | 1.9% | 2.3% | 1.9% | 1.5% | 3.3% | 1.2% | 1.6% | 3.3% | 2.5% |
| Administrative & waste management services | 3.3% | 5.3% | 4.7% | 3.2% | 3.0% | 4.1% | 5.7% | 5.4% | 3.7% | 3.9% |
| Educational services | 0.8% | 1.5% | 1.6% | 0.9% | 1.1% | 1.6% | 1.0% | 1.4% | 1.3% | 1.7% |
| Health care and social assistance | 10.6% | 13.0% | 9.5% | 12.1% | 11.1% | 10.3% | 9.4% | 14.8% | 8.5% | 11.0% |
| Arts, entertainment, and recreation | 0.4% | 2.2% | 0.8% | 0.6% | 0.5% | 1.0% | 0.7% | 1.2% | 0.6% | 1.1% |
| Accommodation and food services | 2.7% | 4.5% | 3.1% | 2.9% | 4.0% | 2.9% | 3.8% | 3.3% | 2.5% | 3.0% |
| Other services, except public administration | 4.6% | 4.3% | 3.5% | 3.5% | 3.9% | 3.5% | 4.1% | 4.3% | 3.9% | 3.7% |
| Government and government enterprises | 22.9% | 17.5% | 19.1% | 22.8% | 25.0% | 21.9% | 22.8% | 14.9% | 25.5% | 17.6% |
| Federal, civilian | 5.8% | 3.1% | 4.2% | 3.6% | 4.1% | 2.7% | 3.0% | 3.2% | 8.8% | 3.5% |
| Military | 2.2% | 2.0% | 3.6% | 5.8% | 3.4% | 5.8% | 4.3% | 0.7% | 6.0% | 1.9% |
| State and local | 14.9% | 12.4% | 11.2% | 13.4% | 17.5% | 13.4% | 15.6% | 11.0% | 10.7% | 12.2% |

(D) Not shown in the original data source to avoid disclosure of confidential (proprietary) information due to the small number of firms for this industry in this geography, but the estimates for this item are included in the total. Source: (U.S. Bureau of Economic Analysis, 2013)

### 3.6.2.4 Farm Sector Economic Characteristics

The farm sector could be directly affected as it could produce some of the crops under consideration for field trials. Planting, cultivation, and harvesting of crops could be affected as the EHECs in the proposed field trials may require different agricultural practices than the current energy crops (e.g., corn for ethanol) that the EHEC trials could replace.

Structurally, the farm sector, as defined in the sectoral economic characteristics above, consists of two North American Industrial Classification System (NAICS) codes:

- Crop Production (NAICS code 111)
- Animal Production (NAICS code 112)

Current energy crops, such as corn and various oil seeds, are largely encompassed within NAICS code 1111, Oilseed and Grain Farming. Some energy crops (for instance, sugarcane and some types of beets) are encompassed in NAICS code 1119, Other Crop Farming. These farm subsectors include the crops that are currently used as energy crops and thus could be affected by substitution of EHECs for conventional energy crops.

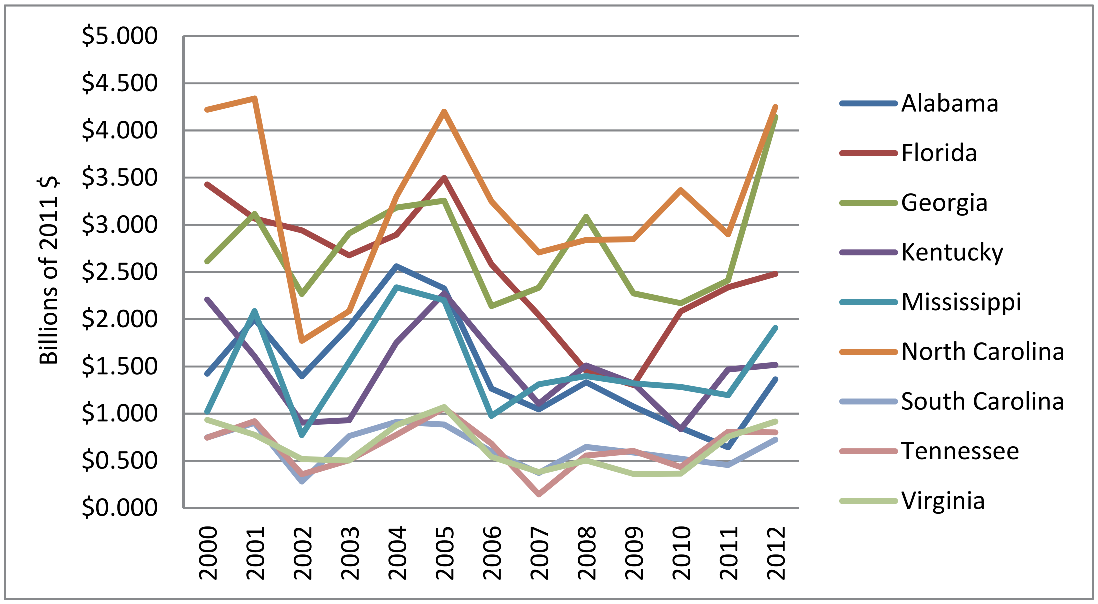
One measure of the economic health of the farm sector is *net farm income*. This measure includes:

- Cash income from sale of crops, livestock, and other farm goods and services such as machine work or custom work;
- Direct payments from the Federal government;
- Estimated non-money income, such as the value of on-farm consumption of self-produced goods and the imputed rental value of farm dwelling;
- Cash expenses such as feed, seeds, breeding stock, electricity, fertilizer, pesticides, fuel, contract labor, employee compensation, property taxes, interest expenses, rents to non-operator landlords, and miscellaneous services;
- Estimated noncash expenses such as capital consumption (depreciation) and perquisites for hired labor; and
- Estimated adjustments for crop inventories.

Net farm income–because it includes estimated non-money income, noncash expenses, and inventory adjustments–is considered an economic measure rather than a purely financial measure. (Net cash income excludes these estimates and is thus a financial or accounting measure.) Net farm income is considered a good indicator of the long-term viability of farms as businesses. However, like net cash income, it may vary considerably from year-to-year based on factors such as planted acreages and livestock breedings, harvests (as impacted by weather events), commodity prices, cost of capital (financial market conditions), extraordinary expenses, and other variables of farming.

Figure 3.6-3Figure 3.6-3 shows the same data graphically. Table 3.6-10: provides data on net farm income by year for the project area by state from 2000 to 2012. The three states with the highest net farm incomes throughout most of this period were North Carolina, Florida, and Georgia. These states also had the greatest degree of volatility in net farm income across this period, as shown by the wide swings in their income trend lines in the figure. Kentucky, Alabama, and Mississippi produced the next highest net farm incomes, and also experienced some volatility in the early years of this period. The states with the lowest net farm incomes were Virginia, Tennessee, and South Carolina. The trend lines for these three states appear flatter relative to the other states, but the relative ups and downs within the lower level of net farm income in these three states were also noteworthy. All states have shown improvements in net farm income since recent lows in the 2009–2010 timeframe.

**Figure 3.6-3: Net Farm Income Trends**




*Source: Table 3.6-10*: *Table 3.6-10*:

**Table 3.6-10: Net Farm Income by Year, 2000–2012 (Billions in 2011 Dollars)**

| Area | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alabama | $1.422 | $2.002 | $1.395 | $1.921 | $2.561 | $2.326 | $1.265 | $1.044 | $1.332 | $1.076 | $0.848 | $0.641 | $1.361 |
| Florida | $3.426 | $3.067 | $2.942 | $2.675 | $2.895 | $3.497 | $2.583 | $2.042 | $1.453 | $1.303 | $2.082 | $2.336 | $2.479 |
| Georgia | $2.614 | $3.115 | $2.266 | $2.909 | $3.181 | $3.254 | $2.137 | $2.331 | $3.083 | $2.274 | $2.171 | $2.412 | $4.142 |
| Kentucky | $2.206 | $1.606 | $0.903 | $0.928 | $1.752 | $2.274 | $1.675 | $1.103 | $1.510 | $1.320 | $0.836 | $1.466 | $1.514 |
| Mississippi | $1.021 | $2.083 | $0.770 | $1.546 | $2.336 | $2.202 | $0.974 | $1.309 | $1.398 | $1.319 | $1.281 | $1.196 | $1.906 |
| North Carolina | $4.219 | $4.338 | $1.769 | $2.087 | $3.300 | $4.199 | $3.249 | $2.707 | $2.841 | $2.848 | $3.366 | $2.898 | $4.246 |
| South Carolina | $0.748 | $0.900 | $0.280 | $0.760 | $0.912 | $0.883 | $0.596 | $0.370 | $0.645 | $0.588 | $0.521 | $0.453 | $0.722 |
| Tennessee | $0.745 | $0.918 | $0.354 | $0.508 | $0.775 | $1.057 | $0.681 | $0.142 | $0.555 | $0.603 | $0.432 | $0.807 | $0.799 |
| Virginia | $0.932 | $0.775 | $0.518 | $0.504 | $0.876 | $1.070 | $0.541 | $0.380 | $0.503 | $0.358 | $0.362 | $0.753 | $0.916 |
| Project Area | $17.333 | $18.805 | $11.198 | $13.837 | $18.588 | $20.762 | $13.700 | $11.427 | $13.319 | $11.689 | $11.899 | $12.962 | $18.084 |
| United States | $63.873 | $67.621 | $47.498 | $72.534 | $101.221 | $88.365 | $62.517 | $74.231 | $87.038 | $62.315 | $79.562 | $117.956 | $111.857 |

*Source*: (U.S. Department of Agriculture Economic Research Service, 2013)

### 3.6.2.5 Forestry Sector Economic Characteristics

The forestry sector could be directly affected as it could produce some of the crops under consideration for field trials. This sector can be subdivided into two general sub-sectors: commercial (or "industrial") forest operations, and private non-industrial forests, largely owned in small holdings by large numbers of families. The U.S. EPA (2013j) provides a succinct summary of the structure of the forestry sector, provided below. This typology applies best to commercial forest operations. However, all types of forest owners use logging establishments.

> Establishments involved in forestry operations are classified in NAICS Code 113. In 2012 there were 15,763 forestry establishments [nationally] listed under the NAICS Code 113. These establishments are divided among three distinct industry groups:
>
> - *Timber tract operations (NAICS code 1131):* This industry comprises establishments primarily engaged in the operation of timber tracts for the purpose of selling standing timber.
> - *Forest nurseries and gathering of forest products (NAICS code 1132):* This industry comprises establishments primarily engaged in (1) growing trees for reforestation or (2) gathering forest products, such as gums, barks, balsam needles, rhizomes, fibers, Spanish moss, ginseng, and truffles.
> - *Logging (NAICS code 1133):* This industry comprises establishments primarily engaged in one or more of the following: (1) cutting timber; (2) cutting and transporting timber; and (3) producing wood chips in the field.

According to the National Woodland Owner Survey (Butler, 2006), there were 4.044 million private non-industrial forest owners in the study area in 2006. Nationally, family forest owners represented 92% of all private forest owners. These family forest owners held their forest land for many reasons; the most commonly cited were beauty/scenery, to pass land on to heirs, privacy, nature protection, and part of a home/cabin. Most planned to do relatively little with their land in the next five years, but some planned harvesting of sawlogs or pulpwood, or harvesting of firewood. Of all family forest owners, 61% owned less than 10 acres.

Based on this profile, family forest owners are not generally commercially oriented or in a position (e.g., size of land holdings) to engage in operations such as participation in an EHEC trial. It is likely that most silvicultural EHEC confined field trials will be undertaken by industrial forest operators (timber tract operations or forest nurseries) or other non-industrial operators such as university research forests.

Data on the economic health of the forestry sector as a whole is not readily available. The Federal government has a more limited role in forestry sector support and information gathering, compared to its extensive involvement in the farm sector through various price support, conservation, and other programs. Much of the responsibility for supporting forestry operations and gathering data on those operations belongs to the states.

### 3.6.2.6 Environmental Justice

The concept of environmental justice first became a required consideration for Federal agencies with the publication of EO 12898 on February 11, 1994 (Executive Order 12898, 1994). The EO requires each Federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." Environmental effects include economic, social, and cultural effects (i.e., socioeconomic effects) as well as effects on the biological or physical environment that affect people.

Fundamental principles of environmental justice require that Federal agencies:

- Avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including socioeconomic effects, on minority populations and low-income populations;
- Ensure the full and fair participation by all potentially affected communities in the decision-making process; and
- Prevent the denial of, reduction in, or delay in the receipt of benefits of the project [or program] by minority and low-income populations.

DOE's Environmental Justice Strategy (2008) integrates the requirements of EO 12898 into DOE operations. It sets out four goals: to identify and address programs, policies, and activities that may have disproportionate effects as described above; to foster greater public participation; to improve research and data collection related to environmental justice; and to integrate environmental justice with activities and processes related to human health and the environment. (U.S. Department of Energy, 2008)

"Adverse" and "disproportionate" are key concepts in an environmental justice impacts analysis. An environmental justice impact occurs only if the impact on a minority or low-income population is harmful, *and* "appreciably exceeds or is likely to appreciably exceed" the impact to the general population or other appropriate comparison group (Council on Environmental Quality, 1997a).

The first step in an environmental justice analysis is to conduct a screening analysis of the socioeconomic study area for the planning action to identify the presence and location of any environmental justice populations. This assessment is provided below. Chapter 4 assesses the potential for disproportionately high and adverse effects on environmental justice populations.

***Definitions.*** Subsequent to publication of the EO, the CEQ issued guidance for considering environmental justice within the NEPA process (Council on Environmental Quality, 1997a). This guidance defines minorities as individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. The guidance further defines a "minority population" as follows:

> *Minority populations should be identified where either: (a) the minority population of the affected area exceeds 50% or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.*

The guidance also makes clear that Indian tribes in the affected area should also be considered in the environmental justice analysis.

The CEQ guidance states that "low-income" should be determined using the annual statistical poverty thresholds from the Bureau of the Census. That is, persons living under the poverty income threshold are potentially of concern. The guidance does not specify how to identify a "low-income population," but in practice the same approach used for minority populations can be followed—where persons in poverty status are greater than 50% of the area's total population, or where the percentage in poverty is meaningfully greater than the percentage in the general population or an appropriate comparison area.

The CEQ guidance makes clear that environmental justice populations are not limited to geographic areas, but may also include geographically dispersed or transient individuals that experience common conditions of environmental exposure or effect. For example, migrant agricultural workers may be subject to adverse impacts from agricultural activities (e.g., due to exposure to pesticides), and these workers are often of minority or low-income status.

The CEQ guidance does not define what constitutes "meaningfully greater." In practice, meaningfully greater is often interpreted to identify an environmental justice population if the percentage of population in minority or poverty status in an area is at least a certain number of percentage points higher than in the comparison area. DOE has applied a threshold of 20% greater than the comparison area in two similar and recent PEISs (*Upper Great Plains Wind Energy Draft Programmatic Environmental Impact Statement* (U.S. Department of Energy Western Area Power Administration and U.S. Department of the Interior Fish and Wildlife Service, 2013) and the *Final Programmatic Environmental Impact Statement for Solar Energy Development* (U.S. Department of the Interior -- Bureau of Land Management; U.S. Department of Energy, 2012). These two PEISs were conducted by DOE for multi-state areas. This Final PEIS also uses the 20% threshold as the criterion for "meaningfully greater."

***Screening Analysis***. Table 3.6-3 shows data for minority populations for the project area and Table 3.6-4 shows the Alabama, Kentucky, Mississippi, South Carolina, and Tennessee as the least affluent states in the project area as defined by median family income and per capita income. Table 3.6-5 provides the poverty guidelines per the 2011 Census Bureau Poverty Rates. Within the project area, only Virginia has figures for Median Family Income and Per Capita Income that exceed the national figures, and only Virginia has a poverty rate that is lower than the national rate. Of the remaining states in the project area, Georgia, North Carolina, and Florida have the next highest levels of Median Family Income and Per Capita Income. Poverty rates are variable but relatively similar (17.0% to 19.9%) except for Mississippi, which has a poverty rate of 22.6% for all individuals. It is important to note that poverty rates for certain populations can be much higher. For instance, the national poverty rate for families with a female householder, with no husband present, and with related children under 5 years of age, is 47.9%. Table 3.6-4 shows data on individuals below the poverty level. These tables also show the corresponding data for the United States, which is the comparison area, or reference population, for the screening analysis. In both tables, the data are expressed as a percentage of the total population. For this screening analysis, the convention noted above has been adopted: if the minority population or population in poverty is over 50%, or is 20 percentage points or more greater than for the reference population, the area is "flagged" as an environmental justice population.

Tables 3.6-3 and 3.6-4 show that the "all minorities" population and the population in poverty do not exceed 50% in any of the states in the project area, nor are these populations 20 percentage points greater than they are for the corresponding U.S. populations. Therefore, according to CEQ guidelines, these states do not have minority or low-income populations for the purposes of environmental justice consideration *at the state level.*

Table 3.6-3 shows that for the Black /African American population specifically, this population as a percentage (37.4%) of the general population in Mississippi is more than 20% greater than the reference U.S. population (12.6%). Thus, the Black /African American population in Mississippi is considered a minority population, at the state level, for the purposes of environmental justice consideration.

It should also be noted that according to the CEQ guidance for considering environmental justice within the NEPA process, Indian tribes in the project area should be considered in the environmental justice analysis. There are many tribes in the project area (500 Nations, 2013) and a number of Federal Indian Reservations (U.S. Bureau of Indian Affairs, 2013). Further, minority and/or low-income agricultural workers, particularly migrant workers, constitute a potential environmental justice population given the agricultural nature of the proposed action.

The presence, or lack thereof, of environmental justice populations at the state level according to the definitions used in this chapter, does not imply any findings regarding the likelihood of disproportionately high and adverse effects on these populations. The existence of environmental justice impacts depends on both the presence of a relevant population, and the nature of the action under consideration. The latter is considered in Chapter 4, Environmental Consequences. Further, environmental justice populations are best identified as part of the analysis for specific actions at specific locations, conducted under NEPA at the implementation level.

### 3.6.2.7 Societal Views of Bioengineering Crops

Socioeconomic analysis may include consideration of general societal views and attitudes about biotechnology in relation to a Proposed Action. These views and attitudes are a broad and complex topic. The USDA APHIS PEIS, *Introduction of Genetically Engineered Organisms* (2007), identifies the following key themes among society's varying views on biotechnology (GE products):

- Potential benefits of biotechnology – A wide variety of genetic modifications to crops could increase yields, improve nutritional content or other valuable plant products, reduce input and management costs of production, increase stress tolerance, and provide other useful characteristics. These developments would provide economic and social benefits and thus are of interest to many stakeholders.

- Public's perception of risk – Members of the public have many concerns about biotechnology, particularly in relation to GM food crops. Understanding of biotechnology and associated risks varies widely across society. Views may be based on perceptions and stigmas rather than facts.

- Choices people have regarding biotechnology – Some members of the public are concerned that consumers would have reduced choices due to adoption of biotechnology-derived products (e.g., an inability to obtain non-GE products). This contributes to the gap between scientific thought and public acceptance of biotechnology.

- Distribution of benefits and burdens or risks of biotechnology across society – There are many disputes about how different groups in society receive benefits or are subject to burdens and risks from biotechnology. For instance, there are concerns that the benefits accrue to large farms and are less available to smaller, family farms. Some members of the public are concerned that scientists might unknowingly create food allergens through genetic engineering, and this might particularly impact infants and children.

These themes have limited applicability to this Final PEIS for the proposed EHECs for two main reasons. First, many of these concerns have to do with GE plants that enter the food system. The proposed EHECs for confined field trials would not enter the food system as the development of the EHECs is intended for biofuel production. Second, the scope of this Final PEIS is limited to the research and development (R&D) phase of EHEC development; specifically, confined field trials. Many of the themes noted above—particularly those related to choices and to the distribution of benefits and risks—have to do with commercialization of GE plants, not with R&D.

Some members of the public may have concerns about potential release into the environment of GM material at the R&D phase. However, the confined field trial protocols that would be required under the proposed EHEC Programs, and which have been widely approved and used in R&D efforts reviewed under NEPA for other GM plants would minimize the risk of such release. An additional societal concern about biofuel plants in particular is the potential for their production to displace production of plants used for food or animal feed, potentially resulting in food shortages, food price increases, and other impacts (Pimentel, et al., 2009).

## 3.7 Wildfires

### 3.7.1 Definition of the Resource

A wildfire is a large, uncontrolled fire that spreads quickly from its original source over an area. The USFS defines a wildland fire as any non-structure fire, other than a prescribed burn, that occurs in the wildland and a large incident as a "wildfire of 100 acres or more occurring in timber, or a wildfire of 300 acres or more occurring in grass or sage" (U.S. Forest Service, 2013). Both living and dead plant material serve as the primary fuel for wildfires. A plant's flammability is its ability to ignite and transfer heat or flames to surrounding plants (or structures). Leaves and small branches ignite first and begin to burn rapidly as the fire spreads and advances to larger branches (or structures). Plants ignite and burn at different rates and intensities depending on the leaf characteristics, including moisture content; structure (shape, size, and thickness); and chemical characteristics (presence of oils, resins, and terpenes).

Wildfires are characterized in terms of the cause of ignition, physical properties (e.g., propagation speed), weather impacts (e.g., wind, lack of rain), and presence of combustible vegetative or human-made fuels or materials. Vegetative fuels include any organic biomass with the capacity to burn, such as a tree's needles or leaves, branches, roots, and trunks; shrubs; grasses; and dead or decaying materials. Human-made fuels are those items originating from humans that can contribute to igniting fires, such as structures (e.g., buildings, debris, fences, woodpiles, carports) near or adjacent to vegetative areas.

### 3.7.2 Existing Conditions

This summarizes the conditions of the project area relative to wildfire potential (e.g., general vegetation, human activities, and fire characteristics of the vegetation communities). This section also provides information on the natural fuel components of EHECs, and an overview of recent wildfires in the Southeastern United States and how the National Fire Danger Rating System assesses fire danger. In addition, general descriptions for fire prevention management are identified. Sections 3.1 and 3.5 provide information on forested lands in the project area.

#### 3.7.2.1 Wildfire Vegetation Concerns

A general overview of the vegetation found in each ecoregion within the project area is identified in Section 3.5. Vegetation in the project area includes bottomland forests; southern mixed forests; a variety of pines (loblolly, shortleaf, and white); and some grasses. The following provides a description of specific vegetation responses to wildfires.

The fire resistance of loblolly pine increases with bark thickness and tree diameter as it ages. Young loblolly pines have relatively thin bark and are susceptible to bark removal (or girdling) by fire until they are approximately four inches in diameter (Extension Forest Resources Department, 1990). Loblolly pines do not regenerate, or resprout, from the root collar when they are topkilled by fire. However, widespread establishment of both loblolly and shortleaf pine seedlings often occurs following fires (Cain & Shelton, 2002).

Hardwood responses to fire can vary greatly among species. For example, many mature oaks and hickories have relatively thick bark. In contrast, species such as red maple, sweetgum, and American beech have thinner bark and are presumably more likely to be girdled by fires (Marshall, Wimberly, Bettinger, & Stanturf, 2008). Hardwood leaves are the dominant fuel source in oak-hickory forests. The timing of fire seasons can vary widely from year to year due to the rapid drying of hardwood leaves; however, fires are most common in the fall when fuel loads (fallen leaves) are heaviest. Fire has become an increasingly valuable tool for landowners in managing oak-hickory-pine forests. Oak and hickory trees tend to invest more energy in root development than other tree species; therefore, regeneration, or resprouting, can be enhanced with understory burns of the right intensity. Timing of the fire treatment, however, is critical. Once seedlings have become established and grown to have a hearty root mass, fires can serve to decrease the less fire-tolerant species that otherwise outcompete oak and hickory seedlings (Wade, et al., 2000).

Fires do not frequently occur in bottomland hardwood forests; they typically occur only once per 100 years (Ober, 2013). Prescribed burns in bottomland hardwood forests are considered harmful to both plants and animals and are not advised as a management practice (Ober, 2013). Southern mixed forests are characterized by medium-tall to tall forests of broad leaf deciduous and needle leaf evergreens. Pine species make up about 50% of the stands. Broad leaf deciduous trees are generally considered fire-resistant plants, whereas needle leaf evergreens are flammable and have a low tolerance for fires. Deciduous plants do not readily ignite during the winter months because they have no leaves to burn. Most deciduous trees and shrubs have moist, supple leaves and tend not to accumulate dry, dead material within the plant (Frost, 2005). On the contrary, needle leaf evergreens contain leaves that ignite and burn at a higher rate due to their chemical and structural characteristics. For example, the fact that pine needles are attached at the base increases their likelihood of being caught on small branches as they fall, and the flammability of shrubs and small trees increases as needles accumulate (Doran, Randall, & Long, 2004).

Main grasses in the area include bluestem, panicums, and longleaf niola. Perennial herbaceous crops are often tolerant of wildfires and extreme temperatures as their roots are protected under the soil; perennial grasses, in particular, may be able to penetrate an area after a fire (D'Antonio & Vitousek, 1992).

A component for some EHECs is the production of terpenes. Terpenes are the energy-dense fuel molecules derived from turpentine, a viscous pleasant smelling substance that flows from some pine tree species (Pinaceae) when the bark or new wood is cut or carved. Terpenes are the main component for many essential oils from plant and tree species, such as conifer wood, citrus fruits, coriander, eucalyptus, lavender, lemongrass, lilies, carnations, roses, rosemary, sage, and thyme, known for their pleasant smell, spiciness, or exhibiting specific pharmacological activities. There are over 30,000 varieties of natural terpenes (Breitmaier, 2006). Pine trees naturally produce around 3% to 5% terpene content. Some EHECs are aiming to increase the terpene storage potential and production capacity coupled with improved terpene composition to a point at which the trees could be tapped while alive, similar to sugar maple trees, to harvest and distill into an increased volume of turpentine. Conifers and pine cones are highly flammable and burn well due to their terpene content.

### 3.7.2.2 Recent Wildfires in the Southeastern United States

The warm weather in the Southeastern region of the United States, in addition to low humidity and high winds, greatly contributes to wildfire activities (Reed M. J., 2013). Findings in the 2008 *Fire in the South 2: The Southern Wildfire Risk Assessment* report identified that not only does the South (comprised of this Final PEIS' project area and Arkansas, Louisiana, Oklahoma, and Texas) have the highest number of wildfires per year than any other region in the U.S. (2002-2006), it has more than 5 million acres at high risk of wildfire (Southern Group of State Foresters, 2008). Drought conditions tend to increase fire frequency and size, with wetter years having fewer fires.

Water availability is a concern for not only irrigation for crops but also in the prevention and mitigation of wildfires. As described in Section 3.3, Water Resources, the project area experienced unusually good water availability conditions for almost four decades prior to noteworthy droughts in the past several years. Recent droughts, such as the one experienced in 2007, illustrate the Southeast's vulnerability to wildfires. Table 3.7-1 provides a listing of wildfire highlights for the project area over the past decade.

**Table 3.7-1: Wildfire Highlights for the Southeastern United States, 2003-2013**

| State | Year | Information |
|---|---|---|
| **Alabama** | March 2007 | Wildfires burned nearly 1,000 acres each day |
| **Florida / Georgia** | April – June 2007 | 124,584 acres burned in and around Okefenokee Swamp (known as the Bugaboo Scrub Fire) |
| **Georgia** | Spring 2004 | Averaged over 100 wildfires daily over a 30-day period |
| **North Carolina** | 2008 | 302 fires burned 9,400 acres in 1-day (almost half the 10-year average for annual burns) |
| **South Carolina** | 2009 | Largest wildfire in 30 years burned 19,130 acres |
| **Tennessee** | June 2007 | 2,000 fires burned 33,000 acres (typical amount for an entire year) |

*Source:* (Southern Group of State Foresters, 2008); (Marshall, Wimberly, Bettinger, & Stanturf, 2008)

### 3.7.2.3 National Fire Danger Rating System

In the United States, the USFS manages the National Fire Danger Rating System (NFDRS) to gauge potential burning conditions and fire threats. Created in 1977 and refined in 1984, the Fire Danger Rating levels consider current and antecedent weather, fuel types, and both live and dead fuel moisture (Bradshaw, Deeming, Burgan, & Cohen, 1984). The USFS developed the Wildland Fire Assessment System (WFAS-MAPS), a model that takes into account these Fire Danger Rating levels (weather forecasts, fuel types, and live and dead fuel moisture) to produce daily national maps of current and forecasted fire dangers based on assessments at reporting fire weather monitoring stations. Fire weather monitoring stations are typically automated sensors to collect information on precipitation, wind speed and direction, air temperature, relative humidity, and fuel moisture. As defined by the WFAS-MAPS, class ratings are a method of normalizing rating classes across different fuel models, indexes, and monitoring station locations. Based on the primary fuel model cataloged for each monitoring station, the fire danger index selected reflects staffing levels and the climatology of the area (U.S. Forest Service, n.d.). Table 3.7-2 provides the Fire Danger Rating levels and color codes for the NFDRS.

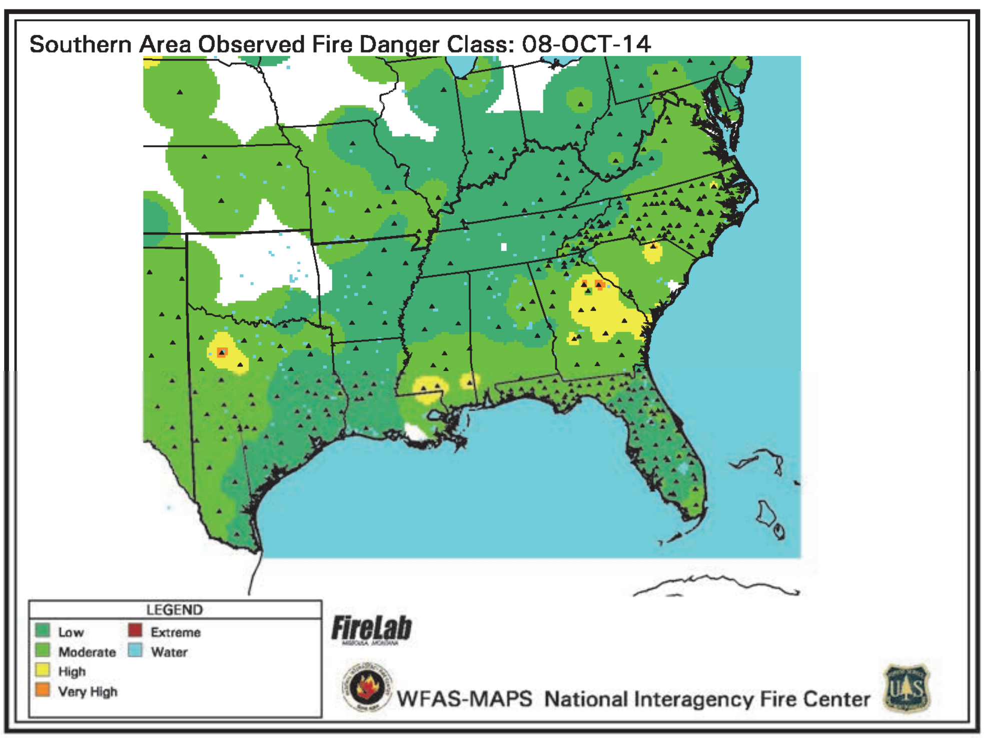
The NFDRS produces regional and nationwide seven-day fire danger forecast maps. For this Final PEIS, the NFDRS Southern Area covers the entire project area (and includes other states). Figure 3.7-1 provides an example NFDRS map for the Southern Area (comprising the Final PEIS project area illustrating areas with very high, high, moderate, and low fire dangers).

**Table 3.7-2: Fire Danger Rating System Color Codes and Descriptions**

| Danger Rating - Color Code | Description |
|---|---|
| **Low (L)** – Dark Green | Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start a fire. Fires in open (dry) grasslands may bum freely a few hours after rain. Wood fires spread slowly by creeping or smoldering and burn in irregular fingers. Little danger of spotting. |
| **Moderate (M)** – Light Green | Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of fire starts is low. Fires in open (dry) grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. Average fire is of moderate intensity, although heavy concentrations of fuel may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and can be controlled relatively easily. |
| **High (H)** – Yellow | All fine dead fuels (e.g., grass, leaves, needles, etc.) ignite readily; fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and difficult to control unless attacked successfully while small. |
| **Very High (VH)** – Orange | Fires start easily, spread rapidly, and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels. |
| **Extreme (E)** – Red | Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high intensity burning will usually be faster and occur from smaller fires than in the Very High rating. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable during extreme burns. The only effective and safe control is on the flanks until the weather changes or the fuel supply lessens. |

*Source:* (Bradshaw, Deeming, Burgan, & Cohen, 1984)

**Figure 3.7-1: Example of a Fire Danger Map**




*Source:* (U.S. Forest Service, n.d.)

### 3.7.2.4 Fire Prevention Management

The management of fire prevention coupled with the ability to control the spread of fires can help with the survival of non-fire dominant plants, animals, and native ecosystems. Fire prevention management includes education, engineering, enforcement, and ignition control. Fire prevention actions are designed to reduce conflicting activities and threats to life and property and for the conservation of natural resources. Education and engineering are vital components of a successful fire prevention program.

Many states utilize various landscape management techniques or prescribed burns. Homeowners are encouraged to create areas of defensible space between natural vegetated or landscaped areas and their homes to serve as a fuel break, or a break in the continuity of plants (Doran, Randall, & Long, 2004). Another approach is the use of prescribed burns to reduce or remove dense vegetation that can be a fuel for wildfires. Prescribed fires are managed burns over an area following specific guidelines to help reduce the existing vegetation (fuel) and the likelihood that an area will be damaged by wildfires (Southern Group of State Foresters, 2008).

Enforcement and ignition control play an integral role in fire prevention management. Debris burning and arson are the leading causes of wildfires for states in the Southeastern U.S. (Marshall, Wimberly, Bettinger, & Stanturf, 2008). Each state in the project area engages in law enforcement activities to conduct investigations to determine the origin and cause of each wildfire. For example, the Georgia Forestry Commission employs law enforcement investigators to combat Georgia's arson problem and enforce the state's forestry burn permit laws (Georgia Forestry Commission, 2005). States have developed specific tools, such as the Florida Fire Management System Mapping Tool, to identify the location of existing/active wildfires as well as all open burn authorizations planned on any particular day. Although these tools in conjunction with the previously discussed fire prevention actions may not completely deter the occurrence of fires, they do offer a cost-effective solution to reduce the number and severity.

## 3.8 Air Quality

### 3.8.1 Definition of the Resource

Air quality is determined by the type and amount of pollutants emitted into the atmosphere, the size and topography of the air basin, and the prevailing meteorological conditions. The levels of pollutants are generally expressed by concentration units of parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$) determined over various periods of time (averaging periods).

The significance of a pollutant concentration in a region or geographical area is determined by comparing it to Federal or state ambient air quality standards. Under the authority of the Clean Air Act (CAA), EPA established nationwide air quality standards to protect public health and welfare, with an adequate margin of safety. These Federal standards, known as the National Ambient Air Quality Standard (NAAQS), represent the maximum allowable atmospheric concentrations and were developed for six criteria pollutants: ozone ($O_3$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), particulate matter less than 10 micrometers in diameter (PM10), particulate matter less than 2.5 micrometers in diameter (PM2.5), sulfur dioxide ($SO_2$), and lead (Pb). Short-term standards (1-hr, 8-hr, or 24-hr periods) were established for pollutants with acute health effects. Long-term standards (annual periods) were established for pollutants with chronic health effects and these standards may not be exceeded if a region is to maintain an attainment status.

Based on measured ambient criteria pollutant data, the EPA designates areas of the U.S. as having air quality equal or better than the NAAQS (attainment) or worse than the NAAQS (nonattainment). Upon achieving attainment, areas are considered to be in maintenance status for a period of 10 or more years. Areas are designated as unclassifiable for a pollutant when there is insufficient ambient air quality data for the EPA to form a basis of attainment status. For the purpose of applying air quality regulations, unclassifiable areas are treated similar to areas that are in attainment of the NAAQS.

Hazardous air pollutants (HAPs) are pollutants that can impact human health or adverse environmental and ecological effects. Exposure to these pollutants may cause cancer or other serious health effects, such as reproductive effects or birth defects, in humans. Federal air quality management programs for HAPs focus on establishing emission limits for particular industrial processes rather than setting ambient exposure standards (i.e., National Emission Standards for Hazardous Air Pollutants (NESHAPs)). Some states have established ambient exposure guidelines for various HAPs and use those guidelines as part of the permit review process for industrial emission sources.

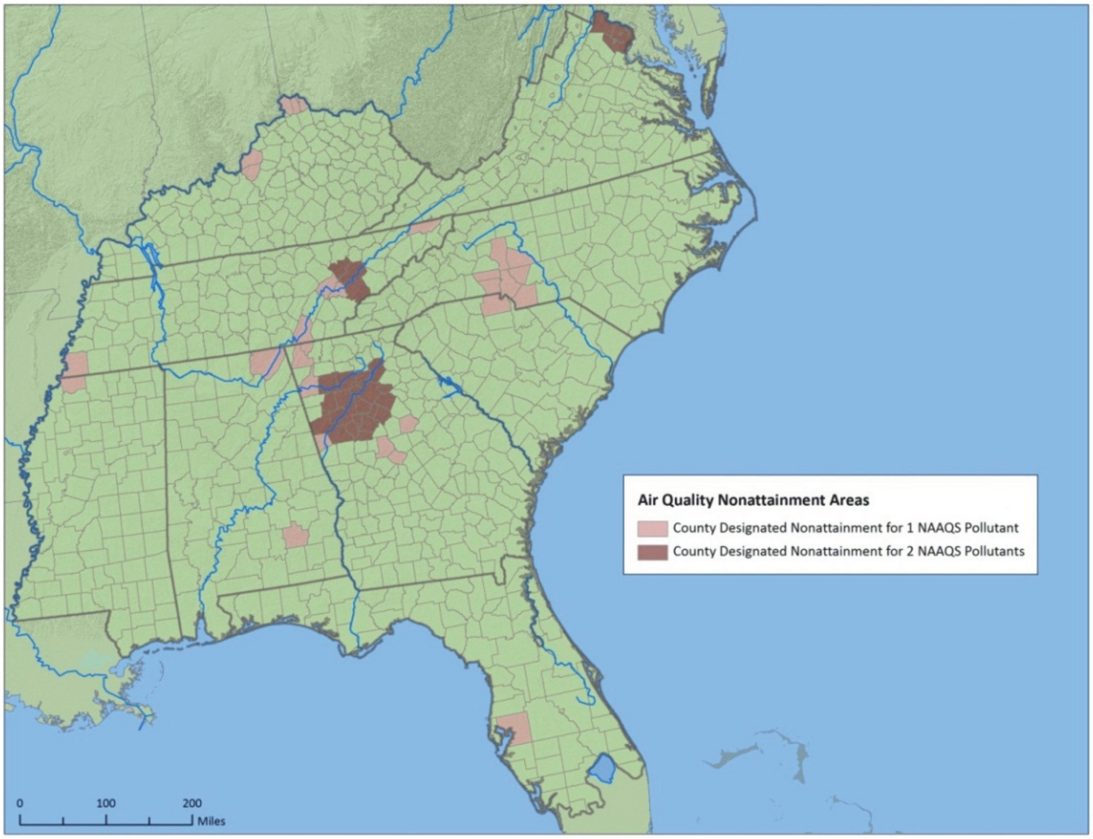
### 3.8.2 Existing Conditions

All areas within a state are designated with respect to each of the six pollutants as attainment (i.e., meeting the NAAQS), nonattainment (i.e., not meeting the NAAQS), or unclassifiable (i.e., insufficient data to classify). Some attainment areas are further classified as maintenance areas. These areas were previously classified as nonattainment but have successfully reduced air pollutant concentrations to below the standards; maintenance areas must continue compliance with the NAAQS and remain subject to certain planning requirements. The purpose of the nonattainment designation is to identify air quality problem areas for which the state and the EPA must find solutions. This Final PEIS focuses on a state review because air quality is managed by each state and not ecoregions. The following information regarding attainment and nonattainment areas was obtained from *The Green Book Nonattainment Areas for Criteria Pollutants* (Environmental Protection Agency, 2013g). Figure 3.8-1 shows the project area and counties that are in nonattainment for the NAAQS.

***Alabama.*** Alabama is in attainment for all criteria pollutants except lead and $PM_{2.5}$. A portion of Pike County is nonattainment for the 2008 lead standard while a portion of Jackson County, which borders Georgia-Tennessee, is designated as nonattainment for the 1997 $PM_{2.5}$ standard.

***Florida***. Hillsborough County is nonattainment for the 2008 lead standard. Nassau and Hillsborough counties are nonattainment for the 2010 $SO_2$standard. All other counties are in attainment for all the criteria pollutants.

**Figure 3.8-1: Location of Nonattainment Counties in the Project Area**




***Georgia***. Georgia is in attainment for the criteria pollutants except ozone and fine particulate matter. 27 counties (including three partial counties) are nonattainment for the 1997 $PM_{2.5}$ standard. EPA designated 15 counties in Georgia as nonattainment for the 2008 8-hr ozone standard and 20 counties for the 1997 8-hr ozone standard. According to the report *The State of Georgia's Environment-2009*, more than 55% of the state's population lives in counties where the ozone levels exceed the NAAQS and nearly 58% live in areas where levels of fine particulates exceed the NAAQS.

***Kentucky***. Bullitt and Jefferson County are in nonattainment for the 1997 $PM_{2.5}$ standards. Campbell County is in nonattainment for the 2010 $SO_2$standard. Boone, Campbell, and Kenton County are nonattainment for the 8-hr ozone 2008 standard.

***Mississippi***. In Mississippi, part of De Soto County is nonattainment for the 2008 8-hr ozone standard. The rest of the state is in attainment for all criteria pollutants.

***North Carolina***. Carbarrus, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, and Union counties are classified as nonattainment for the 1997 and 2008 8-hr ozone standard. Mecklenburg, Durham, Wake, and Forsyth counties are nonattainment for the CO standard. The remainder of the state is in attainment for all criteria pollutants.

***South Carolina.*** York County in South Carolina is nonattainment for the 2008 8-hr ozone standard. The remainder of the state is in attainment for all criteria pollutants.

***Tennessee***. Anderson, Blount, Hamilton, Knox, Loudon, and Roane counties are all in nonattainment for the 1997 $PM_{2.5}$ standard. Anderson, Blount, Knox, Loudon, and Roane County are in nonattainment for the 2006 $PM_{2.5}$ standard. Sullivan is the only county in nonattainment for the 2008 lead standard and the 2010 sulfur dioxide standard. Shelby County is in nonattainment for the CO standard. Anderson, Blount, Knox, and Shelby County are nonattainment for the 2008 8-hr ozone standard.

***Virginia***. The Northern Virginia area, including the independent cities and counties of Alexandria, Arlington, Fairfax, Falls Church, Loudoun, Manassas, Manassas Park, and Prince William, is in nonattainment for the 1997 $PM_{2.5}$ standard, in addition to the 1997 and 2008 8-hr ozone standards. Alexandria and Arlington counties are in nonattainment status for carbon monoxide.

#### 3.8.2.1 Air Quality and Agriculture

The issues surrounding air quality and the agriculture industry involve the activities used to cultivate and harvest crops. Fuel combustion emissions would result from the use of heavy vehicles such as tractors during typical tillage, harvesting, and pesticide application, as well as from vehicles used to haul equipment and personnel. Combustion pollutants include ozone and particulate matter, with the latter also contributing to airborne soil particulates caused by plowing drier soils, unimproved road dust, and wind erosion of exposed soils. Sulfur dioxide emissions, from the burning of sulfur-containing diesel fuel, are also an air quality issue. In 2004, the EPA announced the Nonroad Diesel rule to address $SO_2$emissions by reducing the sulfur content in diesel fuel used in nonroad engines including nonroad engines used by the agricultural industry. The rule reduced sulfur levels in fuel from 3,000 ppm to 15 ppm, also known as ultralow sulfur fuel. This ultralow sulfur fuel enables engine manufacturers to use advanced emission control systems in nonroad engines that provide a higher control of NOx and PM emissions.

Other potential impacts on air quality can arise from traffic and harvest emissions, pesticide drift from spraying, smoke from agricultural burning, and nitrous oxide emissions from the use of nitrogen fertilizer as well as odors and allergens (Fawcett & Towery, 2002). Agricultural practices for both conventional and GE crops have the potential to directly and indirectly affect air quality through the introduction of soil particulates into the air during the planting and harvesting of crops and emissions from internal combustion engines used to plant, maintain, and harvest those crops.

## 3.9 Safety and Human Health

### 3.9.1 Definition of the Resource

As a resource topic, human health and safety is concerned primarily with potential exposure of humans to physical hazards and hazardous chemicals related to EHEC production and harvesting. Farmers are at high risk for fatal and nonfatal injuries, work-related lung diseases, noise-induced hearing loss, skin diseases, and certain cancers associated with chemical use and prolonged sun exposure. Farming is one of the few industries in which families (who often share the work and live on the premises) are also at risk for injuries, illness, and death (Centers for Disease Control and Prevention -- National Institute for Occupational Safety and Health, 2012).

The types of hazards that could affect public health and safety away from the work site include increased concentrations of particulate matter and other criteria air pollutants, additional noise, and offsite exposure due to release of chemicals. Sections 3.8 and 3.11.5 of this Final PEIS discuss the existing air quality and noise environments, respectively.

The Proposed Action involves research, development, and demonstration activities involving the planting and harvesting of EHECs in the Southeastern United States. This Final PEIS describes safety and health in three areas:

- Industrial health and safety, focusing on occupational and worker hazards;
- Public health and safety, focusing on hazards that could affect communities near the Proposed Action; and
- External issues or concerns regarding public health and safety deemed "intentional destructive acts," (e.g., acts of sabotage or terrorism).

## 3.9.2 Existing Conditions – Industrial Health and Safety

Industrial health and safety is concerned with occupational and worker hazards during routine operations. The U.S. Department of Labor, Bureau of Labor Statistics (BLS) maintains statistics on workplace injuries, illnesses, and fatalities. The crop production industry is a subset within the agriculture, forestry, and fishing industries. The subsector comprises establishments, such as farms, orchards, groves, greenhouses, and nurseries that are primarily engaged in growing crops, plants, vines, or trees and their seeds. Worker hazards associated with crop production include use of equipment, exposures to agricultural chemicals, and exposure to plant materials.

### 3.9.2.1 Physical Hazards

Agriculture ranks among the most dangerous industries--between 2003 and 2011, 5,816 agricultural workers died from work-related injuries in the United States (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)). Compared to other private-sector occupations, agricultural workers and their families (who often share the work and live on the premises) encounter a disproportionate number of injuries and diseases associated with physical, chemical, and biologic hazards (Centers for Disease Control and Prevention -- National Institute for Occupational Safety and Health, 2012). The BLS reports that there were 204 fatal occupational injuries in U.S. crop production, including support activities for crop production, in 2012 (U.S. Department of Labor -- Bureau of Labor Statistics, 2013) and another 20,100 workers were temporarily or permanently disabled as the result of injuries related to crop production and support activities (U.S. Department of Labor -- Bureau of Labor Statistics, n.d.).

Agriculture ranks among the most dangerous industries. Between 2003 and 2011, 5,816 agricultural workers died from work-related injuries in the U.S. (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)). The number of injuries reported is likely lower than actual since farmworker fatalities and injuries tend to be underreported. It is also not always possible to link the cause of death with the original injury (e.g., a 1996 farmworker injury may not be recorded as linked with a 2009 death) or the injury with a worksite (e.g., headache) (Bon Appetit Management Company

Foundation, 2011). The most typical sources of physical hazards include tractor accidents, respiratory hazards, and high noise levels.

***Tractor Accidents.*** Farm tractor overturns accounted for 1,533 of the fatal occupational injuries between 2003 and 2011 and were the leading source of deaths in the agriculture, forestry, and fishing industries. The most effective way to prevent tractor overturn deaths is the use of Roll-Over Protective Structures; however, in 2011 only 59% of tractors used on farms in the U.S. were equipped with these devices (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(c)).

***Respiratory Distress.*** Changes to farming mechanisms have both improved working conditions and increased exposure to respiratory hazards—mainly due to the decreased density in animal confinement. Farmworkers' most common respiratory hazards are bioaerosols, such as organic dusts, microorganisms, and endotoxins and chemical toxicants from the breakdown of grain and animal waste. Inorganic dust, from silicates in harvesting and tilling, is prevalent but less common (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)). A Danish study showed that elevated worker exposure to dust, endotoxin, fungi, and aspergillus leads to a higher instance in respiratory diseases (Schlünssen, Madsen, Skov, & Sigsgaard, 2011). Other environmental factors such as respiratory problems due to smoke inhalation and exposure to agrochemicals in air, soil, and water are a concern for people employed in the biofuel industry and are contributing factors to the higher levels of respiratory illness (Nobre & Nobre, 2011).

***Noise-Induced Hearing Loss.*** Thousands of workers every year suffer from preventable hearing loss due to high workplace noise levels. Research has shown that those who live and work on farms have had higher rates of hearing loss than the general population. In fact, farming is among the occupations recognized as having the highest risks for hearing loss. Tractors, forage harvesters, silage blowers, chain saws, skid-steer loaders, and grain dryers, are some of the most typical sources of noise on the farm. Studies suggest that lengthy exposure to these high sound levels have resulted in noise-induced hearing loss to farmworkers of all ages, including teenagers. (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a))

***Injuries.*** Farmworkers routinely use knives, hoes, and other cutting tools; work on ladders; or use machinery in their shops. However, these tools can be hazardous and have the potential for causing severe injuries when used or maintained improperly. Ladders and falls are a major source of death and injury to farmworkers. According to BLS, agricultural workers had a non-fatal, fall-related injury rate of 48.2 per 10,000 workers in 2011—higher than the same type of industry rates in the transportation, mining, or manufacturing industries. Between 2007 and 2011, 167 agricultural workers' deaths were due to falls. Workers in crop production typically use repetitive motions in awkward positions that can cause musculoskeletal injuries. Frequent or heavy lifting, pushing, pulling, carrying of heavy objects, and prolonged awkward positions are all risk factors for injury. Vibration and cold might intensify the potential for and magnitude of injury (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)).

### 3.9.2.2 Chemical Hazards

Given the nature of this document, it is not possible to know which specific chemicals would be used under the Proposed Action. Therefore, this section discusses common chemicals used in crop production.

The most common chemical hazards associated with crop production are from pesticides. Because EHECs are new crops grown on limited acreage in the United States, currently no pesticides are specifically labeled for use. The lack of commercial perennial grass production as biofuel feedstock also makes it difficult to predict how much pesticide or which type would be needed for implementation of the Proposed Action and alternatives.

***Pesticides.*** Pesticides are synthetic organic chemicals used to control weeds in fields and lawns, and unwanted or harmful pests. Pesticides are divided into categories based on their target organisms, including herbicides, insecticides, and fungicides. Under United States law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant (Environmental Protection Agency, 2012d). By their nature, most pesticides create some risk of harm. Pesticides can cause harm to humans, animals, or the environment because they are designed to kill or otherwise adversely affect living organisms. At the same time, pesticides are useful to society by destroying disease-causing organisms and controlling insects, weeds, and other pests (O'Donoghue, et al., 2011).

Pesticides are composed of active ingredients (the chemicals of primary toxicological concern) and inert ingredients (e.g., adjuvants, surfactants, preservatives, solvents, diluents, thickeners, and stabilizers). An active ingredient is one that prevents, destroys, repels, or mitigates a pest, or is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. By law, the active ingredient must be identified by name on the pesticide product's label together with its percentage by weight. All other ingredients in a pesticide product are called inert ingredients. An inert ingredient means any substance (or group of similar substances) other than an active ingredient that is intentionally included in a pesticide product. Called "inerts" by the law, the name does not mean non-toxic. Inert ingredients play key roles in the effectiveness of pesticides, such as to prevent caking or foaming, extend product shelf life, or allow herbicides to penetrate plants. The only inert ingredients approved for use in pesticide products applied to food are those that have either tolerances or tolerance exemptions in 40 CFR Part 180 (the majority are found in sections 180.910 – 960) (Environmental Protection Agency, 2012d).

Due to the predominance of pesticide use in agricultural practices, and studies linking pesticide exposure to health effects there is a concern for the safety of farm workers. According to the Centers for Disease Control and Prevention (CDC), the EPA estimates that 10,000-20,000 physician-diagnosed pesticide poisonings occur each year among the approximately 2 million U.S. agricultural workers (Centers for Disease Control and Prevention -- National Institute for Occupational Safety and Health, 2013a). According to the CDC, rates of acute pesticide poisoning are common in the Southeastern U.S. However, they are not as high as in other areas of the U.S. (Centers for Disease Control and Prevention -- National Institute for Occupational Safety and Health, 2013b).

Workers can be exposed to pesticides when:

- Preparing the pesticides for use, such as by mixing a concentrate with water or loading the pesticide into application equipment;
- Applying the pesticides; and
- Entering an area where pesticides have been applied to perform tasks.

***Handling and Storage.*** Workers who mix, load, or apply pesticides (known as pesticide handlers) can be exposed to toxic pesticides due to spills and splashes, defective, missing, or inadequate protective equipment, direct spray, or drift. Workers in areas that have been treated with pesticides face exposure from direct spray, drift or contact with pesticide residues on the crop or soil (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)). Chemicals must be properly labeled so that farmworkers know the identity and hazards of the chemicals they may be exposed to at work. The Occupational Safety and Health Administration (OSHA) provides information to assist employers and workers ensure that hazard communication is properly addressed in their workplaces. In addition, certain OSHA standards address hazard communications. Employers must train employees on the potential hazards (e.g., chemical or physical) present at the site. Hazard communication programs are implemented to train employees to recognize hazards, to use protective measures (e.g., personal protective equipment [PPE]), and to perform proper actions during an emergency. Medical surveillance may be necessary if overexposure to chemicals becomes apparent. Chemical safety and handling is also addressed by maintaining: (1) a general reduced chemical use policy, (2) current chemical information, (3) first aid training and materials, (4) symptom awareness training, and (5) proper procedures for chemical storage and disposal. Specific state and Federal programs and rules developed for worker safety and use of chemicals protect laboratory workers from exposure to chemicals at potentially hazardous concentrations (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)).

***Application.*** Pesticides can present a hazard to applicators, to harvesters reentering a sprayed field, to family members due to take-home contamination, and to rural residents via air, groundwater, and food. Pesticides can be applied before the crop emerges from the ground (preemergence) or after (postemergence). Preplant incorporated pesticides are those that are mixed in with the soil before planting. In selecting a pesticide and application method, a grower must consider, among other factors, whether a pesticide may be used on the crop because it has been registered by the EPA, the potential adverse effects on the crop, residual effects that can limit crops that can be grown in rotation, effectiveness on expected weeds, and cost (Environmental Protection Agency, 2012d). Pesticide application methods include:

- <u>Sprayers</u>, which are implements or vehicles used to apply liquid crop chemicals, most often pesticides, and increasingly, fertilizers. Sprayers typically include a tank, pump, plumbing, valves, a boom, and nozzles. Sprayers can be mounted on a tractor or other implement, pulled by a tractor, self-propelled, or mounted on airplanes or helicopters. Spot treatment by hand can also be performed with a backpack sprayer (Environmental Protection Agency, 2012d).

- <u>Aerial application</u>, which involves pesticide application from an airplane. When properly managed, aerial application offers speed of dispersal, accessibility to crops on areas where ground equipment cannot operate, and reasonable cost. In many cases, aerial application also allows more timely applications and, therefore, better utilization of pesticides. Limitations on aerial application include weather hazards, fixed obstacles such as radius towers, field size and shape, the distance from the point of application to the landing area, and the danger of contamination of nearby areas due to drift or misapplication (Environmental Protection Agency, 2012d).

- <u>Chemigation</u> is a growing practice in many areas of the country wherein pesticides are applied through irrigation systems. Although there are systems specifically designed for chemigation, in most cases an existing irrigation system is modified to mix the chemical with irrigation water. Concerns about groundwater contamination from this practice arise from accidental backflow; siphoning of chemicals into wells can occur when the irrigation pumping system shuts down unexpectedly (Environmental Protection Agency, 2012d).

Workers may be exposed to pesticides in a variety of ways, including: working in a field where pesticides have recently been applied; breathing in pesticide "drift" from adjoining or nearby fields; working in a pesticide-treated field without appropriate PPE; eating with pesticide-contaminated hands; eating contaminated fruits and vegetables; and eating in a pesticide-contaminated field. Workers may also be exposed to pesticides if they drink from, wash their hands, or bathe in irrigation canals or holding ponds, where pesticides can accumulate (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)).

***Direct Chemical Exposure.*** Direct intake of or contact with pesticides by workers can occur through the skin (dermal), by inhalation (to the lungs), orally (through the mouth), or into the eyes. Various indirect pathways exist, such as hand to mouth or eye contact and tracking pesticides from shoes and clothing into vehicles and homes. The intake amount can be affected by myriad factors, including form of the pesticide (e.g., liquid, powder, granulated), application method, frequency, and duration of application, use of protective equipment, and weather (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(a)).

***Current Pesticide Use in the United States.*** Hundreds of millions of pounds of pesticides are applied to agricultural crops every year to control weeds, insect infestations, plant diseases, and other pests. Annually, the total amount of conventional pesticides (excluding sulfur, petroleum oil, chlorine, hypochlorites, and wood preservatives) applied to crops grown throughout the conterminous United States has increased from a low of about 698 million pounds in the early 1990s to a high of over 800 million pounds in 1996. From 1996 through 2007, there was a slight downward trend in the total amount of pesticides used, reflecting decreases in the use of pesticides, plant growth regulators, and other conventional pesticides (Thelin & Stone, 2013).

***GE Crops and Pesticide Use.*** GE pesticide-tolerant seed varieties allow farmers to scout for weeds and use pesticides only when needed, reducing overall chemical use. Adoption of these seed varieties in corn, cotton, and soybeans over the past 25 years increased the use of post-emergence pesticides and reduced reliance on pre-emergence pesticides for these crops. Farmers of winter wheat, however, came to rely more heavily on pre-emergence pesticides over this period, leading to a decline in scouting for that crop (O'Donoghue, et al., 2011).

Overall, farmers have come to rely less on pesticides. The adoption of GE seed varieties of corn that express toxins derived from a common soil bacterium, *Bacillus thuringiensis* (Bt)—which kills insect pests such as the European corn borer, the corn earworm, and the corn rootworm— has allowed corn farmers to use fewer pesticides. Beginning in the 1990s, cotton farmers coordinated efforts to eradicate the boll weevil, creating a spike in pesticide use. Because these successful efforts are winding down and due to the increased adoption of Bt cotton seed varieties, application rates dropped in the 2000s. Further adoption of the seed varieties, including varieties of corn and cotton that express more than one Bt toxin, will likely lead to continued reductions in pesticide use (O'Donoghue, et al., 2011).

Potato farmers have come to rely more heavily on pesticides with low application rates (especially pyrethoids and imidacloprid), reducing the level of use. Pesticide use on soybean fields was minimal during the 1990s, but picked up in the 2000s, likely due to the introduction of the soybean aphid in northern production areas (O'Donoghue, et al., 2011).

In general, pesticide use increased over 1982-2007; rates of use, however, depended heavily on the crop. Potato farmers increased their use of pesticides with high application rates, such as chlorothalonil and mancozeb. While soybean farmers had used pesticides sparingly, the introduction of Asian soybean rust into the United States in 2004 changed that. The increased use of pesticides on soybean fields is expected to continue as the pathogen that causes the disease becomes established in the South where it can overwinter. In contrast, farmers have reduced their use of pesticides on wheat and cotton crops over 1982-2007 (O'Donoghue, et al., 2011).

Regular, widespread use of the same pesticide increases the risk of developing pesticide resistance. There are 404 unique cases with 220 species (130 dicots and 90 monocots) of pesticide resistant plants in 61 countries (Heap, 2013), and 85 cases within the project area. The use of glyphosate is being threatened by the evolution of glyphosate-resistant weeds (Duke & Powles, 2008). Currently, more than 90% of the soybeans and 80% of the corn planted in North America is glyphosate tolerant (Thelin & Stone, 2013).

***EHECs and Pesticides.*** Perennial grass species, including switchgrass, have historically thrived in the Midwest. They are generally well suited to grow as a biofuel feedstock over most of the continental United States (Keshwani & Cheng, 2009). Current production of switchgrass and giant miscanthus as biofuel feedstocks in the United States is limited to research field trials in several geographic locations (Heaton, Dohleman, & Long, 2008). Switchgrass and giant miscanthus have been found to be susceptible to insects such as the corn leaf aphid, sugarcane aphid, and fall armyworm, as well as to nematodes and pathogens (Heaton, Dohleman, & Long, 2008).

Previous research field trials in Illinois applied pre-plant and pre-emerge applications of pendimethalin and atrazine to prevent growth of grasses and small-seeded broadleaves in switchgrass and Giant Miscanthus plots. Quinclorac and alachlor have also been used to control post-emergent grass weeds with some success (Heaton, Dohleman, & Long, 2008) (Keshwani & Cheng, 2009). In 2009-2011 field trials, Smith, et. al. used Prowl (endimethalin) and 2,4-D and Bicep II Magnum (metolachlor and atrazine) were applied to switchgrass and miscanthus, respectively. The switchgrass did not require pesticide treatment once it was established and matured (Smith, et al., 2013), the study reported.

### 3.9.3 Existing Conditions – Public Health and Safety

The proposed EHEC Programs would not be used for food, feed, or other products to which people are exposed. Therefore, DOE does not consider direct human consumption of products derived from EHECs as part of the affected environment. Additional project- or crop-specific environmental compliance reviews would be necessary if that changes.

### 3.9.3.1 Physical Hazards

The types of hazards that could affect public health and safety at locations away from the EHEC field site include increased concentrations of particulate matter and other criteria air pollutants, additional noise, and offsite exposure due to release of chemicals. Section 3.8 and 3.11.5 discuss the affected environments of air quality and noise, respectively.

### 3.9.3.2 Chemical Hazards

People can be exposed directly to chemicals in general via inhalation, oral, and dermal routes if they live on or near farms that use them. Consumption of adjacent crops affected by spray drift is also a possible route of exposure, as is inhalation and dermal exposure from spray drift to residents near those spraying operations. Aerial broadcast spraying would tend to increase exposure to nearby residents and bystanders compared to ground-level methods. Migration of pesticides and fertilizers to surface water or groundwater used for drinking water also is a potential pathway for exposure (water resources are discussed in Section 3.2).

***Pesticides.*** The extent to which bystanders are exposed to pesticide applications is unknown since systematic monitoring around spray areas is not routine and quantifying exposures is challenging. Persons inadvertently exposed to pesticides often do not know the chemical type or quantity, and persons living near areas of frequent field spraying may receive multiple exposures. In the United States, concerns about health consequences from these exposures may prompt calls to poison control centers.

A study of American Association of Poison Control Centers' 2001 electronic medical records for exposure reports involving persons from 129 agriculturally intensive counties in Kentucky, Tennessee, Louisiana, and Arkansas identified aircraft crop dusters as the main source of exposure (28%) (McKnight, Bryden, & Westneat, 2005). The most common (30.4%) pesticide was malthion and about 20% of the people did not know the pesticide name. Within the study, about 74% cases were symptomatic, though no hospitalizations or deaths were cited (McKnight, Bryden, & Westneat, 2005).

***Toxicity and Related Hazards.*** Substances that are foreign to the human body, such as plant proteins, can elicit allergic or toxic responses ranging from mild irritation to death. These substances are found in many sources. Allergens can be in or on animal hair, pollen, insects, dust mites, plants, pharmaceuticals, and food. Some allergens are simply storage proteins (reserves of metal ions and amino acids) that are harmless to most people but elicit an immune response in others. Toxins, however, cause an adverse health effect in most people when intake exceeds a toxin-specific threshold level. Toxins often accumulate in plants as defense compounds against pests or pathogens.

Characteristics of the primary structure of many allergenic proteins have been entered into databases that can be searched for matches to substances for which the toxicity is unknown. Most plant allergens come primarily from pollen and are classified as environmental. Allergic rhinitis, or hay fever, while relatively mild in terms of effects, causes respiratory and other morbidities in more than 10% of the U.S. population. Anaphylaxis, a much more serious allergic reaction, includes food-induced reactions that have been estimated to cause 150 to 200 deaths annually in the United States.

It is not known if the engineered proteins in the proposed EHEC Programs have any toxic properties but have minimal potential to be allergens.

### 3.9.4 Existing Conditions – Intentional Destructive Acts

DOE considers intentional destructive acts, such as sabotage and terrorism, in each PEIS prepared. This section addresses this issue as associated with the Proposed Action and alternatives. The Proposed Actions and alternatives that could be high targets of opportunity for traditional intentional destructive acts include those that are:

- Sited within the vicinity of a major inland port, container terminal, nuclear power plant or national defense infrastructure; and
- Involve transportation, storage, or use of radioactive, explosive, or toxic materials.

One type of intentional destructive act, which is relevant to GM crop production, is environmental extremism—most often referred to as "eco-terrorism." Eco-terrorism includes criminal acts committed in the name of the environment. These terms are not applied to groups or individuals involved with environmental movements or animal welfare protection/rights activism within the "confines of civil society and the rule of law" (U.S. Department of Labor -- Occupational Safety and Health Administration, n.d.(b)). Independent small cells of individuals or individuals who harass and intimidate their victims perpetrate many of the crimes committed by both animal rights extremists and eco-terrorists (Olson, 2012). Regardless, crimes committed by eco-terrorists and animal rights extremists have caused millions of dollars in property damage, and some have involved the intimidation and harassment of victims. These two types of extremism are often discussed together, because the two broader radical movements from which they draw their philosophical underpinnings have similar beliefs and overlapping membership (Olson, 2012).

## 3.10 Climate and Greenhouse Gas Emissions

### 3.10.1 Definition of the Resource

Both the GHG emissions effects of the Proposed Action and Alternatives, and the relationships of climate change effects to the Proposal Action and Alternatives, are considered in this Final PEIS. The existing climate conditions in the project area are described first, and then the current GHG emissions profile associated with agriculture.

Climate does not have a strict or universally accepted definition. However the World Meteorological Organization (WMO) defines climate as "… the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The most commonly used period is 30 years, as defined by the WMO. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system." (World Meteorological Organization, n.d.)

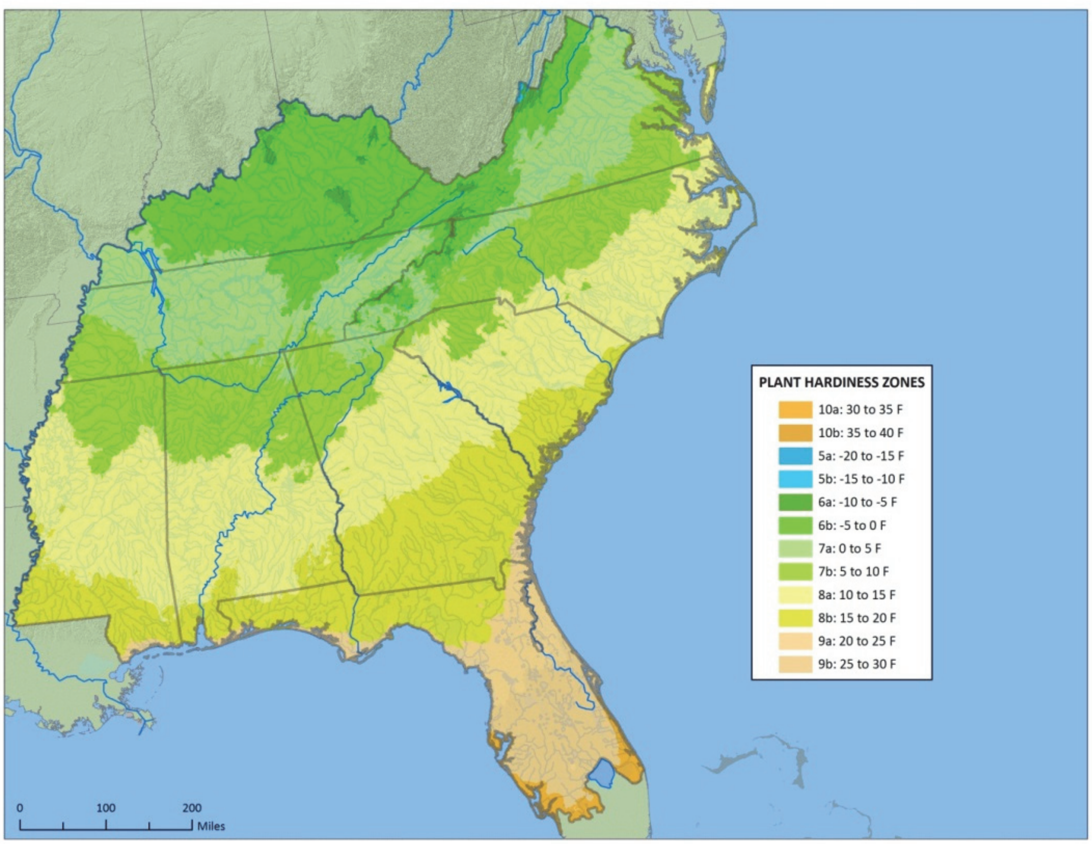
Similarly, the term "climate change" does not have a universally accepted definition, but Article One of the United Nations Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (United Nations, n.d.). The EPA defines climate change as "any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer" (Environmental Protection Agency, 2013b).

### 3.10.2 Existing Conditions

This section describes current climate characteristics and recent trends in the project area, including temperature ranges, precipitation, major storm events, and growing seasons. The project area encompasses a wide range of diverse topography and elevation, with a cross-section of more than 1,000 miles. The entire project area is influenced by oceans and landmasses; consequently, the climatic conditions vary across the project area.

Average minimum temperature is a major determinant of where plants are most likely to grow and thrive. One tool for summarizing the relationship between geography, climate and growing seasons is the USDA's 2012 Plant Hardiness Zone Map, which is the standard by which growers can determine which plants are most likely to thrive at a location (U.S. Department of Agriculture, 2012a). Figure 3.10-1 depicts the Plant Hardiness Zones for the project area.

**Figure 3.10-1: USDA Plant Hardiness Zone Map for the Project Area**




*Source:* (U.S. Department of Agriculture, 2012b)

The plant hardiness zones are a high-level depiction of where crops may be grown based on the date of the last freezing day averaged over a period of 30 years, and it is intended as a guide for growers to decide what to plant. Figure 3.10-1 divides the project area into zones representing the average annual extreme minimum temperature between the period 1976-2005, with each color representing a range of extreme minimum winter temperatures, illustrating how the minimum temperature generally increases the further south one goes. This guide does not show the location of microclimates, which occur on a fine-scale and may be small heat islands—such as those caused by blacktop and concrete—or cool spots caused by small hills and valleys. Light, soil moisture, temperature (beyond the average minimum), rainfall, and humidity also contribute to growing conditions, which vary in combination from year to year.

To provide climatic information at a finer level of detail than the plant hardiness zone, the climatic and meteorological conditions of the individual states in the project are summarized below. Climate information is drawn largely from the states' climate norm summaries prepared by NOAA's National Climatic Data Center (NCDC) in collaboration with each state's climatologist (National Oceanic and Atmospheric Administration -- National Climatic Data Center, 2005). Each state summary also includes information on hurricane activity including numbers of landfalling hurricanes since 1970 to provide a comparison of vulnerability between the states in the project area. Hurricane historical information is provided by NOAA's Atlantic Oceanographic and Meteorological Laboratory (National Oceanic and Atmospheric Administration -- Atlantic Oceanographic and Meteorological Laboratory, 2014).

Note on climate change and hurricane activity: The impact of climate change on Atlantic hurricanes is a subject of intense, ongoing study. The current scientific consensus is that it is premature to state that human activities have already had an effect on Atlantic hurricane activity. However, although scientists have not established a causal link between climate change and hurricane frequency, they have determined that climate change likely contributes to more powerful hurricanes on average. (National Oceanic and Atmospheric Administration -- Geophysical Fluid Dynamics Laboratory, 2013), This would include stronger winds, higher total rainfall, and increased storm surge. These effects are due to higher sea surface temperatures which increase evaporation, thereby pouring more energy and water into the atmosphere which in turn strengthens winds and increases moisture content. Hurricane average intensity is expected to increase by up to 11% and near-storm rainfall rates are expected to increase by about 20%. (National Oceanic and Atmospheric Administration -- Research Council, 2012). Warmer water undergoes thermal expansion; contributing to storm surge in addition to that contributed by stronger winds, as well as the anticipated overall rise in sea level along the Atlantic coast (U.S. Climate Science Program, 2008).

#### 3.10.2.1 Alabama

The climate of Alabama is characterized by moderate seasonal variation, though it is becoming somewhat subtropical near the coast. The summers are typically warm and humid, with little day-to-day temperature change.

***Temperature***. The average high temperatures for the summer range from 80 to 88°F. Slightly cooler temperatures prevail in the higher elevations of the northeastern counties. In nearly every year, at least some locations reach highs of 100 degrees or higher. The highest temperature ever recorded in Alabama was 112°F. In the coldest months (December, January, and February), there are frequent shifts between mild air, which has been moistened and warmed by the Gulf of Mexico, and dry, cool continental air.

Severe cold weather is rare and subzero temperatures are unusual. For most of the state, temperatures in the winter range from 38 to 50°F during the evening. Since cold air on clear nights collects in low places, there is considerable irregularity in the dates of the last spring or the first fall freezes in all sections.

***Precipitation***. Precipitation falls almost entirely as rain. Measurable snow occurs in the northern valleys on an average of about twice each winter for a total of three to four inches. Snow is rare in south Alabama. Most rivers in the state are managed, so typical wet and dry spells do not result in high stream flow variations. More rainfall is needed to maintain adequate soil moisture in Alabama than in states further north where temperatures are lower. On an average annual basis, between 55 and 60 inches falls in the north, 50 to 55 inches in central Alabama and 60 to 65 inches in the south.

***Growing Season***. The length of the growing season ranges from 200 days in the northern counties to almost 300 days along the coast. Dry periods of two to three weeks may occur any time during the growing season (late April through October). For October, usually the driest month, dry spells occur about once in three to five years. The normally low October precipitation is desirable in harvesting cotton, corn, and other crops and is important (since it is still warm) to winter gardens and cover crops that are being started. Pasture grasses need moisture at this time to maintain growth. Local droughts occur nearly every year, but severe statewide droughts are practically unknown.

***Severe Weather***. The tornado season extends from November through early May with the greatest frequency in March and April. Occasionally, a tropical system moving inland will spawn tornadoes. The state experiences, on average, 20 tornadoes each year. Destructive hurricanes visit the coastal area an average once in seven years between July and November. Since 1970, six hurricanes have made landfall in Alabama.

#### 3.10.2.2 Florida

Most of Florida lies within the extreme southern portion of the Northern Hemisphere's humid subtropical climate zone, noted for its long hot and humid summers, and mild and wet winters. The southernmost portion of the state is generally designated as belonging to the tropical savanna region but is located outside the project area. Sometimes also called the wet and dry tropics, tropical savanna precipitation is highly concentrated in the warmer months. The topography of the state is relatively flat, with the highest point rising 450 feet above sea level.

***Temperature***. Large waterbodies, particularly the Atlantic Ocean and the Gulf of Mexico, are the major modifiers of the state's temperature during all seasons, but particularly in the winter. During the winter, Florida has approximately double the amount of hours of sunlight than the states in the northeastern quadrant of the nation. The mean maximum temperature in northern Florida during January is about 65$^{o}$ F. Mean temperatures during Florida's coldest month (January) range from the lower 50s in the north to the upper 60s in the south. Average maximum temperatures in the state begin to reach into the upper 80s in April, first in the interior of the peninsula, and then spreading out towards the coasts. In the hottest month (usually July, but in places August) it is almost the same throughout the entire state, between 81-83°F. Average maximum temperatures rise above 88°F on the west coast during May and along most of the east coast in June. The spatial advance of the summer heat is retarded near the coast by sea breezes that, at times, can reach more than 25 miles into the interior.

***Precipitation***. Florida is only exceeded by Louisiana as the wettest state in the United States. On average, approximately 54 inches of precipitation falls on the state each year. Almost all precipitation is in the form of rain. A large share of Florida's precipitation falls during periods of torrential rain, which here is defined as 3 inches or more within a 24-hour period. The Panhandle and Southeastern Florida are the wettest parts of the state. The state's summer rainy season normally first begins in Southeastern Florida in late April and then moves northward. Summer rain is generally in the form of local thunderstorms, or thunderstorms that form in long squall lines created when hot humid air from the Atlantic Ocean converges with equally hot and humid air from the Gulf of Mexico.

***Growing Season***. The state's agriculture is heavily based on winter warmth, and it cultivates not only citrus, but also winter vegetables. Although nowhere in Florida is far above sea level, during the winter altitude can be a local factor in affecting temperature, with fruit groves planted in depressions being more susceptible to freezes than those planted on higher ground.

***Severe Weather***. Hurricanes are a major feature of Florida's climate. Most tropical storms and hurricanes that have the potential of reaching the United States originate in the Gulf of Mexico, Caribbean Sea, or the Atlantic Ocean a few degrees north of the equator. The length of Florida's coastline is nearly as long as the combined coastlines of all the other states from Virginia to Texas. Consequently, more tropical systems of all kinds have made their first landfall in Florida. The frequency of hurricane passage within 50 miles of the coast Florida varies depending on location, occurring most frequently near the southeast coast (returns every 5-7 years), decreasing in frequency towards the northern end of the state (8-11 years on the Gulf coast, and 12-15 years on the Atlantic coast). (National Oceanic and Atmospheric Administration, 2013) Since 1970, eighteen hurricanes have made landfall in Florida.

#### 3.10.2.3 Georgia

Due to its latitude and proximity to the warm waters of the Gulf of Mexico and Atlantic Ocean, most of Georgia has warm, humid summers and short, mild winters. However, in the northern part of the state, altitude becomes the more predominant influence with resulting cooler summers and colder, but not severe, winters. All four seasons are apparent, but spring is usually short and blustery with rather frequent periods of storminess of varying intensity. In autumn, long periods of mild, sunny weather are common for all of Georgia.

***Temperature***. Average summer temperatures range from about 72°F in the northeast mountains to nearly 82°F in parts of southern Georgia. Summer days are characteristically warm and humid, with high temperatures exceeding 90°F on most days and reaching 100°F during most years. Temperatures usually drop to the middle or low 70s or even below 70°F by early morning, giving some relief from the daytime warmth. The flow of moist of the air from the Gulf of Mexico over the warm land surface results in frequent afternoon thunderstorms in all of Georgia during summer, providing most of the summer rainfall and also relief from the afternoon heat. The highest temperatures occasionally exceed 110°F. The state's all-time high temperature is 112°F. All parts of the state have experienced 100°F weather at one time or another during the period of official records, but such occurrences are highly unusual in the mountain section of the north.

The average temperature for the three winter months ranges from 39 in the north to about 55°F on the lower coast, with the increase being almost uniform from north to south. Cold snaps alternate with longer periods of mild weather. All of Georgia experiences freezing temperatures almost every year, but the frequency of such occurrences varies greatly from the mountains to the coast. Daytime temperatures almost always rise to above freezing in the southern three-fourths of the state, even during the coldest weather.

***Precipitation***. Average annual rainfall in Georgia ranges from more than 75 inches in the extreme northeast corner to about 45 inches in the Central and East Central Divisions. Isolated peaks in the northeastern mountains may receive over 80 inches of precipitation in an average year. Total rainfall varies greatly from year to year in all parts of the state.

***Growing Season***. The timing of Georgia's growing season varies across the state. There is approximately four months difference in the average length of the freeze-free growing season from north to south, ranging from about 170 days in the northernmost areas to near 300 days on the lower coast. In spite of the apparent abundance of rainfall in Georgia, irregular distribution results in the occurrence of agriculturally-damaging dry spells in some parts of the state almost every year.

***Severe Weather***. Hurricanes make occasional landfall in Georgia, with hurricanes passing within 50 miles of the coast on return period of 10-11 years (National Oceanic and Atmospheric Administration, 2013). Georgia experienced more hurricane landfalls in the 19th than the 20th century, with 14 making landfall in the 1800s versus four in the 1900s (Georgia Emergency Management Agency, 2013). Since 1970, one hurricane has made landfall in Georgia.

#### 3.10.2.4 Kentucky

The climate of Kentucky reflects the interplay of several geographic influences including its inland location, its position north of the Gulf of Mexico, and its mid-latitude position.

***Temperature***. Mean annual temperature ranges from 53°F in the northeast to 59°F in the southwest, with seasonal variation in temperature. Summer days are typically sunny, warm, and humid. Most areas of the state receive more than 60% of their sunshine during summer. The average daily high temperature for July increases from about 86°F in the east to 90°F in the west. High temperatures exceed 90°F an average of 20 days per year in the north and east and 40 or more days in the south and west. Temperatures occasionally exceed 100°F.

Winters are rarely harsh, with temperatures remaining above freezing. In January, average daily high temperatures increase from 38°F in the north to 44°F in the south. Temperatures dip below 0°F an average of about five days in the north, and two days in the south. Spring and fall are generally pleasant seasons, though temperatures can change dramatically with the passage of weather fronts. The day-time temperature range is about 20°F during the summer, and winter but increases to near 25°F during the spring and fall, when warm days and cool nights are prevalent.

***Precipitation***. Average annual precipitation ranges from 42 inches in the north to 52 inches in the south. Much of the range is due to a strong precipitation gradient during the winter season. Summer precipitation patterns are less pronounced. Fall is normally Kentucky's dry season, while the spring season is typically the wettest. Thunderstorms are responsible for much of the rainfall during summer, and they often bring intense rainfall that may be highly localized. Rates exceeding one inch per hour are not unusual and 24-hour totals of five inches or more occur an average of about one in 10 years at a given location. Snowfall is most likely from December to March, but it occasionally occurs as early as October or as late as April. Seasonal amounts average from near 10 inches in the south to more than 20 inches in the north. Amounts are highly variable from year to year.

***Growing Season.*** Kentucky's growing season varies across the state. The average date of the last spring freeze ranges from early April in the southwest to early May in the northeast. Meanwhile, the average date of the first fall freeze extends from early October in the northeast to late October in the southwest. The average length of the frost-free period varies from about 165 days in the northeast to 200 days in the southwest, but the average can vary with local topography.

***Severe Weather***. Because Kentucky is not a coastal state, it is generally protected from tropical storms and hurricanes, but may experience flooding and high winds when the remants of landfalling systems come inshore. (National Oceanic and Atmospheric Administration -- National Weather Service, 2008)

#### 3.10.2.5 Mississippi

The climate of Mississippi is controlled by the Gulf of Mexico along its southern coastline, the land mass to the north and its subtropical latitude. The location and seasonal intensity of the Bermuda High – an area of high pressure that forms over the Atlantic Ocean during the summer months – can dominate an entire season in the state. The outcome is a humid subtropical climate type, typified by mostly mild winters without extended periods of temperatures below freezing; long, hot summers; and no routinely recurring wet or dry season.

***Temperature***. The mean annual temperature ranges from 60°F in the northern border counties to 67°F in the coastal counties. In the warmer season (and throughout much of the rest of the year) prevailing southerly winds provide humid, semitropical conditions often favorable for afternoon thunderstorms. Temperatures exceed 100°F at one or more weather station every year. The area experiencing the maximum number of days with temperatures at or above 90°F occurs about 50 miles inland from the moderating effects of the coast. Over 100 days annually may top 90°F in this region.

In the colder season, the state's weather is dominated by the positions of the Polar and Subtropical Jet Streams, and their subsequent control over passages of cold and warm fronts of mid-latitude cyclones. These frontal passages alternately subject the state to cold continental air and warm tropical air, in periods of varying length. Cold spells seldom last over three or four days and the ground rarely freezes. Daily highs in January (the coldest month) average about 48°F in the north to about 61°F along the coast. Daily minimum temperatures in January average 27°F and 43°F in the north and along the coast, respectively.

***Precipitation***. Mississippi is situated in a region where water is a bountiful natural resource, tying with Louisiana as the "wettest" state in the union considering the average amount of precipitation over the state's area. The statewide average of above 56 inches over nearly 31 million acres produces a volume in excess of 142,000,000 acre-feet of water delivered to the state by the atmosphere annually, providing both surface and groundwater in abundance.

***Growing Season***. Average last freeze dates are quite variable, averaging from April 3 in the north to February 20 along the coast. However, one site in east-central Mississippi has a last freeze date that has varied from February 8th to April 21st. Cold spells are usually of short duration and the growing season is long; rainfall is plentiful though not reliably distributed throughout the year. Dry spells accompany harvest time when they are needed most, but drought is a damaging aspect of the climate.

***Severe Weather***. While tornadoes and tropical cyclones can cause severe damage on a localized level, hurricanes have on occasion entered as far north as Meridian and Greenville after crossing part of Alabama or Louisiana. The tropical cyclones are weakened (usually quickly) by passage over land, so loss of life and property damage due to high winds is confined mainly to the coastal areas with losses further inland generally owing to rain damage to crops and from floods. There have been four landfalling hurricanes in Mississippi since 1970.

### 3.10.2.6 North Carolina

North Carolina has one of the most varied climates of any eastern state with the Gulf Stream directly effecting temperatures, especially at the coast. Weather fronts - the separation between air masses of different densities- are common during the winter months along the coastline, and can push inland, bringing warmer than expected temperatures to coastal areas. The southern reaches of the cold Labrador Current - a south-running current that brings cold water from Labrador and Newfoundland - pass between the Gulf Stream and the North Carolina coast, offsetting most of the general warming effect the Gulf Stream might otherwise have. The meeting of the two opposing currents generates atmospheric instability that can lead to sudden storms and other rough weather.

***Temperature***. The most important single influence contributing to the variability of North Carolina climate is altitude. Over the full year, the average temperature varies more than 20°F from the lower coast to the highest elevations. In winter, most of North Carolina is protected by the mountain ranges from the frequent outbreaks of cold air which move southeastward across the central states and the Appalachian Mountains. The temperature drops to 10 to 12°F once during an average winter over central North Carolina, ranging from 10 degrees warmer near the coast to 10 degrees colder in the mountains. Temperatures as low as 0°F tend to occur only within the mountains, but have been reported in the western part of the state.

In spring, the storm systems that bring cold weather southward reach North Carolina less often and less forcefully, and temperatures begin to modify. May is the warmest month. Occasional influxes of cool, dry air from the north continue during the summer, but their effect on temperatures is slight and of short duration. The increase in sunshine that follows usually raises temperatures. When the dryness of the air is sufficient to keep cloudiness at a minimum for several days, temperatures may occasionally reach 100°F or higher in the interior at elevations below 1,500 feet. Ordinarily, however, summer cloudiness develops to limit the sun's heating while temperatures are still in the 90°F range. The average daily maximum reading in mid-summer is below 90°F for most localities.

***Precipitation***. While there are no distinct wet and dry seasons in North Carolina, average rainfall varies around the year. Summer precipitation is normally the greatest, and July is the wettest month. Autumn is the driest season, and November the driest month. In southwestern North Carolina, where moist southerly winds are forced upward when passing over the mountain barrier, the annual average rainfall is more than 90 inches making North Carolina the rainiest of the eastern states. Less than 50 miles to the north, in the valley of the French Broad River, sheltered by mountain ranges on all sides, is the driest point south of Virginia and east of the Mississippi River. Here the average annual precipitation is only 37 inches. East of the Mountains, average annual rainfall ranges mostly between 40 and 55 inches.

***Growing Season***. The average annual freeze-free period lasts from about 130 days in the highest mountain areas to around 290 days on the Outer Banks. At Hatteras, entire seasons often pass without either frost or freezing temperature occurring and tropical fruits can be grown in sheltered spots.

***Severe Weather***. North Carolina experiences high levels of hurricane activity, with hurricanes passing within 50 miles off the coast line once every five to seven years, and hurricane landfalls as high as 20-25 in the period 1950-2010 (National Oceanic and Atmospheric Administration -- National Hurricane Center, 2011). There have been 13 landfalling hurricanes in North Carolina since 1970.

### 3.10.2.7 South Carolina

Several factors combine to give South Carolina a mild and humid climate. The state is located at relatively low latitude (32 to 35°N) and most of the state is less than 1,000 feet in elevation. The warm Gulf Stream current moves along the long coastline. The air over the coastal water is cooler than the air over the land in summer and warmer than the air over land in winter; this has a modifying effect on the temperatures near the coast. The mountains to the north and west block or delay cold air masses approaching from those directions. Even the deep cold air masses which cross the mountains rapidly are warmed somewhat as the air is heated by compression when it descends on the southeastern side.

***Temperature***. Summers are hot, with summer temperatures up to 111°F inland. Hot summer days are relieved by clouds and rain along the shore. Maximum temperatures in summer are reduced slightly in areas where afternoon cloudiness and rain are persistent (e.g., along the Outer Coastal Plain where sea breezes produce clouds and rain during the day, but dissipate at night). Another effect is the drainage of cold air, mostly October - April, into some of the river valleys causing temperatures to be several degrees colder than they would be otherwise.

***Precipitation***. Annual rainfall averages up to 80 inches in the highest elevations of the westernmost, Mountain Region to less than 45 inches in parts of the Inner Coastal Plain and the adjacent Sand Hills region.

***Growing Season***. The growing season for most crops is limited by the fall and spring freezes. The freeze-free period varies from about 200 days in the coldest area to about 280 days along the south coast, but in the area where most of the major crops are grown it is from 210 to 235 days. The average date of the last freezing temperature in spring ranges from early March in the south to the first of April in the north. The first freeze dates range from late October in the north to late November in the south. Freezes have occurred as much as four weeks later than the average date in spring and three weeks earlier than the average date in the fall.

***Severe Weather***. Hurricanes affect the state, with estimated return periods for hurricanes passing within 50 nautical miles of the coast ranging from 8 to 10 years. Most tropical storms that affect South Carolina do little damage and frequently bring rains at a time when they are needed. Most of the hurricanes affect only the Outer Coastal Plain. If they do come inland, they usually decrease in intensity quite rapidly. Considerable flooding accompanies hurricanes, which can come far inland, and high tides, which occur along the coast to the north and east of the storm centers. Five hurricanes have made landfall in South Carolina since 1970.

#### 3.10.2.8 Tennessee

Most aspects of the state's climate are related to the widely varying topography within its borders.

***Temperature***. The temperature decreases 3°F, on average, for every 1,000 feet elevation increase. Thus higher portions of the state, such as the Cumberland Plateau and the mountains of the east, have a lower average temperature than the Great Valley of East Tennessee, which they flank, and other lower parts of the state. Across the state, the average annual temperature varies from over 62°F in the extreme southwest to near 45°F atop the highest peaks of the east.

***Precipitation***. Since the principal source of moist air for this area is the Gulf of Mexico, there exists a gradual decrease of average precipitation from south to north. This effect is largely obscured however, by the overruling influence of topography. Air forced to ascend along mountain flanks cools and condenses out a portion of its moisture. Thus, average precipitation ranges from 46 to 54 inches, increasing from Mississippi River bottomlands along the western border, to the slight hills farther east. The northern minimum, lowest for the entire state, results from the shielding influence of the Great Smoky Mountains to the southeast and the Cumberland Plateau to the northwest. The mountainous eastern border of the state is the wettest, having average annual precipitation ranging up to 80 inches on the higher. Over most of the state, the greatest precipitation occurs during the winter and early spring due to the more frequent passage of large-scale storms over and near the state during those months. A secondary maximum of precipitation occurs in midsummer in response to thunderstorm activity.

***Growing Season***. The length of growing season is also linked to topography, varying from an average of 237 days at low-lying Memphis to a near 130 days on the highest mountains in the east. Most of the state has a growing season of 180 to 220 days, with the mountains having a shorter growing season. Areas along the Mississippi River, parts of the Central Basin of the Middle Tennessee, and the southern end of the Great Valley of East Tennessee have longer growing seasons.

***Severe Weather***. Tennessee typically experiences its most destructive weather during the winter and early spring when the frequent migratory storms bring general rains of high intensity. During this period both widespread flooding and local flash floods can occur. During the summer, heavy thunderstorms (with rain) frequently result in local flash flooding. In the fall, while flood-producing rains are rare, a remnant hurricane on occasion causes serious floods.

#### 3.10.2.9 Virginia

The Atlantic Ocean and Gulf Stream play a dominant role in the variability of Virginia's precipitation climate. The high relief of the Appalachian and Blue Ridge Mountains differentiates precipitation patterns in the state with heavy rainfall on the western slopes and a rain shadow on the eastern slopes.

***Temperature***. The state's complex pattern of rivers and streams, which drain the precipitation and modifies the pattern of moist airflow from which the precipitation falls, also moderate the flow of warm and cold air across the state. Average temperatures display wide variability with January average temperatures ranging from 19 to 47°F and July average temperatures ranging from 60 to 88°F.

***Precipitation***. Much of Virginia's rainfall results from storms associated with warm and cold fronts. These storms generally move from west to east and, in the vicinity of the East Coast, move northeastward. When sufficient cold air invades Virginia from the west and northwest during the winter months, frontal storms may cause heavy snowfalls. Average annual precipitation across the state ranges from 38.2 inches a year in the northeastern and lowland areas, to 47.3 inches a year in the southwestern mountain region.

***Growing Season***. Virginia's climate diversity provides the basis for a wide variety of agricultural products, although the lack of year-to-year consistence of the climate presents risk to agriculture. A climate condition might, in a given year, extend outward into another area. In such a case, drought, crop failure, and economic losses may be extensive.

***Severe Weather***. Hurricanes and tropical storms that cross Virginia, including immediately offshore, occur most frequently in early August and September, and rarely appear before June or after November. During the month of September 10% to 40% of Virginia's rainfall is from tropical systems or their remnants. The period for the recurrence of Hurricanes for various points along the Virginia coastline are longer than North Carolina to the south, ranging from 13 to 15 years, and hurricane strike density is also lower at 5-7 strikes in the period 1950-2010, with the exception of the Norfolk/Virginia Beach area which is higher at 13-15 (National Oceanic and Atmospheric Administration -- National Hurricane Center, 2011). Only one hurricane has made landfall in Virginia since 1970.

### 3.10.3 Greenhouse Gas Emissions

Earth's climate norms are strongly regulated by the greenhouse effect, by which trace gases such as $CO_2$, methane ($CH_4$), and nitrous oxide ($N_2O$) in the atmosphere maintain the Earth's temperature by trapping the sun's radiation as heat. While each of these gases occurs naturally in the atmosphere, human activity has increased the concentration of these gases since the beginning of the Industrial Revolution. Human activity also adds other non-naturally-occurring GHGs to the atmosphere, such as chlorofluorocarbons (CFCs) and sulfur hexafluoride ($SF_6$). Measurements of the emissions of the various GHGs are normalized for their global warming potential to tons of $CO_2$ equivalent ($CO_2$e) (Environmental Protection Agency, 2013a).

If the greenhouse effect becomes stronger, the Earth's average temperature will rise, resulting in global climate change. Even a slight increase in temperature may cause problems for humans, plants, and animals. Historic data indicate that the global surface temperature has increased by 1.33 ± 0.32°F during the last 100 years, and that the rate of warming has accelerated over the last 50 years. Warming can occur as a result of natural influences; however, anthropogenic emissions of GHGs have occurred at an accelerated rate since the Industrial Revolution. For example, concentrations of $CO_2$ have continuously increased from approximately 280 ppm in pre-industrial times to 391 ppm in 20011, an increase of 40%. (Intergovernmental Panel on Climate Change, 2014)

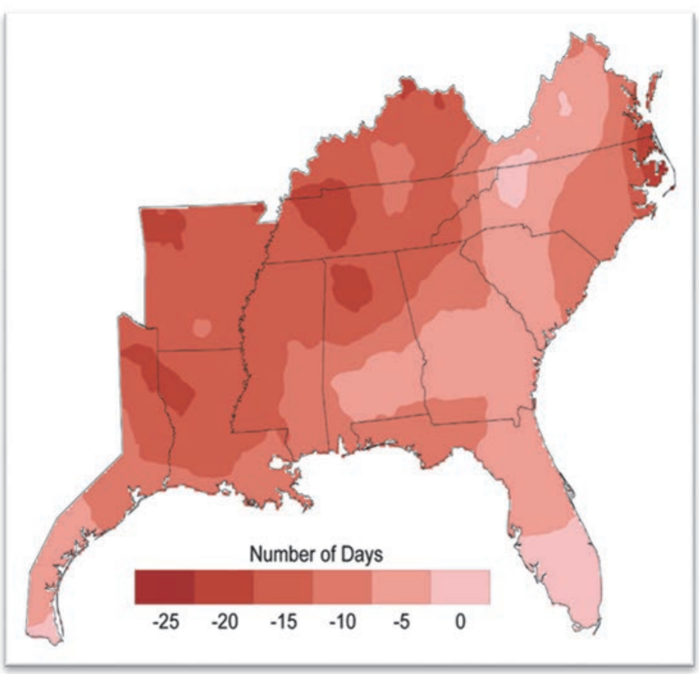
The major GHGs emitted by the U.S. are carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). Water vapor is the most abundant GHG but scientists believe that human activity directly contributes little to the amount of water vapor in the atmosphere, although there are indirect effects that have not yet been quantified. (National Oceanic and Atmospheric Administration -- National Climatic Data Center, 2013) Ozone is technically a GHG but its effects are generally manifested at the local level, and it is a pollutant that is already regulated independently of its warming effects. In addition, water vapor and ozone are not counted in U.S. or international GHG inventories and are not considered in this Final PEIS.

A small proportion of GHG emissions in the U.S. come from hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, which together constitute 2% $CO_2e$ of total U.S. emissions. (Environmental Protection Agency, 2013a) Agriculture is not a major source of these types of emissions and not considered as part of climate section of this Final PEIS.

The average annual temperature of the Southeast did not change substantially over the past 100 years. Since 1970, however, annual average temperature has risen about 2°F, with the greatest seasonal increase in temperature occurring during the winter months. The projected rates of warming are more than double those experienced in the Southeast since 1975, with the greatest temperature increases projected to occur in the summer. The number of hot days is projected to rise at a greater rate than the average temperature. Under a lower GHG emissions scenario, average temperatures in the region are projected to rise by 4.5°F by the 2080s, while a higher emissions scenario yields about 9°F of average warming (with about a 10.5°F increase in summer, and a higher heat index). (U.S. Global Change Research Program, 2009a)

The warming projected for the Southeast during the next 50 to 100 years may create heat-related stress for people, agricultural crops, livestock, trees, transportation and other infrastructure, fish, and wildlife. The change in average temperature is not as important for these sectors and natural systems as the projected increase in maximum and minimum temperatures. Since the mid-1970s, the number of days per year in which the temperature falls below freezing has declined by four to seven days over much of the Southeast. Some areas, such as western Louisiana, have experienced more than 20 fewer freezing days. The changes in the number of freezing days per year are shown in Figure 3.10-2.

**Figure 3.10-2: Change in Freezing Days per Year 1976-2007**




*Source:* (National Oceanic and Atmospheric Administration -- National Climatic Data Center, 2009)

The 2009 and 2014 U.S. Climate Assessments draw on a large body of scientific information including projections published in IPCC climate reports, the results of global climate models such as GFDL-1 (National Oceanic and Atmospheric Administration -- Geophysical Fluid Dynamics Laboratory), and output from regional-scale climate models from various sources including the North American Regional Climate Change Assessment Program (University Corporation for Atmospheric Research). These models project continued warming, with the greatest temperature increases expected in summer, and with the number of hot days still increasing at a greater rate than the average temperature. Environmental effects of climate change include decline in forest growth and agricultural crop production due to the combined effects of thermal stress in two main areas: 1) direct thermal stress to plants, particularly during extended heat waves that are predicted to increase in frequency and duration due to climate change, and 2) declining soil moisture as a result of both higher daytime and nighttime temperatures that increase the rate of moisture loss from the soil, and also inhibit plants' ability to manage heat stress through evaporative cooling. (U.S. Global Change Research Program, 2009a) (U.S. Global Change Research Program, 2014)

Additional long-term sources of stress to agriculture from climate change include changes in the water cycle. Models predict that rainfall will be produced in higher number of extreme rain events. Over time, these may cause soil erosion and declines in soil nutrients. Increased pest predation and plant pathogens have been observed, but the life-cycles of these organisms are complex and in some cases their numbers may decline in response to higher temperatures. The response by the agricultural sector to climate change is best summed in the *2014 National Climate Assessment:* "Although agriculture has a long history of successful adaptation to climate variability, the accelerating pace of climate change and the intensity of projected climate change represent new and unprecedented challenges to the sustainability of U.S. agriculture. In the short term, existing and evolving adaptation strategies will provide substantial adaptive capacity, protecting domestic producers and consumers from many of the impacts of climate change, except possibly the occurrence of protracted extreme events. In the longer term, adaptation will be more difficult and costly because the physiological limits of plant and animal species will be exceeded more frequently, and the productivity of crop and livestock systems will become more variable." (U.S. Global Change Research Program, 2014)

Many crops show positive responses to elevated $CO_2$ and low levels of warming, but higher levels of warming, particularly warmer average nighttime temperatures, often negatively affect growth and yields. Hot nights negatively impact grain yields, and many perennial crops (trees in particular) have a winter chilling requirement for optimal growth that may not be met in a warming climate. Plants that thrive in cooler temperatures will exhibit decreases in yield as temperatures increase. Reductions in yield with increasing temperature in field conditions may not be due to temperature alone: high temperatures are often associated with lack of rainfall. Changes in temperature do not produce linear responses with increasing temperature because the biological response to temperature is nonlinear; therefore, as the temperature increases these effects will be larger.

Extreme precipitation events (heavy downpours) are estimated at least a two-thirds likelihood of reducing crop yields because excesses of water may negatively impact plant growth. These events have become more frequent and more intense in recent decades than at any other time in the historical record, and account for a larger percentage of total precipitation (Kunkel, 2008). Societal factors such as growing population in the project area, increased water withdrawals, falling water tables, increased irrigation demand, and more efficient irrigation systems further complicate projections, but the general assessment is towards increased water stress in the project area under warming scenarios (U.S. Global Change Research Program, 2009b) (U.S. Global Change Research Program, 2014). The interactions of temperature and water dynamics will be complex but are expected, on the balance, to negatively affect crop yields (Backlund, Janetos, Schimel, & Walsh, 2008).

Except for indications that the amount of rainfall from individual hurricanes will increase, climate models provide diverging results for future precipitation for the remainder of the Southeast depending on location. Regional climate models project that Gulf Coast states will tend to have less rainfall in winter and spring, compared with the more northern states in the region. Because higher temperatures lead to more evaporation of moisture from soils and water loss from plants, there is at least a 67% probability that the frequency, duration, and intensity of droughts will increase. (U.S. Global Change Research Program, 2009b) (Seager & Nakamura, 2009).

Increases in GHG concentrations are primarily a result of fossil fuel combustion for power generation, transportation, and construction. Agricultural activities serve as both sources and sinks for GHG emissions. Agriculture sinks of GHG are reservoirs of carbon that have been removed from the atmosphere through the process of biological carbon sequestration by plants and soil organisms. Agriculture and forestry activities have affected GHG levels in the atmosphere through cultivation and fertilization of soils, production of ruminant livestock, livestock manure management, land use conversions, and fuel consumption. The primary GHG emissions for agriculture are from $N_2O$ and $CH_4$. Agriculture contributed 36 % of U.S. $CH_4$ emissions in 2007, and 73% of $N_2O$ emissions. The overwhelming majority of $CH_4$ emissions from farming are from ruminant livestock production and manure management and are not considered in this Final PEIS, since these activities would be unaffected by any EHEC activities. The majority of non-ruminant, non-manure emissions come from the cultivation and fertilization of soils.

GHG emissions from soils (not including forest land) can be net positive even when carbon is being sequestered in the soil due to natural decomposition of organic matter; erosion due to wind, runoff and cultivation techniques; and the application of nitrogen fertilizer, all of which result in GHG emissions. The transition from annual to perennial crops, the application of no-till/low-till cultivation techniques, and increased irrigation can increase carbon sequestration in soils, and cutting back on the quantity of nitrogen fertilizers can reduce $N_2O$ emissions. In 2011 (the most recent year for which comparative agricultural data are available), total GHG emissions in the United States were 6,702 million metric tons (MMT) $CO_2e$, of which the total contribution by agriculture was 461MMT. Of the total emissions from agriculture, 247MMT came from agricultural soil management. (Environmental Protection Agency, 2013h)

GHG emissions data on agriculture for individual states is not collected routinely by any Federal, state, or other entity. Six states in the project area (Virginia, North Carolina, South Carolina, Georgia, and Florida) have conducted and published an official GHG inventory using a standard methodology promulgated by the EPA. Tennessee and Alabama do not have an official GHG inventory but an estimate was calculated by researchers at Tennessee Technological University, and Alabama's emissions were estimated by researchers at the University of Alabama. These data were collected and estimated in different years, and emissions may have increased or decreased since the year of estimate due to changes in agricultural practices, economic influencers on agriculture and the conversion of farmland for urban and industrial development. However, they provide a rough order of magnitude estimate of total emissions of GHG from agricultural soil management in the project area, as shown in Table 3.10-1.

**Table 3.10-1: State Estimates of GHG Emissions from Agriculture for the Project Area**

| State | Year of estimate | Total State GHG Emissions MMT $CO_2e$ | Soils Emissions MMT $CO_2e$ | Percent of Total Emissions | Source |
|---|---|---|---|---|---|
| **Virginia** | 2000 | 162.6 | 3.6 | 2.2% | (Commonwealth of Virginia, 2005) |
| **North Carolina** | 2005 | 192 | 6.7 | 3.5% | (State of North Carolina, 2007) |
| **South Carolina** | 2005 | 93.5 | 1.9 | 2.0% | (State of South Carolina, 2008) |
| **Georgia** | 2005 | 202.2 | 2.9 | 1.4% | (State of Georgia, 2008) |
| **Florida** | 2007 | 336.6 | 13.1 | 3.9% | (State of Florida, 2010) |
| **Tennessee** | 1990 | 134 | 0.8 | 0.6% | (Tennessee Technical University, 1999) |
| **Kentucky** | 2005 | 185 | 1.7 | 0.9% | (Center for Climate Strategies, 2010) |
| **Alabama** | 1990 | 154 | 0.7 | 0.4 | (Herz, 1997) |

Higher temperatures, reduced freezing days, and shifts in the hydrologic cycle towards more intense droughts and heavier rains will all impact agriculture to a lesser or greater degree. A hotter, more water-variable climate will exert stress on many indigenous plants and may favor introduced species, particularly those adapted for the changing climate regime. EHECs could be specifically engineered to thrive in the new environment by incorporating genetic material from warm-weather species that confers the ability to tolerate higher summer temperatures, grow more substantive root systems (to hold soil that would otherwise be eroded by heavy rains and droughts), retain moisture, and resist the increased number of plant pests that are predicted to accompany climate change.

## 3.11 Resources Considered But Not Analyzed in Detail

CEQ's *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* (40 CFR Parts 1500-1508) state that the lead Federal agency shall "identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (40 CFR §1506.3), narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere" (40 CFR §1501.7(a)(3)). In consideration of the site-specific environmental evaluation that must be completed prior to approval of an EHEC Program, DOE has determined the Proposed Action has no potential, at a programmatic level, for major adverse impacts on certain resources, described below, as defined by 40 CFR §1508.27.

### 3.11.1 Aesthetic and Visual Resources

Visual resources are usually defined as the visual quality or character of an area, consisting of both the landscape features and the social environment from which they are viewed. The landscape features that define an area of high visual quality may be natural (e.g., mountain views) or man-made (e.g., city skyline). The term aesthetics refers to the pleasurable characteristics of a physical environment, such as the beauty or attractiveness of an area as perceived visually.

The geographic scope for this Final PEIS is limited to existing croplands, pasturelands, and forested areas; therefore, implementing the Proposed Action and its alternatives would be expected to be visually similar to the existing agricultural lands. The EHEC Programs and activities would be similar to activities and appearance of existing crops within the proposed project area. The potential for physical alterations of the agricultural lands by EHECs would be negligible as existing crops would be replaced by the proposed EHEC plants. Thus, this resource area was eliminated from analysis in this Final PEIS.

### 3.11.2 Cultural Resources

Cultural resources can consist of prehistoric and historic districts, sites, buildings, structures or objects that may be archaeological, architectural, or traditional cultural properties. Historic properties are generally at least 50 years of age or older, although some may achieve historic significance in more recent times. The National Historic Preservation Act (NHPA), as amended directs the Federal government to consider the effects of its actions on historic and cultural resources (16 U.S.C. §470 *et seq*.). In addition, the NHPA established the National Register of Historic Places (National Register) as the U.S. government's official list of districts, sites, buildings, structures, and objects deemed worthy of preservation (16 U.S.C. §470a(a)). It is noteworthy, however, that the NHPA does not necessarily mandate preservation but does require a carefully considered decision making process, similar to the NEPA process. Under Section 106 of the NHPA (implemented by 36 CFR Part 800), a Federal agency must take the effects of an undertaking on historic properties into account prior to implementation through a four-step compliance process (initiate, identify, assess, and resolve). Section 106 requires that Federal agencies provide the Advisory Council on Historic Preservation (ACHP) and the State Historic Preservation Officer or Tribal Historic Preservation Officer with an opportunity to comment on the undertaking prior to implementation.

Implementing the Proposed Action and its alternatives would need to occur on existing croplands, pasturelands, or forest areas; the planting of EHECs would not disturb soils below the current plow zone (upper layer of soil disturbed by a plow). The potential for cultural or historic resources on existing agricultural lands would be negligible as the proposed EHEC plants would only replace existing crops. Therefore, this resource area was eliminated from detailed analysis in this Final PEIS.

However, future site-specific environmental compliance reviews would include surveys for the presence or absence of historic properties and cultural resources, and incorporate consultation activities with the appropriate State Historic Preservation Officers or Tribal Historic Preservation Officers to ensure the proper consideration of these resources. If a potential EHEC Program should disturb the soils below the plow zone, or if the project area has never been plowed, then the Section 106 process would be conducted during site-specific environmental compliance reviews. Activities that would involve deep soil penetrations from plowing may affect unknown buried historic or cultural resources.

### 3.11.3 Floodplains and Wetlands

***Floodplains.*** Floodplains are areas adjacent to rivers, streams, or coastal waters that are subject to periodic inundation. Often floodplains contain a mixture of wetland types and hydric (i.e., water-loving) soils. These dark-colored soils are rich in nutrients, providing ideal conditions for crop production.

EO 11988, *Floodplain Management*, and DOE's *Compliance with Floodplain and Wetland Environmental Review Requirements* (Executive Order 11988, 1977) (U.S. Department of Energy, 2003a) direct Federal agencies to consider alternatives to avoid any direct or indirect impacts on floodplains, unless the agency determines that there is no practical alternative to undertaking the action in a floodplain (10 CFR Part 1022) (U.S. Department of Energy, 2003b). The project alternatives would occur on existing and established agricultural fields, possibly within floodplains. Site-specific environmental compliance review would consider impacts to floodplain hydrology and resources in accordance with EO 11988 and DOE's floodplain environmental review requirements. Therefore, impacts to floodplains, including potentially expanded floodplain areas resulting from climate change effects, are not expected.

***Wetlands.*** It is the goal and intent of DOE, consistent with EO 11990, *Protection of Wetlands*, to mitigate potential impacts to wetlands through avoidance, and to manage for wetlands during the environmental planning process. If possible encroachment on wetlands might occur, site-specific correspondence would be conducted with the U.S. Army Corps of Engineers (USACE) and state agencies, to determine if jurisdictional wetlands would be impacted and to establish appropriate BMPs to minimize adverse impacts.

The geographic scope for this Final PEIS is limited to existing croplands, pasturelands, and forested areas. For this Final PEIS, proposed EHEC field trials would not occur within any wetlands. No direct impacts to wetlands from implementation of the Alternatives. Site-specific BMPs could be developed to specify the buffer widths adjacent to wetlands and aquatic areas, depending on proximity to EHEC confined field trial plots. Each producer would also be required to develop and use crop- and site-specific BMPs to minimize seed dispersal and impact to wetlands.

Indirect impacts to wetlands could result from pesticide, fertilizer, and sediment runoff from the Alternatives. The amount of runoff would vary by location and crop species, and some wetlands (e.g., small, isolated, or seasonal wetlands) would be more vulnerable to direct losses or indirect impacts of drainage (Blann, Anderson, Sands, & Vondracek, 2009). Since the amount of runoff produced from EHECs should not be greater than crops grown for agriculture, no impacts to wetlands are expected to result from the Proposed Action or Alternatives. However, future site- and plant-specific environmental compliance reviews would document wetlands within the project area to ensure the consideration of this resource.

Some possible perennial herbaceous EHECs may invade wetlands, including giant cane and reed canarygrass. BMPs to control invasive species are discussed in Section 4.5, Biological Resources.

### 3.11.4 Infrastructure

Infrastructure includes transportation systems (e.g., roads, bridges, rail, waterways, pipelines), drinking and wastewater pipes, dams and levees, electrical transmission and distribution lines, communications networks, and other structures intended to move goods, people, information, and energy. The types of infrastructure most closely associated with the Proposed Action and Alternatives are road transportation for the movement of agricultural equipment, and water infrastructure for irrigation.

The Alternatives would not cause direct or indirect impacts to regional transportation infrastructure on a programmatic level. EHEC-cultivating activities would not alter existing agricultural transportation, practices, or patterns. The EHEC Programs would not increase the volume of goods moving through these areas; change the types or volume of agricultural inputs (e.g., fuel, fertilizer); or alter the number of people or agricultural products that require transportation. The field trials would use the same types of equipment (e.g., trucks, plows, harvesters) which would operate in existing agricultural areas. Increases in truck traffic near the EHEC field trial locations might occur, but these would be short-term and have minor impacts, if any. The proposed EHEC Programs would not place additional burdens on roads, highways, and bridges in the Project Area, or increase the rate of wear and tear on transportation systems.

The Alternatives would have no direct or indirect impact on non-transportation related infrastructure such as water infrastructure, electrical wires, communications networks, or pipelines. Thus, both transportation and non-transportation infrastructure are excluded from analysis in this Final PEIS.

### 3.11.5 Hazardous Wastes and Materials

Hazardous wastes and materials are defined and managed by the Solid Waste Disposal Act of 1965 and the Resource Conservation and Recovery Act (RCRA) (Resource Conservation and Recovery Act, 1976) to ensure that solid wastes are managed in an environmentally sound manner (42 U.S.C. §6901 et seq.).

In accordance with RCRA Subtitle D, Solid Waste, waste covered by other regulatory statutes (such as the Clean Water Act) is exempt under RCRA's definition of solid waste and therefore RCRA. Agricultural wastes, including manures and crop residues, returned to the soil as fertilizers or soil conditioners are excluded from regulation as hazardous waste (40 CFR §257.1(c)(1)).

A pesticide waste is any material, containing any concentration of pesticides that has been declared a waste. Examples include rinse material from containers and spray equipment, leftover spray solutions, excess pesticides, and canceled or suspended pesticides. Under RCRA regulations, commercial chemical products such as pesticides become "solid wastes" (and thus, potentially, hazardous wastes) at the point where the pesticide's holder (i.e., end-user, dealer, distributor, or registrant) decides to discard them. If a pesticide product is listed in 40 CFR Parts 261.31 or 261.33, or exhibits a hazardous waste characteristic (as identified in 40 CFR Parts 261.21-261.24), it becomes a hazardous waste at the point when its holder decides to discard it. The pesticide's holder, who makes the decision to discard, controls the point at which the pesticide becomes a solid waste. If the pesticide is a hazardous waste, RCRA regulations govern its transportation and storage from that point on. If an end-user decides to dispose of the pesticide in their possession instead of returning the pesticide to the registrant through a recall program, the pesticide would be considered a solid waste subject to RCRA.

If pesticide application may occur during the agricultural practices for the proposed EHEC Programs, the pesticide applicators would comply with current environmental hazardous waste regulations, which are the same for EHECs and conventional crops. Implementing the Alternatives would not generate hazardous wastes, as defined under RCRA, and thus would not be regulated under RCRA. As stated, irrigation return flows and crop residues are specifically exempt from regulation and the pesticide waste management would not have an impact by the Proposed Action and Alternatives.

Pesticides with respect to Human Health and Safety are discussed in Section 3.9, Safety and Human Health. Hazardous materials are considered any solid, liquid, or gas that can harm people, other living organisms, property, or the environment. Chemicals are substances with a specific chemical composition. Some chemicals would be classified as hazardous materials and others not. Primary hazardous chemicals in the agricultural field include fertilizers, anhydrous ammonia, and pesticides. Specific chemical compounds (fertilizers and pesticides) are not known; however, there would no change in the ones used from existing conditions. It is anticipated that the same hazardous materials handling procedures would be used for the EHECs as with conventional crops. No impact is anticipated to hazardous materials.

### 3.11.6 Noise

The sensation of sound is produced when pressure variations having a certain range of characteristics reach a receptive ear. Sound is the term describing pressure variations that are pleasant or useful for communication. Noise is generally defined as unwanted sound, although noise and sound are often used interchangeably. Sound becomes unwanted when it either interferes with normal activities such as sleeping or conversation, or disrupts or diminishes one's quality of life.

Unwanted sounds from road traffic, aircraft, commercial trucks, construction equipment, manufacturing processes, and home maintenance— to name a few sources— are among the noises routinely broadcast into the environment. Noise negatively affects the health and well-being of both humans and wildlife in many ways (Noise Pollution Clearinghouse, n.d.). Responses to noise vary, depending on the type and characteristics of the noise, time of day, expected level of noise, distance between the receptor and noise source, and the receptor's sensitivity. The most noticeable problems related to noise for humans are hearing loss and hearing impairment; however, other concerns may include stress, sleep loss, distraction, loss of productivity, and a reduction in quality of life and opportunities for tranquility. Noise can provoke annoyance responses and changes in social behavior. For animals, noise can disrupt feeding and foraging, migration, and nesting. The effects of noise can be immediate or latent as a result of long-term exposure (Environmental Protection Agency, 1974; Berglund & Lindvall, 1995).

The unit used to describe the intensity of sound is the decibel (dB). Audible sounds to the human ear range from 0 dB to about 140 dB and the frequency range is 20 Hertz (Hz) to 20 Kilohertz (KHz). The noise metric used to approximate the range of human hearing is the A-weighted scale and is denoted as dB(A). For example, conversational speech is ~60 dB(A) and an aircraft taking-off is ~110 dB(A). This noise metric does not account for the duration of the sound or any variation of the sound with time.

Implementing the Alternatives could create minor, temporary noise impacts with no increases in ambient (background) noise levels at or adjacent to the confined field trial locations since the proposed EHEC activities would be similar to activities currently taking place in the project area. Noise from heavy equipment (e.g., tractors, trucks) is common on agricultural lands and in timber areas during harvest activities. The potential for increased noise levels associated with the proposed EHEC Programs would be minor, temporary, and localized. In addition, traffic through communities is not expected to escalate to levels that would increase ambient noise levels along existing transportation routes. Although there may be minor impacts expected when noise is evaluated on this programmatic level, environmental compliance review would be required, including an evaluation of potential associated noise impacts, for these projects on a site-specific basis.  Therefore, this resource area was eliminated from detailed analysis in this Final PEIS.

# 4 Environmental Consequences

## 4.1 Introduction

This Chapter describes the potential environmental impacts, beneficial, or adverse, resulting from the Proposed Action and Alternatives. As this is a programmatic evaluation, site- and EHEC-specific issues are not assessed. The production of EHECs could utilize agricultural practices that are similar to those used in traditional crop agriculture with some variations in equipment and techniques. Production operations and multi-year characteristics for each EHEC could vary. Therefore, this Final PEIS discusses the three broad classes of energy crops (perennial herbaceous, annual herbaceous and woody crops) and identifies the range of possible impacts on resources present in the project area for the Proposed Action and Alternatives, including the No Action Alternative.

As described in Chapter 2, the Final PEIS reviews potential impacts from three Alternatives (development-, pilot-, and deployment-scale) and the No Action Alternative. Under the No Action, financial assistance for the development and implementation of any EHEC Programs would not be provided. Although some private-sector EHEC field trials may occur, DOE assumes that development of EHECs could occur slowly or in an uncoordinated fashion. The No Action provides a comparison to describe the effects of environmental resources of the existing conditions to the proposed Alternatives.

NEPA requires agencies to assess the potential direct and indirect impacts each alternative could have on the existing environment (as characterized in Section 3.0). Direct impacts are those impacts that are caused by the Proposed Action and occur at the same time and place, such as soil disturbance or invasiveness concerns. Indirect impacts are those impacts related to the Proposed Action but result from an intermediate step or process, such as changes in surface water quality because of soil erosion.

For each resource, the potential impact is assessed in terms of context of the action and the intensity of the potential impact, per CEQ regulations (40 CFR §1508.27). *Context* refers to the timing, duration, and where the impact could potentially occur (i.e., local vs. national; pristine vs. disturbed; common species vs. protected species). Context in duration of potential impact is described as short or long term. *Intensity* refers to the magnitude or severity of the effect and whether it is beneficial or adverse. Resource-specific definitions of intensity and context are described at the beginning of each resource section in this chapter. The Final PEIS describes quantitative and qualitative analyses, where possible, in determining whether, and the extent to which, a threshold may be exceeded.

## 4.2 Land Use

### 4.2.1 Impact Criteria

An evaluation of land use impacts involves a comparison of current and future proposed land uses and a determination of the extent to which the Proposed Action and Alternatives might be incompatible with these uses. There is the potential for a major land use impact to occur when an activity:

- Disrupts an existing or planned land use;
- Reduces the land's suitability to support its current or planned use;
- Constitutes a fundamental change in land use;

- Is inconsistent or in conflict with existing land use authority, guidelines, or management plans; and
- Results in the physical division of an established community.

This Final PEIS analysis reviews the potential land use impact for the proposed EHEC Programs regardless of the crop type (perennial herbaceous, annual herbaceous or woody crop). As described in Chapter 2, only existing cropland, pastureland, or forested land could be used for the confined field trials. New non-agricultural lands would not be allowed to enroll in an EHEC Program. As detailed in Section 2.3.1, the number of acres enrolled in the EHEC project areas for crop production shall be limited to no more than 25% of the cropland in a given county. Specific acreage in a given county would be reviewed in future site- and plant-specific environmental compliance review. Table 4.2-1 summarizes the potential land use impacts.

**Table 4.2-1: Potential Land Use Impact Summary**

| Impact Criteria | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| Disrupts an existing or planned land use | ⊙ | ⊙ | ⊙ | ○ |
| Reduces the land's suitability to support its current or planned land use | ○ | ○ | ○ | ○ |
| Constitutes a fundamental change in land use | ⊙ | ⊙ | ⊙ | ○ |
| Is inconsistent or in conflict with existing land use authority, guidelines, or management plans | ○ | ○ | ○ | ○ |
| Results in the physical division of an established community | ○ | ○ | ○ | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.2.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

As described in Chapter 2, only 10% of the existing cropland (including pastureland and forested areas) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%.[19] This equates to a relatively small amount of vegetation being converted from traditional crops, pastureland, or forested lands to EHECs. Under Alternative 1, the EHEC Programs could be implemented on development-scale plots (up to 5 acres) on existing agricultural lands.

[19] The intent of the proposed EHEC Programs is not to convert existing cropland to forested land or vice versa, nor is it to convert up to 25% of the existing agricultural land in any one county. For each of the Alternatives, these percentages are the same restraints proposed in the *Billion Ton Update* report to "simulate the relative inelastic nature of agriculture in the near-term" meaning growers do not swap out crops quickly (U.S. Department of Energy, 2011).

Alternative 1 could cause land use changes only at the local level (i.e., county or multi-county region) which could cause short-term negligible impacts to land use.

Table 4.2–2 indicates the land use by state in the project area for the No Action Alternative. Table 4.2–3 summarizes the changes caused by implementing Alternative 1 (assuming that 10% of the existing cropland was converted to EHEC confined field trial cropland in any county) from the No Action Alternative. Land use changes range between 459,555 acres (91,911 five-acre plots - South Carolina) to 1,329,766 (265,953 five-acre plots - Kentucky) of cropland, pastureland, or forested land converted to EHECs from that of the No Action Alternative.

**Table 4.2-2: Farmland Use (in acres) in the Project Area for Potential EHECs under the No Action Alternative**

| State | 2007 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total Farmland (acres) | Cropland (acres) | Woody Crops (acres) | Pastureland (acres) | House lots (acres) | Farmland in Conservation (acres) | No Action | Alternative 1 (acres) |
| **Alabama** | 9,033,537 | 3,142,958 | 3,375,438 | 2,017,079 | 498,062 | 494,441 | 0 | 853,547 |
| **Florida** | 9,231,570 | 2,953,340 | 2,330,336 | 3,221,202 | 726,692 | 224,867 | 0 | 850,488 |
| **Georgia** | 10,150,539 | 4,478,168 | 3,712,672 | 1,341,985 | 617,714 | 331,166 | 0 | 953,282 |
| **Kentucky** | 13,993,121 | 7,278,098 | 3,107,137 | 2,912,424 | 695,462 | 375,049 | 0 | 1,329,766 |
| **Mississippi** | 11,456,241 | 5,530,825 | 3,610,991 | 1,639,243 | 675,182 | 1,107,406 | 0 | 1,078,106 |
| **North Carolina** | 8,474,671 | 4,895,204 | 2,201,609 | 941,609 | 436,249 | 163,676 | 0 | 803,842 |
| **South Carolina** | 4,889,339 | 2,151,219 | 1,827,191 | 617,136 | 293,793 | 264,950 | 0 | 459,555 |
| **Tennessee** | 10,969,789 | 6,047,348 | 2,042,868 | 2,545,047 | 334,535 | 289,200 | 0 | 1,063,527 |
| **Virginia** | 8,103,925 | 3,274,137 | 2,319,491 | 2,150,933 | 359,364 | 70,112 | 0 | 774,456 |

*Source:* (U.S. Department of Agriculture -- Economic Research Service, 2014)

**Table 4.2-3: Changes under Alternative 1 from the No Action in Farmland Use (in acres) in the Project Area for Potential EHECs**

| State | 2007 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total Farmland (acres) | Cropland (acres) | Woody Crops (acres) | Pastureland (acres) | Alternative 1 (acres) | House lots (acres) | Farmland in Conservation (acres) |
| **Alabama** | 9,033,537 | (314,296) | (337,544) | (201,708) | 853,547 | 498,062 | 494,441 |
| **Florida** | 9,231,570 | (295,334) | (233,034) | (322,120) | 850,488 | 726,692 | 224,867 |
| **Georgia** | 10,150,539 | (447,817) | (371,267) | (134,198) | 953,282 | 617,714 | 331,166 |
| **Kentucky** | 13,993,121 | (727,810) | (310,714) | (291,242) | 1,329,766 | 695,462 | 375,049 |
| **Mississippi** | 11,456,241 | (553,082) | (361,099) | (163,924) | 1,078,106 | 675,182 | 1,107,406 |
| **North Carolina** | 8,474,671 | (489,520) | (220,161) | (94,161) | 803,842 | 436,249 | 163,676 |
| **South Carolina** | 4,889,339 | (215,122) | (182,719) | (61,714) | 459,555 | 293,793 | 264,950 |
| **Tennessee** | 10,969,798 | (604,735) | (204,287) | (254,505) | 1,063,527 | 334,535 | 289,200 |
| **Virginia** | 8,103,925 | (327,414) | (231,949) | (215,093) | 774,456 | 359,364 | 70,112 |

*Source:* (U.S. Department of Agriculture -- Economic Research Service, 2014)

*Table 4.2-3 reflects a 10% conversion of existing cropland to EHEC confined field trials. Conversion to EHEC confined field trials will not exceed 25% of any one county's existing cropland

The agricultural sector, including input suppliers (seed, fertilizer, farm equipment, etc.) could be indirectly impacted by changes in land use. This change in land use could result in minor adverse impacts within communities, as inputs for those traditional crops could not be purchased. Overall, no direct or indirect impacts to land uses could occur through implementation of Alternative 1.

### 4.2.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

Alternative 2 differs from Alternative 1 only by the size of the confined field trial plots and direct and indirect impacts are not anticipated since only 10% of existing cropland (including pastureland and forested lands) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%. This equates to a relatively small amount of vegetation being converted from traditional crops or pastureland to potential EHECs.

### 4.2.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

Alternative 3 differs from Alternatives 1 and 2 only by the size of the confined field trial plots. Only 10% of existing cropland (including pastureland and forested lands) could be converted to EHEC confined field trials each year in each county. The total amount of cropland that can be converted into EHECs (perennial herbaceous, annual herbaceous, and woody crop) in any given county is limited to 25%. This equates to a relatively small amount of vegetation converted from traditional crops or pastureland to potential EHECs and therefore no direct or indirect impacts to land use could occur through implementation of Alternative 3.

### 4.2.5 No Action Alternative

Under the No Action, the proposed EHEC Programs would not be implemented for the establishment and production of energy crops. DOE would not provide financial assistance for the development and implementation of EHEC Programs. In the short term, it would be unlikely that domestic production for bioenergy would meet the demand for the Energy Independence and Security Act (EISA) of 2007 advanced biofuels components. No impacts to land use are anticipated from the No Action.

## 4.3 Water Resources

### 4.3.1 Significance Criteria

Evaluation criteria for impacts on water resources are based on water availability, water quality, usage and associated regulations. An alternative that caused one or more of the following to occur could produce adverse impacts on water resources:

- Violation of a Federal, state, or local law or regulation adopted to protect water resources;
- Degradation of surface water or groundwater quality;
- Overdrafting groundwater basins;
- Reduction of water availability or supply to existing users; or
- Exceedance of safe annual yields of water supply sources.

As identified in Chapter 2, the agricultural practices—farming methods (tilling), agrochemical (pesticides and fertilizers) application amounts, and irrigation use—would be the same for the proposed EHECs as traditional crops until research proves otherwise. At this time, there has not been enough research to distinguish between the impacts on water attributable to growing potential EHECs for biofuel production. As the practices would remain the same; therefore, there would be negligible, if any, impacts to surface water and groundwater quality, and water use and availability from the proposed Alternatives.

Table 4.3-1 identifies the factors considered for determining significance. Additional environmental compliance review would be necessary once the specific EHEC species and locations are known. Table 4.3-2 provides a summary of the potential water resources impacts.

**Table 4.3-1: Crop Production Activities and their Potential Effect on Water Quality**

| Crop Production Activities | Potential Effect on Water Quality |
|---|---|
| Planting and Harvesting | Soil disturbance from tillage practices and soil compaction from the use of heavy equipment could leave soils susceptible to increased wind and water erosion, leading to potential sedimentation and turbidity impacts in surface waters from increased runoff. |
| Pest Management | Use of pesticides may leach into groundwater or move to surface waters through soil erosion or runoff, spray drift, or inadvertent direct overspray. |
| Nutrient Management | Use of fertilizers could lead to leaching of nitrates into groundwater and movement of nitrates and phosphorous into surface waters, potentially causing eutrophication. |
| Irrigation | Irrigation induced runoff could potentially increase movement of nutrients and pesticides into groundwater and surface waters. |

**Table 4.3-2: Potential Water Resources Impact Summary**

| Impact Criteria | Alternative 1 (Perennial, Annual, Woody Crop) | Alternative 2 (Perennial, Annual, Woody Crop) | Alternative 3 (Perennial, Annual, Woody Crop) | No Action |
|---|---|---|---|---|
| Pest Management | + ⨀ + | + ⨀ + | + ⨀ + | ○ |
| Nutrient Management | + ⨀ + | + ⨀ + | + ⨀ + | ○ |
| Sedimentation | + ⨀ + | + ⨀ + | + ⨀ + | ○ |
| Water Use & Availability | + ⨀ + | + ⨀ + | + ⨀ + | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⨀ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.3.2 Alternative 1 – Development-scale Confined Field Trials (up to 5 acres)

### 4.3.2.1 Surface Water

As described in Section 3.2, agricultural practices have the potential to affect surface water quality due to the immense amount of acreage devoted to farming nationwide and the physical and chemical demands that agricultural use has on the land. Impacts on water quality from the proposed EHECs could be primarily driven by agrochemical inputs (pesticides and fertilizers) at the production stage, with the amount varying by crop type and location (Environmental Protection Agency, 2013d). Soil erosion that moves sediments and sediment-bound nutrients and pesticides into waterways is another factor influencing water quality. Many factors contribute to the relative risks of pesticides to the environment, including fate and transport characteristics, method of application, depth to groundwater, and proximity to receiving waters. Half of the sediment deposited in U.S. surface waters is estimated to come from cropland erosion (Terrell & Perfettie, 1993). Management practices used on croplands and crop type determine the extent of erosion.

### Perennial Herbaceous

***Pest Management.*** The lack of commercial perennial herbaceous EHECs (e.g., switchgrass, sugar, and energy cane, leauceana, jatropha, and Chinese tallow) production as biofuel feedstock makes it difficult to predict how much pesticide could be needed for application and what the specific environmental impacts to water resources could be for the proposed EHEC Programs. As discussed in Section 3.9, it is likely that pesticides could be needed, especially to establish and maintain switchgrass and giant miscanthus (Keshwani & Cheng, 2009). As identified in Chapter 2, the agricultural practices—farming methods (tilling), agrochemical (pesticides and fertilizers) application amounts, and irrigation use—could be the same for the proposed EHECs as traditional crops (until research proving otherwise is provided). In non-commercial production, pesticide releases from perennial grass plantings were less than from corn or soybeans (Hill, Nelson, Tilman, Polasky, & Tiffany, 2006). Research in small field trials has shown that perennial grasses are generally less susceptible to pests than traditional row crops, with switchgrass plantings using approximately 90% less pesticides than traditional row crops (Keshwani & Cheng, 2009). When possible, the proposed EHEC Programs would work to avoid and minimize the discharge of herbicides and pesticides into waters of the United States, to the extent practicable. Long-term minor beneficial impacts from implementation Alternative 1 could occur if perennial EHECs are used related to pesticide use.

***Nutrient Management.*** One of the key benefits of using perennial species as cellulosic feedstocks involves the internal recycling and storage of nutrients, allowing for the removal of biomass at the end of the growing season with minimal loss of nutrients from the ecosystem (Heaton, Dohleman, & Long, 2008). Due to a longer growing season and minimal nutrient requirements, perennial grasses have the potential for large yields and reduced environmental impacts from nutrient runoff. Perennial grasses are also able to recycle nutrients by removing nutrients from aboveground tissues for winter storage in their roots or rhizomes, thereby reducing the need for additional fertilizer and overall production costs (Smith, et al., 2013). Relative to annual row crops such as corn, production of switchgrass and giant miscanthus require less fertilizer and reduce surface and subsurface nutrient losses. Conversion of row crops to perennial grass production could reduce surface water impacts from nutrient loading and cause long-term beneficial impacts (Environmental Protection Agency, 2011b).

There is minimal acreage of perennial herbaceous EHECs grown commercially at the present time; therefore, it is difficult to predict what fertilizer inputs farmers would use to cultivate them. Impacts could be minor for Alternative 1; however, potential major adverse impacts could occur if farmers increase fertilizer application rates and irrigation rates to dramatically increase yields (Keshwani & Cheng, 2009). BMPs for fertilizer application can be utilized to reduce potential adverse impacts to water quality. One practice is nutrient management; decreasing the amounts of phosphorus and nitrogen available for runoff or erosion loss or for leaching can reduce impacts on water quality. Nutrient management also helps reduce expenses by avoiding over-application of fertilizer. This is usually achieved by developing a nutrient budget for the crop, applying nutrients at the proper time, applying only the types and amounts of nutrients necessary to produce a crop, and considering the environmental hazards of the site (Sharpley, Daniel, Sims, Lemunyon, Stevens, & Parry, 2003). When possible, the proposed EHEC Programs would work to avoid and minimize the discharge of nutrients into waters of the United States, to the extent practicable.

***Sedimentation.*** Perennial grasses, such as switchgrass, are used frequently as an erosion control management practice to reduce sediment loads from row crops (Environmental Protection Agency, 2011b). Switchgrass can reduce erosion by 99.2% when compared to an average of corn, wheat, and soybeans. Similar results are expected for giant miscanthus, which has been shown to produce more root biomass in field comparisons with switchgrass (Heaton, Dohleman, & Long, 2008). Because of their perennial root structure and assuming conservation-oriented agricultural practices, production of perennial herbaceous EHECs (such as switchgrass and giant miscanthus) is not expected to increase sediment loads to surface waters, except possibly during planting stages. A decrease in soil disturbance could lead to decreased soil erosion potential, and a subsequent decrease in potential sedimentation and turbidity in nearby surface waters. Therefore implementation of Alternative 1, with respect to sediment, using perennial herbaceous EHECs could have long-term beneficial impacts to surface water quality.

### Annual Herbaceous

***Pest Management.*** Pest management of annual herbaceous EHECs (such as sugar beets, sorghum, and camelina) depends on crop production practices. For example, growing continuous corn (rather than growing it in rotation with other crops) can increase population densities of pests, such as the corn rootworm, resulting in increased pesticide applications to control these pest species (Environmental Protection Agency, 2011b). Soybean double-cropping (growing soybeans continuously) is another option to increase returns that would similarly increase the potential for pests and might require additional pesticides. When possible, the proposed EHEC Programs would work to avoid and minimize the discharge of herbicides and pesticides into waters of the United States, to the extent practicable. Total pesticide use could vary by EHEC and crop location but minor adverse impacts to water quality may result under Alternative 1 from pesticides for annual herbaceous crops.

BMPs for pest management can reduce potential adverse impacts to water quality. Integrated pest management (IPM) practices help reduce pesticide use by tailoring treatment to pest infestation cycles, and by targeting the amount and timing of applications. IPM practices focus on extensive monitoring of pest problems, comprehensive understanding of the life-cycles of pests and their interaction with the environment, and precise timing of pesticide applications to minimize pesticide use. In addition to providing environmental benefits of lower pesticide use, IPM often lowers chemical pesticide expenses and pest damage to crops, as well as preventing the development of pesticide-resistant pests. The use of cover crops is an IPM practice that can dramatically reduce chemical application and soil erosion. (Environmental Protection Agency, 2011b)

***Nutrient Management.*** Corn, the dominant ethanol feedstock in the United States has been bred to maximize the allocation of carbon and nitrogen into the grain (Soil and Water Conservation Society, 2010). As a result of this allocation of nutrients into the grain and the annual lifespan of corn, substantial fertilizer application is required to maintain high yields. Of the annual row crops, corn has the highest nutrient application rate and the highest nutrient loading to surface water per unit land area (Soil and Water Conservation Society, 2010). By one estimate, which surveyed 19 U.S. States, approximately 96% of corn acreage received nitrogen fertilizer in 2005, with an average of 138 pounds per acre. Not all annual herbaceous crops require the same amount of nutrients however; fewer nutrients are applied to soybean acres than corn and at much lower rates because soybean is a legume. Legumes have associations in their roots with bacteria that can acquire atmospheric nitrogen and convert it into bioavailable forms, reducing the need for external addition of nitrogen fertilizer. Unfortunately, losses of nitrogen and phosphorus from soybeans can still occur at quantities that can degrade water quality (Environmental Protection Agency, 2011b). Based on current annual herbaceous EHECs, it is anticipated that implementation of Alternative 1 could have minor adverse impacts; however, long-term adverse impacts to water quality may result if nitrogen and phosphorus loading to surface and coastal waters were to occur. Total fertilizer use could vary by EHEC and crop location.

BMPs for fertilizer application can reduce potential adverse impacts to water quality. When possible, the proposed EHEC Programs would work to avoid and minimize the discharge of nutrients into waters of the United States, to the extent practicable. Nutrient management can reduce impacts on water quality by decreasing the amounts of phosphorus and nitrogen available for runoff, erosion loss, or for leaching. Nutrient management also helps reduce expenses by avoiding over-application of fertilizer. This is usually achieved by developing a nutrient budget for the crop, applying nutrients at the proper time, applying only the types and amounts of nutrients necessary to produce a crop, and considering the environmental hazards of the site. (Sharpley, Daniel, Sims, Lemunyon, Stevens, & Parry, 2003)

***Sedimentation.*** Intensive agricultural practices, such as annual tillage of crops, over-harvesting of cellulosic residues, or annual crop production on erodible lands, can cause sediment deposition in waterways. An increase in soil disturbance could lead to increased soil erosion potential, and an increase in potential sedimentation and turbidity in nearby surface waters during rain and irrigation events (Environmental Protection Agency, 2011b). Since EHEC agricultural practices used be the same as conventional crops, implementation of Alternative 1 could result in negligible impacts, with respect to sediment, although there is the potential for long-term adverse direct impacts to surface water from growing annual herbaceous EHECs if increases in soil disturbance were to occur. Erosion concerns could vary by EHEC and crop location.

BMPs for sediment control can reduce potential adverse impacts to water quality. By leaving substantial residues of plant and organic matter on the soil surface, conservation tillage can reduce soil erosion by wind or by water; increase water infiltration and moisture retention; decrease surface sediment and water runoff; and reduce agrochemical runoff. The filtering action of increased organic matter in the top layer of soil could also cause cleaner runoff by reducing contaminants, such as sediment and adsorbed or dissolved pesticide chemicals, and thus benefit the quality of surface waters. The EPA identifies conservation tillage as the first of its core agricultural management practices for water quality protection. (Environmental Protection Agency, 2011b)

### Woody Crops

***Pest management.*** Short-rotation woody crops, such as hybrid poplars (*Populus spp*.), southern pine, and eucalyptus, are fast-growing tree species grown on plantations and harvested in cycles shorter than is typical of conventional wood products, generally between 3 and 15 years (Volk, et al., 2010). Pesticides may be used with woody crops but in smaller quantities than for herbaceous crops (Geo-Marine, Inc., 2010). There could be beneficial impacts with respect to pesticide runoff and short-rotation woody crops under Alternative 1 if the short-rotation woody EHECs replaced herbaceous crops. When possible, the proposed EHEC Programs would work to avoid and minimize the discharge of herbicides and pesticides into waters of the United States, to the extent practicable. If the short-rotation woody crop EHECs replaced similar crops, there could be minimal impacts.

***Nutrient Management.*** Nutrient losses from short-rotation woody crops are, in general, less than in annually cropped systems. Initially after planting, short-rotation woody crops can exhibit losses of nitrogen at rates comparable to conventional corn production, but following this establishment phase, nitrogen losses decline to low levels. Longer rotation lengths could improve nutrient retention on site and reduce losses to waterways. (Soil and Water Conservation Society, 2010); (Volk, et al., 2010)

Some woody crop species (e.g., loblolly pine) have low water and fertilizer requirements; however, these are plant-specific characteristics. Some woody crop species are highly sensitive to drought and require larger fertilizer inputs (Soil and Water Conservation Society, 2010). Therefore, impacts on water quality from woody crop EHECs from nutrient loss could vary by species.

BMPs for fertilizer application can reduce potential adverse impacts to water quality. When possible, the proposed EHEC Programs would work to avoid and minimize the discharge of nutrients into waters of the United States, to the extent practicable. Nutrient management can reduce impacts on water quality by decreasing the amounts of phosphorus and nitrogen available for runoff, erosion loss, or for leaching. Nutrient management also helps reduce expenses by avoiding over-application of fertilizer. This is usually achieved by developing a nutrient budget for the crop, applying nutrients at the proper time, applying only the types and amounts of nutrients necessary to produce a crop, and considering the environmental hazards of the site. (Sharpley, Daniel, Sims, Lemunyon, Stevens, & Parry, 2003)

***Sedimentation.*** Forest soils generally exhibit low erosion rates and thus cause small sediment losses to surface waterways (Soil and Water Conservation Society, 2010). Inputs are reduced under short-rotation woody crops and less runoff, sediment loss, and nutrient loss were measured on three instrumented watersheds in Tennessee, Alabama, and Mississippi (Geo-Marine, Inc., 2010). The input amounts for woody crops are generally lower than traditional row crops (e.g., corn). The ability to harvest and allow regrowth for two to three growing cycles without replanting means a long period with little soil disturbance. This could reduce sediment and nutrient loss in runoff to water bodies enhancing water quality. Under Alternative 1, beneficial impacts are likely to result.

### 4.3.2.2 Groundwater

As discussed in Section 3.2, groundwater can be used for public and private drinking water supplies; fertilizers can increase the concentration of nitrate in groundwater wells, especially shallow wells (less than 200 feet deep). Use of pesticides for EHEC production may introduce these chemicals to water through spray drift, cleaning of pesticide application equipment, soil erosion, or filtration through soils.

***Perennial Herbaceous.*** Decreased use of fertilizers and pesticides to grow perennial herbaceous EHECs compared to corn production could cause reduced nitrate and pesticide leaching into groundwater should have long-term beneficial impacts on groundwater. If the crops are not being converted from annual to perennial crops, then no impacts are anticipated.

***Annual Herbaceous.*** Increased annual herbaceous production for biofuels could worsen the problem of contaminated groundwater because of additional nitrogen inputs from agrochemicals used to grow the annual EHECs. USDA projects that reaching 15 BGY of ethanol from corn would result in a 2.8% increase in nitrogen leaching to groundwater, with the greatest increases occurring in the Great Lakes

States and the Southeastern United States (1.6% increase in corn acreage) (Environmental Protection Agency, 2011b). Similar estimates for other annual herbaceous EHECs were not identified.

***Woody Crops.*** Since pesticides and fertilizer are used in lesser quantities on woody crops, there could be negligible impacts regarding pesticide and fertilizer contamination under Alternative 1 with respect to groundwater. Forest plantations and short rotation woody crops established on grasslands, arable lands, and native forests can reduce streamflow and lower the water table in some situations due to a combination of higher transpiration rates and, compared to grassland and cropland, higher interception and evaporation of precipitation. Effects on streamflow are most apparent in dry regions and years and on sites with coarse-textured soils (Vance, Loehle, Wigley, & Weatherford, 2014). For example, eucalyptus can produce more biomass per unit water consumed than native Southeastern pines; however, their rapid biomass production has proportionally higher transpiration costs and therefore uses greater amounts of water (Vance, Loehle, Wigley, & Weatherford, 2014). Modeling conducted by the U.S. Forest Service to examine the potential effects of expanding the distribution of eucalyptus plantations in USDA Plant Hardiness Zones 8b and greater (much of the project area in the Southeastern United States) found that water consumption could be equal to or reduced in comparison to some pine plantations but varies by location, land cover type before eucalyptus establishment, and the hydrologic conditions of the site and surrounding area (Vose, Miniat, Sun, & Caldwell, 2014). The potential impact on groundwater and stream flow depends on the woody crop species, area extent, size, and spatial distribution of the woody crop plantations (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service -- Biotechnology Regulatory Service, 2012) (Volk, et al., 2010). The potential impact on groundwater and stream flow depends on the woody crop species, area extent, size, and spatial distribution of the woody crop plantations. A few small (25 acres or less) and well-dispersed plantations, such as Alternative 1, may only have localized impacts and negligible impacts at the watershed scale.

Potential impacts from growing woody EHECs on water use, streamflow, and groundwater recharge in vulnerable environments can be reduced by limiting the proportion of the landscapes or watersheds on which they are established and by selecting species and clones with lower transpiration rates. Standards and guidelines state that short-rotation woody crops should not deplete ground or surface water supplies, buffers be placed between operations and water sources, and that management plans and practices be based on best available scientific information. (Vance, Loehle, Wigley, & Weatherford, 2014)

### 4.3.2.3 Water Use and Availability

Agricultural production fundamentally depends on water. When used, irrigation can amount to 100 to 1,000 times the volume of water required to convert EHECs into a given volume of biofuel (Environmental Protection Agency, 2011b).

The amount of water required to grow biofuel crops varies with crop and region, because precipitation, evapotranspiration, and soil conditions vary regionally. Irrigation requirements for proposed EHECs would be on a case-by-case basis; at the present time, potential water use by a specific EHEC is unknown. The nature of water availability and all its associated impacts on human and ecological communities resulting from EHEC Programs is difficult to generalize, but impacts could be adverse in areas with already stressed aquifers or surface watersheds. Water availability for EHEC Programs would likely not change appreciably for Alternative 1, since the majority of the Southeastern United States does not require supplemental irrigation for conventional agriculture (Kenny, et al., 2009). However, higher temperatures and less rainfall from global climate change could increase the need for irrigation, which could be constrained by water availability. Production of EHECs could exacerbate stress on water availability. Future site- and plant-specific environmental documentation would review irrigation requirements and potential impacts to water availability. It is anticipated that the project-specific environmental reviews would provide information on water use and availability, in addition to identifying potential BMPs – tailored to each proposed EHEC project – to meet USDA APHIS BRS regulatory requirements. DOE or another Federal agency may require a recipient to implement appropriate BMPs as a condition of receiving funding or permits for a proposed EHEC project.

***Perennial Herbaceous.*** Perennial herbaceous EHECs, such as switchgrass or miscanthus, are both C4 grasses that use water efficiently and are adapted to warmer environments. Neither requires water inputs to attain high yields, except when summers are dry and in dry years (Environmental Protection Agency, 2011b). However, both species have been found to increase yields with higher water inputs so farmers might use irrigation to increase their yields and subsequent profits (Heaton, Dohleman, & Long, 2008), which could have an adverse impact on water use and availability. Implementation of Alternative 1 using perennial herbaceous grasses could have minor beneficial impacts, with respect to water use, although there is the potential for adverse impacts on water use if higher water inputs were applied.

Depending on where perennial grasses are grown, whether irrigation is required, and what crops they replace (if any), perennial grass production could improve or worsen water availability. If perennial grasses replace more water-dependent crops, groundwater availability could be improved in states where aquifers provide most of the water to agriculture (U.S. Department of Agriculture -- National Agricultural Statistics Service, 2009) (Kenny, et al., 2009).

An alternative to utilization of high quality fresh ground and surface water for irrigation is to maximize the use of treated and recycled waters for energy crop production. Irrigation with treated wastewater provides a means to irrigate future bioenergy crops without burdening local water resources while at the same time not excessively overloading the crops with nutrients (Dimitriou, et al., 2011). It could offset the impacts of utilizing higher quality well and surface waters for growing energy crops in regions. (Dimitriou, et al., 2011)

***Annual Herbaceous.*** As with perennial herbaceous EHECs, the annual crop species and location grown could improve or worsen water use and availability. In areas where rainfall is available, many annual EHECs could be grown without irrigation; in areas with less rainfall, farmers might irrigate the EHECs to produce as much biomass as they can (improve profitability), which could have potential adverse impacts. Implementation of Alternative 1 could have no impact on water use and availability, although there is the potential for adverse impacts on water use if higher water inputs were applied.

As mentioned under Perennial Herbaceous, maximizing the use of treated and recycled waters for EHEC production could reduce the use of fresh ground and surface water. Irrigation with treated wastewater provides a means to irrigate future bioenergy crops without burdening local water resources while at the same time not excessively overloading the crops with nutrients. It could offset the impacts of utilizing higher quality well and surface waters for growing energy crops in regions. (Dimitriou, et al., 2011)

***Woody Crops.*** Woody crops are usually not irrigated since they require little additional water (Soil and Water Conservation Society, 2010) (Volk, et al., 2010). However, woody crops can still impact regional water availability due to their much higher evapotranspiration rate. Because water transpired through leaves comes from the roots, plants with deep reaching roots can more constantly transpire water. Therefore, herbaceous plants generally transpire less than woody plants because they usually have less extensive foliage. Conifer forests tend to have higher rates of evapotranspiration than deciduous forests. For example, conversion of natural pine savanna and low-intensity pasture to plantations of slash pine and loblolly pine in the Southeastern United States could result in nearly 1,000 gallons of additional water consumed per gallon of ethanol (Soil and Water Conservation Society, 2010); (Volk, et al., 2010). Additional irrigation water may be required to maintain high biomass accumulation (Geo-Marine, Inc., 2010), though precision application systems can reduce the amount of water applied. However, since woody crops are only considered renewable biomass if cultivated on previously managed forested lands or existing forest plantations, the risk of increased evapotranspiration rates is low.

Although some woody crop species do not require irrigation, other species naturally occur on wet sites and may actually be less water use efficient and more susceptible to drought (Soil and Water Conservation Society, 2010). If yield can be increased substantially with irrigation, farmers could employ irrigation to improve the productivity and profitability of their operations.

Several authors report that evapotranspiration from woody crop plantations of willow and poplar is, in most cases, higher than herbaceous crops but lower than conventional forests (Dimitriou, et al., 2011). Actual water consumption by a woody crop in relation to other crops grown in the same area is dependent on site-specific factors such as soil type and precipitation, and varies by species. Implementation of Alternative 1 could result in negligible impacts from woody crop EHECs, with respect to water use and availability; however, there is the potential for adverse impacts on water use if higher water inputs were applied to increase biomass or yield.

### 4.3.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

As described in Alternative 1, the impacts on water resources could vary based on EHEC crop species and location. Increasing the acres of EHECs grown (confined field trial size) should not change the potential impacts from those described in Alternative 1. Similar to Alternative 1, future site- and plant-specific environmental documentation would review irrigation requirements and potential impacts to water availability. It is anticipated that the project-specific environmental reviews would provide information on water use and availability, in addition to identifying potential BMPs – tailored to each proposed EHEC project – to meet USDA APHIS BRS regulatory requirements. DOE or another Federal agency may require a recipient to implement appropriate BMPs as a condition of receiving funding or permits for a proposed EHEC project.

### 4.3.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

As described in Alternative 1, the impacts on water resources vary based on EHEC crop species and location. Increasing the acres of EHECs grown (confined field trial size) should not change the potential impacts from those described in Alternative 1. Similar to Alternatives 1 and 2, future site- and plant-specific environmental documentation would review irrigation requirements and potential impacts to water availability. It is anticipated that the project-specific environmental reviews would provide information on water use and availability, in addition to identifying potential BMPs – tailored to each proposed EHEC project – to meet USDA APHIS BRS regulatory requirements. DOE or another Federal agency may require a recipient to implement appropriate BMPs as a condition of receiving funding or permits for a proposed EHEC project.

### 4.3.5 No Action Alternative

Under the No Action Alternative, the development of EHECs could occur slowly or in an uncoordinated fashion. There could be no impact to water quality or water quantity used for irrigation purposes from existing conditions, unless there was a substantial increase in permits approved for producing EHECs under the No Action Alternative.

## 4.4 Geology and Soils

### 4.4.1 Impact Criteria

Impacts to soil and geological resources could be considered major if implementation of an action resulted in any of the following:

- Substantial erosion that decreases the area's agricultural viability through substantial soil loss;
- Substantial erosion that increases pollution of nearby waterbodies due to increased sediment, fertilizers, or pesticides; and
- Altered soil characteristics due to soil compaction, degradation of soil structure, nutrient loss, increased salinity, change in pH, and reduced soil biological activity (U.S. Department of Agriculture -- Natural Resources Conservation Service, 2014).

This section describes potential impacts and possible BMPs that could be implemented to minimize or avoid these effects. Table 4.4-1 provides a summary of the potential geology and soils impacts.

**Table 4.4-1: Potential Geology and Soils Impact Summary**

| Impact Criteria | Alternative 1 (Perennial, Annual, Woody Crop) | Alternative 2 (Perennial, Annual, Woody Crop) | Alternative 3 (Perennial, Annual, Woody Crop) | No Action (Perennial, Annual, Woody Crop) |
|---|---|---|---|---|
| Subsidence | ○⊙ | +⊙+ | +⊙+ | ○ |
| Erosion | ⊙+ | +⊙+ | +⊙+ | ○ |
| Prime and Unique Farmland | ○○○ | ○○○ | ○○○ | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

### 4.4.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

Previous studies have been conducted to examine the impacts to soils from growing energy crops. Impacts to soils vary depending on plant type and location. The ecological implications of the Proposed Action could be positive – especially in cases where perennial biomass crops displace annual agricultural crops (Cook & Beyea, n.d.).

***Perennial Herbaceous.*** Perennial herbaceous crops, such as switchgrass, provide improved soil and environment conditions in comparison to row crops (e.g., corn), in large part because these grasses do not require intensive cultivation or soil disturbance after establishment. One property of perennial herbaceous soils is decreased soil density, due to the deep rooting system and perennial roots; this soil characteristic minimizes risk of soil compaction. In one study, soil bulk density of switchgrass grown in a riparian buffer was 83% of that of corn in a similar setting. The greater porosity, more abundant and interconnected pore spaces, and plants' fibrous and extensive roots facilitate numerous benefits, including decreased water available for runoff, resulting in lower off-site delivery of sediment, pesticides, and nutrients. One study reported that switchgrass hedges reduced runoff by 15% over plots without hedges. A different study reported that warm season grasses, such as switchgrass, were 33% and 330% more effective than cool-season grasses for reducing leaching of metolachlor and atrazine, respectively, because these crops are taller with stiffer stems and deeper root systems than cool-season grasses. Warm-season grasses (WSGs) can also control wind erosion. Growing perennial herbaceous crops can be particularly effective for controlling wind erosion near the soil surface, unlike trees, which only can reduce wind velocity at increased heights above the soil surface. One estimate (for Tifton, GA) suggests that establishment of perennial herbaceous crops could reduce erosion by 39% relative to annual crops (Perlack, Ranney, & Wright, 1992). (Blanco-Canqui, 2010)

It is difficult to estimate the potential impacts to soils resulting from pesticide application resulting from the proposed EHECs without knowing how much pesticide would be needed for application. As discussed in Section 3.9, pesticides may be used to assist in establishing and maintaining the proposed EHECs, such as switchgrass and giant miscanthus (Keshwani & Cheng, 2009). However, as the agricultural practices—farming methods (tilling), agrochemical (pesticides) application amounts, and irrigation use—are assumed to be the same for the proposed EHECs as traditional crops (until research proves otherwise), impacts to soils from pesticide application is assumed to be similar to current soil quality and possibly reduced as pesticide releases from perennial grass plantings were less than from traditional row crops, such as corn or soybeans (Hill, Nelson, Tilman, Polasky, & Tiffany, 2006).

One benefit to soils from perennial herbaceous crops is efficient use of soil nutrients and, therefore, less demand for fertilizer usage. Switchgrass, in particular, is recognized for its efficiency in utilizing soil nutrients. A four-year study in New York found in a field scale size study that switchgrass showed no yield response to nitrogen fertilizer in the first four years of the stand (Bosworth, Kelly, & Monahan, 2013). In fact, in 2010, the no Nitrogen (N) treatment had considerably higher yield than did the highest N treated plots. Average yield was nearly 20% higher for the no N treatment versus the highest N treatment (276.6 kg/ac) in 2010 (Mayton, Hansen, Crawford, Crawford, & Viands, 2011).

An additional benefit to soils from perennial herbaceous crops is increased soil organic carbon. One study showed that the conversion of land from annual crops (cotton, wheat and corn) to native perennial grasses (as part of the Conservation Reserve Program) added an average of 1.1 Mg C/ha/year to the soil. (Cook & Beyea, n.d.)

***Annual Herbaceous***. Growing annual energy crops, such as sorghum, back-to-back in the same location presents a set of problems for soils that are not observed with perennial herbaceous crops. One such problem is the potential for depletion of nutrients within topsoil layers. Nitrogen deficiency is the most common soil issue faced by growers who produce sorghum for biomass yield. A standard recommendation frequently cited for biomass production is 10 pounds of nitrogen per dry ton of biomass removed. A second problem is the build-up of pest pressures. Common examples of pests that can severely damage a sorghum crop include cutworms on seedlings, nematodes on roots, greenbugs, or fall armyworms on leaves, and sugarcane borers on the stalks. As such, it is recommended that annual crops, including sorghum, be rotated with alternate winter/summer crops to mitigate these risks. A third problem is the potential for diseases. Examples of diseases that can affect sorghum include anthracnose, downy mildew, and Fusarium. (Blade Energy Crops, 2010)

Erosion is a concern in the harvesting of annual energy crops due to the annual crop harvests and potential for barren fields during the non-growing seasons. However, in practice, the effects of erosion can be mitigated. Research revealed that cover crops reduced erosion by more than 94% compared to bare soil during the intercropping period; for the effect to be observed, researchers estimated that at least 3.71 tons/acre of cover crop biomass must be buried into the soil (American Society of Agronomy, 2010).

***Woody Crops.*** Major forest management activities affecting soil involve: 1) harvesting a stand of trees; 2) removing trees from the site; 3) regenerating a new stand; and 4) stand improvement between initial reestablishment and harvesting. Timber harvesting consists of cutting trees and possibly other vegetation on the logging site. During the actual felling of trees, disturbances of the surface soil are usually minor. After cutting, trees are moved to a collection point, and transported to a mill or other processing site. The principal activities affecting soil during the transportation stage are skidding operations and road construction. After harvesting, and removal of logs, the area may regenerate naturally or forest managers may choose to establish a new stand by planting, which may involve exposing the bare soil and removing competing vegetation. In some cases, cutting and removing the trees may adequately prepare the site; in other cases, special site preparation techniques such as tractor raking, burning the debris, or spraying pesticides may be needed on the site. During the growth phase, forest managers also may choose to thin competing vegetation or add nutrients to the soil (in the form of fertilizer) in order to promote faster growth. (Swank, DeBano, & Nelson, n.d.)

Each of these activities has a different set of impacts on nearby waterbodies and soils. Impacts to waterbodies are not discussed in this subsection, as they are fully analyzed in Chapter 4.3. The primary impact of tree harvesting on soils is erosion. Forest management activities associated with timber harvesting can affect the physical, biological, and chemical properties of the soil. The type and magnitude of erosion depends on the amount of soil exposed by management practices, the kind of soil, slope steepness, weather conditions, and any treatments following the disturbance. Any management activity that exposes or compacts the soil and reduces infiltration can concentrate surface runoff and thereby accelerate erosion. Felling trees alone seldom causes erosion; in contrast, road building, skidding, and stacking logs, and some site preparation activities can produce major soil surface disturbance that greatly increases erosion on a site. In extreme cases, landslides can occur. (Swank, DeBano, & Nelson, n.d.)

Since the early 1970s, BMPs have been implemented to mitigate water quality impacts from erosion that result from vegetation removal; BMPs accomplish this goal through controlling storm water runoff or capturing eroded sediment. BMPs to control runoff in forested areas include: broad-based dips, turn-outs, cross-drains, water bars, and inside ditch lines. BMPs to capture sediment include: filter areas, silt fences, brush barriers, sediment traps, straw bales, and check dams (North Carolina Forest Service, 2012).

According to a 2008 Southern Group of State Foresters report, regional BMP implementation throughout 13 southern states was about 87%. Between 1985 and 2007, BMP implementation in the State of Florida rose from about 84% to about 99% (Ice, Schilling, & Vowell, 2010).

The nutrients contained in soils within forested areas also can be affected by forest management practices. Cutting alters the processes that regulate nutrient cycling, which frequently accelerates nutrient leeching and loss in dissolved form. The soil nutrient regimes on a particular site can also change when one forest type is changed to another because tree species differ in ability to retain and cycle nutrients. The type of logging also may affect the amount of nutrients removed from a site. For example, whole tree logging, which removes most of the aboveground tree parts, is of concern to many forest managers. Whole-tree timber harvesting removes two to five times the amount of nutrients from a site compared to when only the bole (i.e., trunk) is removed with the several tree tops and branches left to remain in the forest floor as mulch and compost. (Swank, DeBano, & Nelson, n.d.)

Well and intensively managed plantations of Short Rotation Woody Crops, such as poplars, can benefit soil and the environment, as compared to traditional agricultural management practices. One benefit is increased soil organic carbon, which results from the high input of leaf and root litter, coupled with reduced soil disturbance. After four years of establishment, woody crops can store more soil organic carbon than either corn or switchgrass. In a different study, the conversion of land from annual crops to fast-growing woody crops added an average of 0.45 to 0.89 tons/acre over the course of the rotation, although there was a transient loss of soil carbon from increased erosion and mineralization until canopy closure at about six years (Cook & Beyea, n.d.). A second benefit to soils from woody crops is reduced long-term erosion, which results from several properties of larger trees; one estimate (for Tifton, GA) suggests that establishment of woody crops could reduce erosion by 50% relative to annual crops (Perlack, Ranney, & Wright, 1992).

Through their extensive root system, woody trees reduce runoff and soil erosion by increasing water infiltration, anchoring the soil, and stabilizing stream banks. There is evidence that the symbionts formed through photosynthetic production in trees with sufficient nutrition will enhance the formation of carbonic acid in the root zone. This mild acid will enhance the release nutrients from underlying minerals and rocks. Also, symbiotic fungi can transport nutrients from soil to tree to help with the growth and support of healthy forests. One study showed that forests with high-nutrient availability use 58 + 3% of their photosynthates for plant biomass production, while forests with low-nutrient availability only convert 42 + of annual photosynthates to biomass. (Vicca, 2012)

Woody crops also reduce erosion potential by intercepting water droplets on their leaves, thereby decreasing runoff and sediment transport capacity. One study, involving plantations of poplar and willow at 136 sites, found that woody crops effectively controlled sediment loss in 42% of the sites. Another study reported that soil erosion loss from row crops areas was about 9.81 tons/acre, but it was only 0.89 tons/acre/year under woody crops. It should be noted, however, that the initial establishment of woody crops strips the soil of ground cover and may lead to substantial erosion on hilly sites in the first two years of the life of the plantation (Perlack, Ranney, & Wright, 1992). A third benefit to soils from woody crops is that larger trees are better at facilitating water infiltration into soils. Presence of tree litter on the soil surface at various stages of decomposition protects soil against raindrop impact and minimizes crusting or surface sealing. Steady state infiltration rates do appear to increase with tree crop age (Cook

& Beyea, n.d.). One study showed that conversion of cropland soils to fast-growing biomass trees increased soil porosity (i.e., open spaces within the soil) and microbial activities after six years of conversion (relative to annual crops). (Blanco-Canqui, 2010)

Although prime farmland is most prominent within the Coastal Plains and Interior Lowlands physiographic provinces of the project area, the Proposed Action involves using existing agricultural land, pasture land, or forested lands; there would be no conversion to non-agricultural uses. No impacts to prime and unique farmland would occur.

### 4.4.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

For perennial herbaceous and woody crop EHEC, the positive impacts discussed in Section 4.4.2, including increased soil organic content, reduced erosion, improved infiltration, reduced fertilizer application needs, and pesticide filtration, could be proportionally greater for Alternative 2 due to the increase in acres. For annual herbaceous EHECs, which can present a number of potential negative impacts to soils, including nutrient deficiency, increased pest and disease pressures, and increased erosion, the impacts would not be greater by converting fields from traditional crops to annual herbaceous EHECs. Negative impacts could be greater, however, if the agricultural lands were converted from traditional perennial herbaceous crops or woody crops to annual herbaceous EHECs based on the reasons discussed in Section 4.4.2.

Although prime farmland is most prominent within the Coastal Plains and Interior Lowlands physiographic provinces of the project area, the Proposed Action involves using existing agricultural land, pasture land, or forested lands therefore there would be no conversion to non-agricultural uses. Impacts to prime and unique farmland could not occur.

### 4.4.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

The use of cover crops during planting cycles could reduce soil loss and also provide soil organic matter if incorporated into the soil. For perennial herbaceous and woody crop EHECs, the positive impacts discussed in Section 4.4.2, including increased soil organic content, reduced erosion, improved infiltration, and pesticide filtration could be proportionally greater for Alternative 3. For annual herbaceous EHECs, which can present a number of potential negative impacts to soils, including nutrient deficiency, increased pest/disease pressures, and increased erosion, the impacts would not be greater by converting fields from traditional to annual herbaceous EHECs. Negative impacts could be greater, however, if the agricultural lands were converted from perennial herbaceous or woody crops to annual herbaceous EHECs (based on the reasons discussed in Section 4.4.2). At this scale, there could be potential negative impacts (proportional to Alternatives 1 and 2) to waterways from erosion and sedimentation. This is discussed in detail in Section 4.3, Water Resources Section.

Although prime farmland is most prominent within the Coastal Plains and Interior Lowlands physiographic provinces of the project area, the Proposed Action involves using existing agricultural land, pasture land, or forested lands therefore there would be no conversion to non-agricultural uses. No impacts to prime and unique farmland could occur.

### 4.4.5 No Action Alternative

Under the No Action Alternative, future conditions could remain similar to current agricultural conditions. Development of EHECs is assumed to occur slowly or in an uncoordinated fashion, and EHECs could be planted sparsely. EHECs planted could be under permit or notification as appropriate. There would be no impacts to geology and soils from the No Action Alternative.

## 4.5 Biological Resources

### 4.5.1 Impact Criteria

Impacts to biological resources could be considered major if the project would:

- Have a substantial adverse effect, either directly or indirectly through habitat modifications, on any species identified as a threatened, endangered, candidate, sensitive, or special-status in plans, policies, or regulations by a State Fish and Wildlife agency or the USFWS;
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in plans, policies, or regulations by a State Fish and Wildlife agency or the USFWS;
- Result in a fundamental change in the range and diversity of native species in the project area;
- Result in the decline of native plant species populations;
- Interfere substantially with wildlife corridors, wildlife nursery sites, or the movement of native resident or migratory fish, migratory birds, or wildlife species;
- Conflict with local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance; or
- Conflict with the provisions of an approved local, regional, state, or Federal habitat conservation plans.

For listed species, impacts were classified using the following terminology from the ESA:

- No effect: If the Proposed Action would not affect a listed species or designated critical habitat.
- May affect/not likely to adversely affect: If impacts on wildlife or special status species are discountable (i.e., unlikely to occur and not able to be meaningfully measured, detected, or evaluated) or completely beneficial.
- May affect/likely to adversely affect: If an adverse effect on wildlife or a listed species occurs as a direct or indirect result of Proposed Actions and the effect is either not discountable or completely beneficial.
- Likely to jeopardize proposed species/adversely modify proposed critical habitat: If the DOE or USFWS identified situations in which actions could jeopardize the continued existence of wildlife or a proposed species or adversely modify critical habitat to a species within or outside of the project area.

This Final PEIS analysis reviews the potential impacts to biological resources from the proposed EHEC Programs irrespective of the crop type (perennial herbaceous, annual herbaceous, or woody crop). Given the nine-state project area and the programmatic nature of the project, the impacts of potential EHECs by crop type could not be undertaken; therefore, potential impacts are qualitatively discussed for vegetation, wildlife, pesticide use on natural resources, and invasive species concerns. Potential effects to protected species and habitats is reviewed under each Alternative. Table 4.5-1 provides a summary of the potential impacts on biological resources.

**Table 4.5-1: Biological Resources Impact Summary**

| Impact Criteria | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| Habitat Modification to Vegetation | ○⊙ | ○⊙ | ⊙ | ○ |
| Wildlife Life-cycle Impacts | ⊙ | **unknown** | **unknown** | ○ |
| Increase Use of or Detrimental Impacts resulting from Pesticides | ⊙ | ⊙ | ⊙ | ○ |
| Increased in Invasive Species | ⊙ | ⊙ | ⊙⦸ | ○ |

LEGEND
⊗ = Major impact
⦸ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.5.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres

***Vegetation***. Under Alternative 1, short- and long-term, minor to moderate adverse impacts on vegetation could be expected. Only existing croplands, pasturelands, or forested lands could be used for the EHEC field trials. Development in active agricultural plots would result in minimal impacts on natural vegetation and development in forested habitats would result in direct removal of trees and associated understory vegetation necessary to accommodate the development footprint. Indirect damage to trees and understory vegetation would also be expected to occur as a result of damage to root systems, soil compaction, and landscape modification associated with field trial preparation. The field trial plots could be converted from non-EHEC species to EHECs thereby influencing the distribution of cultivated species on agricultural lands (see Section 4.1, Land Use). The crop species currently cultivated on agricultural lands are typically monocultures that may support both native and non-native plant species crops, many of which have been specially adapted for agriculture through conventional plant breeding techniques.

The conversion of non-agricultural lands that may contain substantial plant biodiversity to agricultural lands with minimal species diversity would not take place. Project-site evaluations may be conducted to avoid growing EHECs in sensitive habitats, priority watersheds, and other geographic areas with sensitive natural resources. Future site- and plant-specific environmental documentation would review potential impacts to vegetation. It is anticipated that the project-specific environmental reviews would provide information on vegetation in the project area, in addition to identifying potential BMPs – tailored to each proposed EHEC project – to meet USDA APHIS BRS regulatory requirements and to prevent the spread of EHEC species from these fields to the surrounding environment (see Invasive Species below), thereby minimizing the potential impacts of genetic contamination or invasive species spread to and disruption of native plant communities in the surrounding area.

Land cover may change from agricultural fields to forested land or vice-versa, depending on the EHEC species being demonstrated. Because these fields are already used for agriculture or forestry, the land would have already experienced regular disturbance such as plowing, planting, irrigation, fertilization, and the application of pesticides. Many native species could have already been removed on the existing agricultural lands; those remaining could be opportunistic species that are tolerant of variable, transient, or unpredictable environments.

***Wildlife***. The potential impacts on wildlife vary; not only by the wildlife species in question, but also by the type of EHEC. EHECs have the potential to affect—positively or negatively—the fitness of other species, population dynamics, ecological roles, and interactions, which in turn may promote changes in community structure and function both to the farmland and nearby ecosystems. The current scientific literature is primarily retrospective, focused on few species, countries, and ecoregions; additional plant- and site-specific studies would need to be undertaken to determine the impacts of EHECs on wildlife, particularly any concerns about potential toxicity to nearby wildlife. Although the exact impacts cannot be predicted without further research, minor adverse impacts are anticipated since only existing croplands, pasturelands, and forested lands would be used under Alternative 1. Any local impacts to wildlife populations at EHEC field trial sites would be dependent on the wildlife species, crop species and its genetic modification, and the location of the field trial. Native wildlife habitat loss should not occur under Alternative 1 because lands currently in agricultural production would be used for the proposed EHEC field trials.

Direct consequences to wildlife from implementing Alternative 1 could include changes in habitat form and function at both the site-specific and regional landscape scales. Monoculture crop production provides a fair amount of forage and cover for specific wildlife, but overall it does not sufficiently provide for the ecological needs of most wildlife, especially neo-tropical migratory birds. Potential impacts of herbaceous EHECs could include richness, diversity, and abundance for lower songbird and small mammal species. The potential impacts differ by species and the responses vary by crop, land type, harvest practices, and the habitat near the crops. (Wittemyer, 2013). The potential indirect impacts to habitat include changes in the vegetation structure, soil structure, and in the hydrologic cycle; these effects, in turn, can alter food abundance (e.g., seeds, insects) and cover for thermal protection, escape, or breeding (e.g., courtship, nests). This may affect wildlife by changes in predation pressure, parasitism, disease, and competitive and social interactions. Reduced cover could increase the access of predators to small mammal prey species, but the overall effects are not known. Indirectly, reptiles and amphibians may see reduced population sizes resulting from increased predation risks associated with a more open environment. However, the indirect effects require specific study and observation over the course of several years in order to fully understand local population dynamics.

A large percent of the indirect impacts to wildlife could stem from the direct impacts to vegetation, and there has been scant examination of the broader ecological and associated indirect effects on wildlife. These impacts result from changes in plant community composition, structure, and productivity, which together largely determine wildlife habitat suitability. The direct effects of land use conversions on habitat are more easily measured than are the indirect effects. While the use of land is relatively easy to document, assessing its quality (productive, economic, habitat, etc.) is more challenging.

***Migratory Birds.*** The Migratory Bird Treaty Act (16 U.S.C. §§ 703-711) makes it unlawful for anyone to kill, capture, collect, possess, buy, sell, trade, ship, import, or export any migratory bird, including feathers, parts, nests, or eggs. EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, requires Federal officials to consider the impacts of planned actions on migratory bird populations and habitats for all planning activities. Potential impacts associated with the implementation of the Alternatives are expected to be temporary in nature, mainly occurring during the conversion of traditional cropland to EHECs and would be similar to impacts observed for existing agricultural lands. An indirect effect on birds, in particular, may include increased exposure and predation due to vegetation removal and composition shifts.

APHIS has determined that it is reasonable to assume that the activities at field test sites, such as planting, collecting samples, and eventual harvesting, would not impact migratory bird populations since they are not expected to nest or permanently inhabit the confined field test sites (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2010). Project-site evaluations could be conducted to avoid growing EHECs in sensitive geographic areas that would impact migratory bird populations. DOE or the Federal agency proposing an action related to an EHEC Program would be required to complete environmental compliance reviews, such as NEPA reviews, for site- and plant-specific projects to identify potential impacts and BMPs – tailored to each proposed EHEC project – to meet USDA APHIS BRS regulatory requirements. DOE (or other Federal agency) may require a recipient of funding or a permit to implement appropriate BMPs as a condition of funding or permitting for a proposed EHEC project.

***Threatened and Endangered Species and Critical Habitat.*** Potential impacts on threatened and endangered species and critical habitat—assuming they are present in the project area—could range from minor to major depending on the extent of the disturbance or impact. For this Final PEIS, at the programmatic level, no effect to threatened and endangered species or critical habitat are anticipated since only existing croplands, pasturelands, or forested lands could be used for EHEC field trials; these existing agricultural and forested lands are not likely to contain permanent habitat for protected species. Some protected species may visit existing croplands, pasturelands, or forested lands for foraging, transit, or for temporary shelter, depending on the location and species. If protected species were to enter the site, their presence would likely be fleeting.

For any future EHEC Program, site- and plant-specific environmental compliance reviews would be undertaken to identify any potential effects to species and habitats. Future site- and plant-specific environmental evaluations, such as NEPA reviews, would be required prior to selection of plot(s) for proposed EHEC field trials. Site- and plant-specific environmental reviews could include desktop research to determine the presence of threatened and endangered species and critical habitat. In addition, these project-specific environmental reviews may warrant surveys of the project area to identify the potential of listed species or habitats on an individual parcel of land proposed as a field trial location. Adverse effects could occur if individual listed plants or wildlife species are harmed or result in a take[20] to a protected species; any loss or disturbance to threatened or endangered species could be substantial in the context of their limited population sizes. If the proposed EHEC could affect a protected species,

[20] A "take" is defined, in the ESA, as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

consultation with USFWS could be conducted to determine potential adverse effects. The environmental compliance reviews for EHEC-specific projects to identify potential BMPs – tailored to the proposed EHEC – to meet USDA APHIS BRS regulatory requirements. DOE (or other Federal agency) may require a recipient of funding or a permit to implement appropriate BMPs as a condition of funding or permitting for a proposed EHEC project.

For this PEIS, potential impacts to protected species or critical habitat are unknown as further studies (site- and plant-specific) would be required for any proposed EHEC project.

***Life-cycle***. Impacts to life-cycles could vary widely, underscoring the importance of area and species-specific studies. Direct mortality to wildlife as a result of the proposed EHEC field trials would vary by wildlife species; however, as the proposed EHECs would be conducted on existing croplands, pasturelands, or forested lands, impacts from traditional agricultural practices (i.e., plowing) would be similar to existing conditions. The conversion of existing agricultural lands to the proposed EHECs has the potential to affect bird species, specifically altering their presence in certain areas; their reproductive success (i.e., destruction of nests, eggs, or young); increase in predation; increase in parasites; and collisions with farm equipment and vehicles. However, there is limited data on the direct effects of cropland conversion on avian species due to the pre-existing declines of many of these species.

Even less data exists on the effect of cropland conversion for reptiles and amphibians. Croplands may be used by reptiles and amphibians because the habitat structure provides more micro sites (i.e., sunning and shading spots). Reptiles and amphibians require various stages of vegetative succession within their habitat, which historically was achieved through natural disturbance regimes. Some populations of reptiles and amphibians may experience localized extirpations due to direct contact with mechanized equipment because they are not fast enough to move out of the way of potential danger. Site- and plant-specific environmental reviews would need to be conducted to determine the presence of threatened and endangered species and critical habitat at an individual parcel of land proposed as a field trial location.

Reduced use of pesticides for GE crops could result in benefits for wildlife, including reptiles and amphibians. Widespread use of chemical pesticides to control primary pests often disrupts the natural controls that prevent the outbreak of secondary pests by destroying natural insect enemies. If the planting of GE pest-resistant crop varieties eliminates the need for broad-spectrum insecticidal control of primary pests, naturally occurring control agents are more likely to suppress secondary pest populations, maintaining a diversity and abundance of prey for amphibians and other birds and rodents (Dale, Clarke, & Fontes, 2002). If a proposed EHEC includes a pest-resistant component, site- and plant-specific environmental reviews would be conducted to determine any potential impacts.

In a clear correlation, invertebrate community studies have indicated that the diversity of invertebrates is often related to plant species diversity, structural diversity, patch size, and density. Invertebrate species' responses to conversion correlate to the lifestyle and habitat preferences for a species. Managed monoculture could create a uniform plant height and remove smaller topographical features, such as grass tussocks. This could result in a decrease in plant structural diversity within a field and thus a potential decrease in invertebrate diversity based on a species preference for structure. The proposed EHEC field trials could result in a dense, uniform plant stand that could have minimal structural diversity, thereby potentially minimizing niches for invertebrates.

In recent years, commercialized GM crops have reduced the impacts of agriculture on biodiversity, through enhanced adoption of conservation tillage practices, reduction of insecticide use, use of more environmentally benign herbicides, and increasing yields to alleviate pressure to convert additional land into agricultural use. For example, impacts to soil-based organisms from GM crops included few to no effects on woodlice, collembolans, mites, earthworms, nematodes, and protozoa. Although some effects, ranging from no effect to minor and major adverse effects, were reported for GM crops on microorganisms, they were mostly a result of differences in geography, temperature, plant variety, and soil type. Similar results were observed for the impacts of GM corn on snails (where no negative effects were observed). (Carpenter, 2011)

Other studies have focused on the effects of GM crops on non-target insects. For example, Ferry et al. focused on the effects of GM canola on a predatory ground beetle (*Pterostichus madidus*). Survival, weight gain, and adult reproductive fitness did not differ between beetles fed prey reared on GM plants and those fed prey from control plants. The Ferry et al. study concluded that cultivation of GM canola may lead to conservation of non-target predatory and scavenging organisms beneficial in pest control, such as carabids, and may provide more sustainable agricultural systems than current practices. Minimal impacts on beneficial carabids in agro-ecosystems suggest that GM canola crops are likely to be compatible with integrated pest management systems (Ferry, Mulligan, Stewart, Tabashnik, Port, & Gatehouse, 2006). Other studies have shown that crops modified to be toxic to insect pests could have a direct harmful effect on non-target insects if they eat the plant. Although an indirect effect could be the reduction of insects as a food source for other wildlife, such as farmland birds, it is challenging to study the indirect effects on non-target insects (or other organisms) for food chains of multi-trophic species (species of different trophic levels within the same food chain) (Connor, Glare, & Nap, 2003). Potential minor indirect impacts to life-cycles for various species may occur. Additional site- and plant-specific studies would be required to fully review if the proposed EHECs could indirectly influence life-cycle or species diversity for native species and protected species.

***Pesticide Use on Natural Resources***. The majority of research conducted on the effects of GE crops on wildlife focuses on pesticide use and its effects. The net result is that pesticide use can have major adverse impacts on wildlife, but further studies are needed to determine if GE crops, such as the proposed EHECs, require more or less pesticides.

Animals may be impacted indirectly by agricultural practices, such as tillage. The proposed EHEC field trials should follow standard agricultural practices. Farmers could continue to use EPA-registered pesticides, and weed management practices, as appropriate. Depending on the EHEC, increases in tillage to control weeds may increase soil erosion resulting in possible indirect impacts on wildlife. The use of pesticide application on wildlife and wildlife habitat may have environmental risks; however, the EPA evaluates pesticides via the pesticide registration process and each pesticide must undergo re-evaluation to retain registered status under FIFRA.

GE crops are often engineered either to withstand more effective pesticides or to become less attractive to pests. As a result, these crops may require fewer pesticides. A National Research Council study concludes that GE crops lead to reduced pesticide use or lower toxicity compared to conventional crops (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014). However, another study finds that farmers apply broad-spectrum pesticides to GE crops later in the season and use more of it (Smith J. M., 2005).

The rate of application may be accelerating due to weeds becoming immune to the pesticide and may require increase applications for pest control in the long-term. This may offset the potential economic and environmental advantages of GM crops regarding pesticide use (Smith J. M., 2005).

The use of pesticides on the proposed EHECs has not been studied and would need to be in order to determine potential benefits or impacts on wildlife. Impacts could include altering the composition of the soil and adversely impacting nematodes and beneficial soil bacteria. Additionally, wildlife could attempt to feed on the proposed EHEC, which could have unknown effects on the wildlife. Pesticide-tolerant plants may have many indirect adverse effects on wildlife. Implementation of Alternative 1 is likely to result in minor adverse, with respect to pesticide application; although there is the potential for major adverse impacts if increased amounts or applications were applied depending on the EHEC species and location. When possible, depending on the proposed EHEC species, DOE or another Federal agency would require the recipient of a grant or permit to avoid and minimize the use of herbicides and pesticides to the extent practicable. Site- and plant-specific environmental reviews would need to be conducted to determine the presence of protected species and critical habitat at an individual parcel of land proposed as a field trial location.

***Invasive Species***. A known concern of GM crops on wildlife is the potential invasiveness of those crops. Pollen and seeds can easily disperse between farms with the movement of animals, farm equipment, and weather. It is therefore possible that the proposed EHECs themselves could become weeds, such as kudzu, which was imported to prevent soil erosion but instead became a pest in the south. Many prospective EHECs have similar characteristics to successful invasive species (e.g., rapid growth with little chemical or nutrient input) and are more likely to become invasive than the reference plants in studies (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014).

Invasive species, regardless of how they come to inhabit an ecosystem, pose threats. When a new and aggressive species is introduced into an ecosystem, the species might not have natural predators or controls. Therefore, it can breed and spread quickly, taking over an area and can impact wildlife. The indirect threats of invasive species include changing the food web, decreasing biodiversity, and altering ecosystem conditions.

A variety of the plants proposed as EHECs include genera and species non-native to the areas where production is proposed; several are known invasive pests in other regions where they have been introduced (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014). Under the proposed EHEC Program, excluded crops include those plants that the USDA has determined to be either a noxious weed or and invasive species, or has the potential to be invasive or noxious as determined by the Secretary of Agriculture in consultation with other Federal or state agencies. It is the bio-geographical context of a given plant that is important in determining whether it may be invasive in a particular location (National Invasive Species Council, 2008).

Future site- and plant-specific environmental documentation, such as NEPA reviews, would be required prior to the proposed EHEC field trial plot selection. The environmental reviews may include a site-specific analysis to determine if the proposed EHEC is on a Federal or state noxious weed list; conduct a weed risk assessment and climate matching analysis; and evaluate the potential of the proposed EHEC to cross-pollinate with related species or other closely related taxa.

Potential impacts of proposed EHECs on the environment could be caused by the hybridization of the GE plants and their wild relatives that may result in a weedy or invasive plant species causing economic or ecological damage. Such hybridization could occur in either case of GE crops or non-GE crops; research has not shown that GE organisms are more likely to be invasive than non-GE organisms (Chapman & Burke, 2006). According to Firbank (2008) impacts on biodiversity at the field level include gene transfer from a GM feedstock to wild relatives especially if the GE crops are located in an area of genetic diversity. This is an issue where the planted variety is much more abundant than the native plant and through hybridization can "swamp out" the less abundant population. Given the confined nature and size of the field trials this is unlikely to occur. Additionally, given the presence of a single GE gene in an organism that has 30,000 genes, this would have a negligible impact on biodiversity. (Firbank, 2008)

Such risk is considered by USDA APHIS BRS prior to use of GE organisms outside of controlled conditions (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). A permit request would need to be approved by APHIS BRS and, depending on the nature of the GE trait, by EPA for any GE crop proposed for establishment as a proposed EHEC (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). The potential for major adverse impacts from establishment of invasive species grown as EHECs at development scale (Alternative 1) are therefore minimal, regardless of whether the crop is developed as a GE or non-GE crop as the crop could be grown under specified conditions designed to contain the crop in a confined field trial.

In addition to the spread of GE crops onto non-agricultural lands, cross pollination between GM and non-GE crops can be prevented using bioconfinement techniques, such as Genetic Use Restriction Technology; chloroplast transformation; or the manual removal of flowers. Contamination may occur when unharvested seeds fall on the ground and then grow in subsequent years; however, field trials have mandatory volunteer monitoring to limit this type of contamination. Crops might serve as conduits through which new genes move to wild plants, and then could become weeds. Areas of concern include the spread or transfer of genetically modified genes naturally (transgenes) to wild or weedy relatives, evolution of resistance to pests, accumulation of pesticide toxins (which remain active in the soil after the crop is plowed under) are areas of concern. However, evidence indicates that, in the absence of pesticide applications, GE pesticide-tolerant crops are no more likely to be invasive in agricultural fields or in natural habitats than their non-GM counterparts. (Dale, Clarke, & Fontes, 2002)

In order to determine a complete set of measures to mitigate the effects of GE crops on wildlife, additional studies would be needed to assess the full range of potential impacts a specific EHEC could have on wildlife. This incomplete data also renders any list of mitigation measures as incomplete. In the interim, BMPs considered in the USDA APHIS BRS permitting process to minimize the potential inadvertent spread of the EHEC from the proposed confined field area could include:

- Applying multiple pesticides with different modes of action;
- Timing the harvest to minimized the spread of seed;
- Rotating crops;
- Field trial location selected away from sexually-compatible species;
- Isolation distances;
- Planting weed-free seed;
- Fallow areas around the field test plot;
- Border rows around the field test plot;

- Management of propagules (flowering / seed production) including manual removal of flowers;
- Scouting fields routinely;
- Monitoring for sexually-compatible species;
- Inspecting and cleaning equipment to reduce the transmission of weeds to other fields; and
- Maintaining field borders (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014).

Extreme care should be exercised when introducing fitness traits into an EHEC that is sexually-compatible with a known invasive species (such as sorghum compatible with Johnsongrass). A site- and plant-specific environmental review would be completed by DOE or another Federal agency to determine whether potential impacts from the proposed EHEC could include the introduction of invasive species. Future site- and plant-specific environmental reviews would identify specific BMPs – tailored to each proposed EHEC project – to avoid or minimize the risk of an escape. The USDA APHIS permitting process would include procedures and strategies to minimize escapes during planting, transport, harvesting, storage, and management; monitoring protocols to identify any species escapes; and methods to control and eradicate escaped EHECs. DOE or another Federal agency may require a recipient of a grant or permit to implement appropriate BMPs to address invasiveness as a condition of funding or permitting for a proposed EHEC project.

Under Alternative 1, negligible to no impacts are anticipated from the introduction or establishment of invasive species would be anticipated with the implementation of appropriate BMPs, as directed by USDA APHIS requirements, given the smaller size of the field trial.

### 4.5.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

Impacts on vegetation would be the same as those described for Alternative 1 but at a larger scale. Larger areas of land cover may change from agricultural fields to forested land or vice-versa, depending on the EHEC being demonstrated. Because the field trials would occur on existing croplands, pasturelands, or forested areas already used for agriculture or silviculture, the land would have already experienced regular disturbance such as ploughing, planting, irrigation, fertilization, and the application of pesticides. Many native species would have already been removed; those remaining could be opportunistic species that are tolerant of variable, transient, or unpredictable environments. Short- and long-term, minor to moderate adverse impacts on vegetation may occur but are not anticipated.

Impacts to wildlife under Alternative 2 would be similar to the impacts described under Alternative 1 but on a larger scale (up to 250 acres). Potential impacts on wildlife would vary depending on the species, but also by the type of EHEC. Additional plant- and site-specific environmental compliance reviews would need to be undertaken to determine the impacts of EHECs on wildlife, particularly any concerns about potential toxicity to nearby wildlife at a particular field trial location. When possible, depending on the proposed EHEC species, DOE or another Federal agency would require the recipient of a grant or permit to avoid and minimize the use of herbicides and pesticides to the extent practicable. Negligible to minor adverse impacts to wildlife in the project area are anticipated. However, the local impacts to wildlife populations at potential field trial sites would need to be reviewed to determine if the crop modification impacts life-cycle or species diversity.

The potential for impacts associated with Alternative 2 would be similar to those associated with Alternative 1. A site- and plant-specific environmental review would be completed by DOE or another the Federal agency to determine whether potential impacts from the proposed EHEC could include introduction of an invasive species and the potential invasiveness of a specific EHEC proposed for establishment on an individual parcel of land. Future site- and plant-specific environmental reviews would identify specific BMPs – tailored to each proposed EHEC project – to avoid or minimize the risk of an escape. Given the size of field trials under Alternative 2, confinement issues of the EHEC may require manual removal of flowers or other requirements. The additional site- and plant-specific BMPs could include procedures to minimize escapes during planting, transport, harvesting, storage, and management; monitoring protocols to identify any species escapes; and methods to control and eradicate escaped EHECs. A permit request would need to be approved by APHIS BRS and, depending on the nature of the GE trait, by EPA for any GE crop proposed for establishment as a proposed EHEC (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). DOE or another Federal agency may require a recipient of a grant or permit to implement appropriate BMPs to address invasiveness as a condition of funding or permitting for a proposed EHEC project.

For this PEIS, there could be minor adverse impacts from establishment of invasive species grown as EHECs under Alternative 2 given the size of the field trials, regardless of whether the crop is developed as a GE or non-GE crop. Future site- and plant-specific environmental reviews would need to be conducted to determine potential impacts and identify BMPs that DOE or another Federal agency may require as a condition of funding or permitting.

### 4.5.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

Impacts on vegetation would be the same as those described for Alternatives 1 and 2 but on an even larger scale. Only existing croplands, pasturelands, or forested land would be used for the proposed EHEC confined field trials, but at a larger scale. Larger areas of land cover may change from existing croplands and pasturelands to forested land or vice-versa, depending on the EHEC being demonstrated. Because the field trials would occur on existing croplands, pasturelands, or forested areas already used for agriculture or silviculture, the land would have already experienced regular disturbance such as plowing, planting, irrigation, fertilization, and the application of pesticides. Many native species would have already been removed; remaining native species could be opportunistic species that are tolerant of variable, transient, or unpredictable environments. Large populations of grasses and trees could produce pollen clouds that may land in adjacent landscapes. Short- and long-term, minor to moderate adverse impacts to vegetation could be expected through implementation of Alternative 3.

Impacts to wildlife under Alternative 3 would be similar to the impacts described under Alternative 1 but for a much larger area. Potential impacts on wildlife would vary depending on the species, but also by the type of EHEC. Additional plant- and site-specific environmental compliance reviews would need to be undertaken to determine the impacts of the EHEC on wildlife, particularly any concerns about potential toxicity to nearby wildlife at a specific field trial location given the larger size of the field trial and its potential to cause a greater impact. DOE or another Federal agency could require the recipient of funding or a permit to avoid and minimize the use of herbicides and pesticides to the extent practicable. Negligible to minor impacts to wildlife in the project area are anticipated. However, the local impacts to wildlife populations at potential field trial sites need to be reviewed to determine if the crop modification impacts life-cycle or species diversity.

The impacts associated with Alternative 3 would be similar to those associated with Alternative 2. Site- and plant-specific environmental compliance reviews would be required prior to selecting the EHEC project area to identify the potential invasiveness of a specific EHEC proposed for establishment on an individual parcel of land. A site- and plant-specific environmental review would be completed by DOE or another Federal agency to determine whether potential impacts from the proposed EHEC could include introduction of an invasive species and the potential invasiveness of a specific EHEC proposed for establishment on an individual parcel of land. Future site- and plant-specific environmental reviews would identify specific BMPs – tailored to each proposed EHEC project – to avoid or minimize the risk of an escape. Given the size of field trials under Alternative 3, confinement issues of the EHEC may require manual removal of flowers or other requirements. Additional site- and plant-specific BMPs could include procedures to minimize escapes during planting, transport, harvesting, storage, and management; monitoring protocols to identify any species escapes; and methods to control and eradicate escaped EHECs. A permit request would need to be approved by USDA APHIS BRS and, depending on the nature of the GE trait, by EPA for any GE crop proposed for establishment as a proposed EHEC (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). DOE or another Federal agency may require a recipient of a grant or permit to implement appropriate BMPs to address invasiveness as a condition of funding or permitting for a proposed EHEC project.

For this PEIS, given the large size of the field trials under Alternatives 3, there could be short- and long-term, minor to major adverse impacts from the introduction or establishment of invasive species grown as EHECs, regardless of whether the crop is developed as a GE or non-GE crop. Future site- and plant-specific environmental reviews would need to be conducted to determine potential impacts and identify BMPs that DOE or another Federal agency may require as a condition of funding or permitting.

### 4.5.5 No Action Alternative

Under the No Action Alternative, future conditions would remain similar to current agricultural conditions. Existing croplands, pasturelands, or forested lands would remain in their present state. Development of EHECs is assumed to occur slowly or in an uncoordinated fashion; EHECs could be planted sparsely. A permit request would need to be approved by APHIS BRS and, depending on the nature of the GE trait, by EPA for any GE crop proposed for establishment as a proposed EHEC (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). Vegetation and wildlife would not change from existing conditions. In addition, no changes to crop cover would occur that would have the potential to result in an increase of invasive plants. Impacts associated with invasive or GE plants would remain the same as current conditions in the field for the No Action Alternative.

## 4.6 Socioeconomics and Environmental Justice

### 4.6.1 Impact Criteria

Under the Alternatives of this Final PEIS, EHEC Program participants could grow EHECs in confined field trials. This may result in changes to the crops grown on a participating field and changes to agronomic and silvicultural practices. These changes have many socioeconomic dimensions; the various characteristics of EHECs considered may each have socioeconomic implications relative to the characteristics of the plants they replace. For instance, different EHECs may require increased or decreased expenditures on fertilizers relative to conventional crops. Socioeconomic effects also result from specific practices and protocols associated with confined field trials; for instance, requirements to fence the entire field add costs compared to ordinary crop production.

Socioeconomic effects can be beneficial or adverse. Beneficial include increased economic output, employment, net business income, labor income, and improved quality of life. Adverse impacts include reductions in economic indicators, increased costs to non-participating businesses or households, strain on public infrastructure or services, and impacts to quality of life (e.g., increased traffic or crime; reduced community social cohesion). In addition, increased environmental health or safety risks and adverse social and economic effects, when they disproportionately affect minority or low-income populations, are Environmental Justice concerns.

Among various potential socioeconomic effects of EHEC field trials, this section identifies costs to EHEC Program participants (e.g., the additional costs involved in confined field trials). It is important to note at the outset that increased costs to participants are not necessarily adverse impacts. Program participants will certainly understand that participation results in changes—often increases—to their costs of production. At the same time, they will receive financial compensation and other benefits (e.g., valuable experience with emerging products). They would not accept cost increases and participate in the program if they believed that the net economic effects on their operation could be negative. Thus, net economic effects on program participants should generally be positive or neutral (although business risks must be acknowledged). The potential impacts on non-participants are of greater interest, and could be beneficial or adverse.

Adverse socioeconomic impacts would be considered major if they result in any of the following:

*Major Economic Impacts*

- Reduce net business income of participant businesses or other businesses to a degree that would result in the failure of multiple businesses at the county level.
- Reduce labor earnings at the county level to a degree that would result in the failure of multiple businesses at the county level.
- Reduce labor earnings of multiple individuals to a degree that creates serious financial hardship for those individuals (e.g., agricultural workers).
- Reduce employment to a degree that would result in a measurable (0.1%) increase in the unemployment rate at the county level.
- Result in macroeconomic changes that are adverse to producers or consumers, such as changes in the price of commodities or inputs that stress producer or consumer budgets.

*Demographic or Social Impacts*

- Result in a change in population at the county level (e.g., due to increased or decreased employment) that could place a substantial strain on local public or private infrastructure and services (schools, police service, housing, etc.) or public finances.
- Result in substantial reductions in quality of life for a large number of residents in the surrounding community(ies).

*Impacts on Environmental Justice Populations*

- Result in disproportionately high and adverse human health or environmental (including economic) effects on minority populations or low-income populations. (This criterion reflects the requirements of EO 12898.)

The potential for major socioeconomic impact cannot be determined at the level of EHEC characteristics because various characteristics may have contradictory socioeconomic implications. For instance, one characteristic may increase fertilization costs while another may reduce irrigation costs. The analysis below applies the impact criteria based on the likely *net effects* of the proposed EHEC field trials on socioeconomic indicators such as employment and labor income. The impact analysis identifies the range of potential socioeconomic effects, and addresses the likelihood that these effects, *occurring at the scale of each of the alternatives*, could meet the criteria above.

As described in Chapter, 2, the proposed EHEC Programs includes parameters and assumptions; some of these limit the scope of the socioeconomic impact analysis. It is also important to note that in some cases the land parcels that would participate in the EHEC Programs may be research fields that are used routinely for confined field trials by universities or industry. For parcels that were previously used for some other confined field trial, many of the socioeconomic effects specific to confined field trials (mainly additional costs relative to conventional commercial crop production) would already be in place. The effects of confined field trial protocols described below largely apply to cases where conventional commercial production fields could change to the proposed EHEC confined field trials.

Throughout this section, the terms "business" and "businesses" encompass commercial for-profit farm and forest operations (whether sole proprietors or corporations), for-profit and not-for-profit research organizations, universities, and any other organized entities that may participate in or be affected by a proposed EHEC confined field trial. Further, the term "participant" refers to entities that directly participate in a trial (e.g., receive financial assistance), but does not encompass upstream and downstream businesses or other unrelated businesses that may be affected by the proposed EHEC confined field trial. The terms "crop," "field," and "plot" encompass both agricultural and silvicultural species and land parcels.

This Final PEIS analysis reviews the economic impacts, demographic and social impacts, and environmental justice populations for the proposed EHEC Programs regardless of the crop type (perennial herbaceous, annual herbaceous, or woody crop). Much of this analysis and the identification of potential impacts are presented in a qualitative basis from assumptions for a hypothetical EHEC Program. Table 4.6-1 provides a summary of the potential socioeconomic and environmental justice impacts.

**Table 4.6-1: Potential Socioeconomic and Environmental Justice Impact Summary**

| Impact Criteria | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| Net business income | ⊙ | ⊙ | ⊙ | ○ |
| Labor earnings | +⊙ | +⊙ | +⊙ | ○ |
| Employment | +⊙ | +⊙ | +⊙ | ○ |
| Macroeconomic changes | ○ | ○ | ○ | ○ |
| Public or private infrastructure and services; public finances | ○ | ○ | ○ | ○ |
| Quality of life | ⊙ | ⊙ | ⊙ | ○ |
| Environmental justice | ○ | ○ | ○ | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.6.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

### 4.6.2.1 Economic Effects

***Net Income Effects***. Changes to net business income can occur due to changes in income, expenses, or both. The following material examines in turn the potential for changes to expenses, to income, or to both simultaneously. The discussion examines the potential for changes to participant businesses, to upstream (supplier) and downstream (product buyer) businesses, and to other un-related businesses (e.g., neighboring farms).

*Changes to Business Expenses*. Various EHEC characteristics could result in direct changes to expenses for program participants, relative to the commercial crops that could be replaced. These changes could occur individually or in combination, and could result in increased or decreased costs. For instance, EHECs might have considerably higher propagation costs since the seeds, root stock, tree seedlings, or other propagation materials may be specially produced. Conventional commercial crop varieties are mass-produced. As another example, changing from pasture to production of an annual EHEC could result in new annual costs for soil tillage, discing, and cultivation, and for seeding—operations that are unnecessary or infrequent for pasturelands.

Expenses for growing EHECs could be less than for conventional crops in some cases. For instance, conversion from an annual commercial crop, such as corn or soybeans, to a perennial or woody EHEC could reduce soil management costs and avoid operational costs of annual seeding. In addition, perennial herbaceous and woody crops typically require less fertilizer, irrigation, and pesticide application than annual herbaceous crops.

In addition to changes in expenses due to changing crops, the nature of confined field trials results in additional costs relative to conventional commercial production. The example field trial protocols and procedures identified in Section 2.2.5 all have costs to the permittee that would not be incurred in conventional commercial crop production.

At the scale of Alternative 1, the net effect of expense changes due to changing crops and adopting confined field trial protocols is most likely an increase in expenses for the EHEC Program participant relative to current commercial crops. This is because the additional fixed costs and the intensive variable costs of confined field trials could be spread across a relatively small acreage, and would likely overwhelm any variable cost savings associated with crop conversion. For example, consider the conversion of a field from annual commercial corn to a perennial herbaceous EHEC. Any foregone soil preparation operations previously associated with annual corn are relatively low intensity operations, probably performed at the scale of Alternative 1 by a single farm equipment operator, a limited number of times each year. Further, if the operator practices low- or no-till methods, the relative soil preparation savings of converting to a perennial herbaceous crop could be reduced. In comparison, many confined field trial protocols are high intensity operations, even for perennial herbaceous crops—as an example, weekly crop monitoring and hand removal of emergent seed heads. These activities may require multiple persons on multiple occasions during the growing season. Fixed costs, such as fencing and gating the site, could be substantial. For these and other similar reasons, the total costs of a confined field trial of a perennial herbaceous crop are likely to be greater than the total costs of growing an annual herbaceous crop.

Upstream and downstream businesses might see indirect changes to their expenses. It may cost more to provide certain services—for example, field monitoring, pesticide or fertilizer application services— to program participants compared to customers with conventional operations. However, these costs could generally be recoverable as business income through charges to program participants (see "Changes to Business Income" below).

Unrelated businesses could experience indirectly increased costs due to EHEC planting. For example, organic corn farmers often use a variety of measures to prevent unwanted genetic material from entering their fields. These measures include isolation of the farm, physical barriers or buffer zones between organic production and non-organic production, planting border or barrier rows to intercept pollen, changing planting schedules to ensure flowering at different times, and formal communications between neighboring farms (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2013). Organic and specialty crop farmers in proximity to an EHEC field trial location may feel a need to increase these types of defensive expenditures. EHEC Program participants would be required to reproductively isolate their crops through confined field trial protocols. However, neighboring farmers may still perceive risks and increase their expenses. While this would not be the "fault" of the program or program or program participants, it is a potential effect. In addition, the neighboring farmers may not be able to recover these expenses in the price of their products; this could lead to local opposition to EHEC trials.

Notwithstanding the potential changes related to business expenses, only minor adverse impacts on net business income under Alternative 1 are anticipated for the following reasons:

- Participating farm and forestry businesses would only take part in the EHEC field trials if they anticipate that they can support any changes in expenditures. In addition, the scale of Alternative 1 is too small to have substantial negative effects on any particular participating business. Even if a single grower engaged in multiple 5-acre field trials, for the types of land and crops that are likely to be converted—e.g., extensive field crops such as corn or soybeans, pasture, or plantation forests—the acreage could be a small portion of a typical grower's acreage. Therefore, the associated expenses could be a small portion of a typical participating business's expenses; any increased costs not covered by the financial assistance received from the EHEC Programs should be absorbable.

- The real need for defensive expenditures on the part of unrelated businesses is doubtful. Unrelated businesses would only undertake such expenditures if the expenditures addressed a strongly felt risk and those expenditures themselves did not put the business at substantial financial risk.

- The possibility of unexpected, out-of-scale costs for participants or unrelated businesses cannot be entirely eliminated. However, such costs (for example, the hypothetical and unlikely use of extraordinary defensive expenditures, or need for extraordinary mitigation costs, due to failure of confined field trial protocols) could be due to a series of events that are unlikely. If they occurred, there could be major adverse cost impacts to farmers and local communities.

*Changes to Business Income*. Business income of EHEC Program participants could change as a direct result of confined field trial program participation as these farm or forestry operations would no longer have income from the sale of a conventional crop from the enrolled acreage. However, they would receive financial assistance from an EHEC Program. The commercial roll-out phase, when growers could receive sales income from EHECs, would be covered by future plant- and site-specific environmental reviews. This Final PEIS assumes that no grower would participate in an EHEC Program if the grower perceived a substantial business risk from participation. Unforeseen major events that could result in participant business failures are always possible, but unlikely and too speculative to be considered in this Final PEIS.

The income of upstream and downstream businesses could be affected indirectly by growers' participation in an EHEC Program. As EHEC Program participants change their agronomic or silvicultural practices relative to their current crops, their purchases of material inputs, equipment, and services could change. As a result, certain upstream suppliers might see reduced purchases or no purchases from the participant. Others might see increased purchases from participants due to the additional expenses associated with different crops or confined field trial requirements; this could increase business income and potentially profitability.

Downstream businesses also could be affected. Under the conditions of the confined field trials considered in this Final PEIS, harvested crops would not be sold and processed. Thus, downstream businesses that purchased farm and forest products previously grown on the enrolled land parcels would not realize income from the processing of those products. Businesses involved in harvesting and transporting crops (e.g., grain haulers, loggers) would be variously affected. Crop harvesting services may still be needed (e.g., leasing of harvest machinery, logging of woody EHECs prior to destruction of the biomass) but the particular companies involved and their gross and net income may change (positively or negatively) due to changes in crops or in harvest practices. Companies that transport crops from field to buyers—if utilized prior to enrollment of specific parcels in EHEC Programs—could lose income from the enrolled parcels. Their services would not be required for the duration of each confined field trial, as there would be no buyer to receive the transported crops. To the extent that fields enrolled in EHEC Programs were previously utilized for other confined field trials with similar prohibitions against transport of the crop, there would be no such changes and effects. The scale of conversion would be reviewed in future site- and plant-specific environmental reviews.

The income of unrelated businesses could potentially be affected by EHEC Programs, under limited and mostly hypothetical conditions. If release of pollen from a field trial occurred and a sexually-compatible specialty crop in a nearby field was cross-pollinated, the affected grower could lose the ability to sell that crop into its intended niche market and could lose income as a result. Such occurrences are unlikely, but could have major long-term adverse impacts if they occurred.

Notwithstanding the many potential changes related to business income, negligible impacts from income-related effects on net business income under Alternative 1 are expected for the following reasons:

- Given reasonably likely EHEC Program participant precautions with respect to taking business risks, it is unlikely that participation could actually result in the failure of a participating business.
- At the scale of Alternative 1, income losses to upstream or downstream businesses would be marginal. Upstream and downstream businesses have many customers; the income reductions from the acreages involved could be a small to negligible portion of the income of such businesses. The chances are small that any such businesses would fail.
- Losses of income for unrelated businesses are unlikely. This type of impact depends upon multiple hypothetical events occurring. For instance, loss of specialty crop income requires a combination of a failure of confined field trial protocols, presence of a sexually-compatible specialty crop field nearby, actual commingling of genetic material in that field (depends on distance, timing, etc.), and other contingencies. However, in any case where unauthorized release of genetic material and commingling with other crops occurred, there could be major adverse impacts. The value of the crop could be completely lost because the crop would have to be seized and destroyed, unless there was a way to effectively separate the regulated article from portions of the crop. In addition, the cost to eradicate an invasive species would need to be considered.

*Net Effects of Changes to Business Income and Expenses.* Combinations of expense and income effects are anticipated to result in minor to no impacts under Alternative 1. The effects of expense and income changes would each be small, and the effects of any reasonable combination of these changes would be small as well. However, if unauthorized release of genetic material and commingling of this material with other crops occurred, the impacts on net business income, there could be major adverse impacts. Both the loss of crop values and the extraordinary expenses to deal with such an event could contribute to the impacts.

***Labor Earnings Effects***. Labor earnings are the sum of wage and salary disbursements, supplements to wages and salaries, and proprietors' income. Labor earnings provide most of the income received by most working-age individuals (employees and self-employed business owners), and thus are critical to local economies because those individuals, as consumers, use their earnings to purchase goods and services from businesses in the local area. If the proposed field trials resulted in the participating farm or forestry operations using fewer employees, replacing high-wage with low-wage employees, or reducing proprietor income, the labor earnings accruing in the local economy could be reduced, with potential negative effects on local businesses. In addition, reduced hours or wage rates are adverse effects for the individual workers involved. Associated losses in income affect their and their families' lifestyles and financial stability. Such losses can affect communities if they lead to additional demands on and expenditures for social and health services. However, minor to no impacts from effects on labor earnings are expected under Alternative 1 for the following reasons:

- Confined field trials typically require greater manpower or more skilled labor than ordinary commercial crop operations, due to their many additional requirements. (See the example list of additional requirements in the "Net Income Effects" section above.) Thus, in most cases wage and salary disbursements could be higher. This could be a beneficial effect on labor earnings.

***Unemployment Rate Effects***. The unemployment rate in a geographic area may increase—in general terms, and if hiring by other businesses is not increasing—if businesses lay off workers due to income losses, increased costs, changes in their products, or utilization of new technologies. The unemployment rate may decrease if the labor needs of business increase and additional workers are hired.

Changing from conventional crops to EHECs may directly change the labor requirements for participating businesses, potentially including reduced labor needs that result in lay-offs. Lay-offs could also occur indirectly if other businesses in a local economy (e.g., fertilizer and irrigation equipment businesses) experience reduced business income due to reduced purchases from farm or forestry operations growing EHECs or reduced consumer expenditures by the employees or proprietors of those operations. Lay-offs per se are not necessarily negative. While they are important and often stressful events to the individuals involved, they only become longer-term adverse events if the local labor market cannot offer alternatives and individuals involved cannot find other work providing similar income. Lay-offs and hirings are part of the normal evolution of an economy over time. They become important to an area's economy if the net effect is an increase in the unemployment rate.

Major increases in the unemployment rate (0.1% or more) at the county level are not expected under Alternative 1 as confined field trials typically require greater manpower than ordinary operations, due to their many additional requirements.

Decreases in the unemployment rate under this alternative are not expected. Labor needs of EHEC Program participants may increase, but at the scale of Alternative 1, numbers of hew hires would be small relative to the total labor force of any county.

***Macroeconomic Effects***. Changes in commodity prices or other macroeconomic effects would not occur under Alternative 1. Most commodity prices are set at the international, national, and regional levels, with some set at a state- or sub-state-level, all depending on the crop or input. Under Alternative 1, changes to supply and demand of any inputs or outputs would be far too small to affect scarcity and prices in commodity markets.

#### 4.6.2.2 Demographic or Social Effects

***Population-Driven Effects***. Large-scale trends in society and the economy, often based on technological changes, are typically the drivers of population changes in a local or regional area. Long-term reductions in the population of many rural areas have occurred as technology changes have allowed a smaller number of farmers to grow larger amounts of crops. Some rural areas have grown in recent decades as internet technologies have allowed professionals to move from cities to areas they perceive to have higher quality of life. Sometimes an area's population changes quickly due to a momentous event, such as the departure or arrival of a major business, or a natural disaster. The common thread through these developments and events is a change in employment opportunities. While many other factors are important to population changes, such as young people leaving rural areas for the lifestyle options offered by cities, increased or decreased availability of jobs predominantly drives population changes in rural areas.

When the population of a rural area increases dramatically, communities may experience stress if population growth exceeds the capacity of local public and private infrastructure, facilities, and services. Schools may become overcrowded and services provided by local government may be overwhelmed. Shortages in housing availability may occur, driving up rents and home prices. For example, large influxes of workers due to natural gas development have produced similar impacts in rural agricultural communities (Jacquet, n.d.). Conversely, population decreases may affect the ability of communities to pay for infrastructure, facilities, and services, resulting in financial stress on local governments and potentially increased taxes and fees on remaining residents. Rents and housing values may fall.

When land converts from conventional crops to EHECs, direct changes may occur in the number of people employed. Different crops have different agronomic or silvicultural requirements, which may increase or decrease labor requirements. Under Alternative 1, impacts from population changes and resulting strains on local or county-level public infrastructure and services or public finances are not expected as confined field trials typically have higher labor requirements than conventional crops. Thus, decreased population due to reduced unemployment is unlikely.

***Quality of Life Effects***. Quality of life is a broad notion encompassing objective and subjective criteria (Costanza, et al., 2008). It may encompass economic factors such as access to good jobs and sufficient income to maintain a particular standard of living. It may include access to and quality of community and social services such as health care, senior care, good schools, and community amenities such as parks and recreation centers. People often perceive quality of life in terms of low rates of undesirable conditions such as crime, pollution, and traffic. Many people relate quality of life to natural resource-related factors such as access to local food, sustained provision of ecological services, and maintenance of attractive landscapes (Committee on Twenty-First Century Systems Agriculture, 2010). As described in Section 4.6.2.1, economic effects encompass several key aspects of the economic component of quality of life. This section addresses aspects of quality of life related to undesirable conditions and natural resource-related factors.

Agricultural production systems can negatively impact these aspects of quality of life. As an example, the impacts of large-scale confined animal feeding operations (CAFOs) on neighboring residents are well-known (Committee on Twenty-First Century Systems Agriculture, 2010) and include unpleasant odors, impacts to respiratory health, and undesirable visuals. Croplands may negatively impact neighbors due to dust generated during soil tilling and other in-field operations, smells from fertilization, concerns generated by pesticide applications, noise from in-field operations, traffic inconveniences from slow-moving machinery, and other factors pertaining to agricultural operations. In most agricultural areas, most residents accept these impacts from croplands. Working forested lands are also typically welcomed and generate few negative impacts, although in some cases the harvest phase of forest management may present issues in terms of logging truck traffic.

Land cover changes are unlikely. Conversions of forested land to annual or perennial cropland are rare due to the costs involved in grubbing tree stumps and roots, extra tilling and discing, and other preparations to make the cleared area suitable for planting. Conversions from pasturelands to annual herbaceous crops are somewhat unlikely because in most parts of the country, pasture occurs on lands that are not optimal for annual crops due to thin soils, topography, or other factors.

In summary, adverse impacts to local quality of life due to the proposed EHEC trials are unlikely, and any such effects would be of low intensity. Under Alternative 1, major long-term impacts would not occur because the scale of land cover changes would not be sufficient to affect a large number of local residents, even if multiple 5-acre trials occurred within a single county.

### 4.6.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

#### 4.6.3.1 Economic Effects

Under Alternative 2, minor to no impacts due to economic effects of the proposed EHEC confined field trials are anticipated. The types of effects on net income, labor earnings, the unemployment rate, and macroeconomic considerations would not change under this alternative relative to Alternative 1. Given, the scale of this alternative—250-acre field trials compared to 5-acre field trials under Alternative 1— the magnitude of some effects, such as the gross level of increased costs, would increase. However, the scale of this alternative would still be small compared to any county's economy. Even if multiple 250-acre field trials occurred in a single county, any adverse impacts would not have sufficient scale to meet the major adverse impact criteria.

#### 4.6.3.2 Demographic or Social Effects

Minor to negligible impacts due to demographic or social effects of EHEC confined field trials are anticipated under Alternative 2. The types of effects and the manner in which the proposed field trials would affect population-driven changes to communities or create quality of life effects would not change under this alternative and would be similar to those under Alternative 1. Even if multiple 250-acre field trials occurred in a single county, any adverse demographic or social effects would not meet the major adverse impact criteria.

### 4.6.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

#### 4.6.4.1 Economic Effects

The intent of deployment-scale confined field trials is to test production of an EHEC at a scale that could be commercially successful for growers and for a small biofuels facility. Thus, production practices at this scale may more closely approximate commercial practices than at the development and pilot scales.

EHEC production would still have to follow confined field trial protocols (Section 2.2.5); protocols might differ by field trial size. For instance, individual plot blocks might be larger, and the area dedicated to inter-block alleys and surrounding fallow strips might be proportionately smaller. However, confined field trial protocols would generally still involve additional expenses compared to ordinary commercial production, and there would still be no sale of the crop. Thus, the same types of socioeconomic effects noted under Alternative 1 would apply to Alternative 3.

**Net Income Effects**

***Changes to Business Expenses***. As discussed under Alternative 1, confined field trials at the scale of Alternative 3 would result in direct changes to expenses for EHEC Program participants. These changes would reflect different agronomic and silvicultural practices used due to a change in crops, and the added expense of confined field trials relative to ordinary commercial production of agricultural and forest crops.

At the scale of Alternatives 1 and 2, the net costs to an EHEC Program participant are likely to be greater than the costs of producing the commercial crops that the EHEC replaces. At the scale of Alternative 3, the net cost trade-off is less clear. There would probably be economies of scale compared to the other alternatives. Fixed costs of an EHEC field trial at this scale are likely to be less on a per-acre basis. For example, equipment and tools could be used across a larger acreage, resulting in reductions in per-acre rental or depreciation costs and post-trial cleaning costs. Perimeter buffer strips and fencing could cost less per acre due to geometric perimeter-to-area ratios of large versus small areas. Variable costs could probably have some economies of scale as well; for example, the acres covered by an individual field trial laborer may increase.

However, there are additional costs associated with confined field trials at the scale of Alternative 3. APHIS has additional oversight of larger trials that may include all or some of the following: more frequent inspection of large trials relative to small trials, third party auditing, submission of a contingency plan that addresses the mitigation of unauthorized releases, submission of a management plan to assure APHIS that adequate resources are available to execute the specified permit conditions. Because these costs are spread over a large acreage, the additional costs may not be all that high on a per acre basis.

The net effects of the cost factors identified above are not clear. To the extent that the per-acre costs of a confined field trial are less at the scale of Alternative 3 than in the other alternatives, the business risks to the EHEC Program participant would be reduced. On the other hand, at this scale, the total cost of production would be much higher and the associated risk would be amplified accordingly. Further, the acreage in the program would be a much higher proportion of the participant's total acreage, increasing business risk. There is also some increased financial risk from potential release of genetic material (see below). However, under ordinary conditions at least two factors mitigate the potential for major adverse impacts due to participant business failures:

- Participants would receive financial incentives provided by the EHEC Program. This income would offset some portion (perhaps all) of the costs of production, and in some cases may be more certain than income from commercial crops, which are subject to the vagaries of agricultural markets. (See "Changes to Business Income" below.)

- Program participants would self-select. Most, if not all, participants would make careful evaluations of the cost risk involved in program participation, including consideration of uncertainties around the costs of a new field trial endeavor, and would not participate if doing so would place their businesses at risk of failure.

Upstream and downstream businesses might see indirect changes to their expenses, but these costs could generally be recovered as business income through charges to program participants (see below).

Unrelated businesses could experience indirectly increased costs due to planting of EHECs. As discussed under Alternative 1, confined field trial protocols should protect neighboring farms from cross-pollination from EHECs, but these neighbors may perceive greater risks at the scale of Alternative 3, leading to increased defensive expenditures. However, they would not make such expenditures if those expenditures themselves put the business at substantial financial risk.

Should unauthorized release and commingling of genetic material actually occur, the cost of mitigation to the receiving operator, the program participant or the program could be high. This is addressed in the business income context at the end of the next subsection.

*Changes to Business Income*. Under this alternative, EHEC Program participants would see substantially greater reductions in total crop sale incomes compared to conventional production, but the financial incentives received from the EHEC Programs could be substantially greater than under the other alternatives. Either these payments would help offset the crop sale income reductions or the recipients could have other financial resources that make participation feasible and worthwhile, in consideration of other real or perceived benefits such as obtaining valuable experience in adopting an EHEC and improved market entry position should the EHEC prove to be commercially viable. One can reasonably assume that the incentives or other resources would be sufficient to largely insulate a participant from the risk of business failure; otherwise, the operator would not enroll in the Program.

Some upstream business may see increased purchases from participants due to the additional expenses associated with different crops or confined field trial requirements. This would increase their business income and potentially profitability as well.

There is potential for some upstream or downstream businesses to see substantial reductions in business income due to the scale of Alternative 3. For instance, if due to a crop change, sales of fertilizer or pesticide no longer occurred for 15,000 acres of land, this sales loss could have a noticeable impact on the income of an agricultural input supplier. The impact could vary considerably based on whether the sales loss occurred to one supplier or was spread across many suppliers, and based on the size of each supplier. Agricultural input supply businesses vary considerably in size. The impact would also depend on the extent to which the crop(s) displaced by a large EHEC field trial were shifted to other nearby lands, in which case the inputs in question would still be needed. The impact would further depend on whether the field trial required other inputs that would be purchased from the same supplier(s).

Similarly, the nature of income losses to downstream businesses that purchase farm and forest products is also highly dependent on many factors. These include the degree to which a single business or multiple businesses previously served the 15,000 acres now in EHEC production, the degree of crop shift to other lands, the degree to which certain downstream businesses could still provide services (such as cutting plants at maturity but not hauling them away), and other factors. In short, the magnitude of sales losses to upstream and downstream businesses in any local area due to crop changes under Alternative 3 cannot be determined at the level of this Final PEIS. However, many factors would have to be present for multiple businesses to experience income losses that result in business failures. Thus, minor to no impacts to upstream or downstream businesses could occur due to business income losses under Alternative 3.

As in Alternative 1, unrelated businesses could experience income losses under Alternative 3 if cross-pollination from an EHEC field trial occurred and prevented or devalued the sales of a neighboring crop. In any alternative, the losses could be large if unauthorized release and commingling occurred. The value of the crop could be completely lost because the crop could be seized and destroyed, unless there was a way to effectively separate the regulated article from portions of the crop. Such losses may accrue to the operator whose field was impacted, or may accrue to the program participant through a liability claim, and could result in business failures. Losses might also accrue to the program itself if it backstops the liability of the EHEC Program participants. Alternative 3 may have an increased risk for unauthorized release of genetic material outside the confined field trial. For example, research has demonstrated that the out-crossing frequency of alfalfa is nearly 10 times greater for commercial-scale fields than research-scale plots (St. Amand, Skinner, & Peaden, 2000). Also, it is probably more likely that an unauthorized release could be detected from a large field than a small field. Given the many factors and relative risks involved in confined field trial protocols, it is difficult to say if unauthorized release and commingling of genetic material is any more likely at the scale of Alternative 3. Such an event, and its economic implications, are hypothetical, but could have major adverse impacts if it occurred.

*Net Effects of Changes to Business Income and Expenses*. Various combinations of expense and income effects are possible under any alternative. At the scale of Alternative 3, the implications of negatively reinforcing effects could be more serious—if they occurred. However, this would require the coming together of multiple unlikely or hypothetical factors and events. For instance, failure of confinement protocols, presence of a sexually-compatible crop nearby, and actual cross-pollination would all have to occur. Only then could economic consequences emerge. While this is a risk, it is due to a series of events that are speculative. The impact on net business income could have major adverse impacts if it occurred—businesses might fail as a result.

***Labor Earnings Effects***. The amount of labor earnings generated by 15,000 acres of conventional crops could be considerably greater than that generated by the acreages under Alternatives 1 and 2. However, minor to no impacts to labor earnings are anticipated from the conversion of that acreage to EHECs under Alternative 3 as although confined field trials may require greater manpower or more skilled labor than ordinary commercial crop operations, the labor requirements under Alternative 3 may be closer to the labor requirements of conventional commercial crops. Thus, wage and salary income of workers would still be available to support individual workers and the local economy under Alternative 3. In addition, proprietor income could be supported by financial assistance and available to support the local economy.

***Unemployment Rate Effects***. Given the economic effects discussed above, major increases in the unemployment rate at the county level under Alternative 3 are not anticipated as the direct labor requirements for EHEC field trials at this scale may be greater and are unlikely to be substantially less than those of conventional crops. Different skill set requirements may mean some individual workers may be replaced, while others would be hired; the net change in the number of employed persons and in the unemployment rate would be minor. It is unlikely that labor income would decline substantially, if at all. There would be no substantial impact on employment supported by consumer expenditures supported by labor income.

***Macroeconomic Effects***. Changes in commodity prices or other macroeconomic effects are not anticipated under Alternative 3. While Alternative 3 has the largest acreage, its scale is still insufficient to affect any farm or forest product prices as most such prices are set at international, national, and regional levels, depending on the crop. With respect to input prices, almost all farm and forest input prices are also set at international, national, and regional levels, and thus would not be affected. Some farm output and input prices are set at sub-regional levels (e.g., land and commodity markets at the level of a state or major portion of a state). These would also not be affected by changes at the scale of Alternative 3.

### 4.6.4.2 Demographic or Social Effects

***Population-Driven Effects***. While the acreage involved in field trials is substantially greater in Alternative 3 than Alternatives 1 and 2, the potential for population-driven effects on local public or private infrastructure and services (schools, police service, housing, etc.) or public finances is not substantially different. As described for the Alternatives 1 and 2, changes in employment are the main and probably only factor that could drive changes in population. Specifically, in Alternative 3, the likelihood of substantial population changes and resulting in major adverse impacts is low as population decreases are unlikely because EHEC field trials would have greater or similar labor requirements compared to the crops they replace and any population increases attributable to greater labor requirements would be small. Therefore, stress on public finances is highly unlikely.

***Quality of Life Effects***. Possible undesirable conditions that could affect residents in communities surrounding EHEC field trials include dust generated during soil tilling and other in-field operations, smells from fertilization, concerns generated by pesticide applications, noise from in-field operations, traffic inconveniences from slow-moving machinery, and other factors pertaining to agricultural operations. At the scale of Alternative 3, more persons in surrounding communities could be exposed to these conditions than under Alternatives 1 and 2. However, it is unlikely that the intensity of these concerns would be greater than for the conventional crops that EHECs would replace. Some operational changes due to EHECs could be perceived as benign, such as the increased presence of personnel in the fields for monitoring and evaluation, or for hand removal of emergent seed heads. Other changes might include increased cultivation operations to control weeds, which could in some cases result in additional dust production. As noted for Alternative 1, this and many other operational effects are likely to be accepted by most residents as consequences of living in proximity to working agricultural lands. Relative to conventional crops, increased pesticide applications might result from strict weed control requirements or requirements to suppress volunteer EHEC plants post-trial. To the extent pesticide applications increase, at the scale of this alternative this could be a concern to local residents. However, the types of pesticide likely to be used (e.g., Roundup) would not be likely to create real human health issues. In short, any negative operationally related quality of life effects under Alternative 3 are not likely to result in substantial reductions in quality of life for a large number of residents in the surrounding community(ies), and thus would not be considered major adverse impacts. In some cases, quality of life factors could improve; for instance, if an EHEC field trial shifts land from annual crops to perennial or woody crops, in-field mechanical operations and their dust, noise, and other effects would in many cases decrease.

Natural resource-related quality of life factors include access to local food, and sustained provision of ecological services. At the scale of Alternative 3, EHECs could have positive or negative effects on these factors. Conversion to an EHEC of a large acreage of conventional crops grown for local consumption could have an adverse impact. However, this type of conversion is unlikely; most conventional cropland is dedicated to extensive crops such as corn and soybeans that are grown for commodity markets rather than local consumption. Conversion of forest used for biomass crops, or of pasture, to annual EHECs could have negative effects on provision of ecosystem services. For instance, this may reduce water retention and filtration services. This type of conversion is also unlikely, due to costs of converting forest land to cropland, and because forest and pasture land do not generally make good cropland. Conversion of existing cropland to perennial or woody EHECs is more likely, which would typically result in an improvement in ecosystem services. Based on these considerations for likely scenarios, Alternative 3 could result in minor to no adverse impacts to quality of life.

### 4.6.5 No Action Alternative

Under the No Action Alternative, DOE would not implement the proposed EHEC Program, EHEC confined field trials, or financial incentives for EHEC development associated with the field trials. The No Action Alternative serves as the baseline for comparison to the continued conventional commercial crop production—existing croplands, pasturelands, and forested lands—on land that might be converted to EHEC field trials under the Alternatives.

#### 4.6.5.1 Economic Effects

Under the No Action Alternative, the general socioeconomic conditions and trends as described in Chapter 3 would continue. In the near term, net business income, labor income, and employment from lands that might be considered for EHEC field trials under the Alternatives would continue at rates similar to recent years. Macroeconomic effects of current cropping patterns would be the same. In the longer term, the crop choices of producers and the resulting business income, labor income, employment, and macroeconomic effects would change based on evolving market forces and other factors apart from the confined field trial incentives provided by the EHEC Program.

With the No Action Alternative, in the absence of DOE funding and support for EHEC Programs, scientific understanding and innovation in the responsible use of EHECs would develop more slowly or not at all. It is possible that some EHEC field trials could occur, using other public and private funding sources, but at a much more limited rate than would occur with Federal financial incentives for confined field trials.

#### 4.6.5.2 Demographic or Social Effects

Based on the continuation of current cropping patterns and resulting business income, labor income, and employment in the short term, current population trends would continue under the No Action Alternative in areas that might be considered for EHEC field trials under the Action Alternatives. Therefore, no strains on local public or private infrastructure and services or public finances would occur due to changes in cropping patterns.  Further, no changes to local quality of life factors would occur based on changed cropping patterns.

In summary, no economic, demographic, or social impacts are anticipated from the No Action Alternative.  However, the benefits for producers, communities, and the nation of developing well-researched, low-risk EHECs suitable for commercial production would be foregone.

### 4.6.6 Effects on Environmental Justice Populations

Under EO 12898, Federal agencies must identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations (environmental justice populations).  Environmental effects include economic, social, and cultural effects.  "Adverse" and "disproportionate" are key concepts in an environmental justice impacts analysis.  An environmental justice impact may be disproportionately high and adverse if the impact on the identified population is harmful, *and* "appreciably exceeds or is likely to appreciably exceed" the impact to the general population or other appropriate comparison group (Council on Environmental Quality, 1997a).

As discussed in the preceding portions of this socioeconomics section (Section 4.6), no major adverse economic impacts or demographic/social impacts are expected for any of the alternatives.  In addition, Section 4.9, Safety and Human Health, finds that no human safety and health impacts, including to agricultural worker safety and health, are anticipated under any of the alternatives.  Therefore, disproportionately high and adverse impacts on minority or low income populations are not anticipated on a programmatic level, but site-specific analysis would still be required.

## 4.7 Wildfires

### 4.7.1 Significance Criteria

Wildfires are a major concern for forest and shrubland ecosystems.  As reported by the USDA Forest Service, "the danger of destructive wildfires has become a major problem in many areas of the United States due to an increase in the human population and to decades of fuel accumulation resulting from wildfire suppression and climatic variability" (Marshall, Wimberly, Bettinger, & Stanturf, 2008).  Factors contributing to wildfires include fuel conditions (flammability of the vegetation), seasonality, topography, and climate conditions.  Wildfires typically occur in the spring and fall when low humidity coupled with windy conditions can cause vegetative fuels on the ground to lose their moisture content (dry out), thereby increasing the risk of wildfires.  In the United States, the majority of wildfires (as much as 90%) are started by human activities, such as unattended campfires, discarded cigarettes, debris burning, and arson; however, a small number of wildfires result from natural causes, such as lightning strikes or lava (National Park Service).  There are few existing plant guides that identify or rank plants by their flammability (Doran, Randall, & Long, 2004).  Overall, most plants would likely burn during drought conditions, regardless of their flammability, which exacerbates the spread, intensity, and overall danger once a wildfire is started.

Vegetation communities respond differently to wildfires.  For this Final PEIS, potential wildfire impacts were reviewed for perennial herbaceous, annual herbaceous, and woody crops.  The factor considered for determining significance is high wildfire potential, defined as an increase in the likelihood to contribute to a wildfire. Table 4.7-1 provides a summary of the impacts for wildfire potential.

**Table 4.7-1: Wildfires Impact Summary**

| Impact Criteria Analyzed | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| High Wildfire Potential | ⊙ | ⃠ | ⃠ | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.7.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

***Perennial Herbaceous.*** Specialized cell types for terpene accumulation are present in most plants. The best characterized examples of terpene accumulation (such as taxol) are specific to the plant/terpene and may have potential as an extractible biofuel. Recent terpene research has focused mainly on terpenes related to flavors or fragrances for tobacco or tomatoes. One main focus has been to increase terpene storage capacity to avoid toxicity. It may be challenging to genetically engineer perennial herbaceous and other non-terpene accumulating plants to produce terpenes, particularly in the volumes needed for biofuel production.

A proposed perennial herbaceous EHEC developed with terpene production and accumulation would likely have an extensive (and deep) root system characteristic of perennial herbaceous plants, which can be highly productive and resilient to environmental stresses (Glover, 2007). As mentioned in Section 3.7, plants ignite and burn at different rates and intensities depending on leaf moisture content, leaf structure, and chemical characteristics. It is not clear that genetically modifying a perennial herbaceous crop could present a greater fire hazard than existing perennials commonly found in the project area. The potential flammability from a proposed terpene producing perennial herbaceous EHEC would be dependent on these characteristics, in combination with weather conditions and seasonality at the site location for the field trial. USDA reported that fields of giant Miscanthus may pose a fire risk (U.S. Department of Agriculture - National Resources Conservation Service, 2011). Additional site- and plant-specific environmental compliance review would be conducted for any terpene producing perennial herbaceous EHEC. Under Alternative 1, negligible short-term impact could occur due to changes in the genetic makeup of a perennial herbaceous EHEC to create or increase terpene content given the size of the field trials.

These confined field trials are small (less than 5 acres) and could be managed to reduce available fuel or dry litter buildup. With the removal of fuel, if a wildfire were to occur, it would be less severe and more easily suppressed (National Park Service). The confined field trial sites could be located at established planting areas managed to reduce the risk of wildfire spreading to or from nearby areas using firebreaks between trial sites or adjacent forested area. The implementation of BMPs could include adequately spaced field borders (30 to 100 ft) particularly near structures, utilities, and adjacent fields or wild land areas to prevent accidental fires from escaping. Due to the small size of these field trials under Alternative 1, there is no reason to believe that the proposed perennial herbaceous EHECs pose an increased fire risk.

***Annual Herbaceous.*** As described under Perennial Herbaceous, specialized cell types for terpene accumulation are present in most plants. Annual herbaceous plants are known to produce and accumulate terpenes as a defensive mechanism to herbivores; some plants can emit volatile blends in response to herbivore predation or other stresses. For example, volatile terpenes can be released from the leaves of a maize plant after an attack by caterpillars; the emitted terpene attracts parasitic wasps that are natural enemies of the caterpillars (Turlings, 2013). These natural terpenes are attractants based on scent or flavor, but are not a biofuel.

Some annual herbaceous crops, such as species of grasses, may tolerate or even enhance a wildfire, whereas others respond well after a wildfire establishing and spreading easily into new areas (D'Antonio & Vitousek, 1992). As mentioned in Section 3.7, plants ignite and burn at different rates and intensities depending on leaf moisture content, leaf structure, and chemical characteristics. It is not clear that genetically modifying an annual herbaceous crop could present a greater fire hazard than existing annuals commonly found in the Southeastern United States. The potential flammability from a proposed terpene producing annual herbaceous EHEC would be dependent on these characteristics, in combination with weather conditions and seasonality at the site location for the field trial. Additional site- and plant-specific environmental compliance review need to be conducted for any terpene producing annual herbaceous EHEC. Although annual herbaceous EHECs are likely to exhibit similar wildfire potentials as non-GM annuals, under Alternative 1, a minor impact is anticipated from any changes in the genetic makeup of an annual herbaceous EHEC to create or increase terpene content given the size of the field trials. These confined field trials are small (less than 5 acres) and could be managed to reduce available fuel or dry litter buildup. With the removal of fuel, if a wildfire were to occur, it would be less severe and more easily suppressed (National Park Service). The confined field trial sites could be located at established planting areas managed to reduce the risk of wildfire spreading to or from nearby areas using firebreaks between trial sites or adjacent forested area. Due to the small size of these field trials under Alternative 1, there is no reason to believe that the proposed annual herbaceous EHECs pose an increased fire risk.

***Woody Crops.*** Woody crops, such as pines and poplars, respond to fire differently depending on the species, age of the tree, and the types of fuels available in the area. Younger pines are particularly susceptible to wildfires. As described in Chapter 3, terpene is a major component in pine tree resin and pine trees naturally produce around 3% to 5% terpene content. Higher terpene content can lead to higher flammability, as seen in conifers and pine cones, which are more flammable due to their terpene content.

An increase in the terpene storage potential and production capacity may increase the likelihood for wildfire potential. However, it is not clear that genetically modifying a woody crop could present a greater fire hazard than existing pine plantations commonly found in the Southeastern United States. To assess the terpene content in loblolly pine, Thompson et al. (2006) assessed the total terpene content in the inside (heartwood), middle (inner sapwood), and outside (outer sapwood) of increment core sections from twelve 40-year-old loblolly pines of similar size and diameter in Mississippi. The analysis revealed the average terpene content of the core samples as 2.3% for heatwood, 0.77% for inner sapwood, and 0.35% for outer sapwood (Thompson, Cooper, & Ingram, 2006). In addition, the fire resistance of a loblolly pine increases with bark thickness and tree diameter as it ages. When loblolly pines are about 2 inches in diameter and reaching the age of 10, the young, relatively thin bark begins to thicken (Wade D. D., 1993).

Research on terpene content and flammability suggests a limited correlation between terpene content and flammability. A 2008 study found that in Mediterranean shrubland and forest environments, flammability had an important relationship with leaf hydration, with weak correlations found between terpene content and flammability. The research indicated that arid conditions likely increase fire risk through decreased hydration leading to increased flammability of the species. (G. A. Alessio, 2008)

Although not engineered to produce additional terpenes, another woody crop, Eucalyptus, was not found to present a greater fire hazard than commonly found pine plantations in the Southeastern U.S. As reported in the Finding of No Significant Impact (FONSI) signed by USDA APHIS, a comparison of a Pinus species (*P. pinaster*) to Eucalyptus (*E. globulus*) assessing the risk of wildfire in live and dead material in northern Spain found Pinus litter flammability was higher than that of Eucalyptus, which was higher than that of a hardwood species. While differences between commonly found Southeastern U.S. pines, the Eucalyptus studied, and the proposed EHECs are likely, basic similarities within the genera are likely relevant. (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service -- Biotechnology Regulatory Service, 2012)

The potential flammability from woody crop EHECs with increased terpenes would be dependent on the type of tree, leaf structure, and chemical characteristics, coupled with weather conditions and seasonality at the site location for the field trial. Additional site- and plant-specific environmental compliance review would need to be conducted for any woody crop EHEC with increased terpene production. Changes in the genetic makeup of a woody crop EHEC to create or increase terpene content is likely to cause a minor adverse impact.

The Southeastern United States poses a historical risk of wildfires. However, the probability that a woody crop confined field trial would increase the risk and severity of forest fires in the Southeastern United States is small. These confined field trials are small (less than 5 acres) and could be managed to reduce available fuel or dry litter buildup. With the removal of fuel, if a wildfire were to occur, it would be less severe and more easily suppressed (National Park Service). The confined field trial sites could be located at established planting areas managed to reduce the risk of wildfire spreading to or from nearby areas using firebreaks between trial sites or adjacent forested area. Due to the small size of these field trials under Alternative 1, there is no reason to believe that the proposed EHECs they pose any more of a fire risk than other forest tree plantings.

### 4.7.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

Alternative 2 differs from Alternative 1only by the size of the confined field trial plots. Wildfire potentials would be similar as those identified in Alternative 1. However, given the increased size of the field trials, the potential for wildfires could increase to major adverse impacts. The potential impacts can be decreased in intensity by employing BMPs. A variety of BMPs could be employed to deter the spread of a wildfire, reduce wildfire hazards, and prevent the spread of any unintentional wildfires that may occur:

- *Defined fuel breaks created around the field trial site* – fuel breaks are areas without any fuels (plants, grasses, or trees). Depending on local conditions at each site, the firebreak may be a road, a cultivated strip, or a plowed fire line 10 to 20 feet wide. For giant Miscanthus, the field borders may need to be 30 to 100 ft wide. The wider the fuel break, the more defensible the area will be to halt or deter a wildfire from spreading.

- *Incorporate defensible space* – defensible space is an area free of vegetation or other fuels that can be defended to prevent a wildfire from spreading (can include irrigated areas).

- *Maintain irrigation* – keep field trial sites properly watered to prevent crops from dying out.

- *Fuel reduction programs* – selectively thin field trial sites to remove any potential dying plants or overgrowth.

- *Weekly reviews of the NFDRS Southern Area maps* – NFDRS' Southern Area seven-day fire danger forecast maps should be reviewed weekly to determine the potential for wildfire conditions in the field trial area.

Under Alternative 2, major or long-term mitigable to minor adverse impacts could occur. Appropriate BMPs would be identified in future site- and plant-specific environmental reviews. DOE or another Federal agency may require a recipient of funding or a permit to implement appropriate BMPs as a condition of funding or permitting for a proposed EHEC project.

### 4.7.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

Alternative 3 differs from Alternatives 1and 2 only by the much larger size of the confined field trial plots. Wildfire potentials would be similar as those identified in Alternative 2. Given the size of the field trials (up to 15,000 acres), the potential for wildfires could increase to major adverse impacts that can mitigated to minor adverse with BMPs. A variety of BMPs could be employed to deter the spread of a wildfire, reduce wildfire hazards, and prevent the spread of any unintentional wildfires that may occur:

- *Defined fuel breaks created around the field trial site* – fuel breaks are areas without any fuels (plants, grasses, or trees). Depending on local conditions at each site, the firebreak may be a road, a cultivated strip, or a plowed fire line 10 to 20 feet wide. For giant Miscanthus, the field borders may need to be 30 to 100 ft wide. Wider fuel breaks could provide a more defensible area for these larger size field trials as a way to halt or deter a wildfire from spreading.

- *Incorporate defensible space* – defensible space is an area free of vegetation or other fuels that can be defended to prevent a wildfire from spreading (can include irrigated areas).

- *Maintain irrigation* – keep field trial sites properly watered to prevent crops from dying out.

- *Fuel reduction programs* – selectively thin field trial sites to remove any potential dying plants or overgrowth.

- *Weekly reviews of the NFDRS Southern Area maps* – NFDRS' Southern Area seven-day fire danger forecast maps should be reviewed weekly to determine the potential for wildfire conditions in the field trial area.

Under Alternative 3, major or long-term mitigable to minor adverse impacts could occur. As appropriate, BMPs would be identified in future site- and plant-specific environmental reviews. DOE or another Federal agency may require a recipient of funding or a permit to implement appropriate BMPs and as a condition of funding or permitting for a proposed EHEC project.

### 4.7.5 No Action Alternative

Under the No Action Alternative, the EHEC Programs would not be implemented for the establishment and production of EHECs. EHECs could be developed at a slower pace; any EHECs planted would follow USDA APHIS permit requirements for field trials. No changes to crop cover having the potential to result in increased wildfire potential could occur from the No Action Alternative. Therefore, no impacts associated with wildfire potential are anticipated from the No Action Alternative.

## 4.8 Air Quality

### 4.8.1 Impact Criteria

The environmental consequences to local and regional air quality conditions from a proposed Federal action are determined based upon the increases in regulated pollutant emissions relative to ambient air quality. Specifically, the impact in NAAQS attainment areas could be considered a major adverse impact if the net increases in pollutant emissions from the action could result in any of the following scenarios:

- Cause or contribute to a violation of any national or state ambient air quality standard;
- Expose sensitive receptors to substantially increased pollutant concentrations; or
- Exceed any Evaluation Criteria established by a SIP.

This Final PEIS analysis reviews the impacts to air quality related to combustion from farm equipment vehicles, dust emissions from agricultural practices, emissions from pesticide applications, and off-gassing for the proposed EHEC Programs regardless of the crop type (perennial herbaceous, annual herbaceous, or woody crop). Effects on air quality in NAAQS nonattainment areas are considered a major adverse impact if the net changes in project-related pollutant emissions result in any of the following scenarios:

- Cause or contribute to a violation of any national or state ambient air quality standard;
- Increase the frequency or severity of a violation of any ambient air quality standard; or
- Delay the attainment of any standard or other milestone contained in the SIP.

With respect to the General Conformity Rule, effects on air quality could be considered a major adverse impact if the proposed Federal action could exceed *de minimis* threshold levels established in 40 CFR §93.153(b) for individual pollutants in a non-attainment area or for pollutants for which the area has been redesignated as a maintenance area.

The *de minimis* threshold emissions rates were established by EPA in the General Conformity Rule to focus analysis requirements on those Federal actions with the potential to have major adverse air quality impacts. Table 4.8–1 presents these thresholds, by regulated pollutant; these thresholds would apply to the entire Proposed Action in the nonattainment area. These *de minimis* thresholds are similar, in most cases, to the definitions for major stationary sources of criteria and precursors to criteria pollutants under the CAA's New Source Review (NSR) Program (CAA Title I). As shown in Table 4.8–1, *de minimis* thresholds vary depending upon the severity of the nonattainment area classification. The *de minimis* thresholds apply to the entire Proposed Action in the nonattainment area. EPA has not established *de minimis* threshold emissions rate for PM2.5; regardless, the proposed EHEC Programs, no matter which alternative chosen, is not expected to cause an adverse impact on fine particulate emissions.

**Table 4.8-1: Conformity *de minimis* Emission Thresholds**

| Pollutant | Area Type | Tons/Year |
|---|---|---|
| **Ozone (VOC or $NO_x$)** | Serious nonattainment | 50 |
| | Severe nonattainment | 25 |
| | Extreme nonattainment | 10 |
| | Other areas outside an ozone transport region | 100 |
| **Ozone ($NO_x$)** | Marginal and moderate nonattainment inside an ozone transport region | 100 |
| | Maintenance | 100 |
| **Ozone (VOC)** | Marginal and moderate nonattainment inside an ozone transport region | 50 |
| | Maintenance within an ozone transport region | 50 |
| | Maintenance outside an ozone transport region | 100 |
| **CO, $SO_2$ and $NO_2$** | All nonattainment & maintenance | 100 |
| **$PM_{10}$** | Serious nonattainment | 70 |
| | Moderate nonattainment and maintenance | 100 |
| **$PM_{2.5}$** | All nonattainment & maintenance | 100 |
| **Lead (Pb)** | All nonattainment & maintenance | 25 |

*Source*: (Environmental Protection Agency, 2013k)

Table 4.8–2 provides a summary of the potential air quality impacts.

**Table 4.8-2: Potential Air Quality Impact Summary**

| Impact Criteria | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| Ozone | ⨀ | ⨀ | ⨀ | ○ |
| $PM_{2.5}$ | ○ | ○ | ○ | ○ |
| VOCs (fertilizer/pesticides) | ○ | ○ | ○ | ○ |
| VOCs (off-gassing) | ⨀ | ⨀ | ⨀ | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⨀ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.8.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

Combustion of fuels associated with cultivation and harvesting of crops and airborne particles (dust) generated during tillage and harvesting result in air pollutant emissions, which adversely affect air quality, with effects varying by region. Air emissions also result from the application of fertilizers and pesticides used in cultivating the crops.

### 4.8.2.1 Products of combustions from farm equipment vehicles

EHECs can be planted, managed, and harvested using existing agricultural equipment. This includes cultivation and harvesting of EHECs, which requires a range of mechanized equipment that use different fuels, including diesel, gasoline, natural gas, and electric power (Environmental Protection Agency, 2010a). Primary emissions from fuel use include nitrogen oxides ($NO_x$), VOCs, CO, $SO_2$, coarse and fine particulate matter ($PM_{10}$ and $PM_{2.5}$), and GHGs (discussed in Section 4.10). Benzene, formaldehyde, and acetaldehyde emissions may also result from gasoline use (Environmental Protection Agency, 2010b). Combustion of any carbon-based fuel produces $CO_2$, but the overall impact of a given fuel on the climate depends on how the fuel is made. For example, natural gas results in less $CO_2$ accumulation than fuels made from petroleum or coal. Agricultural equipment engines commonly burn gasoline and diesel fuel, resulting in byproducts from exhaust and evaporation of the fuel that contribute to air pollution (Environmental Protection Agency, 2013i). Ozone is not emitted directly by plants or farm equipment but is formed in the atmosphere by chemical reactions of precursor pollutants in the presence of sunlight (National Park Service, 2014). Potential effects of ozone are evaluated based on emissions of these precursor pollutants, such as $NO_X$ and particulate matter (PM).

Conventional tillage is typically used under conditions where weeds cannot be effectively controlled through chemical or other methods. Additional sources of emission from agricultural practices are those associated with generation of electricity used for irrigation water pumping. Irrigation use for EHECs would vary depending on plant type and region, and emissions associated with this use depend on the source of the electricity consumed (e.g., coal). Projected fossil energy inputs (i.e., fertilizers and fuel) are estimated to be lower than annual crops such as corn. EHECs such as perennial grasses and woody crops are harvested less often than annuals crops, thus requiring less agricultural farm equipment use. By-products of combustion from farm equipment should have negligible impacts on air quality and current pollutant state levels under Alternative 1.

### 4.8.2.2 Dust generated during agricultural activities

Tillage and other agricultural activities (e.g. seedbed preparation, planting, and harvesting) not only are associated with emissions due to burning of fossil fuels but also result in the release of soil PM into the air (Holmen, et al., 2006). Compared with annual row crops, herbaceous perennial and short-rotation woody crops are likely to reduce wind-blown dust and tillage dust (except during establishment) due to more continuous cover of the soil, thus protecting air quality. For example, perennial grasses—switchgrass and miscanthus—provide uniform surface cover and extensive root systems relative to row crops (e.g. corn and sorghum), thus improving soil stability and susceptibility to wind erosion and dispersal of dust particles (Evers, Blanco-Canqui, Staggenborg, & Tatarko, 2013). Wind-blown dust could increase, however, in areas where agricultural crops and crop residues (i.e. stalks, leaves, and seedpods) are more intensively collected for energy rather than being left on the field to protect the soil from wind or water erosion. Dust generated during tillage should also be reduced with perennial crops given they are harvested and replanted less often than typical annual crops. This is in contrast to the annual planting and maintenance of many conventional agricultural crops such as corn and soybeans (U.S. Congress Office of Technology Assessment, 1993).

Conservation tillage practices commonly used in agriculture to reduce particulate matter generation by up to 85% include the number of passes through a field and changing key soil properties such as water-holding capacity (Madden, Southard, & Mitchell, 2008). Energy crops, such as switchgrass and loblolly pine, should require less use of tractors and other farm equipment because these can be harvested annually for several years before replanting. Potential exists for EHECs to alter the cropping systems toward limited or no tillage. They can be re-established without the need of new cultivation and land preparation operations and have a longer lifespan for energy crop production, therefore reducing overall fugitive dust emissions from cropping activities (Bioenergy Crops, 2013). Implementation of Alternative 1 could cause long-term minor beneficial impacts on air quality at the regional and state levels for $PM_{2.5}$ emissions.

### 4.8.2.3 VOCs/HAPs from fertilizer/pesticide application

Fertilizer and pesticide application are primary sources of VOC and HAP (hazardous air pollutant) emissions associated with crop production. Application of inorganic and organic fertilizers can increase $CH_4$ emissions from the soil, in addition to pollutants, $NO_x$ and ammonia ($NH_3$) (Jarecki, Parkin, Chan, Hatfield, & Jones, 2008). Agricultural pesticides consist of insecticides, fungicides, and herbicides. Pesticides enter the atmosphere through volatilization from soil and plant surfaces, drift (the movement of pesticide through the air to unintended sites), and wind erosion (U.S. Department of Agriculture, 2012c). Pesticides are typically applied to crops by ground spray equipment or aircraft. The amount of drift and the distance traveled by the airborne pesticides varies widely and is influenced by a range of factors, including weather conditions, topography, the crop or area being sprayed, application equipment and methods, and practices followed by the applicator (Kiely, Donaldson, & Grube, 2004).

Minor beneficial impacts on air quality from fertilizer and pesticide emissions is expected for Alternative 1. EHECs such as perennial grasses are expected to require less pesticide than row crops, except when initially establishing the plantings when inputs can be comparable (Parrish & Fike, 2005). Studies have shown perennial grasses (e.g. giant miscanthus) have lower nutrient requirements than annual row crops due to effective internal cycling of nutrients from aboveground material to the roots and rhizomes as it goes dormant, resulting in less fertilizer usage (U.S. Department of Agriculture, 2011). Additionally, crops like switchgrass have few natural pests or diseases, so growers would not need to apply large amounts of pesticides as done with row crops. Many energy crops have also demonstrated the ability to out-compete weeds, thus it is anticipated that they would need little or no pesticides once established (Ceres, 2014).

### 4.8.2.4 EHEC Off-gassing

Vegetation releases many of the VOCs commonly found in the atmosphere. VOCs are a major precursor of both ozone and secondary organic aerosols in the troposphere. Aerosols can scatter or absorb solar radiation, modifying the Earth's climate (de Gouw, et al., 2005). Scientists estimate that trees and plants emit about two-thirds of the VOCs currently in the air (Carlton, Pinder, Bhave, & Pouliot, 2010). Plant emissions are dominated by isoprene, a highly reactive VOC. Changes in the flux of isoprene may have a substantial impact on the composition of the troposphere, and in particular, ozone and aerosol particles. Land use and land cover changes could play an important part in governing future isoprene emissions and hence atmospheric composition and air quality (Ashworth, Folberth, Hewitt, & Wild, 2012).

Woody crops, such as loblolly pine, emit terpenes, a class of VOCs, which are used to produce turpentine, varnishes, and lacquers. If emitted in large enough quantities, terpenes could contribute to air pollution, particularly in Florida where loblolly pine trees are abundant. Trees emit chemicals into the atmosphere in response to various environmental triggers, such as defense against insect pests and climate change. Coniferous forests emit increased levels of terpenes as ambient temperature increases (J.G. Slownik et. al., 2010). In addition, non-woody crops such as perennial grasses produce various VOCs (such as methanol, acetaldehyde, and acetone). The composition of the atmosphere can potentially be altered by the increase in VOC release from herbaceous plants if grown on a large scale (Miresmailli, Zeri, Zangerl, Bernacchi, Berenbaum, & DeLucia, 2012). The exact composition of VOC emissions varies with species; therefore, the impact on air quality of different plants, particularly when planted over extensive acreages, would vary (Simpson & McPherson, 2011). Woody crops may have an impact on regional surface concentrations of VOCs, but recent studies have shown that resulting increases in regional ozone concentrations are minor on a small scale (Ashworth, Folberth, Hewitt, & Wild, 2012). Minor adverse impacts from plant off-gassing on air quality are expected for Alternative 1.

### 4.8.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

Impacts on air quality would be the same as those described under Alternative 1. Negligible impacts to air quality from the proposed field trials would occur. Even if multiple 250-acre field trials occurred in a single county, no adverse air quality impacts are anticipated.

### 4.8.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

Under Alterative 3, impacts on air quality would be similar to those described under Alternative 1. The scale of this alternative—15,000-acre field trials compared to 5-acre field trials under Alternative 1 and 250-acre field trial under Alternative 2—would not result in any differences. A potential adverse impact to air quality could be seen with Alternative 3 with respect to increased woody crops and the resulting VOC concentrations depending on the type and acreage of energy crop planted. However, this would be dependent on the EHEC. Negligible impacts to air quality are anticipated.

### 4.8.5 No Action Alternative

Impacts on air quality would be the same as those seen with conventional crops. Additional impacts are not expected.

## 4.9 Safety and Human Health

### 4.9.1 Impact Criteria

Impacts from pesticides and other agrochemicals could be considered major adverse impacts if the Federal action resulted in worker, resident, or visitor exposure to these materials, or if the action generated quantities of these materials beyond the capability of current management procedures. Impacts were assessed based on the potential impacts of crop production and harvesting activities. This Final PEIS analysis reviews the impacts to safety and human health and intentional destructive acts related to physical and chemical hazards for the proposed EHEC Programs regardless of the crop type (perennial herbaceous, annual herbaceous, or woody crop). Table 4.9-1 provides a summary of the potential safety and human health impacts.

**Table 4.9-1: Potential Safety and Human Health Impact Summary**

| Significance Criteria Analyzed | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| Physical Hazards | ○ | ○ | ○ | ○ |
| Chemical Hazards | ○ | ○ | ○ | ○ |
| Intentional Destructive Acts | ⊙ | ⊙ | ⊙ | ○ |

LEGEND
⊗ = Major impact
⦸ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 4.9.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

### 4.9.2.1 Industrial Health and Safety

The main concerns with regard to industrial worker health and safety include physical hazards (tractor and other machinery accidents, respiratory distress, noise-induced hearing loss, and injuries) and chemical hazards (pesticides and other agrochemicals), as described in Chapter 3.

***Physical Hazards.*** These are inherent risks in crop production and harvesting which would not be changed by the planting of EHECs. Alternative 1 would not result in a change in management practices from conventional farming since workers would continue to use equipment. Therefore, implementation of Alternative 1 would not cause any direct or indirect effects on worker health and safety.

***Chemical Hazards.*** Growing and harvesting the EHECs would be required to follow the same standards and safety procedures as all other crops regarding pesticide handling, therefore implementation of Alternative 1 would have no direct impacts on worker health and safety. Workers may be indirectly exposed to agrochemicals by working in a field where pesticides have recently been applied; breathing in pesticide "drift" from adjoining or nearby fields or working in a pesticide-treated field without appropriate PPE. Safety training could mitigate the minimal indirect impacts, and these could be the same for EHECs as for conventionally-grown crops.

### 4.9.2.2 Public Health and Safety

***Physical Hazards.*** The types of physical hazards that could affect public health and safety at locations away from the EHEC confined field trial location include increased traffic, increased concentrations of particulate matter and other criteria air pollutants, and additional noise. There might be an increase in traffic near the confined trial locations, particularly during planting and harvesting times. However, this could be temporary and the field trial locations could occur on similar land use so the area's existing infrastructure could handle the additional traffic. Additional site-specific environmental compliance review could be conducted if the confined field trial took place in an area that could not handle the temporary increase in traffic. Section 4.8 concludes that there would be minimal impacts to air quality and no impacts to noise from implementation of the Alternatives. Therefore, implementation of Alternative 1 would not cause any direct or indirect effects on public health and safety.

***Chemical Hazards.*** People can be exposed directly to chemicals in general via inhalation, oral, and dermal routes if they live on or near farms that use them. As previously stated, under the Alternatives, the

EHECs would not be used for human food, animal feed, and various other products that people consume or to which they are exposed. DOE does not anticipate any public contact with the crops. Therefore, the only possible route of exposure would be indirect dermal exposure through drift.

It is not known if the engineered proteins in the proposed EHEC species have any toxic properties. The EHECs have minimal potential to be allergenic to humans who inadvertently encounter the crops. Crop-specific levels of allergencity could be researched in laboratory studies and environmental compliance reviews prior to the field trials to determine the potential impacts on humans. It is not possible to quantify this risk, but DOE assumes that there could be minimal indirect impact, if any, and no direct impact on public health and safety from the alternatives. The FDA would examine the properties of each new crop for possible toxicity or allergens.

#### 4.9.2.3 Intentional Destructive Acts

Whether acts of sabotage or terrorism could occur, the exact nature and location of the acts, or the magnitude of the consequences of such acts are inherently uncertain and the possibilities are infinite. Nevertheless, DOE considered acts of intentional destruction associated with growing and harvesting related to the confined field trials. DOE considers the most hazardous of such acts to be the deliberate destruction of the proposed EHECs. It is unknown if there would be pesticides or other agrochemicals kept on site and if so, which ones. Consequences of such an event under Alternative 1 would be limited and likely would not result in injury or harm to the public or workers.

DOE could reduce the risk of intentional destructive acts by imposing restrictions to applicants, such as limiting access to the field trial locations. When choosing the site locations, the aim would be to avoid other targets such as near major inland ports, container terminals, nuclear power plants, or national defense infrastructure. Another potential measure would be to not publicize the field trial locations.

### 4.9.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

Increasing the scale of the confined field trial from 5 acres to 250 acres, as defined in Alternative 2, would have similar impacts as discussed for Alternative 1. Due to the larger confined field trial size (more acres); there could be a slightly greater opportunity for intentional destructive acts to occur. Potential mitigation measures would remain the same.

### 4.9.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

Increasing the scale of the confined field trials to 15,000 acres, as defined in Alternative 3 would have similar impacts to Alternative 1. Due to the larger confined field trial size, there could be a slightly greater opportunity for intentional destructive acts to occur. Potential mitigation measures would remain the same.

### 4.9.5 No Action Alternative

Under the No Action Alternative, the EHEC Programs would not be implemented for the establishment and production of EHECs. Impacts on human health and safety would be similar to safety concerns for conventional crops.

#### 4.9.5.1 Industrial and Public Health and Safety

Under the No Action Alternative, there could be negligible direct and indirect impacts to industrial health and safety and public health and safety. Existing croplands, pasturelands, and forested lands have the potential to include GM crops. However, growth and harvesting of these crops would not be funded by DOE. People would continue to apply for permits and continue to use the land for growing crops, which would have the same physical and chemical risks as the Alternatives.

#### 4.9.5.2 Intentional Destructive Acts

Since the No Action Alternative involves maintaining the status of existing cropland, it is unlikely that an intentional destructive act could occur.

## 4.10 Climate and Greenhouse Gas Emissions

### 4.10.1 Impact Criteria

Table 4.10–1 provides a summary of the potential climate change impacts.

**Table 4.10-1: Potential Climate Change Impact Summary**

| Impact Criteria | Alternative 1 | Alternative 2 | Alternative 3 | No Action |
|---|---|---|---|---|
| GHG emissions from soils | ○ | ⊙○ | ⊙ | ○ |
| GHG emissions from agricultural equipment and vehicles | ○ | ○ | ○ | ○ |

LEGEND
⊗ = Major impact
⃠ = Major or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

The contribution of GHG emissions from agriculture to the national total is small (10%) compared to those from other economic sectors such as transportation (28%) and electricity (32%) (Environmental Protection Agency, 2014b) The conversion of land from annual to perennial and woody crops may increase or decrease GHG emissions. Perennial grasses and forest may require less fertilizer application, and therefore result in lower nitrogen emissions (reduced GHG emissions), but there is still scientific uncertainty about the ability of intensely managed and harvested commercial forest species, such as loblolly pine, to effect long-term carbon storage (Bragg & Guldin, 2010). Conversely, converting large areas of farm or forested lands to EHEC cultivation involving the frequent disturbance of topsoil and application of large quantities of nitrogen fertilizer could result in increases in GHG emissions.

Considerable research has been conducted to measure the changes in the GHG flux (i.e., the rate of exchange of GHGs between the soil and the atmosphere) that occurs as a consequence of the conversion of land between different cultivation schemes, for example cropland to forest, grassland to forest, and forest to grassland. Meehan (Meehan, 2013) modeled the replacement of annual energy crops with perennial energy crops, and determined that the switch from continuous corn production to perennial grass production increased below-ground carbon sequestration by 30% and decreased annual $N_2O$ emissions by 84%. In addition, (Tilman, 2006) examined the entire production life-cycle (including fossil fuel inputs and biofuels burning) of grassland biomass and concluded that the process could be carbon-negative. These examples suggest that the conversion of land producing annual conventional crops to EHEC perennial crops (such as jatropha or switchgrass) could decrease emissions, or even be carbon-negative if other GHG-emitting aspects of cultivation are not enhanced.

Field trials that have attempted to measure GHG emissions from agricultural land conversion have produced a variety of results, which are summarized in Table 4.10-2 and Table 4.10-3. The inconsistency is due to differences in the types of soils, plant species, the length of time a plot of agricultural land had been under cultivation, differences in climate, the methodologies used by different research projects, difficulty in obtaining accurate measurements and many other factors. The science and standard methods for assessing, describing, and comparing carbon flux in different agricultural settings and under different land use change scenarios are still in development and a subject of intense study. (Dunn, 2013)

Overall, the research shows that net carbon sequestration in soils increases when converted from farmland or abandoned pasture to forest, thereby reducing GHG emissions from soils. There are exceptions to this general observation: in some cases, it appears to be related to the soil disturbance or disruption of land in carbon "steady-state" during the conversion to forest or grassland, which releases carbon from the soil to the atmosphere during ploughing and other activities. In other cases, dry climates limit growth rates after land use conversion, which result in lower or negative rates of carbon sequestration than moist climates after land use conversion.

**Table 4.10-2: Amount of Carbon Sequestration from Land Use Conversion to Grassland or Pasture**

| Conversion to Grassland | Average C sequestration rate (g/ $m^2$ /year) | Source |
|---|---|---|
| Cool steppe pasture to perennial grassland | 110 | (Post & Kwon, 2000) |
| Subtropical moist forest converted to pasture – Atlantic | (16.22) | (Post & Kwon, 2000) |
| Subtropical moist forest converted to pasture – Southeast | 10.81 | (Post & Kwon, 2000) |
| Subtropical moist forest converted to pasture – South | 113.51 | (Post & Kwon, 2000) |
| Agriculturally degraded land to monoculture grass | 14-62 | (Tilman, 2006) |
| Agriculturally degraded land to high-diversity grass | 330-440 | (Tilman, 2006) |
| Cropland to miscanthus | Gain | (Dunn, 2013) |
| Cropland to switchgrass | Gain | (Dunn, 2013) |
| Forestland to switchgrass | Loss | (Dunn, 2013) |
| Forestland to miscanthus | Gain | (Dunn, 2013) |

***Annual Herbaceous***. Research on the carbon sequestration potential of annual crops has mixed conclusions. Cultivating annual crops such as corn can result in short-term carbon sequestration in soils during their growth phase (Clay, 2012). However, because the intensive production of annual crops includes the regular disturbance of the upper layers of the soil during planting, harvesting, and fertilizing, annual crops may be net releasers of carbon through soil erosion and accelerated decomposition of organic matter. This has been a particular problem in the Southeastern region of the U.S., which has experienced noteworthy loss of topsoil and soil carbon due to intensive cropping (Franzleubbers, 2005). Overall, the cultivation of annual crops is likely to result in a net release of carbon from the soil but, as is the case with other crops, the damage to topsoil can be repaired and carbon sequestration enhanced through the use of low-till/no-till and reduced use of nitrogen fertilizers.

***Perennial Herbaceous.*** Perennial species such as switchgrass and miscanthus also sequester carbon in soils. Representative GHG emissions data related to land conversion to grassland are in Table 4.10-2.

Case studies of the conversion of forested lands to grassland almost always results in carbon loss from the soil, with the exception of certain cases in the tropics and a model (Dunn, 2013) that indicated that miscanthus could sequester more carbon than the forest it replaced. Because the proposed EHECs considered in this Final PEIS are anticipated to be planted in existing agricultural areas (at agricultural testing stations and similar installations with existing fields), and be confined to test plots as part of a research program, large-scale conversion of forest land to grassland is not anticipated as part of EHEC Program-sponsored confined field trials. Case studies in the United States on subtropical lands indicate that GHG emissions are impacted positively when cropland and degraded/marginal land benefit are converted to grassland, especially where multiple species of grasses are planted together (Tilman, 2006).

Overall, there could be a reduction in GHG emissions from perennial grasses and an increase in soil carbon, so long as these crops do not replace forested lands. Low-till and no-till regimes with minimal application of nitrogen fertilizers, and the implementation of other sustainable farming practices that minimize soil exhaustion and erosion could enhance carbon storage (depending on the crop) and minimize GHG emissions. (Robertson, 2000)

***Woody Crops***. Representative metrics on carbon sequestration during the establishment phase of conversion of fields to forested land are shown in Table 4.10-3.

**Table 4.10-3: Land Use Change and Carbon Sequestration to Forested Land**

| Type of Land Use Change | Average C sequestration rate ($g/m^2/y$) |
|---|---|
| Old field to managed pine | 65.66 |
| Abandoned field to mixed forest | 2.15 |
| Warm temperate old field to pine (natural succession) | 2.94 |
| Old field to managed pine | 24.8<br>3.6 |
| Long-term agriculture to subtropical dry secondary forest | 80 |
| Abandoned pasture to subtropical dry forest | (13.08) |
| Forest plantation with intensive site preparation | (51.49) |
| Long-term agriculture to subtropical moist forest | 105.0 |
| 10-year crop to subtropical wet forest | 28.0<br>148.8 |
| Long-term agriculture to subtropical wet forest | 98.7 |
| Field to loblolly pine | Increase |

*Source:* (Post & Kwon, 2000) (Post and Kwon is a review article that cited multiple sources)

Certain species considered in this Final PEIS, such as loblolly pine, have been closely studied for their carbon sequestering capabilities, including their enhancement of below-ground, long-term carbon storage, which could be less susceptible to subsequent release upon harvest. This research shows that carbon sequestration is maximized when the trees have reached full growth (i.e., 50 years) (Nepal, 2009), which may not match the most economically-viable harvest schedule for EHECs. EHEC forests that are grown and harvested intensively, including commercially popular species such as pine and eucalyptus, may either reduce soil carbon storage or alter carbon-nitrogen ratios and affect other soil nutrient profiles in harmful ways (Berthrong, 2009). However, earlier analysis of the effects of forest harvesting on carbon and nitrogen content have indicated that overall, harvesting trees had minor impact on soil carbon or nitrogen, although this was dependent on tree species, the type of harvesting (saw-cutting vs. whole tree harvesting), and subsequent site activities such as burning and removal of woody debris (Johnson, 2001). The research also shows that the degree of carbon sequestration is tied to soil fertility, with marginal soils or drier areas of the country performing poorly for carbon sequestration compared to fertile or enhanced soils (Oren, 2009).

The impact on carbon sequestration of land use conversion to forests in the project area could be largely positive (i.e., there could be a net gain of carbon to the soils), especially compared with conventional crops the cultivation of which is a net GHG emitter, based on the emissions reports from the states in the project area. Carbon sequestration may be negatively impacted by tillage that disturbs the soil, the application of fertilizers, drought, and intense harvest schedules.

***Potential Emissions Scenarios***. The Proposed Action could cause the conversion of land used for conventional crops to land used for EHECs. The GHG emissions and carbon sequestration associated with the cultivation of and conversion of agricultural land for energy crops have been assessed and quantified in a number of studies (West & Marland, 2001) (Meehan, 2013) (Duval, 2013). Crops have different carbon and nitrogen footprints depending on a number of factors including their ability to recharge soil carbon and nitrogen, whether they are annual or perennial crops, the cropping and tilling methods that are used, the existing soil types and amount of fertilizer applied (Johnsen, 2013). Perennial crops would likely sequester more carbon in the soil and emit less GHGs than annual crops. From these studies, it is not possible to develop precise predictions of the carbon flux from the cultivation of a particular crop, but the carbon flux under no-till/low-till practices is more likely to be negative (i.e., more carbon sequestered in the soil, which means less GHG emissions). Table 4.10-4 summarizes a range of potential changes in soil carbon emissions by land conversion type and land area.

If the land is not converted (e.g. annual EHECs are grown in areas where annual crops were cultivated, or woody EHECs are grown on forested lands, or perennial EHECs are grown where perennials were cultivated) this Final PEIS assumes that, after a period of slightly increased emissions from soil disturbance as a result of plowing and other site preparation, soil GHG emissions could remain approximately the same. The exception would be the conversion of forest from one type of crop to another, requiring substantial soil disturbance.

Table 4.10-4 integrates the results of the various studies discussed in the previous pages (Duval, 2013) (Post & Kwon, 2000) (West & Marland, 2001) (Meehan, 2013) into a single summary which presents potential ranges in changes in carbon emissions as a result of the Alternatives, with negative values indicating carbon sequestered, and positive changes indicating carbon emitted.

EHEC-related land use changes could alter biogeochemical and GHG budgets as agricultural land is converted from conventional crops to EHECs. It is possible to make some qualitative evaluations of possible outcomes for processes that affect carbon flux and $NO_2$ production. Based on field trials in which GHG flux changes as a result of crop changes have been quantified, there is variability in the potential flux of GHGs from the cultivation of EHECs. The maximum potential increases in GHG emissions in Alternatives 1, 2, and 3 due to conversion would be associated with soil disturbance (e.g., when a "wild" forest or abandoned fields are converted to a managed forest or when a forest is converted to grassland) as the vegetation that was fixing carbon in biomass is removed and the steady-state of carbon input to the soil is disrupted, releasing $CO_2$ as organic matter decays. At the other end of the emissions spectrum, maximum carbon sequestration (negative $CO_2$e emissions) from Alternatives 1, 2, and 3 would occur when cultivated fields are converted to forests or agriculturally degraded lands are converted to multi-species grassland.

**Table 4.10-4: Potential Range of Changes in Soil Carbon Emissions due to Land Conversion (g/m$^2$/yr)[21]**

| | Low | High | Alternative 1 | | Alternative 2 | | Alternative 3 | |
|---|---|---|---|---|---|---|---|---|
| | g C/m2/ year | g C/m2/ year | low (metric T C/year) | high (metric T C/year) | low (metric T C/year) | high (metric T C/year) | low (metric T C/year) | high (metric T C/year) |
| **Conversion to Forest** | | | | | | | | |
| Abandoned Field or pasture | 13.08 | -2.15 | 0.05 | 0.01 | 2.65 | -0.44 | 158.80 | -26.10 |
| Cultivated Field | -2.94 | -148.80 | -0.01 | -0.60 | -0.59 | -30.11 | -35.69 | -1,806.58 |
| Conversion from Forest w/ intensive site prep | 51.49 | no value | 0.21 | no value | 10.42 | no value | 625.14 | no value |
| **Conversion to Perennial Grasses** | | | | | | | | |
| Abandoned field or pasture | 0.00 | -110.00 | 0.05 | -0.45 | 52.09 | -22.26 | 158.77 | -1,335.51 |
| Agriculturally degraded land | 0.14 | -440.00 | 0.00 | -1.78 | -0.03 | -89.03 | -1.70 | -5,342.04 |
| Forest | 16.22 | 113.51 | 0.07 | 0.46 | 3.28 | 22.97 | 196.93 | 1,378.12 |
| **Conversion to Annuals** | Range highly dependent on soil treatment and management techniques, rather than the type of crop conversion | | | | | | | |

[21] Negative values represent carbon sequestered.

### 4.10.2 Alternative 1 - Development-scale Confined Field Trials (up to 5 acres)

Alternative 1 could result in a range of potential GHG emissions from soils with a maximum of 0.21 tons $CO_2$e/year emitted from the soils and a minimum of 1.78 tons $CO_2$e/year sequestered in the soils (Table 4.10-4). Negligible adverse impacts to GHG emissions or climate are anticipated.

As detailed in Chapter 2, one of the assumptions for the proposed EHEC Programs is that standard agricultural and silvicultural practices would be used for the duration of the confined field trials. GHG emissions data have not been reported by states in the project area in sufficient granularity to determine what the current emissions from farm equipment are. Rather, they are typically bundled as part of transportation emissions. However, the USDA estimates that emissions from farm equipment are small relative to the emissions and sequestration flux from soils management, crop conversion, forestry and other agricultural activities (U.S. Department of Agriculture, 2010). Because the cultivation practices on the land used for field trials would remain the same as current practices, the contribution of agricultural equipment to GHG emissions would remain the same (i.e., small relative to total agricultural emissions). Therefore, no impacts to GHG emissions or climate from agricultural equipment and vehicles are anticipated.

### 4.10.3 Alternative 2 - Pilot-scale Confined Field Trials (up to 250 acres)

Based on the analysis of emissions summarized in Table 4.10-4, Alternative 2 would result in a maximum of 10.42 tons $CO_2$e/year emitted from soils and a minimum of 89.0 tons $CO_2$e/year sequestered in the soils. Negligible adverse impacts to GHG emissions or climate are anticipated from Alternative 2.

Because the cultivation practices on the land used for the proposed EHEC field trials would remain the same as current practices, the contribution of agricultural equipment to GHG emissions would remain the same (i.e., small relative to total agricultural emissions). Therefore, no impacts to GHG emissions or climate from agricultural equipment and vehicles are anticipated.

### 4.10.4 Alternative 3 - Deployment-scale Confined Field Trials (up to 15,000 acres)

Based on the analysis of emissions summarized in Table 4.10-4, Alternative 3 would result in a range from of 642.9 tons$CO_2$e/year emitted from the soils to 5,340.7 tons$CO_2$e/year sequestered in the soils. Minor adverse impacts to GHG emissions or climate are anticipated.

Because the cultivation practices on the land used for the proposed EHEC field trials would remain essentially the same as current practices, the contribution of agricultural equipment to GHG emissions would remain the same (i.e., small relative to total agricultural emissions). Therefore, no impacts to GHG emissions or climate from agricultural equipment and vehicles are anticipated.

### 4.10.5 No Action Alternative

Under the No Action Alternative, the EHEC Programs would not be implemented for the establishment and production of EHECs. No changes to crop cover would occur from the No Action Alternative. Emissions from agricultural soils in the project area would remain as described in Chapter 3, Existing Environment. No additional impacts to GHG emissions or climate would occur.

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# 5 Cumulative Impacts

CEQ regulations implementing NEPA requires assessment of cumulative impacts of a Proposed Action (40 CFR Parts 1500-1508). A cumulative impact is defined as an "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions" (40 CFR §1508.7). Cumulative impacts can result from individually minor but collectively major actions taking place over time (40 CFR §1508.7). CEQ's guidance for considering cumulative effects states that NEPA documents "should compare the cumulative effects of multiple actions with appropriate national, regional, state, or community goals to determine whether the total effect is significant" (Council on Environmental Quality, 1997b).

Section 5.1 presents the methodology used to evaluate cumulative impacts; Section 5.2 discusses other actions that may have cumulative effects when combined with the potential impacts from the proposed EHEC Program. Section 5.3 identifies and describes the cumulative impacts for particular resource areas discussed in Chapters 3 and 4.

## 5.1 Cumulative Impacts Methodology

This section of the Final PEIS assesses the potential cumulative environmental impacts from implementing the Proposed Action. First, DOE identified other projects that may be categorized as occurring in the past, present, and reasonably foreseeable future. Some of these projects were identified early in the NEPA planning process through internet research. Projects were selected projects using a number of different methods, such as:

- Reviewing actions recently proposed by other Federal agencies, including USDA APHIS, with a GM crop;
- Identifying relevant and current DOE ARPA-E PETRO Program projects; and
- Reviewing projects recently proposed or implemented by academic institutions, public entities, or private entities.

Cumulative impacts are generally best assessed by resource area (e.g., water resources, socioeconomic impacts). Impacts may arise from single or multiple actions, and may result in additive or interactive effects. Interactive effects may, in some cases, be countervailing (adverse cumulative effect is less than the sum of the individual effects) or synergistic (net adverse cumulative effect is greater than the sum of the individual effects) (Council on Environmental Quality, 1997b). The factors considered in determining the context and intensity of cumulative impacts are the same as those presented in Chapter 4.

It should be noted that while the direct impacts of some individual projects were considered, there is little quantitative data available for most of the projects listed in Table 5.2-1. An integral part of the cumulative impacts analysis involves determining whether impacts from the Proposed Action could contribute to ongoing or foreseeable resource trends. The cumulative impacts analyses does not assess all potential environmental impacts from the identified projects, but only those impacts resulting from both an Action Alternative and other past, present, and reasonably foreseeable future actions that influence a particular resource area. As a quantitative analysis cannot be formalized, DOE assessed the potential cumulative impacts qualitatively.

## 5.2 Past, Present, and Reasonably Foreseeable Future Projects

CEQ defines a cumulative effect as "an impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). Cumulative effects cover the direct and indirect effects of the Proposed Action and other past, present, or reasonably foreseeable (future) projects that are related in the sense that they may affect the same resources as the Proposed Action. Table 5.2-1 lists projects that DOE identified that, when considering the Proposed Action in this Final PEIS, could result in incremental impacts to a number of resource areas if planted within the project area. DOE identified these projects through its review of recent NEPA documentation, public scoping, and internet research. Table 5.2-1 provides the project title, geographic location, project sponsor, a brief project description, and the completion year, based upon available information. More descriptive information on each listed project is provided after Table 5.2-1.

**Table 5.2-1: Past, Present, and Reasonably Foreseeable Future Projects**

| Name | Location | Sponsor | Brief Description | Completion Year |
|---|---|---|---|---|
| GM Crops in Refuge Farming Programs | USFWS Southeast Region | USFWS | Evaluate the future use of GM crops on National Wildlife Refuge (NWR) lands that allow farming as a wildlife management tool to meet NWR-specific goals/objectives | N/A* |
| Controlled Release of a GE Eucalyptus Hybrid | Southeastern United States | APHIS / ArborGen | Confined field trails and permits for the interstate movement, planting, and flowering of GE Eucalyptus at confined field sites | 2010-current |
| Understanding the Effects of Bioenergy Crop Production on Soil and Water Resources | GA | USDA ARS | Establish plantings for watershed research of a farm converted from conventional crops to bioenergy crops | 2016 |
| Carbon Sequestration and Nitrogen Cycling for Greenhouse Gas Mitigation by Southeastern U.S. Annual and Perennial Energy Crops | Southeastern United States (GA) | USDA-ARS | Research on perennial grass production, soil physical properties, and GHG emission data collection. Supply plant seed stock of energy cane and napier grass to three sites | 2015 |
| Switchgrass Research at Pee Dee Research and Education Center | Florence, SC | Clemson Univ. | Exploration of warm-season grasses (switchgrass) to produce ethanol from plant cellulose for raw material in coal-fired electric generation facilities or for synthetic fuels | Ongoing |
| Jet Fuel From Camelina Sativa: A Systems Approach | Raleigh, NC | DOE ARPA-E | Develop GM *Camelina sativa* to produce high quantities of modified oils and terpenes | 2014 |
| Tappable Pine Trees - Commercial Production of Terpene Biofuels in Pine | Gainesville, FL | DOE ARPA-E | Develop GM pine to increase the amount of turpentine from 4% to 20% of its dry weight | 2016 |

*USFWS has chosen to not pursue this Proposed Action to grow GE crops on NWR lands and has curtailed the NEPA analysis.

### 5.2.1 Project Descriptions

**Southeast Region Programmatic EA for Genetically Modified Crops in Refuge Farming Programs**

The USFWS is preparing a Programmatic EA to evaluate the future use of GM crops on NWRs in the Southeast Region that allow farming. These refuges use farming as a wildlife management tool to meet refuge-specific goals and objectives. Of the almost four million acres of refuge lands in the Southeast about 1% (or about 44,000 acres) are currently devoted to farming. GM- and non-GM crops were used together in a crop rotation practice following regional policy requiring that farmed acres be rotated to a non-glyphosate GM crop/non-GM crop seed every four years. This rotation greatly reduced the chances of target pest species developing resistance to the pesticide glyphosate.

**EAs for Controlled Release of a GE Eucalyptus Hybrid**

The USDA APHIS prepared an EA in response to a confined environmental release and movement permit to allow the interstate movement, planting and flowering of GE eucalyptus trees at six confined field site locations in Alabama, Florida, Mississippi, and South Carolina encompassing a total of 14.7 acres. In 2010, APHIS completed an EA and FONSI for a permit application to authorize the planting, field testing, and flowering of a GE eucalyptus hybrid clone engineered to express various genes on 28 confined field site locations in the Southeastern United States, including Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. There are currently six active permits under which ArborGen is authorized by APHIS to grow GE eucalyptus which include 32 unique locations in these states. No plantings at any of the 32 locations are authorized by APHIS to exceed 20 acres in size. As of September 2011, 67 acres of trees are being grown on 18 of the 32 permitted locations. Each individual confined field test sites site ranges in size from 0.5 to 7.7 acres.

**Understanding the Effects of Bioenergy Crop Production on Soil and Water Resources**

The USDA ARS is establishing research plantings on cooperator-leased property to facilitate watershed research on bioenergy crops. The intent of the watershed study is to evaluate a farm converted from conventional crops to bioenergy crops. A total of 47 acres of *Miscanthus X giganteus* material propagated from an ongoing Miscanthus commercial propagation program were planted. The planted crop has been managed using techniques suitable for large scale commercial production of Miscanthus and forms the basis for future watershed studies.

**Carbon Sequestration and Nitrogen Cycling for GHG Mitigation by Southeastern U.S. Annual and Perennial Energy Crops**

The USDA ARS is researching low-input production methods for napier grass, energy cane, forage sorghum, and sweet sorghum. The project focus is on the development of efficient and economical harvesting, field drying, densification, and storage methods for the studied crops. Research areas include carbon sequestration in the soil and plant, in addition to nitrogen cycling by legumes and emission of nitrous oxide from different cropping systems. Project results from October 2012 show two sites in the Southeast USA Coastal Plains were used for field trials of two bioenergy grasses (napier grass and energy cane) to obtain data on crop production. Plots were established in Tift County and Peach County, GA on marginal lands that were previously weed fallow. Treatments for the grasses include different winter covers (clover, lupine, or no winter cover) and different fertilizer nitrogen rates. Weekly sampling of

GHG fluxes have been monitored. Future research will provide data on these two bioenergy crops and potential production under non-irrigated conditions with varying levels of nitrogen input.

**Switchgrass Research at Pee Dee Research and Education Center**

Clemson University, in collaboration with USDA ARS, are initiating studies to maximize production of native warm-season grasses under the climatic, soil, and socioeconomic conditions encountered by farmers and other landowners in South Carolina. Field research studies were conducted at Clemson's Pee Dee Research and Education Center, a 2,300-acre facility in Florence, SC. Many soils in this region are sandy and prone to drought, making them marginal for growing crops like corn. However, the soils may be suitable for the production of the more drought tolerant native warm-season grasses. Special research focus is being given to develop switchgrass farms among the rural communities in this region. In addition to field research studies, basic research is also being conducted on switchgrass.

**Jet Fuel from *Camelina Sativa*: A Systems Approach (DOE ARPA-E PETRO Program)**

The research is focused on GM camelina to produce high quantities of both modified oils and terpenes. These components are optimized for thermocatalytic conversion into energy-dense drop-in transportation fuels. The GM camelina captures more carbon than current varieties and has higher oil yields. In addition, the GM camelina is more tolerant to drought and heat, which makes it suitable for farming in warmer and drier climate zones in the United States. The increased productivity of this GM camelina and the development of energy-effective harvesting, extraction, and conversion technology may provide an alternative non-petrochemical source of fuel.

**Tappable Pine Trees (DOE ARPA-E PETRO Program**

The research is working to increase the amount of turpentine in harvested pine, currently a tree species used in the paper pulping industry, from 4% to 20% of its dry weight. Pine trees naturally produce around 3-5% terpene content in the wood. The team is aiming to increase terpene storage potential and production capacity while improving the terpene composition to a point at which the trees could be tapped while alive, like sugar maples.

## 5.3 Summary of Cumulative Impacts

Cumulative impacts assessment is relative to the same resource categories analyzed in Chapter 4 of this Final PEIS. However, assessing cumulative impacts for many resource areas on a regional basis for unknown EHECs at undetermined confined field trial locations would be purely speculative at the programmatic level of this analysis. Therefore, the cumulative impacts discussion of individual resource categories focuses solely on those categories identified as having potential cumulative impacts. Table 5.3-1 provides a summary of the potential cumulative impacts for the projects identified earlier. More descriptive information on the specific resource areas begins in Section 5.3-1.

**Table 5.3-1: Summary of Potential Cumulative Impacts**

| Environmental Resources Considered | Cumulative Impacts |
|---|---|
| Water Resources | ⊙, + |
| Geology and Soils | + |
| Biological Resources | ⃠⊙ |
| Wildfire | ⃠ |
| Climate Change and GHGs | + |

LEGEND
⊗ = Major impact
⃠ = Moderate or long-term impact mitigable to minor impact
⊙ = Minor, short-term impact
○ = No impact
\+ = Beneficial impact

## 5.3.1 Resource Areas with Potential Cumulative Impacts

### 5.3.1.1 Water Resources

An analysis of cumulative impacts on water resources addresses potential cumulative impacts on both surface water and groundwater resources. Agriculture impacts water resources through soil erosion, run-off of agricultural chemicals, and water use for agricultural production. BMPs could be applied to reduce potential adverse impacts.

**Surface Water**

*Moderate Beneficial*

The conversion to perennial EHECs or short rotation woody crops provides greater water use efficiency and a general reduction in agrochemical use than traditional row crops, such as corn. This conversion could limit runoff from agricultural fields and the potential need for irrigation past the initial establishment period. If matched appropriately to the site, perennial EHECs would better utilize growing conditions where traditional agricultural crops do poorly, thus increasing productivity. Under the Proposed Action and Alternatives, the benefits associated with increased water quality and decreased water quantity could be only locally significant and could have minor positive changes. Cumulatively, when considered with the projects in Table 5.3-1, the effects could have regional beneficial impacts and long-term moderate beneficial impacts.

*Minor to Moderate Adverse*

Stresses on the Southeastern United States' surface water quality are associated with intensive agricultural practices, urban development, coastal processes, and mining activities, as described in Section 3.2. Many streams and rivers have been affected by sediment from agriculture and high levels of nitrate, phosphorus, and pesticides. Production of annual herbaceous EHECs combined with production of corn for ethanol and soybeans for biodiesel could have adverse impacts on water quality because it could increase nutrient, sediment, and pesticide loadings to waterbodies, including the Gulf of Mexico and Chesapeake Bay, although fewer negative impacts are expected with soy production (since they require fewer agrochemicals). The increased fertilizer runoff contributes to eutrophication, coastal hypoxia, and other areas of concern.

**Groundwater**

Groundwater quality in the Southeastern United States has been affected by historic and current agriculture practices, specifically applications of pesticides, fertilizer and manure, and nitrate concentrations in shallow wells are elevated within most of the Region (Winrock International, 2009). Because groundwater moves slowly, the flushing of nutrient-contaminated groundwater from an aquifer can take many years, even several decades. Cumulatively, the continued agriculture practices in the area might continue to contaminate groundwater—some of which are used for drinking water. Private drinking water wells could see increases in nitrate and public drinking water systems could see increases in their costs to lower nitrate levels. However, some of the potential increased nutrient loadings from corn grown for ethanol might be reduced if farmers grow other EHECs and continue using conservation practices.

**Water Use and Availability**

Historically, rainfall in the project area has been adequate to maintain water resources, and the region relies on a balanced mix of groundwater and surface water sources instead of irrigation. Cumulative adverse impacts on water quantity could be major if they exceeded annual yields of water supply. Implementation of the Alternatives when considered with the projects in Table 5.2-1 could have minor adverse impacts on water use since most of the Region does not require irrigation for EHEC production. Farmers might irrigate the EHECs to produce as much biomass as they can (improve profitability), which could have adverse impacts, but these could be local and cumulatively minor in intensity.

Cumulative impacts from short rotation woody crop EHECs in conjunction with the projects listed in Table 5.2-1 could adversely impact the Region's hydrology. As discussed in Section 4.3.2.3, large-scale woody crop plantations may potentially lower the water table, affect groundwater recharge, and stream flow dynamics. The intensity of the impact on groundwater and stream flow depends on the area extent, size, and spatial distribution of the plantations. The Alternatives considered alone could not have any impact but considered cumulatively, there might be adverse impact on the Region's hydrology. Moderate forest thinning and residue removal is unlikely to substantially affect overall water availability.

Due to a lack of available data in the project area on planting EHEC woody crops, it is difficult to determine the intensity of the effects on hydrology if large acreages were planted. The USFS has indicated that collection of data and modeling will be useful to determine the long-term impacts of planting large acreages. Site-specific BMPs would need to be addressed prior to implementation of the Action Alternatives. (Soil and Water Conservation Society, 2010) (Vance, Loehle, Wigley, & Weatherford, 2014)

***BMPs.*** Conservation practices, if widely employed, can mitigate impacts to surface water quality. As discussed in Section 4.2, there are several BMPs to reduce the risks of pesticides and the amount of agrochemicals available for runoff or erosion for leaching. In addition, there are several BMPs to reduce the risks of pesticides and the amount of agrochemicals (fertilizer in particular) available to contaminate groundwater. Contamination rates likely are greater where there is higher runoff relative to infiltration, a high water table, or a direct surface– groundwater connection. Further site-specific and plant-specific environmental compliance reviews would be required before implementation of the Alternatives Analysis. The environmental reviews would identify specific BMPs – tailored to each proposed EHEC project – to avoid or minimize indirect and cumulative adverse impacts.

An alternative to utilization of high quality fresh ground and surface water for irrigation is to maximize the use of treated and recycled waters for EHEC production. Irrigation with treated wastewater provides a means to irrigate future bioenergy crops without burdening local water resources while at the same time not excessively overloading the crops with nutrients. It could offset the impacts of utilizing higher quality well and surface waters for growing energy crops in regions. (Dimitriou, et al., 2011)

#### 5.3.1.2 Geology and Soils

*Minor Beneficial*

The Proposed Action could have cumulative beneficial effects on soils at multiple levels, including a reduction of soil erosion, and increase in soil organic matter, and soil carbon deposition, relative to traditional crops, fallowed land under annual species, or previously cleared forestland that has not been revegetated.

#### 5.3.1.3 Biological Resources

Biological resources are reviewed by vegetation, wildlife, and non-native species related to agriculture. Protected species are reviewed on a state-specific basis for wildlife. For the purposes of this Final PEIS, protected species include migratory birds and listed or candidate species under Federal and state laws within the project area.

*Minor to Major Moderate Adverse Impact Mitigable to Moderate Impacts*

**Vegetation**

Past and ongoing impacts to vegetation in the project area from agriculture or conversion to cropland or development have resulted in habitat loss and fragmentation and are expected to continue into the foreseeable future. Implementation of the Alternatives could result in a minor contribution to losses and fragmentation of regional habitat within the project area and ecoregion.

Cumulative indirect impacts to vegetation could occur from the conversion of large amounts of agricultural land from traditional crops to EHECs. Indirect effects on habitat of EHEC planting and harvest could also include erosion, sedimentation, spread of invasive species, reduction in habitat quality, and habitat fragmentation. Some vegetation loss could occur. In addition, non-native species occurring in the area or introduced to the sites could expand into areas disturbed by production and harvest activities; however, field trial sites could be managed to avoid these concerns. The habitat quality of these areas may subsequently be reduced. Erosion of disturbed soils may contribute to reduction in habitat or habitat quality. Sedimentation from disturbed soils may degrade habitat along drainages or in wetlands that occur downstream. Crop management practices could reduce the potential for erosion and sedimentation impacts. Overall these indirect impacts could result in a small contribution to cumulative impacts on native habitats within the region.

The potential cumulative effects on vegetation could impact native fish and wildlife as habitats are fragmented, degraded, or destroyed from crop establishment. Not all species are harmed by conversion of land to more intensive uses, and so the cumulative effects will be localized and site-specific. The establishment of new crops in areas previously cropped for a different style of agriculture may itself cause some direct mortality and range shifting at the local scale of wildlife. Crop management practices and additional environmental compliance reviews should help to prevent and minimize any major adverse impacts; however, fragmentation may be unavoidable.

**Wildlife**

Direct impacts are not expected to impact wildlife at a population level. However, the intensity of indirect impacts is dependent on potential land use changes; the quantity and habitat quality of any land converted from forested land or pastureland for EHECs could determine the level of cumulative impacts. Direct effects on wildlife could occur from conflicts with tractors or other agricultural machinery that may result in mortality and could occur with the establishment any type of crop. Direct impacts are expected to occur during the establishment and harvest stages of the Alternative Actions; these impacts are expected to be short-term and localized. Indirect impacts could be the result of habitat change as cropland use is shifted from traditional crops to EHECs, and are expected to be both positive and negative but not major. These habitat changes could impact such aspects as food availability, type and quantity of cover for escape and breeding, and the availability of adequate nesting sites. Wildlife in lands adjacent to the EHEC confined field trials may either be positively or negatively impacted, depending on the habitat quality provided by the EHECs.

The temporary change from agricultural crops to a forested crop may result in a temporary change in resident animal and plant species, but after harvest and termination of the confined field trial, it is reasonably foreseeable that the land will return to agriculture or be replanted to tree production or research. At the end of the field trial, transgenic plant material could be removed from the test site or destroyed in accordance with USDA APHIS BRS permit conditions established for these permits.

Wildlife could also be disturbed by the noise and human presence during EHEC planting and harvesting, especially if there are more people or harvesting occurs more often with the proposed EHEC than the conventional crop. These indirect impacts could result in minor contribution to cumulative impacts on wildlife populations within the region.

Ecosystem health and biodiversity, including fish and wildlife, are impacted by uncertain environmental factors such as nutrient and sediment runoff. Nutrient loadings from EHEC production into surface waters depend on many different factors and are therefore widely variable. Regardless, the ability to reduce chemical exposure of biota can be beneficial to the ecosystem and local biodiversity. Future site- and plant-specific environmental compliance reviews for EHEC-specific projects would be undertaken to identify potential wildlife impacts and appropriate BMPs – tailored to the proposed EHEC – to meet USDA APHIS BRS permitting requirements. DOE may require other site- and plant-specific BMPs.

**Threatened and Endangered Species, Critical Habitat, and Migratory Birds**

Potential impacts on threatened and endangered species and migratory birds, assuming they are present in the project area, could range from low to high depending on the extent of the disturbance or impact. High impacts could occur if individual plants or wildlife species are harmed or result in a take[22] to a protected species. This is because any loss or disturbance to threatened or endangered species could be substantial in the context their limited population sizes.

Any potential minor adverse impacts associated with the implementation of the Alternative Actions are expected to be temporary in nature, mainly occurring during the conversion of traditional cropland to EHECs.

For any future EHEC Program, site- and plant-specific environmental compliance reviews would be undertaken to identify any potential effects to species and habitats. Future site- and plant-specific environmental evaluations, such as NEPA reviews, would be required prior to the proposed EHEC field trial plot selection. The site- and plant-specific environmental reviews could include desktop research to determine the presence of threatened and endangered species and critical habitat. In addition, these project-specific environmental reviews may warrant surveys of the project area to identify the potential of listed species or habitats on an individual parcel of land proposed as a field trial location. Adverse effects could occur if individual listed plants or wildlife species are harmed or result in a 'take' to a protected species; any loss or disturbance to threatened or endangered species could be substantial in the context of their limited population sizes. If impacts from the proposed EHEC could affect a protected species, or if the impacts could result in the regional decline of native wildlife or plant species, consultation with USFWS and applicable State agencies would be conducted to determine overall impacts and to identify BMPs tailored to the proposed EHEC project.

Site-specific environmental compliance reviews would be conducted to identify adverse impacts associated with each conversion to EHECs. When protected species are present or in the vicinity of a proposed field trial site, consultation with the appropriate regulatory agency (e.g., USFWS, NMFS, state wildlife agencies) would need to occur.

**<u>Non-native Species</u>**

Cumulative effects related to non-native (invasive) or noxious plants would be highly dependent upon the location of the confined field trial sites; however, the cumulative invasive and noxious plant effects of the EHECs, when taken into consideration with other Title IX 2014 Farm Act programs and state programs, would be minor. USFWS, USDA, and other DOE bioenergy programs could limit the cumulative effects of invasive and noxious plants as each program would be required to follow all applicable Federal, state, and local environmental regulations and mitigation measures.

Plants that the USDA has determined to be a noxious weed, an invasive species, or has the potential to be invasive or noxious as determined by the Secretary of Agriculture in consultation with other Federal or state agencies, would be only be allowed under the EHEC Programs as potential crops under careful scrutiny. It is the bio-geographical context of a given plant that is important in determining whether it may be invasive at a particular location. Weed risk assessments predict that in certain regions, switchgrass and some woody crop species or varieties could become invasive in some regions if

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[22] A "take" is defined, in the ESA, as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

cultivated without preventative measures, and that the perennial grass Giant Miscanthus poses little risk of becoming invasive. The USDA ensures that field trials do not occur for invasive or noxious plants. (National Wildlife Federation, 2008).

Potential impacts of GE crops on the environment could be caused by the hybridization of the GE plants and their wild relatives that may result in a weedy or invasive plant species. Such risk is considered by APHIS' BRS prior to the use of GE organisms outside of controlled conditions (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006). Any GE crop proposed for establishment under a proposed EHEC Program must be approved by USDA APHIS BRS and depending on the nature of the GE trait, by EPA for use (U.S. Department of Agriculture -- Animal and Plant Health Inspection Service, 2006).

Future site- and project-specific environmental compliance reviews would be required prior to EHEC project area selection could identify the potential invasiveness of specific EHECs proposed for establishment on an individual parcel of land. It could determine if the proposed EHEC is on a Federal or State Noxious Weed list, conduct a Weed Risk Assessment and climate matching analysis, and evaluate the potential of the EHEC to cross-pollinate with related species or other closely related taxa. This review could also determine if additional assessment under NEPA is required prior to approval of the EHEC contract.

Therefore, there is little potential for impacts from establishment of invasive species grown as EHECs, regardless of whether the crop is developed as a GE or non-GE crop and given the assumed cropland limitations for the proposed EHEC Program.

***BMPs.*** Activities may result in temporary localized impacts to biological resources in the preparation of the land for EHEC production; however, these potential impacts can be mitigated through the implementation of BMPs (e.g., the installation of silt fencing, temporary covers, vegetative filter strips, or retention basins) and would be identified in USDA APHIS BRS permitting requirements specific to the proposed EHEC project. DOE may require other site- and plant-specific BMPs. Other practices to reduce potential adverse cumulative impacts to biological resources include incorporation of conservation buffers into and along the borders of currently producing agricultural fields. Buffers provide multiple benefits to ecosystems, including the conservation and continuity of natural habitats, increased habitat areas, the protection of sensitive habitats such as watersheds and an increased access to local natural resources. Buffers can be designed and tailored towards local ecosystems and site-specific conservation needs.

The USDA APHIS BRS permit may identify specific BMPs tailored to each proposed EHEC project to reduce or eliminate the potential localized negative impacts to protected species. BMPs could minimize the potential inadvertent spread of EHECs out of the confined field trial area, such as timing the harvest to minimize the spread of seed, and inspection and washing of mechanical equipment prior to exiting a field. DOE (or other Federal agency) may require a recipient of funding or a permit to implement appropriate BMPs as a condition of funding or permitting for a proposed EHEC project. DOE may require other site- and plant-specific BMPs. If the environmental compliance review recognizes that species or critical habitat protected under the ESA are potentially present, and the proposed confined field trial on the land could be determined to have negative impacts, it is not likely the site could be approved by DOE or another Federal agency for the confined field trial.

#### 5.3.1.4 Wildfire

*Minor to Moderate Adverse with Mitigation to Moderate Impacts*

A proposed perennial herbaceous EHEC developed with terpene production and accumulation would likely have an extensive (and deep) root system characteristic of perennial herbaceous plants, which can be highly productive and resilient to environmental stresses (Glover, 2007). The potential flammability from a proposed terpene producing perennial herbaceous EHEC could be dependent on these characteristics, in combination with weather conditions and seasonality at the site location for the field trial. There could be minor to moderate cumulative adverse impacts on wildfire risk due to changes in the genetic makeup of a perennial herbaceous EHEC to create or increase terpene content given the size of the field trials.

Annual herbaceous plants are known to produce and accumulate terpenes. These natural terpenes are attractants based on scent or flavor, but are not a biofuel. The potential flammability from a proposed terpene producing annual herbaceous EHEC could be limited. Although annual herbaceous EHECs are likely to exhibit similar wildfire potentials as non-GM annuals, cumulatively, minor to adverse impacts are anticipated from any changes in the genetic makeup of an annual herbaceous EHEC to create or increase terpene content.

Woody crops respond to fire differently depending on the species, age of the tree, and the types of fuels available in the area. Younger pines are particularly susceptible to wildfires. As described in Chapter 3, terpene is a major component in pine tree resin and pine trees naturally produce around 3% to 5% terpene content. Higher terpene content can lead to higher flammability, as seen in conifers and pine cones, which are more flammable due to their terpene content. An increase in the terpene storage potential and production capacity may increase the likelihood for wildfire potential. However, it is not clear that genetically modifying a woody crop could present a greater fire hazard than existing pine plantations commonly found in the Southeastern United States. The potential flammability from woody crop EHECs with increased terpenes could be dependent on the type of tree, leaf structure, and chemical characteristics, coupled with weather conditions and seasonality at the site location for the field trial. Additional site- and plant-specific environmental compliance review could need to be conducted for any woody crop EHEC with increased terpene production. Cumulatively, the potential impacts for wildfire risk could be moderate adverse and mitigated to moderate with the implementation of BMPs.

***BMPs.*** The Southeastern United States poses a historical risk of wildfires. With the removal of fuel, if a wildfire were to occur, it could be less severe and more easily suppressed (National Park Service). The confined field trial sites could be located at established planting areas managed to reduce the risk of wildfire spreading to or from nearby areas using firebreaks between trial sites or adjacent forested area. USDA APHIS BRS permits may identify specific BMPs tailored to each proposed EHEC project to reduce or eliminate the potential for wildfire impacts. DOE may require other site- and plant-specific BMPs. DOE (or other Federal agency) may require a recipient of funding or a permit to implement appropriate BMPs as a condition of funding or permitting for a proposed EHEC project.

#### 5.3.1.5 Climate Change and GHG Emissions

*Minor Beneficial*

The proposed EHEC Programs could generate net energy savings and greater soil carbon sequestration as lands are converted to EHECs. The impacts would be locally or regionally beneficial.

### 5.3.2 Conclusion

The only cumulative impacts associated with the proposed EHEC confined field trial locations (which would be under USDA APHIS BRS permit) are those related to initial EHEC planting, annual EHECs, or short rotation woody crops production. Based on the analysis provided in the Final PEIS, DOE has determined no past, present, or reasonably foreseeable actions could aggregate with effects of the Alternatives to create cumulative impacts or reduce the long-term productivity or sustainability of any of the resources associated with the confined field trials or their ecosystems. Long-term adverse cumulative impacts are not anticipated resulting from the Alternatives and projects listed in Table 5.2-1.

# 6 Other Required Analyses

In addition to the analyses discussed in Chapters 4 and 5, NEPA requires an additional evaluation of the Proposed Action's potential impacts with regard to any irreversible or irretrievable commitment of resources, the relationship between local short-term and long-term productivity, and unavoidable adverse impacts.

## 6.1 Irreversible or Irretrievable Commitment of Resources

As required under CEQ regulations (10 CFR §1502.16), potential impacts to irreversible and irretrievable commitment of resources resulting from implementation of the Proposed Action must be analyzed. Resources that are irreversibly or irretrievably committed to a project are those that are typically used on a long-term basis that cannot be recovered. These resources are irretrievable in that they would be used for one project when they could have been used for other purposes. Another impact that falls under the category of irretrievable commitment of resources is the destruction of natural resources that could limit the range of potential uses of the particular resource.

The proposed funding of EHEC Programs would not require the commitment of non-renewable resources; the Proposed Action would use existing croplands, pasture lands, or forested lands. The only commitment of resources would be the use of existing agricultural lands for growing EHECs. However, the confined field trials described in the Action Alternatives would use non-renewable resources for the field trial's duration. These resources include energy (fuels), water, biological, and geological (soils). The use of gasoline or other fuels for operating heavy equipment (e.g., tractors), if there are permanent impacts to water quality or quantity, if any threatened or endangered species are harmed or result in a take by the project, or the permanent commitment of a land area EHEC growth and harvest could result in an irreversible or irretrievable commitment of resources. Any impacts on other biological resources would be localized and incremental, although permanent. Any future Federal involvement in a specific EHEC project would require an additional site- and plant-specific environmental compliance review.

Use of these resources would represent an incremental effect on the regional consumption of these commodities. In addition, growing and harvesting of the EHECs for the confined field trials, if implemented, would commit work-force time for agricultural, silviculture, research, environmental review and compliance, operation, and maintenance.

There would be no irreversible or irretrievable commitment of resources with respect to noise, air quality, visual resources, land use, infrastructure, cultural resources, hazardous wastes or materials, socioeconomic resources (other than labor discussed above), or environmental justice. Where any potential irreversible or irretrievable commitments of resources are identified, they would only apply to the confined field trials.

## 6.2 Relationship between Short-term and Long-term Productivity

NEPA regulations require that the relationship between short-term use of the environment and the potential impacts of such use on the maintenance and enhancement of long-term productivity of the affected environment be addressed. Impacts that narrow the range of beneficial uses of the environment are of particular concern (40 CFR §1502.16). Such impacts can arise from the possibility that choosing one development option reduces future flexibility in pursuing other options, or from the possibility that giving over a parcel of land or other resource to a certain use eliminates the possibility of other uses being performed at the site. It is anticipated that implementation of the Action Alternatives would not result in any impacts that would narrow the range of future beneficial uses of the environment because it would not pose any long-term risks to health, safety, or the general welfare of the public communities surrounding the confined field trials. The confined field trials would be temporary (15 years). The USDA APHIS BRS permit may identify specific BMPs tailored to each proposed EHEC project to reduce or eliminate potential environmental impacts. DOE may require other site- and plant-specific BMPs. DOE (or other Federal agency) may require a recipient of funding or a permit to implement appropriate BMPs as a condition of funding or permitting for a proposed EHEC project.

DOE is not altering any current uses of the environment in the project areas. Any future Federal involvement in a specific EHEC project would involve additional environmental compliance review at a site- and plant-specific level. At that point, each specifically identified project would need to evaluate and disclose the potential long-term effects on productivity of each environmental resource area and discuss potential trade-offs that may be necessary to achieve the goals established by DOE.

## 6.3 Unavoidable Adverse Impacts

As required under CEQ regulations (40 CFR §1502.16), this Final PEIS evaluates the unavoidable adverse impacts from implementation of the Proposed Action. One potential unavoidable adverse impact is the use of pesticides, a tool frequently used for economical crop production. If pesticides are used to produce EHECs, weeds may have the potential to develop resistance to the applied pesticides. Under all of the Action Alternatives, the development of pesticide-resistant weeds may be an unavoidable impact. The USDA APHIS BRS permit may identify specific BMPs tailored to each proposed EHEC project to reduce or eliminate the potential negative impacts from pesticides. DOE may require other site- and plant-specific BMPs. Growers may mitigate the rate at which weeds develop resistance by adopting BMPs for pesticide use.

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# 8 Reviewers, Cooperating Agencies, and Preparers

## 8.1 Agency Reviewers

| Name | Agency/Division |
|---|---|
| ***Department of Energy*** | |
| Jonathan Burbaum | ARPA-E PETRO Program Director |
| Jeffrey Dorman | ARPA-E Environmental Protection Specialist |
| Geoffrey Goode | ARPA-E Office of Chief Counsel |
| Brian Plunkett | ARPA-E Office of Chief Counsel |
| Alvand Salehi | ARPA-E Office of Chief Counsel |
| Michael Saretsky | ARPA-E Office of Chief Counsel |

## 8.2 Cooperating Agency Reviewers

Neil Hoffman, Science Advisor, USDA APHIS BRS

Marilyn Buford, National Program Leader, Silviculture Research, USDA Forest Service Research & Development

## 8.3 Preparers

| Name | Education/Expertise |
|---|---|
| ***Booz Allen Hamilton*** | |
| Daniel Adamek | Ph.D., Molecular Biophysics, 18 years of experience in fundamental and applied biomolecular science and materials science. |
| Sari Atchue | B.S., Environmental Science, Over 5 years of experience in sustainability and environmental compliance and policy. |
| Vincent Bonifera Jr. | M.S., Technical Management and Chemical Engineering, 18 years of experience in addressing environmental impacts related to air quality. |
| Joshua Brown | B.A., Economics, B.A., Geography, Over 5 years of experience in GIS cartography and geospatial and economic analysis. |
| Nicholas Burton | B.A., Geosciences, Over 2 years of experience in providing legislative, regulatory, and technical expertise to clients on environmental issues. |
| Leslie Catherwood | B.A., Political Science, 15 years of experience in policy, communications, and outreach on natural resource issues. |
| Jennifer Curtin | J.D., Law, Over 26 years of experience providing legislative, regulatory, and policy expertise to clients on environmental issues. |
| Phebe Davol | M.S., Soil Science, Over 31 years of experience in soil investigations, assessments, and remediation; and environmental compliance. |
| Olwen Huxley | M.A., Energy and Environmental Analysis, Over 19 years of experience in sustainability, and energy and environmental policy. |
| Raymond Klug | B.S., Chemistry, Over 6 years of experience in environmental investigation, restoration, policy and compliance. |
| David Lee | Ph.D., Plant Molecular Genetics, Over 12 years of experience in biofuels, synthetic biology, and genetic resources related to agriculture. |
| Amanda Pereira | M.S., Urban and Regional Planning, 15 years of experience in NEPA and environmental compliance documentation focusing on land use and planning. |
| Richard Pinkham | M.S., Natural Resources Policy and Resource Economics, Over 23 years of experience focusing on socioeconomic assessments. |
| Lauren Pittenger | Ph.D., Food Science and Technology, Over 13 years of experience in scientific research and management within public health care programs, specifically in the area of infectious diseases. |
| Marshall Popkin | M.S., Environmental Science and Policy, 10 years of experience in environmental compliance related to geology and soils. |

| | |
|---|---|
| Chelsea Rothe | B.S., Biology, 3 years of experience in environmental compliance, remediation, and data management. |
| Jennifer Salerno | M.S., Environmental Studies, Over 15 years of experience providing regulatory and policy expertise in environmental issues, including NEPA, natural resources, endangered species, and sustainability. |
| Rachel Schneider | M.S., Environmental Engineering and Science, Over 13 years of NEPA experience, including natural resources, wetlands, and water resources |
| Chung Shih | Chung Shih, Ph.D. Civil and Environmental Engineering, Over 5 years of experience in the GIS |
| David Walls | Master of Natural Resources, Over 17 years of experience in environmental assessment, compliance, and regulatory issues. |

## 8.4 Disclosures

**NATIONAL ENVIRONMENTAL POLICY ACT DISCLOSURE STATEMENT FOR PREPARATION OF THE *ENGINEERED HIGH ENERGY CROPS (EHEC) PROGRAMS PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT***

The Council of Environmental Quality (CEQ) Regulations at Title 40 of the *Code of Federal Regulations* (CFR) Section 1506.5(c), which have been adopted by the U.S. Department of Energy (10 CFR 1021), require contractors and subcontractors who will prepare an environmental impact statement to execute a disclosure specifying that they have no financial or other interest in the outcome of the project.

"Financial or other interest in the outcome of the project" is defined as any direct financial benefits such as a promise of future construction or design work in the project, as well as indirect financial benefits the contractor is aware of.

In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows, to the best of their actual knowledge as the date set forth below:

(a) _X_ Offeror and any proposed subcontractors have no financial or other interest in the outcome of the project.

(b)___ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract, or agree to the attached plan to mitigate, neutralize or avoid any such conflict of interest.

Financial or Other Interests
1.
2.
3.

Certified by:

[signature]
Signature

Gary M. Rahl
Name

Senior Vice President
Title

Booz Allen Hamilton Inc.
Company

November 24, 2014
Date

# 9 Abbreviations and Acronyms

| | |
|---|---|
| AARC | Average Annual Rate of Change |
| ACHP | Advisory Council On Historic Preservation |
| AL | Alabama |
| APHIS | Animal and Plant Health Inspection Service |
| ARPA-E | Advanced Research Projects Agency-Energy |
| BCAP | Biomass Crop Assistance Program |
| BGY | Billion Gallons Per Year |
| BLM | Bureau of Land Management |
| BLS | Bureau of Labor Statistics |
| BMP | Best Management Practice |
| BRS | Biotechnology Regulatory Services |
| CAA | Clean Air Act |
| CDC | Centers for Disease Control and Prevention |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| $CH_4$ | Methane |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| CRP | Conservation Reserve Program |
| CWA | Clean Water Act |
| DARPA | Defense Advanced Research Projects Agency |
| DDT | Dichlorodiphenyltrichloroethane |
| DOE | Department of Energy |
| DSHEFS | Division of Surveillance, Hazard Evaluations, and Field Studies |
| EA | Environmental Assessment |
| EHEC | Engineered High Energy Crop |
| EIS | Environmental Impact Statement |
| EISA | Energy Independence and Security Act |
| EJ | Environmental Justice |
| EO | Executive Order |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act of 1973 |
| FDA | Food and Drug Administration |
| FFDCA | Federal Food, Drug, and Cosmetic Act |
| FIA | Forest Inventory and Analysis |
| FIFRA | Federal Insecticide, Fungicide, and Rodenticide Act |
| FL | Florida |
| FONSI | Finding of No Significant Impact |
| FSA | Farm Service Agency |
| GA | Georgia |

| | |
|---|---|
| GE | Genetically Engineered |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GM | Genetically Modified |
| GMO | Genetically Modified Organism |
| HAP | Hazardous Air Pollutant |
| HHS | U.S. Department of Health and Human Services |
| IPM | Integrated Pest Management |
| LCCS | Land Cover Classification System |
| MBTA | Migratory Bird Treaty Act of 1918 |
| MMT | Million Metric Tons |
| MOU | Memorandum of Understanding |
| $N_2O$ | Nitrous Oxide |
| NAAQS | National Ambient Air Quality Standard |
| NACP | North Atlantic Coastal Plain |
| NAICS | North American Industry Classification System |
| NAWQA | National Water Quality Assessment Program |
| NC | North Carolina |
| NCDC | National Climatic Data Center |
| NDAA | National Defense Authorization Act |
| NEPA | National Environmental Policy Act of 1969 |
| NFDRS | National Fire Danger Rating System |
| NHPA | National Historic Preservation Act |
| NIOSH | National Institute for Occupational Safety and Health |
| NISC | National Invasive Species Council |
| NMFS | National Marine Fisheries Service |
| $NO_2$ | Nitrogen Dioxide |
| $NO_3$ | Nitrate |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Intent |
| NRCS | Natural Resources Conservation Service |
| NPS | National Park Service |
| NSR | New Source Review |
| NWR | National Wildlife Refuge |
| OSHA | Occupational Safety and Health Act |
| PEIS | Programmatic Environmental Impact Statement |
| PETRO | Plants Engineered To Replace Oil |
| PM | Particulate Matter |
| PPA | Plant Protection Act |
| PPE | Personal Protective Equipment |
| R&D | Research and Development |
| RCRA | Resource Conservation and Recovery Act |

| | |
|---|---|
| RFI | Request For Information |
| RFS | Renewable Fuel Standard |
| ROD | Record of Decision |
| SIP | State Implementation Plan |
| $SO_2$ | Sulfur Dioxide |
| TDS | Total Dissolved Solids |
| TN | Tennessee |
| USACE | U.S. Army Corps of Engineers |
| USDA | U.S. Department of Agriculture |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| VA | Virginia |
| VOC | Volatile Organic Compound |
| WFAS | Wildland Fire Assessment System |
| WMO | World Meteorological Organization |

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# 10 Glossary of Terms

| Term | Definition |
| --- | --- |
| **Action Alternative** | An action alternative is an alternative other than the No Action Alternative analyzed in an EIS. The Alternatives in an EIS comprise the range of reasonable alternatives. |
| **Affected Environment** | The physical, biological, and human-related environment that is sensitive to changes resulting from the Proposed Action. The extent of the affected environment may not be the same for all potentially affected resource areas (40 CFR §1502.15). |
| **Alternative Fuels** | Term for "non-conventional" transportation fuels derived from natural gas or biomass (such as ethanol and methanol). |
| **Bioenergy** | Conversion of complex carbohydrates in organic material into energy. |
| **Biofuel** | Fuels made from biomass resources or their processing and conversion derivatives. Biofuels may include ethanol, biodiesel, and methanol. |
| **Biotechnology** | The science of modifying the genetic composition of plants, animals, and microorganisms. Historically, biotechnology has relied on conventional plant and animal breeding practices to modify genetic composition. |
| **Cellulose** | A carbohydrate; principal component of wood. Made of linked lignin molecules that strengthen the cell walls of most plants. |
| **Climate change** | Any significant change in the measures of climate lasting for an extended period of time (i.e., major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer). |
| **Conventional Fuel** | Fossil fuels: coal, oil, and natural gas. |
| **Cooperating Agency** | Any Federal agency other than the lead agency with jurisdiction by law or special expertise with respect to any environmental impact involved in proposed legislation, Proposed Action or reasonable alternative. Cooperating agencies may include a state or local agency with similar qualifications at the invitation of the lead Federal agency (40 CFR §1508.5). |
| **Council on Environmental Quality (CEQ)** | Established to develop Federal agency-wide policy and regulations for implementing the procedural provisions of NEPA, resolve interagency disagreements concerning proposed Federal actions, and to ensure that Federal agency programs and procedures are in compliance with NEPA. |
| **Cropland** | Land used for long-term crop rotation that could have been cropped without additional improvement. |
| **Crop Residue** | Plant material remaining after harvesting, including leaves, stalks, and roots. |

| Term | Definition |
| --- | --- |
| **Cumulative Effect** | The incremental environmental impact or effect of the Proposed Action, together with impacts of past, present, and reasonably foreseeable future actions, regardless of what Federal or non-Federal agency or person undertakes such other actions. Can result from individually minor but collectively significant actions taking place over a period of time (40 CFR §1508.7). |
| **Engineered High Energy Crops (EHECs)** | Plants specifically engineered for increased energy production. EHECs are agriculturally-viable photosynthetic species that contain genetic material that has been intentionally introduced through biotechnology, interspecific hybridization or other engineering processes (excluding processes that occur in nature without human intervention); and are intended to produce more energy per acre by producing fuel molecules that can easily be introduced into existing energy infrastructure. |
| **Energy Crops** | Crops grown specifically for fuel value; include food crops such as corn and sugarcane, and non-food crops, such as poplar trees and switchgrass. |
| **Environmental Consequences** | Environmental effects of project alternatives, including the Proposed Action, any adverse environmental effects which cannot be avoided, the relationship between short-term uses of the human environment, and any irreversible or irretrievable commitments of resources which would be involved if the proposal should be implemented (40 CFR §1502.16). |
| **Environmental Impact Statement (EIS)** | Document providing fair discussion of significant environmental impacts for a Proposed Action and informing decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. A Federal agency must prepare an EIS when a Proposed Action constitutes a major Federal action that may have significant impacts to the natural or human environment (40 CFR Parts 1500–1508, DOE 10 CFR Part 1021). |
| **Field Trial** | Experiments conducted to evaluate the performance of a new technique or crop variety, including biotech-derived varieties, outside the laboratory (in the field) with specific requirements (location, plot size, methodology) and under stringent terms and conditions that confine the experimental crop. |
| **Forested Land** | Land with at least 10% occupied by forest trees of any size, or land that formerly had such tree cover and that will be naturally or artificially regenerated. The minimum area for classification of forest land is 1 acre. |
| **Fossil Fuels** | Remains of dead plants and animals of a previous geologic era that can be burned to release energy. It takes millions of years to form fossil fuels. Examples of fossil fuels are coal, oil, and natural gas. |

| Term | Definition |
|---|---|
| **Fuel** | Any material that can be burned to make energy. |
| **Gene** | The fundamental physical and functional unit of heredity. A gene is typically a specific segment of a chromosome and encodes a specific functional product (such as a protein or RNA molecule). |
| **Genetic Engineering** | The targeted manipulation of an organism's genome by introducing, eliminating or rearranging specific DNA sequences using the methods of modern molecular biology. (Biotechnology) |
| **Genetic Modification** | Production of heritable improvements in plants or animals for specific uses, via either genetic engineering or selection and breeding. |
| **Genetically Modified Organisms (GMOs)** | Organisms whose genetic material has been altered using genetic engineering techniques. |
| **Greenhouse gases (GHGs)** | Gases, such as water vapor, $CO_2$, tropospheric ozone, methane, and low level ozone that are transparent to solar radiation, but opaque to long wave radiation, and which contribute to the greenhouse effect. |
| **GHG effect** | A process by which thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases, and is re-radiated in all directions. |
| **Herbaceous energy crops** | Perennial non-woody crops that are harvested annually, though they may take two to three years to reach full productivity. Examples include: switchgrass, reed canarygrass, miscanthus, and giant cane. |
| **Herbaceous plants** | Non-woody species of vegetation usually of low lignin content such as grasses. |
| **Hybrid** | Offspring of any cross between two organisms of different genotypes. |
| **Impact (Effect)** | A direct result of an action which occurs at the same time and place; or an indirect result of an action which occurs later in time or in a different place and is reasonably foreseeable; or the cumulative results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (40 CFR §1508.8). |
| **Interspecific Hybridization** | The process of mating two species (within the same genus). Offspring display traits and characteristics of both parents, and are often sterile; thus, hybrid sterility prevents gene movement from one species to another. |
| **Invasive species** | Plant or animal that is not native to an ecosystem and which causes, or is likely to cause, economic or environmental harm or harm to human health. |

| Term | Definition |
| --- | --- |
| **Mitigation** | Planning actions taken to avoid an impact, minimize the degree or magnitude of the impact, reduce the impact over time, or compensate for the impact (40 CFR §1508.20). |
| **National Environmental Policy Act of 1969 (NEPA)** | Requires all agencies to examine the environmental impacts of their actions, incorporate environmental information, and utilize public participation in the planning and implementation of all actions. Federal agencies must integrate NEPA with other planning requirements and prepare appropriate NEPA documents to facilitate better environmental decision making. Federal agencies must review and comment on Federal agency environmental plans/documents when the agency has jurisdiction by law or special expertise (42 U.S.C. §§4321-4327) (40 CFR Parts 1500-1508). |
| **Native species** | A species that, with respect to a particular ecosystem, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem. |
| **No Action Alternative** | Alternative where current conditions and trends are projected into the future without another Proposed Action. The No Action Alternative provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the Alternatives (40 CFR §1502.14(d)). |
| **Notice of Intent (NOI)** | A notice that an EIS will be prepared and considered (40 CFR §1508.22). |
| **Pastureland** | Open land used primarily for pasture and grazing. |
| **Petroleum** | Substance comprising a complex blend of hydrocarbons derived from crude oil through the process of separation, conversion, upgrading, and finishing, including motor fuel, jet oil, lubricants, petroleum solvents, and used oil. |
| **Photosynthesis** | A complex process used by many plants and bacteria to build carbohydrates from carbon dioxide and water, using energy derived from light. Photosynthesis is the key initial step in the growth of biomass and is depicted by the equation: $CO_2 + H_2O$ + light + chlorophyll = $(CH_2O) + O_2$ |
| **Prime and Unique Farmland** | Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses (land could be cropland, pastureland, rangeland, forested land, or other land, but not urban built-up land or water). Unique farmland is land other than prime farmland that is used for the production of specific high value food and fiber crops (7 CFR §657.5). |

| Term | Definition |
|---|---|
| **Programmatic Environmental Impact Statement (PEIS)** | An evaluation of the potential environmental consequences of implementing a new Federal program on a national, regional, or programmatic scale (40 CFR §1502). |
| **Propagule** | A vegetative structure that can detach from a plant to create a new plant (e.g., bud, sucker, or spore). |
| **Proposed Action** | Activity proposed to accomplish a Federal agency's purpose and need; details the actions to be taken, or that will result, to allow alternatives to be developed and environmental impacts analyzed (40 CFR §1508.23). |
| **Reasonably Foreseeable** | Future actions for which there is a reasonable expectation that the action could occur, such as a Proposed Action under analysis by a Federal agency, a project for which construction has started, or an action that has obtained the necessary regulatory approvals or has funding committed to the action. |
| **Record of Decision (ROD)** | Concise public document that records a Federal agency's decision(s) concerning a Proposed Action for which the agency has prepared an EIS. A ROD identifies the alternatives considered, the environmentally preferable alternative(s), factors balanced by the agency in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not (40 CFR §1505.2). |
| **Relationship of Short-Term Uses and Long-Term Productivity** | The balance or trade-off between short-term uses and long-term productivity need to be defined in relation to the proposed activity in question. Each resource, of necessity, has to be provided with its own definitions of short- term and long-term (40 CFR §1502.16). |
| **Renewable Energy** | Energy derived from resources that are regenerative or for all practical purposes cannot be depleted. Types of renewable energy resources include moving water (hydro, tidal, and wave power); thermal gradients in ocean water; biomass; geothermal energy; solar energy; and wind energy. Municipal solid wastes are also considered to be a renewable energy resource. |
| **Scope** | Range of actions, alternatives, and impacts analyzed in an EIS (40 CFR §1508.25). |
| **Scoping** | Process used to identify the scope and significance of issues related to a Proposed Action while involving the public and other key stakeholders in developing alternatives and weighing the importance of issues to be analyzed in the EIS (40 CFR §1501.7). |

| Term | Definition |
|---|---|
| **Significant** | Use in NEPA requires consideration of both context and intensity (40 CFR §1508.27): Context - significance of an action must be analyzed in its current and proposed short-and long-term effects on the whole of a given resource (e.g.-affected region) and Intensity – refers to the severity of the effect. |
| **Sustainable** | An ecosystem condition in which biodiversity, renewability, and resource productivity are maintained over time. |
| **Terpene** | Energy-dense fuel molecules derived from turpentine, a viscous pleasant smelling substance that flows from some pine tree species (Pinaceae) when the bark or new wood is cut or carved. Terpenes are the main component for many essential oils from plant and tree species known for their pleasant smell, spiciness, or exhibiting specific pharmacological activities. There are over 30,000 varieties of natural terpenes. |
| **Tiering** | The coverage of general matters in a broader EIS with a subsequent narrower EIS(s) or EA(s) incorporating the general discussion by reference and concentrating solely on the issues specific to the subsequent EIS(s) or EA(s). |
| **Timberland** | Forested lands used for the production of commercial wood products. Commercial timberlands are used for repeated growing and harvesting of trees. |
| **Transgene** | A gene or genetic material that has been transferred naturally, or by any of a number of genetic engineering techniques from one organism to another. |
| **Unavoidable Adverse Effects** | Effects that cannot be avoided due to constraints in alternatives. These effects do not have to be avoided by the planning agency, but they must be disclosed, discussed, and mitigated, if possible (40 CFR §1500.2(e)). |
| **Variety** | A subdivision of a species for taxonomic classification also referred to as a 'cultivar.' A variety is a group of individual plants that is uniform, stable, and distinct genetically from other groups of individuals in the same species. |