USDA

United States
Department
of Agriculture

Marketing and
Regulatory
Programs

Witchweed Eradication Program in North and South Carolina

Environmental Assessment, April 2020

Witchweed Eradication Program in North and South Carolina

Environmental Assessment, April 2020

Agency Contact:
Anne Lebrun
Policy Manager
Plant Protection and Quarantine, Plant Health Programs
Animal and Plant Health Inspection Service
U.S. Department of Agriculture
4700 River Road, Unit 60
Riverdale, MD 20737–1232

Table of Contents

I. Introduction

A. Background

In 1957, the U.S. Congress allocated funds to address the issue of management of witchweed (*Striga* spp.), an introduced exotic plant (identified in North and South Carolina in 1955), as a serious threat to the agricultural economy and the environment of these States. Congress tasked the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) with developing a program for controlling witchweed.

Mission: Under the Plant Protection Act of 2000, APHIS has the responsibility for taking actions to exclude, eradicate, and/or control plant pests (7 United States Code (U.S.C.) 7701 et seq.). A plant pest is defined as any living stage of any entities, including parasites that can directly or indirectly injure, cause damage to, or cause disease in any plant or plant product (7 U.S.C. 7701 et seq.). The mission of USDA APHIS Plant Protection and Quarantine (PPQ) is to safeguard U.S. agriculture and natural resources against the entry, establishment, and spread of economically and environmentally significant pests, and to facilitate the safe trade of agricultural products (APHIS PPQ, 2015).

1. Witchweed Information

a. Biology and Parasitism

Witchweed is one of over 30 weed species of the genus *Striga* and the plant family Orobanchaceae (Csurhes et al., 2016) (see appendix A). The species of concern called Asiatic witchweed or red witchweed (*S. asiatica*) is described in Gagnon (2011) and Csurhes et al. (2016) as a stiff, branched, 6 to 12 inches tall plant covered with coarse, short, white hairs. Its flowers are small (less than 0.5 inches in diameter) and vary in color from red, purple, and white to yellow. The plant usually emerges from the ground in late June or early July; fruits bear capsules containing 250 to 500 microscopic dust-like seeds in different shapes, often twisted. Its leaves are bright green, linear and round, about 1 inch long, and nearly opposite of one another with roots that are succulent, round, white, and with no hairs (figure 1).

Like most *Striga* species, witchweed is a parasitic plant, meaning it cannot live in the absence of a host. Unlike many other weeds that merely compete with crops for resources, witchweed attaches itself directly to the root system of its hosts, sucking up water and valuable nutrients. This dramatically affects the yields of the hosts. Examples of affected hosts are corn, sorghum, rice, sugarcane, wheat, and many other crops (Csurhes et al., 2016; CABI, 2017). Witchweed also parasitizes certain weedy grasses, such as Johnson grass, Bermuda grass, crabgrass, and barnyard grass (APHIS PPQ, 2011). (See table 1 for examples of witchweed hosts.)

Figure 1. Witchweed, *Striga asiatica* (L.). (Photograph from APHIS PPQ Archive, APHIS PPQ (Nail et al., 2014))

Table 1. Examples of Witchweed Host Crops (Csurhes et al., 2016)

***Striga* Species**	**Examples of Host Plants**
S. asiatica	Poaceae (grass family), especially the crop plants maize (corn), sorghum, rice and sugarcane, but sometimes wheat, barley, millet and others. Wild plants and weeds of the following genera: *Sorghum, Digitaria, Paspalum, Echinochloa, Imperata, Pennisetum, Cynodon, Chrysopogon, Elionurus, Eleusine, Eragrostis,* and *Loudetia, Hyparrhenia*

The reproductive biology of *Striga* can be summarized from CABI (2017) as follows: Witchweed reproduces by seed only, and most populations seem to be autogamous, meaning they self-pollinate. Numerous tiny seeds are released and dispersed by wind, water, and people. Seeds can remain viable in soil up to 15 years. Because witchweed seedlings lack sufficient resources to establish independently, they have to attach to the root system of a suitable host within a few days of germination. The roots of the potential host release germination stimulants (chemicals called strigolactones), which trigger a response from witchweed. This response usually takes 7 to 14 days (a period called conditioning). After germination, the root of the witchweed embryo grows towards the roots of the host plant due to a chemical attraction by strigolactones (a process called chemotropism). Once the root of witchweed and the root of the host plant come into contact, they merge to form a larger tissue (called a haustorium). As a result of the merge, the host plant may suffer stunting, wilting, foliage burning, and eventually death. (Figure 2 illustrates the chemotropism process.) Until witchweed emerges from the ground, its seedling continues to draw water, minerals, and sugar from the host, after which the parasitic weed produces some of its own sugars. However, because this photosynthesis[1] is less efficient than that in a normal green plant, the parasitic witchweed remains dependent upon the host plant for growth. A few days later, kernel shells (fruits) of the parasite open, liberating thousands of minuscule seeds into the environment (APHIS PPQ, 2011).

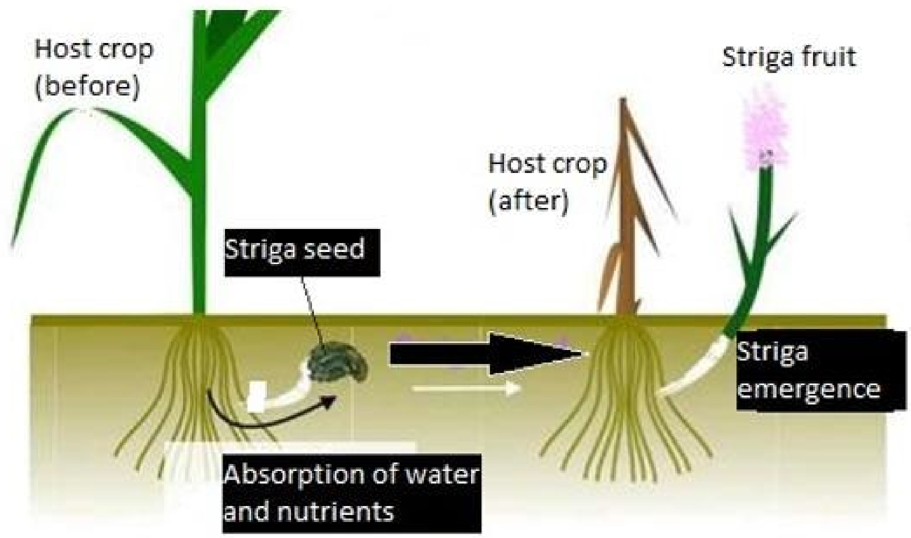

Figure 2. Witchweed chemotropism and parasitism on host crop. (Source: Adapted from Nagoya University ITbM, 2015)

b. Distribution and Spread

Witchweed is probably native to Africa and Asia, where it has spread from country to country, and has increased abundantly wherever habitat conditions were favorable, that is, relatively dry, infertile soil, and high temperature conditions (CABI, 2017). Witchweed was eventually introduced into the United States (APHIS PPQ, 2011; Spallek et al., 2013; Csurhes et al., 2016; CABI, 2017). While it is unclear exactly how or when this introduction took place, this pest was first identified in a cornfield in the Carolinas around 1955 (APHIS PPQ, 2011). Its current distribution in the United States is limited to North and South Carolina.

---

[1] Process by which green plants (those with green pigment or chlorophyll) use sunlight to produce foods from carbon dioxide and water.

Witchweed is very prolific. A single witchweed plant can produce as many as 50,000 seeds (APHIS PPQ, 2011; Jones, 2011; Gagnon, 2011; Csurhes et al., 2016; CABI, 2017). In 1956, witchweed had infested about 494,000 acres of land in the Carolinas, and there is a considerable possibility for further spread to other semi-arid regions of North and South America if it is not controlled (CABI, 2017).

Potential pathways for accidental introduction include, but are not limited to, the movement of crop seeds, soil, and other plant materials from infested areas. Countries where *Striga* species are prominent and that do not have strong regulations may continue to be potential sources of witchweed seeds. The tiny size of these seeds makes it easy for them to pass undetected through entry ports. If quarantine efforts are not effective, the spread of witchweed may continue to grow.

c. Economic Impact

In the United States, witchweed is only found in North and South Carolina; however, it is considered a national threat because of its potential economic impact in the Midwest Corn Belt[2] should the parasitic plant establish in this region (Jones, 2011). Establishment could cause reductions in crop seed or biomass production between 95 and 100 percent, particularly in corn, sorghum, and other grain crops (Gagnon, 2011).

In other regions of the world, witchweed has devastated the agricultural economy of areas where it is native. In Africa, for instance, over 100 million people have suffered crop damage estimated between 20 and 80 percent, equivalent to approximately $1 billion per year (Spallek et al., 2013). Similar productivity decreases have been noted in Asia and the Middle East (Spallek et al., 2013; Csurhes et al., 2016).

2. Witchweed History and Control in the United States

The history of control and eradication efforts of witchweed in the United States is well summarized in a previous National Environmental Policy Act (NEPA) document by APHIS (APHIS PPQ, 1986). In 1959, when the first eradication efforts started, 2,4-D was the only herbicide available for use to control witchweed in corn fields. A few years later a second herbicide, paraquat, was found to be effective against witchweed in corn. After 1964, other herbicides, such as dinitroaniline, trifluralin, and oxyfluorfen, as well as associated tank mixes became available for use, which improved the effectiveness of the eradication program. The discovery that ethylene gas could enable the germination of

---

[2] According to the editors of Encyclopedia Britannica, the **Corn Belt** is the traditional area in the Midwestern United States, roughly covering western Indiana, Illinois, Iowa, Missouri, eastern Nebraska, and eastern Kansas, in which corn (maize) and soybeans are the dominant crops (www.britannica.com/place/Corn-Belt)

preconditioned witchweed seed was a promising development because the dormant witchweed seed bank in the soil could be identified and destroyed.

In addition to chemical applications, changes in farming practices (e.g., soil tillage after harvest) helped destroy grasses and weeds that potentially hosted witchweed, and thereby improved the program. For illustration, from its discovery in 1955 to the year 1983, witchweed had infested about 419,637 cumulative acres in 38 counties in North and South Carolina. Thanks to the eradication effort since 1959, the number of newly infested properties found annually steadily declined to the point that witchweed now occurs only in a few counties including Bladen, Cumberland, Pender, Sampson, and Robeson (North Carolina); and Marion and Horry (South Carolina). Lassiter (2015) estimates that witchweed infestations cover about 1,141 acres on 82 farms and 118 fields in North Carolina; and 130.3 acres on 15 farms and 18 fields in South Carolina.

Previous NEPA Documentation

In 1983, APHIS started a draft environmental impact statement (EIS) titled "Witchweed Cooperative Federal-State Eradication Program" that was never finalized because APHIS realized the program was not expected to have any significant impact on the environment. Instead, APHIS prepared an environmental assessment (EA) which was completed in 1986. At that time the program area included 20 counties in southeastern North Carolina, and an adjacent 6 counties in northeastern South Carolina. The information presented in the current assessment provides today's status of the witchweed program, the scope of which has decreased significantly since the first EA in 1986. This includes program changes, such as new control methods and new program practices to accomplish more effective eradication.

APHIS prepared the current EA to comply with NEPA (42 U.S.C. 4321 et seq.), as described in the implementing regulations promulgated by the Council on Environmental Quality (40 Code of Federal Regulations (CFR) §§1500–1508), USDA (7 CFR part 1b), and APHIS (7 CFR part 372), and to satisfy Executive Order (EO) 12898.

B. Purpose and Need

The purpose of the proposed action in this EA is to eradicate exotic witchweed from areas where it is still present (figure 3). The total infestation size of the current affected area in both North and South Carolina is over 1,271 acres (Lassiter, 2015).

There is a need to protect the natural environment and the agricultural economy of the United States by continuing to pursue the eradication of witchweed in the areas currently impacted in North and South Carolina. Overall, efforts to contain and eradicate witchweed would directly protect approximately 2,100 acres of corn worth $1.5 million in the area immediately impacted, and by preventing the spread of this damaging weed, the program indirectly protects nearly 88 million acres of this crop valued at $49 billion in 2015 (USDA OBPA, 2018). Also, given that witchweed seeds can remain viable in the soil for over a decade and emerge at any time in crop fields, the pursuit of this eradication program is even more needed.

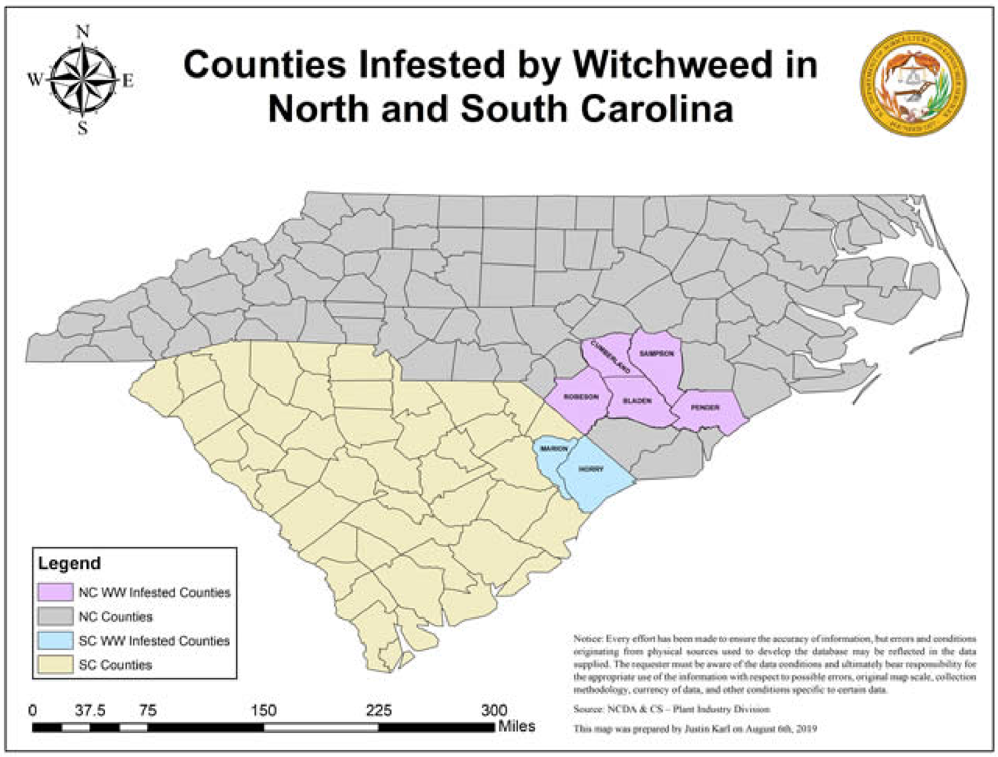

Figure 3. Witchweed-infested Counties in North and South Carolina (Lassiter, 2018[3])

[3] Lassiter. 2018. Witchweed Eradication Project (online) http://www.ncagr.gov/PLANTINDUSTRY/plant/weed/witchnc.htm

II. Proposed Action and Alternatives

This EA analyzes the proposed action and its alternatives and their potential effects on the environment. This chapter describes three alternatives including the no action alternative, quarantine alternative, and eradication alternative (preferred).

A. No Action Alternative

With the no action alternative, the status of witchweed will remain unchanged, that is, Federal and State Governments will not impose any quarantine regulations or restrictions of movement of materials upon witchweed-infested counties in North and South Carolina (see section B). Also, Federal and State Governments will not implement any eradication program in the affected lands in these States (see section C).

B. Quarantine Alternative

In this EA, the quarantine area covers all seven regulated counties in North and Sounth Carolina where witchweed is currently active (USDA APHIS, 2007); these are shown in figures 3 and 4.

Given that witchweed seeds can be spread by wind, water, and people, the quarantine alternative would prevent the human-assisted spread of witchweed by restricting the movement of potentially contaminated agricultural equipment and commodities to uninfested areas. By applying this alternative, APHIS expects to confine witchweed within the boundaries where it is currently present without necessarily eradicating the parasitic plant. Under this alternative, only quarantine regulations and restrictions would be imposed on the intrastate and interstate movement of articles determined to be potential vectors of witchweed. Such regulated articles include, but are not limited to (7 CFR § 301.80):

- soil (including compost, humus, sand, and manure);
- plants with roots;
- grass sod;
- plant crowns and roots for propagation;
- root crops (except those from which all soil has been removed);
- peanuts in shells and peanut shells, except boiled or roasted peanuts;
- small grains and soybeans;
- hay, straw, fodder, and plant litter of any kind;
- seed cotton and gin trash;
- stumpwood;
- long green cucumbers, cantaloupes, peppers, squash, tomatoes, and

watermelons, except those from which all soil has been removed;
- pickling cucumbers, string beans, and field peas;
- cabbage, except firm heads with loose outer leaves removed;
- leaf tobacco, except flue-cured leaf tobacco;
- ear corn, except shucked ear corn;
- sorghum;
- used crates, boxes, burlap bags, cotton-picking sacks, and other used farm products containers;
- used farm tools;
- used mechanized cultivating equipment and used harvesting equipment;
- used mechanized soil-moving equipment; and
- any other products, articles, or means of conveyance not covered here, but determined by an inspector that they present a hazard of the spread of witchweed.

In order to be moved outside the regulatory quarantine area, the above-listed regulated articles would need to be treated, as appropriate. Treatments for produce would include washing all soil from the commodity, clipping off tops and roots, and removal of outer leaves. Regulated articles that cannot be steam-cleaned or washed with pressurized water would be fumigated with methyl bromide (7 CFR § 301.80).

B. Eradication Alternative (Preferred Alternative)

The witchweed eradication alternative is usually accomplished in three steps. First, the land is surveyed to find and map infested areas. Second, infestations are quarantined to prevent the human spread of witchweed beyond the infested areas (alternative B). And third, control activities using herbicides and cultural practices are conducted to prevent existing witchweed plants from producing more seeds, and to destroy seeds that are already in the soil.

1. Surveys

Visual surveys are conducted by APHIS and State cooperators to locate and map witchweed-infested areas. The general public also contributes in this effort by reporting witchweed finds to survey officials, who then remove the parasitic plant to stop its reproduction and destroy potential seed banks in the soil. Field personnel usually carry out these yearly activities on foot, in vehicles, and on horseback, between the months of May and October.

There are four types of witchweed surveys conducted in North and South Carolina according to the program manual (SCDA, 2015):

a. Delimiting Survey

This survey is conducted around the periphery of known infestations, where herbicide treatment is eventually done to prevent the outward spread of the parasite.

b. Detection Survey

This survey is done in areas where infestations are not known to occur to determine if herbicide treatment is needed.

c. Appraisal Survey

This survey is done on infested properties to determine the need for herbicide application, the adequacy of treatment, or the criteria for release.

d. Release Survey

This survey is conducted on previously infested fields that have been treated and released from the quarantine.

Table 2 shows the total acreage surveyed in North and South Carolina in 2009 (87,355 acres). The surveyed acreage is broken down by survey types as defined above.

Table 2: Witchweed Surveyed Acreage by Survey Type in North and South Carolina in 2009 (Iverson et al., 2011)

State	Survey Type	Total Acres
North Carolina	Detection	23,078
	Delimiting	9,450
	Appraisal	16,254
	Release	32,255
Total Acres Surveyed		**81,037**
South Carolina	Delimiting	4,806
	Appraisal	396
	Release	1,116
Total Acres Surveyed		**6,318**
Total Acres Surveyed in both States		**87,355**

At the end of the 2015 growing season, the witchweed program surveyed 9,814 acres and treated 148 acres in South Carolina. In North Carolina, about 57,200 acres were surveyed and 1,873 acres were treated by the program, that is, a total of about 67,000 acres surveyed, of which over

2,000 acres were treated (USDA OBPA, 2018). Comparable reductions in survey and treatment are expected if the success of the program continues.

2. Containment Through Quarantine

As indicated in section B above, APHIS expects to contain witchweed within the quarantined counties by limiting the transport of potentially contaminated agricultural materials across these counties. At the end of the 2015 growing season, the total area infested in both North and South Carolina quarantine counties was 1,140 acres, a reduction of about 132 acres from the year 2014 (USDA OBPA, 2018).

3. Eradication

Witchweed eradication primarily consists of chemical control as well as some cultural practices.

a. Chemical Control

In order to ensure complete eradication of witchweed in North and South Carolina, chemical treatments are conducted to prevent existing plants from producing seeds, and also to destroy any seeds in the soil. The herbicides used kill both emerged witchweed in corn, and alternative grass hosts in rotational broad-leaved crops (e.g., tobacco and soybeans).

Chemical depletion of the seed bank is done by injecting ethylene gas into soil to encourage suicidal germination[4] of witchweed seeds. Fumigants (e.g., methyl bromide) are also applied to soil to devitalize seeds. They are usually applied by a USDA-certified pesticide applicator following the program safety measures and according to the label directions.

Methods of application of herbicides depend on the herbicide types (table 3). Applicators use various sprayers such as broadcast sprayers, wiper applicators, hand held sprayers, controlled droplet applicators, and shielded sprayers.

Herbicides are used to kill witchweed and grass hosts. According to Iverson et al. (2011), more than 4,700 acres of land were treated in 2009 with 28 different chemicals, including glyphosate, which was efficient in controlling both witchweed and many host grasses. Table 4 provides a list of herbicides being applied to witchweed infestations in North and South Carolina, along with crops labeled and herbicide targets. The first four herbicides in table 4 (trifluralin; 2,4-D; oxyfluorfen; and paraquat) have historically accounted for 97 percent of the total chemical types used by the program, according to a previous APHIS assessment (APHIS PPQ,

[4] Suicidal germination: Technique by which ethylene gas (natural ripening agent produced by fruits, vegetables, and flowers) is injected into the soil under proper environmental conditions, which stimulates the germination of witchweed seeds followed by the death of seedlings due to lack of hosts. Fumigants are also used to devitalize these seeds.

1986).

Table 3. Chemical Treatment Application Methods (SCDA, 2015).

Application Methods[5]	Explanations
Preplant incorporated (PPI)	Herbicide is applied to the soil before crop is planted or transplants set; it is then mixed into soil by disking or other mechanical means. Herbicide is thoroughly incorporated into the top 1–3 inches of soil (disk twice, and cross disk if possible). Incorporation is usually done immediately after application. Example: PPI Treflan applied before planting soybeans.
Preemergence Surface (PES)	Herbicide is applied after planting, but before the crop emerges; no incorporation. Example: PES Atrazine after planting corn.
Postemergence transplant (PTP)	Applications made immediately after a transplanted crop is set out, normally overtop, but may be directed. Example: PTP Dacthal applied just after sweet potatoes are set out.
Surface Applied (SA)	Herbicide applied to soil surface before crop or weed emerges.
Semi Overtop (SOT)	For Clarity® and Dicamba, early season applications. Raise nozzle so that herbicide is deposited on most of the leaves.
Overtop Postemergence (OT)	Application made broadcast over the top after the crop is above ground. Method applicable to any crop size, for seeded or transplanted crop, or when no crop is present. Examples: OT Gramoxone in noncrop; and OT Blazer or Basagran in soybeans.
Off Season (OS)	Treatment made several months before crops are planted. Granular herbicides are usually applied in December-March. Example: OS granular Treflan applied to gardens or yards.
Postemergence directed (PD)	Application made to miss the upper portion of a crop. Only the lower portion, if any, of the crop is wet. Example: PD 2,4-D, Gramoxone and Goal in corn, or PD Reflex in soybeans.
Water incorporation (WI)	Chemical application (e.g., fumigation) requires enough water, by either rainfall or irrigation, to entrap the chemical (fumigant) material in the soil. Water is used here as a liquid tarpaulin.
Postemergence directed incorporated (PD-INC)	Application made to miss the upper portion of the crop; only the lower portion, if any, of the crop is wet; and incorporation to soil is done immediately. Example: PD-INC Treflan in corn.
Soil injection (INJ)	Placement beneath the soil surface with a knife or blade injector, with a minimum of mixing or stirring. Example: soil INJ of Ethylene or Methyl Bromide.

[5] The same treatment application method when used in different crops may require minor application changes. Read Methods and Comments for the particular crop before beginning treatment.

Table 4. Herbicides, Labeled Crops, and Main Targets (SCDA, 2015).

Herbicide (trade or common names[6])	Examples of Crop Labeled	Targets
Treflan® - G, EC, 5G, 10G (trifluralin)	corn, cotton, sorghum, soybeans, lima beans, snap beans, cabbage, turnip greens, collards, mustard, kale, okra, English peas, sunflower, southern peas, pepper, tomato, wood shrubs, roses, flowers, noncropland, asparagus, forage legumes, vineyards, lawns, nursery stock, ornamentals, ground covers, carrots, cole crops, peach, pecan, plum, and walnut trees	Grass and witchweed
2,4-D (dichlorophenoxyacetic acid)	corn, sorghum, pastures, lawns, turf, idle cropland and noncropland, peanuts, soybeans, and most crops	Witchweed
Gramoxone®SL 2.0 (paraquat)	asparagus, corn, soybean, cotton, peanut, sorghum, tomato, pepper, sugarcane, various trees, noncrop areas, onion, blueberries, woody ornamental, vineyards, pre-harvest – Irish potato, sunflower (star fire – harvest aid – cotton and soybeans), idle cropland and noncropland, and various crops	Witchweed seeds
Goal® 2XL (oxyfluorfen)	corn, cotton, soybeans, onion, cole crops, conifers, fruit trees, woody ornamental, noncrops	Witchweed
Ethylene	corn, cotton, soybeans, onion, cole crops, conifers, fruit trees, woody ornamental, and noncrops	Grass and witchweed
Poast® (sethoxydim)	cotton, soybeans, strawberry, other berries, peanut, tomato, Bell pepper, sunflower, Irish potato, cauliflower, beans, peas, spinach, eggplant, cabbage, broccoli, all squash, lettuce, cantaloupe, cucumbers, pumpkin, watermelon, musk melon, asparagus, grape, non-bearing crops, flowers, ground covers, woody ornamental, noncropland, centipede lawns, various trees, onion, and sweet potato	Grass
Prowl® or Stomp® 3.3 EC (pendimethalin)	cotton, beans, garlic, corn, peas, grain sorghum, peanuts, Irish potato, soybeans, sunflower, tobacco, nonbearing fruit, nut crops, and vineyards including – apple, cherry, grape, peach, pear, plum, and English walnut	Grass and witchweed
Roundup® (glyphosate)	cotton-preharvest, idle cropland and noncropland, idle areas in crops, pastures, around pond and bodies of water woody ornamental, various trees, vineyards, farmstead, industrial and public areas	Grass and witchweed
Dacthal® (DCPA)	cabbage, collards, greens, cole crops, beans, peas, turnips, onions, garlic, radish, sweet potato, strawberry, Irish potato, cotton, turf – established and newly sprigged or seeded strawberries, garlic, onions, tomato, eggplant, peppers, squash, cantaloupe, watermelon, and 120 – ornamentals at lining out or established	Grass and witchweed

The above-listed herbicides in table 4 are applied according to different rates and methods. They are applied either alone or in combination with another herbicide as follows (SCDA, 2015; USDA APHIS, 2019a):

[6] Other common names available at https://cals.arizona.edu/crops/pdfs/Herbicide%20table%20(4)012611.pdf

(1) Oxyfluorfen (Goal® 2XL)

This herbicide belongs to the diphenyl-ether class. It is effective in controlling grass and witchweed, and is used as a preemergence surface applied (PES) or postemergence directed (PD) herbicide, at a rate of 0.25 to 0.75 pounds per acre (lb/A) (maximum use: 1.25 lb/A/year/field). It is usually applied with a shielded sprayer at a recommended buffer of at least 100 feet from gardens, yards, commercial vegetables, ornamentals, or dwellings.

A preemergence Goal® 2XL treatment may control witchweed for the entire season at 0.75 lb/A under ideally moist conditions. Under less than ideal conditions, a repeat treatment would be necessary. A postemergence Goal® 2XL treatment kills emerged witchweed by contact, and provides residual control if adequate rainfall follows. The activation of a PES Goal® 2XL application depends upon moisture; ¼ to ½ inch of rain is required within 7 days after application to activate the herbicide. A similar amount of rain is required every 7 to 10 days to maintain optimum activity of the herbicide on emerging witchweed. Witchweed that emerges in treated soil during drought will not be killed if it is over 1.5 inches tall when an activating rainfall occurs. Corn must be at least 24 inches tall before the application, but 30 inches or greater is preferable. It is not recommended to use Goal® 2XL within 30 days of harvest nor to exceed the rate of 1.25 lbs/A per year.

(2) Paraquat (Gramoxone® SL 2.0)

Gramoxone or N, N′-dimethyl-4,4′-bipyridinium dichloride is a quaternary ammonium compound with paraquat as its active cation. This herbicide is used as PD and overtop (OT), with application rates ranging from 0.125 to 0.5 lb/A (0.25 lb/A standard). Corn must be 20 inches tall for a 0.125 lbs/A rate (80–100 percent effective), and 24 inches tall for a 0.25 lbs/A rate (95–100 percent effective).

Paraquat is a fast-acting contact herbicide effective on a wide spectrum of postemergent weeds, including broadleaf grasses. It quickly defoliates and desiccates growing plants with abundant green tissues, which indicates its high toxicity to such target plants. Plants with abundant green tissues seem to absorb paraquat faster, causing them to produce superoxides during photosynthesis, which then destroy plant cells; however, this product is less effective on dry, drought-stressed, woody, or fully mature plants (USDA APHIS, 2019a).

Paraquat is registered in the United States as a restricted use pesticide (RUP). RUPs are not available to the general public and can only be applied by certified applicators. The paraquat label states that "pesticide must only be applied when the potential for drift to adjacent sensitive areas (e.g. residential areas, water bodies, known habitat for threatened or endangered species, non-target crops) is minimal (i.e., when wind is blowing away from the sensitive areas)."

(3) Trifluralin (Treflan® 5G, 10G, EC; Trilin; Tri-4; Passport)

This dinitroaniline-class chemical is used as an OT, PD, preplant-incorporated (PPI), or postemergence directed-incorporated (PD-INC) herbicide. Because trifluralin is soil-incorporated, organic matter and clay content tend to influence its application rate. The standard rate for Treflan® 5G is 3.0–4.0 lb/A, and for Treflan® 10G is 4 lb/A. The recommended rate for johnsongrass (a witchweed host) control is 0.5-1.0lb/A (or 1.0–2.0 lb/A); a rate of 0.75–1.0 1b/A is considered standard for a full season witchweed control.

Using equipment that mixes the soil thoroughly (e.g., double cross disking or power takeoff (PTO)-driven rotary cultivators), applicators should ensure ground cover is reduced by soil tillage prior to trifluralin application. Trifluralin is effective in controlling grass and witchweed in about 38 crops (see crops labeled in table 4) when applied PPI with disc or power rotary tiller. It is recommended to use maximum rates in field border areas (road shoulders). It is not recommended to apply Treflan® granules to foliage that is wet or on muck soils[7]. Application to wet soils or soil subject to prolonged periods of flooding may result in poor weed control.

Trifluralin label states that this "pesticide must only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, water bodies, known habitat for threatened or endangered species, nontarget crops) is minimal (i.e., when wind is blowing away from the sensitive areas)." Unless listed as rotation crops for use with treflan PPI, vegetables should not be planted within 5 months after the application of this herbicide.

(4) 2,4-Dichlorophenoxyacetic acid (2,4-D)

2,4-D is a plant growth regulator (synthetic auxin herbicide) in the phenoxyacetic acid family. It is used postemergence for selective control of broadleaf weeds. The ecological risk assessment conducted by USDA APHIS (2019a) indicates that 2,4-D causes disruption of multiple growth processes in susceptible plants. It affects proteins in the plasma membrane, interferes with RNA production, and changes the properties and integrity of the plasma membrane. Growth from excessive cell division destroys the

[7] Muck (or sapric) soil falls under the category of Histosol. This soil type is composed of thick organic materials that are saturated (see USDA NRCS, 2018. Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils, Version 8.2 www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053171.pdf)

plant’s vascular transport system. Symptoms from 2,4-D damage include growth and reproduction abnormalities, especially on new growth, such as stem and petiole twisting (epinasty), leaf malformations (parallel venation, leaf strapping, and cupping), undifferentiated cell masses and adventitious root formation on stems, stunted root growth in broadleaf plants, and rolled leaves (onion leafing), fused brace roots, leaning stems, and stalk brittleness in grass plants, as well as sterile or multiple florets and nonviable seed production. Under most environmental conditions 2,4-D ester and 2,4-D salt formulations rapidly dissociate to 2,4-D acid.

(5) Sethoxydim (Poast®)

Sethoxydim (Poast®) belongs to the cyclohexanone-class of herbicides. It is sprayed OT on small grass hosts 2 to 4 inches tall, at a rate of 0.2 lb/A well before witchweed emerges. For hosts such as corn (field or sweet corn), the recommended Poast® application rate is 1.0-1.5 pints/acre (USEPA, 2004). Essentially, all grass crops (e.g., sorghum, corn, small grains, and rice) are susceptible to sethoxydim. Sethoxydim is not effective on broadleaf weeds. Its effectiveness in crops depends on the preharvest interval (PHI), that is, the minimum number of days between the first application and the harvest, as specified on the label. The Poast® label allows both aerial and ground application, and it also states that “the pesticide must only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, water bodies, known habitats for threatened or endangered species, or nontarget crops) is minimal and when wind is blowing away from sensitive areas.”

(6) Dimethyl tetrachloroterephthalate (DCPA) (Dacthal®)

DCPA is a selective herbicide in the class of phthalates, applied PES, OT or PD at a rate of 8.0 lb/acre. The program operation manual (SCDA, 2015) indicates that Dacthal® is extremely good in controlling witchweed, and warns users about potential runoff, drift, or wind erosion. The Dacthal® label indicates that “the pesticide should only be applied when the potential for drift to adjacent sensitive areas (e.g., water bodies, known habitats for threatened or endangered species, non-target crops) is minimal and when wind is blowing away from sensitive areas.”

(7) Pendimethalin (Prowl® H2O, Prowl® 3.3 EC)

Pendimethalin belongs to the dinitroaniline class and is applied as PES, PPI, or PD at the standard rate of 0.75–1.5 lb active ingredient (a.i)/A for Prowl® H2O herbicide, and 2.0–4.0 lbs a.i./A for Stomp® 3.3 EC. Prowl® H2O is a water-based formulation labeled for preemergence control of annual grasses and witchweed, as well as many crops, such as cotton, soybeans, corn, peanut, tobacco, and horticultural plants (see table 4). Prowl® H2O label indicates that this product is most effective when applied by ground or aerial equipment and subsequently incorporated into soil by rainfall, sprinkler irrigation, or mechanical tillage prior to weed seedling germination (USEPA, 2015b). It must be applied broadcast with a ground sprayer when the crop is at least 4 inches tall up to layby[8]; use nozzles if crop foliage would prevent uniform coverage of the soil surface within the rows (USEPA, 2015b).

Prowl 3.3 EC herbicide controls most annual grasses and certain broadleaf weeds as they germinate, but it will not control established weeds. Users should destroy existing weeds before applying Prowl 3.3 EC (except as recommended in specific postemergence combination treatments), and follow label directions to avoid crop injury.

(8) Glyphosate (Roundup®, Rattler, Jury, Weedoff, Rodeo, or Pondmaster)

Glyphosate is a phosphanoglycine-class herbicide and is spot-applied either OT or PD at the standard rate of 1.0–2.0 lb/A (or 1 to 2 percent solution when using handheld spray equipment). This herbicide is applied in different ways including broadcast sprayer, wiper applicators, hand held sprayers, and shielded sprayers.

Roundup® is labeled for spot sprays on asparagus, cotton, forage grasses, and soybeans, and for fallow land, non-cropland, no-till, and preharvest - cotton and vine crops. Roundup® is a nonspecific, postemergence herbicide that kills grass and witchweed in noncrop, field border, and idle cropland areas; it also controls many annual and perennial grasses, broadleaf weeds, and tree and woody brush species.

The Roundup® label states to "[a]pply this product only when the potential for drift to adjacent sensitive areas (e.g., residential areas, water bodies, known habitats for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas). Avoid direct application to any body of water." For handheld sprayers, the label states "Take care not to spray or allow spray to drift outside the target area in order to avoid unwanted crop destruction." Applicators should avoid Roundup® contact with foliage or green stems of desirable plants as severe injury may result. There should be at least a 14-day waiting period before livestock can use treated pasture.

(9) Combination Goal® 2XL and Gramoxone® SL 2.0

The combination of Goal® 2XL and Gramoxone® SL 2.0 is effective where grass is too large for Goal® 2XL alone. For instance, corn must be 24 inches tall before application. The program manual indicates that users

[8] Application directly to the soil between rows as a directed spray following the last normal cultivation.

of this product should follow the label carefully and not apply it within 30 days of harvest nor permit spray to drift to sensitive crops (SCDA, 2015). It is recommended to use Goal® 2XL at its intended rate (see section above on Goal®) plus 0.25 lb/A Gramoxone® SL 2.0 for small weeds, or Goal® 2XL at intended rate (see section above on Goal®) plus 0.25–0.5 lb/A Gramoxone® SL for large, dense, and matted weeds.

(10) Combination Goal® 2XL and 2,4-D

The combination of Goal® 2XL and 2,4-D is effective only for broadleaf weeds, especially vines, when they are a problem.

The program manual indicates that users of this product should not apply it within 30 days of harvest, and that applicators should use Goal® at the intended rate (see section above on Goal®) plus 2,4-D applied at the rate of 1.0 lb/A (SCDA, 2015).

(11) Combination 2,4-D and Gramoxone® SL 2.0

The combination of 2,4-D and Gramoxone® SL 2.0 is effective when applied postemergence. It kills witchweed at any size, and will eliminate grass 12 inches tall if used twice on a 21-day cycle. The recommended rate of application is 1.0 lb/A of 2,4-D plus 0.125 lb/A of Gramoxone® SL 2.0. This combination is a RUP, and users should follow the label carefully (SCDA, 2015).

b. Cultural Control

While the use of herbicides successfully halted the spread of witchweed by reducing the acreage supporting this pest by 99 percent (USDA APHIS, 2011), managers believe the program is more effective if chemical control is coupled with cultural management.

Cultural management is a set of non-chemical farm practices that aims at controling witchweed from the seed selection of a crop to land preparation, harvest and postharvest of the crop. The witchweed program operation manual lists some of these practices including tillage, disking, roguing (or handpulling), crop rotation, and planting of false hosts (SCDA, 2015). As part of integrated weed management, cultural practices using hand and/or mechanical tools help eliminate witchweed and other unwanted grasses by making it difficult for witchweed and host grasses to adapt to any one of the management techniques listed above.

(1) Soil Tillage

Tilling soil[9] generally helps suppress grasses and weeds that compete with crops for space, water, and nutrients. As part of the soil preparation process for chemical applications, the witchweed program applies disking, which helps aerate soil and mixes herbicides with soil particles. The program applies disking for border treatments around fields and for non-cropland in order to kill witchweed and weed grass, preferably when these plants are small (less than 8 inches tall) relative to well-established grass (8 inches plus) that may require up to four disk passes (table 5). Disking two to four times in a growing season has been very effective in controlling witchweed (80–100 percent efficacy) with a control estimated to last up to 10 weeks (SCDA, 2015). The program manual also suggests hoeing at 2–3 week intervals, and roguing (handpulling) witchweed help eliminate witchweed seed pods by preventing seeds from entering the soil. Handpulled witchweed should be disposed in plastic bags, and the seeds should be destroyed by fumigation, heat, or microwave, according to the following options (SCDA, 2015):

- In the fields where witchweed has bloomed because treatments were not applied on schedule, follow roguing immediately with an herbicide treatment or disking, and spot fumigate when witchweed has brown pods.
- In released fields where witchweed is blooming, follow roguing immediately with an herbicide treatment, and spot fumigate when witchweed has brown pods.
- Any area that will require hand roguing should be treated with ethylene in the first 2 weeks of the month of June in order to kill witchweed before it attaches to a plant host.

Table 5. Recommended Disking Treatment of Non-Cropland. (SCDA, 2015)

Approximative Date	Method	Comments	Optional Disking
May 15	Disk twice or until all grass is killed.	All grass killed	-----
June 12	Ethylene and disk twice	Wait 3 days then disk twice	Treflan® or Gramoxone® (full rate)
July 17	Disk twice	All grass killed	Roundup®, Gramoxone®, or Treflan® (.75 lb/A)
August 21	Disk twice	All grass killed	Roundup® or Gramoxone®
September 18	Disk twice	Mandatory for full season control	Gramoxone®

[9] Soil tillage is a mechanical preparation of soil by digging and stirring the ground. Examples of tilling methods include disking, hoeing, raking, ploughing, harrowing, and cultivating with cultivator shanks.

(2) Field Fallowing and Crop Rotation

Field fallowing (leaving fields tilled but unplanted) can be used to increase fertility of the field. Given witchweed's preference of infertile soils in general, improving soil fertility can help manage witchweed (CABI, 2017). In addition, fallow fields can stimulate witchweed germination and seed depletion (30 percent efficacy), although not as effectively as host crops (e.g., corn 70 percent effective), false hosts (e.g., tobacco 80 percent effective), or ethylene (90 percent effective) (SCDA, 2015).

Crop rotation with fallow may be effective in reducing witchweed infestations and increase corn yields by reducing witchweed seed numbers in the soil. An example is rotation of corn with fallow, broadleaf crops, and/or leguminous crops in space (field) and time (seasons or growing cycles).

(3) Use of False Hosts

False hosts are crops that may stimulate the germination of witchweed seedlings but are unsuitable to this pest. Inter-cropping corn with false hosts seems to limit witchweed performance while increasing the yield of the host crop, particularly under wet conditions when the inter-crop further reduces the transpiration of the parasite (CABI, 2017). For instance, the planting of false host crops (e.g., cotton, cowpea, soybean, pearl millet, sunflowers, and linseed) and certain forages that are not suitable for witchweed may stimulate the germination of witchweed seedlings that fail to penetrate the false host's root beyond the cortex; therefore, the witchweed would eventually die due to lack of resources (CABI, 2017). Best results are obtained when false hosts are planted at a time and density that ensure optimum germination of the pest (CABI, 2017). Table 6 shows some of the agents that stimulate witchweed seed germination by category and depletion rate. Among these agents are false hosts, some of which are described as super stimulants (e.g., cotton is approximately 90 percent), excellent stimulants (e.g., tobacco and okra are approximately 80 percent), and good stimulants (e.g., coastal bermuda and various millets are approximately 70 percent).

Table 6. Agent Stimulating Witchweed Seed Germination by Category and Depletion Rate (%) (SCDA, 2015).

Category	Plant or Agent	Rate (%)	Host Status*
Super	Ethylene	90	F (correct application)**
	Cotton	90	F
	Johnsongrass	90	H
Excellent	Tobacco	80	F
	Okra	80	F
Good	Corn	70	H
	Sorghum	70	H
	Coastal Bermuda	70	F
	Crabgrass	70	H
	Millets – Various	70	H-F
Fair	Soybean	55	F
	Peanut	58	F
	Cantaloupe	56	F
	Collard	54	F
	Sweet Potato	53	F
	Southern Peas	50	F
	Beans	50	F
	Tomato	50	F
Poor	Watermelon	45	F
	Cucumber	40	F
	Fallow	30+	N

* Status: Host (H); False Host (F); and Non-Host (N).
**Adequate soil temperature and moisture.

III. Affected Environment

This chapter provides general information regarding the environment of the Coastal Plain region of North and South Carolina, where the witchweed-regulated counties are located (figure 4). This region is characterized by low, flat to gently sloping land along the Atlantic Ocean that rises at a rate of 1 foot per mile westward in North Carolina and approximately 2 feet per mile westward in South Carolina. The elevation varies from sea level on the east (outer bank) to about 300 feet (90 meters) on the west (inner bank). Most of the best farmland in North and South Carolina are found in the Coastal Plain region (Gade et al., 2002). The human population in the witchweed quarantine counties is 926,814[10]. Relevant physical and human elements of the environment presented in this chapter are:

- Soils
- Vegetation and Wildlife
- Agriculture
- Water Quality
- Air Quality
- Historic Properties
- Human Environment

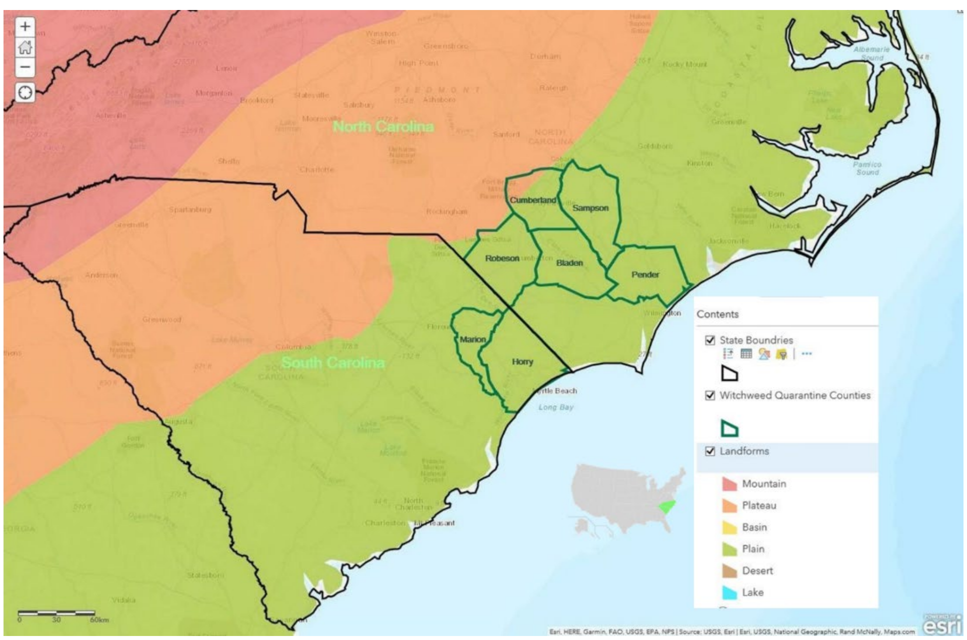

Figure 4. Map of witchweed quarantine counties in the Carolinas' Coastal Plain region.

[10] Number estimated from 2013–2019 U.S. Census American Community Survey https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2017/

A. Soils

The general structure of the Coastal Plain soils consists of alternating layers of sand, silt, clay, and eventually limestone that thicken and dip eastward. These soils originate from both the marine sediments of the Atlantic Coast and land residues deposited over granite. Their texture classes are variable including sand, sandy loam, sandy clay loam, loam, and clay (Stringer et al., 2016). While most soils belong to the orders Ultisols (e.g., sandy soils with clay-loam mix) and Histosols (e.g., organic and loamy soils) some areas can present mixtures from various categories or types (Figure 5):

- Sandy soils with clay-loam mix (order Ultisols) appear to be the most widely distributed ones in the Coastal Plain region (Stringer et al., 2016), and they are generally acidic, highly leached and weathered (Gade et al., 2002).

- Organic soils (order Histosols) are predominant in wetlands, where high rainfall and poor drainage allow organic matter to cumulate over time. Many of these soil types are found in the coastline (including areas of Pender and Horry Counties) from the accumulation of sediments moved in by offshore currents (Gade et al., 2002).

- Loamy soils are mostly found on agricultural lands; they are a mix of sand, silt, and/or clay associated with organic matter. Loamy soils with well-balanced texture provide the foundation for prime farmlands[11] (Gade et al., 2002).

[11] Prime farmland, as defined by USDA, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. www.nrcs.usda.gov/wps/portal/nrcs/detail/pr/soils/?cid=nrcs141p2_037285

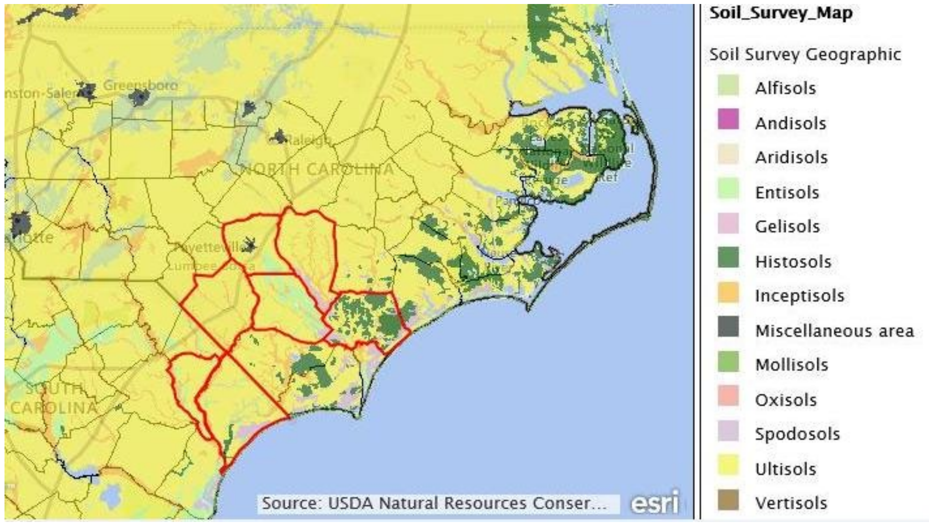

Figure 5. Map of major soils in the witchweed quarantine counties. Most soils in the quarantine counties belong to the orders Ultisols and Histosols.

B. Vegetation and Wildlife

As indicated in chapter 1, witchweed can parasitize certain natural grasses that may be found in the program area. According to the South Carolina Department of Natural Resources (SCDNR), the natural vegetation of the Coastal Plain is composed of three main types including grassland, pine woodland, and river bottomland forest (table 7). This natural vegetation serves as cover and food for wildlife.

Table 7. Coastal Plain Vegetation and Wildlife. (SCDNR, undated)

Vegetation Type	General Description	Examples of Associated Wildlife Species
Grassland	Farmland, managed open pine forest, and other cleared spaces including golf courses and urban yards.	Common ground-dove, eastern meadowlark, field sparrow, grasshopper sparrow, loggerhead shrike, northern bobwhite, painted bunting, barn owl, American woodcock, Bewick's wren, meadow vole, and Eastern woodrat.
Pine Woodland	Pine-dominated forests (loblolly, longleaf, hollies, and wax myrtle) on flat lands with high water table part of the year. Understory is essentially absent or very scattered while herbaceous flora is quite rich, consisting of many grasses and sedges.	American kestrel, Bachman's sparrow, brown-headed nuthatch, Henslow's sparrow, northern bobwhite, red-cockaded woodpecker, black bear, northern yellow bat, eastern diamondback rattlesnake, mimic glass lizard, pine woods snake, slender glass lizard, eastern fox squirrel, and eastern woodrat.
River Bottomland Forest	Hardwood-dominated woodlands with moist soils usually associated with broad floodplains. Characteristic trees include sweetgum, loblolly pine, water oak, willow oak,	Black-throated green warbler, Kentucky warbler, little blue heron, rusty blackbird, swainson's warbler, yellow-crowned night heron, black bear, northern yellow bat, Acadian flycatcher, American alligator, black swamp snake, Gulf Coast mud salamander, river cooter, spiny softshell

	laurel oak, cherry bark oak, and American holly. A subtype dominated by bald cypress and water tupelo occurring on lower elevation sites interspersed with oak-dominated woodland species such as bald cypress, water tupelo, swamp gum, Carolina ash, water elm and red maple.	turtle, striped mud turtle, mink, Rafinesque's big-eared bat, southeastern bat, star-nosed mole, American woodcock, great blue heron, great egret, Louisiana waterthrush, wood duck, bird-voiced treefrog, common snapping turtle, spotted turtle, eastern woodrat, and eastern fox squirrel.

C. Agriculture

The Coastal Plain region of North and South Carolina is predominantly agricultural, where field crops (such as tobacco, corn, soybeans, peanuts, and potatoes) are produced in large scale. Corn for grain is usually mass-produced for flour, grits, and other human food products, while corn for silage is produced for animals (Gade et al., 2002). Table 8 shows top field crops and livestock produced in the witchweed-regulated counties.

D. Water Quality

Three watersheds (Cape Fear, Lumber, and Yadkin-Pee Dee) overlap the witchweed quarantine counties. Gade et al. (2002) indicate that rivers and tributaries in North Carolina are used mostly for power generation (83 percent), domestic and commercial activities (9 percent), industrial and mining (6 percent), and agricultural practices (2 percent).

Table 8. Top Field Crops and Livestock Produced in the Witchweed-Regulated Counties (USDA AgCensus, 2012) and Total Areas Infested. (Lassiter, 2015 and 2018)[12]

Regulated Counties	Total Land	Top Crops and Livestock Produced	Total Area Infested
Bladen, NC	117, 323 acres (492 farms)	Corn, soybeans, wheat, forage and grass; chickens, turkeys, hogs and pigs, and cattle and calves	562.50 acres* (88 farms and fields)
Cumberland, NC	82,317 acres (389 farms)	Soybeans for beans, corn for grain, wheat for grain, all winter wheat for grain, cotton; broilers and other meat-type chickens, turkeys, hogs and pigs, cattle and calves, horses and ponies	209.30 acres* (49 farms and fields)
Pender, NC	55,775 acres (335 farms)	Soybeans for beans, corn for grain, wheat for grain, all winter wheat for grain, forage-land used for all hay and haylage, grass silage, and greenchop; broilers and other meat-type chickens, turkeys, hogs and pigs, roosters	32.30 acres* (6 farms and fields)
Robeson, NC	265,546 acres (941farms)	Soybeans for beans, corn for grain, wheat for grain, all winter wheat for grain cotton; broilers and other meat-type chickens, hogs and pigs, turkeys, cattle and calves	314.90 acres* (28 farms and fields)

[12] In the Datatable * is for Lassiter (2015) and ** is for Lassiter (2018): Witchweed Eradication Project at http://www.ncagr.gov/PLANTINDUSTRY/plant/weed/witchnc.htm

Sampson, NC	291,635 acres (1,067 farms)	Soybeans for beans, wheat for grain, all winter wheat for grain; corn for grain, cotton; broilers and other meat-type chickens, turkeys, hogs and pigs, pullets for laying flock replacement	0.0 acre** (0 farms and fields)
Marion, SC	80,213 acres (275 farms)	Soybeans for beans, corn for grain, peanuts for nuts, wheat for grain, all winter wheat for grain; broilers and other meat-type chickens, hogs and pigs, cattle and calves, goats, all horses and ponies	51.7 acres** (20 farms and fields)
Horry, SC	177,569 acres (938 farms)	Soybeans for beans, corn for grain, wheat for grain, all winter wheat for grain, peanuts for nuts; broilers and other meat-type chickens, hogs and pigs, cattle and calves, horses and ponies	78.6 acres** (13 farms and fields)

Water uses, among other factors (e.g., the activities carried nearby rivers and tributaries) may impact the quality of waters. For example, water systems that are intensely used for businesses or commercial productions, as well as waters that may be located nearby industrial facilities (e.g., mining sites) would likely be polluted. Pollutants may be found at the water surface, underground, or both. Surface pollutants usually originate from point sources (e.g., discharges from specific factories or sewage treatment plant) or from non-point sources (e.g., hardly traced origins of fertilizers, animal wastes, and sediments). Ground water pollutants usually originate from commercial, industrial, institutional, residential, and agricultural facilities (Gade et al. (2002).

Under the Clean Water Act that was amended in 1972 (33 U.S.C. §1251 et seq., 1972[13], the U.S. Environmental Protection Agency (USEPA) implements pollution control programs such as setting wastewater standards for industry, and the agency also develops national water quality criteria recommendations for pollutants in surface waters.

Figure 6 shows a map of water systems in the witchweed quarantine counties, where some sections (in red) may be impaired. According to the USEPA, the main cause of the impairment of these water systems are dissolved oxygen, fecal coliform, biota (benthos) accumulation, mercury, and very low pH.

E. Air Quality

The Clean Air Act (CAA), which was last amended in 1990, is the primary Federal law that protects the Nation’s air quality for the purposes of public health and welfare. It requires the USEPA to set National Ambient Air Quality Standards (NAAQS) for specific pollutants (40 CFR part 50) considered harmful to public health and the environment. These

[13] 33 U.S.C. §1251 et seq. (1972): Summary of CWA available online at https://www.epa.gov/laws-regulations/summary-clean-water-act

pollutants are known as criteria pollutants including ozone, particulate matter, carbon monoxide (CO), nitrogen dioxide, sulfur dioxide (SO_2), and lead. The CAA identifies two types of national ambient air quality standards (primary and secondary). The primary standards provide public health protection, including protecting the health of sensitive populations (e.g., asthmatics, children, and the elderly), and the secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. The severity of air pollution regulations in a particular area is based upon whether that area is in attainment (compliance) or nonattainment (non compliance) with the NAAQS. Criteria air pollutants are reviewed periodically for a possible revision by USEPA (NCDEQ, 2016). According to USEPA[14], none of the witchweed-regulated counties in North and South Carolina appears on the nonattainment list for all criteria pollutants as of summer of 2019.

F. Historic Properties

In accordance with Section 106 of the National Historic Preservation Act of 1966 and its implementing regulations, APHIS prepared two documents, one for North Carolina and another one for South Carolina. Each document included a summary of the proposed action, the project location, a list of historic resources within the area of potential effect, as well as associated maps. The status of all historic properties identified in the witchweed program area is presented below. (Details can be found in appendices B and C.)

[14] EPA Green Book online: https://www3.epa.gov/airquality/greenbook/anayo_sc.html

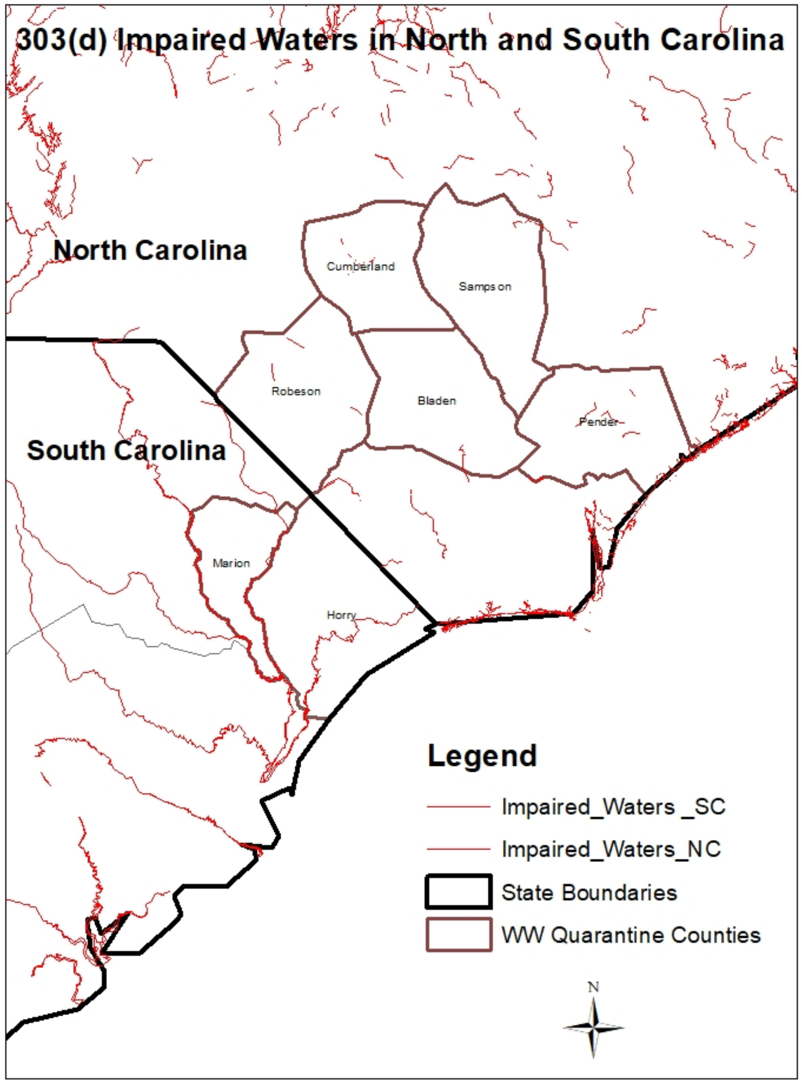

Figure 6. Map of 303d Listed and Impaired Waters for the USA[15]

In North Carolina, there are currently 172 State (not Federal)-registered historic properties in the witchweed-infested counties (13 in Bladen, 70 in Cumberland, 23 in Robeson, 49 in Sampson, and 17 in Pender Counties) of which a few plantations in Sampson County (Clear Run Farm, Lewis Highsmith Farm, Hollingsworth-Hines Farm, and Marcheston Killett Farm) display historic agricultural articles (e.g., cotton barns and gins) or active cultivated fields (soybeans, corn, and tobacco).

[15] Source: The information supporting this service resides in the Reach Address Database (RAD) which is part of the Watershed Assessment, Tracking & Environmental Results System (WATERS). The 303(d) Listed Impaired Waters program system provides impaired water data and impaired water features reflecting river segments, lakes, and estuaries designated under Section 303(d) of the Clean Water Act.

In South Carolina, there are currently 45 State (not Federal)-registered historic properties in the witchweed-infested counties (14 in Marion County and 31 in Horry County). None of these properties are an active cultivated farm or field.

APHIS sent the above-mentioned information and its analyses to the North Carolina and South Carolina State Historic Preservation Offices (SHPOs) for their reviews and determination as to whether or not these historic properties would be affected by the witchweed program (chapter 4).

G. Human Environment

The human environment of the coastal plain region of North and South Carolina is predominantly rural (Gade et al., 2002). According to U.S. Census Bureau's most recent demographic data released in December 2018, only Cumberland (NC) and Horry (SC), among the seven quarantine counties, are classified as urban (only 3.4 percent and 30.4 percent rural, respectively), while the other five are mostly rural (over 60 percent rural) based on population densities (table 9). Therefore, farmers would be the most likely affected by the witchweed program in terms of crop production and revenue from agriculture. For instance, Lassiter (2015) notes that witchweed affects over 1,271 acres of farms and fields. In the suppressive areas at the end of 2005, agricultural producers grew roughly 15 to 20 percent of corn, 20 to 25 percent of soybeans, 30 percent of cotton, and 25 to 35 percent of tobacco, sweet potatoes, peanuts, and other crops (USDA APHIS, 2007).

Table 9. Human Demographics in the Witchweed Quarantine Counties as of 2017 Census[16] and 2010 Census (rural versus urban)[17].

Counties	2017 Census Total Population	2017 Census Population Density	2010 Census Total Population	2010 Census Urban Population	2010 Rural Population	2010 Census Percent Rural
Bladen, NC	34,130	39	35,190	3,085	32,105	91.2
Cumberland, NC	332,766	510	319,431	276,729	42,702	13.4
Robeson, NC	134,187	141	134,168	50,161	84,007	62.6
Sampson, NC	63,664	67	63,431	9,538	53,893	85
Pender, NC	57,630	66	52,217	16,315	35,902	68.8
Marion, SC	31,765	65	33,062	12,976	20,086	60.8
Horry, SC	310,186	274	269,291	187,492	81,799	30.4

[16] 2017 Census data released in December of 2018 http://www.towncharts.com (the density is the average number of people per square mile).

[17] 2010 Census data Rural vs. Urban: counties with less than 50 percent of the population living in rural areas are classified as mostly urban; 50 to 99.9 percent are classified as mostly rural; and 100 percent rural are classified as completely rural https://www2.census.gov/geo/docs/reference/ua/ (select County Rural Lookup) https://accessnc.nccommerce.com/DemographicsReports/

IV. Potential Environmental Consequences

This chapter of the EA analyzes the potential environmental consequences of the proposed action and its alternatives.

A. No Action Alternative

Under the no action alternative, no Federal and State governments will impose any quarantine regulations or restrictions upon witchweed-infested counties in North and South Carolina, nor will they implement any eradication program in those counties. As a result of the no government action alternative:

1. Soil

The status of the currently infested lands will remain as is. The seed bank in infested soils may remain viable for years but USDA APHIS would not positively or negatively impact the soils in the program area.

2. Vegetation and Wildlife

In general, vegetation constitutes food and shelter for wildlife (including birds and mammals). Under this alternative, USDA APHIS would not manage or treat any vegetation or potential witchweed host grasses (e.g., American barnyard grass *Echinochloa muricata*) in the program area.

3. Agriculture

Under this alternative, USDA APHIS will not treat any witchweed-infested farmlands. Without a coordinated eradication program (that includes chemical treatment) the number and acreage of such withweed-infested lands may grow rapidly leading eventually to an increasing need for herbicides by individual farmers as they try to kill witchweed on their own. The yields for corn, sorghum, and other impacted cereals could significantly decrease unless a coordinated government program, which includes some chemical controls, is implemented. USDA estimates that more than 2,000 acres of corn valued at $1.5 million could be directly impacted by witchweed (USDA OBPA, 2018). This could also cause other economic concerns, including a decrease in income and increase in financial burdens for farmers.

4. Water Quality

The no action alternative would cause no change in the water quality. The current water impairment causes would remain the same (dissolved oxygen, fecal coliform bacteria, biota accumulation, and low pH). However, as witchweed may continue to spread, the need for herbicide use by farmers could increase, and possibly result in an increased runoff and drift of these chemicals into water bodies in the affected area.

5. Air Quality

There would be likely no effect on air quality as a result of no Government action. Impairment to air quality (if any) would originate from other sources (e.g., forest fires) (NCDEQ, 2016), and not from the impact of witchweed.

6. Historic Properties

Nearly no historic property assessed in the program area had active cornfields. In the event witchweed is found in a historic farm or cornfield, the owner of this property would need to treat it in order to avoid the spread of witchweed beyond the historic property. Under the no action alternative, USDA APHIS will not treat any potential witchweed-infested property.

7. Human Environment

Witchweed is not a direct public health risk, and no significant health impacts are expected as a result of the no Government action alternative. However, the possible spread of witchweed beyond current infested areas may cause socioeconomic impacts on rural populations, including a decrease in cereal production and related income, as well as an increase in financial stress and anxiety for farmers. USDA OBPA (2018) estimates that more than 2,000 acres of corn valued at $1.5 million are directly affected by witchweed. Such socioeconomic impacts on rural communities may increase if witchweed continues to spread under a no Government action alternative.

B. Quarantine Alternative

Under this alternative, APHIS will impose regulations and restrictions on the movement of articles (vectors of witchweed) from quarantined areas to other areas unless such articles are appropriately treated. For instance, treatments for produce would include washing all soil from the commodity, clipping off tops and roots, removing outer leaves, and fumigating regulated articles that remained uncleaned despite the steam cleaning or power wash (7 CFR § 301.80).

The State quarantine regulations that restrict the human movement of regulated articles from witchweed-infested counties would have no negative impacts on natural resources (soil, water, air, natural vegetation and wildlife) or on agriculture, historic plantations, or human population. Quarantine regulations have proven in the past to have positive impacts on agricultural production by preventing losses in cereal crops, including 10 percent in yield losses for corn alone and an estimated $3.7 billion in treatment costs (USDA APHIS, 2007). Although farmers are required to incur some compliance costs for quarantined farms, the annual reduction in witchweed-infested acres is a positive impact on growers (USDA APHIS, 2007). However, while the quarantine alternative would confine witchweed in currently infested counties, this pest may continue to spread naturally if no chemical treatment is associated with the Quarantine Alternative (see Eradication Alternative).

C. Eradication Alternative (Preferred Alternative)

Through the eradication alternative, Federal and State Governments will conduct chemical control activities using herbicides (as described in chapter 2), as well as cultural practices (such as disking, hoeing, roguing or handpulling, false hosts, and crop rotation) to suppress witchweed. These efforts prevent existing witchweed plants from producing more seeds, and also help destroy seeds that are already in the soil. The eradication alternative would continue the quarantine practices of Alternative B, Quarantine Alternative.

1. Chemical Control

Historically, four major herbicides (2,4-D, oxyfluorfen, paraquat, and trifluralin) have been used in the witchweed program; they accounted for about 97 percent of the total acreage treated chemically in North and South Carolina (APHIS PPQ, 1986). The ecological risk assessment conducted by USDA APHIS (2019a) describes the effects each herbicide has on the environment (including abiotic and biotic components) as a result of the preferred action.

Given the mode of toxic action and the relative toxicity of the herbicides used by the program, the equipment and methods used for their application, the qualification of the applicators, among other precautionary and safety measures described in the previous paragraphs, APHIS does not anticipate any significant impacts to soil, vegetation and wildlife, agriculture, water quality, air quality, historic properties, and human health.

a. Soil

Soil is potentially exposed to herbicides whether these are preplant-incorporated, surface-applied, water-mixed, or soil-injected (SCDA, 2015). Of the four major herbicides used in the witchweed program, only Treflan® (trifluralin) is soil-applied (preplant-incorporated), that is, the herbicide is mixed with tilled soil. The other three major herbicides (oxyflurfen, paraquat, and 2,4-D) are foliar-applied (postemergence-directed or overtop), that is, they are applied on the emerged plants without requiring soil to be disturbed.

For the soil-applied herbicide (trifluralin), the program generally applies the herbicide 18 inches above the ground surface. The resulting suppression of witchweed from infested lands makes soil nutrients more available to host crops.

One potential environmental effect of the soil-applied herbicide may be the disturbance of micro-organism populations (Adomako and Akyeampong, 2016), but this effect is expected to be minor according to the risk assessment linked to this EA (USDA APHIS, 2019a). Also, study by Durkin (2011) shows that trifluralin is relatively nontoxic to most soil organisms (e.g., earthworms) based on a contact toxicity study in *Eisenia foetida* with an acute inhalation median lethality concentration (LC_{50}) of >1000 g a.i./cm^2, or to the soil isopod (pill bug) *Porcellio scaber*, based on a study related to mortality, feeding, and body weight over a 3-week period of exposure.

Another potential effect of trifluralin on the environment may be soil erosion due to disking during herbicide application; however, the program applies disking in the wettest/rainiest time of the year, and the landscape in the treatment areas is generally flat. Also, treated areas are mostly croplands, where regular plantings and production practices help mitigate soil erosion (Carl Lightfoot, pers. comm.)

Foliar-applied herbicides used by the program are also expected to have no adverse effects on soil and soil micro-organisms given that they are spot-applied over the leaves or the top of treated plants, not tilled into soil. Although some herbicides may end up on the soil surface, negative impacts are unlikely (USDA APHIS, 2019a).

USDA APHIS uses both soil-applied and foliar-applied herbicides following label instructions and all precautionary measures that keep soils from negative impacts. The witchweed chemical program causes no substantial erosion or sedimentation that would adversely affect any unique conditions of soil environment.

b. Vegetation and Wildlife

Witchweed program activities are conducted primarily on cultivated croplands (and to some extent to road edges, home gardens, and home yards), and not necessarily in wild areas or natural vegetation. Therefore, potential host grasses that may naturally grow in the proximity of witchweed suppressive areas would be treated by the program in adherence to label requirements and other precautionary measures in place for sensitive species (SCDA, 2015; USDA APHIS, 2019a).

With respect to wildlife, because herbicides are applied by tractor-driven equipment or by the use of hand held tools, wildlife present in the field during the chemical application would likely move away from equipment and applicators; therefore, the probability of direct exposure is unlikely. However, wildlife may be subject to dermal or oral exposure to herbicides if they re-enter the field after treatment, but it is unlikely that they would receive a toxic level of herbicide given that test animals are often repelled by herbicide residues (APHIS PPQ, 1986). The program personnel will follow herbicide label instructions in order to minimize potential offsite drift and runoff, which would further reduce any chances of exposure. The program will also mitigate direct and indirect exposure by applying appropriate buffers from water bodies (USDA APHIS, 2019a). Impacts to threatened and endangered (T&E) species, bald and golden eagles, and migratory birds are discussed in detail in Chapter 5, Other Environmental Review Considerations.

c. Agriculture

The program applies herbicides on croplands according to the manufacturer's label directions and recommended rates (chapter 2). In general, these chemicals do not persist in the environment (generally they last 2 to 3 weeks) as they degrade quickly in sunlight and do not bioaccumulate[18]. Mitigation measures implemented by the program minimize the exposure risk for livestock. For instance, treated pastures are not to be grazed by livestock for a certain number of days, according to label information, and farmers will be advised of such precautionary measures by USDA APHIS personnel while these workers monitor the treated pastures until such time that livestock are allowed to graze again. All herbicide applications will be conducted or supervised by certified USDA pesticide applicators. Therefore, the chemical control of witchweed is unlikely to cause any significant impact on crops and farm animals.

d. Water Quality

Of the major herbicides used by the program, oxyfluorfen and 2,4-D have the potential to leach (USDA APHIS, 2019a), and this happens particularly on predominantly sandy soils in areas with high rainfall rates. However, this leaching potential is very low or unlikely under most soil conditions (Anatra-Cordone et al., 2005) including agricultural soils, where most herbicide applications would take place.

Other major herbicides the program uses (such as trifluralin) are not soluble in water (with solubility of less than 1 mg/L) and, as a result, they have low propensities to leach (USDA APHIS, 2019a). Applying USEPA's required precautionary measures (particularly the use of appropriate buffers and the avoidance of spraying areas adjacent to waterbodies) would mitigate potential drifts and water contamination risks (SCDA, 2015). Therefore, herbicides used in the witchweed program are not expected to adversely affect water quality.

With regard to methyl bromide, it appears to be slightly soluble in water, where trace amounts have been found (USEPA, 2016). However, field fumigation with methyl bromide by the program would not adversely affect the water quality given that water is not included in regulatory

[18] Bioaccumulation is the accumulation over time of an herbicide in living organisms.

fumigation treatments; safety precautions linked to the application methods would prevent any accidental release or disposal of the fumigant into potential nearby ponds, creeks, or other water sources. For instance, fumigation is usually conducted under a tarpaulin[19] or other gas impervious material in a manner prescribed by USDA, under the supervision of a certified pesticide applicator, and in accordance with the label directions.

As shown in the NEPAssist-generated map (figure 6), sections of water bodies in the witchweed-regulated counties are impaired due to dissolved oxygen, fecal coliform, biota, mercury, and/or low pH, and not from the program chemical leaching.

Recent hurricane events (Florence in 2018 and Matthew in 2016) had caused water flooding in the Coastal Plain region of North and South Carolina. However, there is currently no evidence (neither from field observations nor from the literature) suggesting the program has impacted in any way the quality of waters in the flooded witchweed quarantine counties. USDA APHIS does not expect any significant adverse effects on the water quality as a result of the current proposed action.

e. Air Quality

The application of herbicides will have no significant adverse effects on the air quality because no aerial application will be conducted by the program. In 2011 and 2016, the Department of Environmental Quality noticed some air debris in Brunswick and Pender Counties in North Carolina (NCDEQ, 2016). This air pollution originated from wildfires, and not from the herbicide program. Under the preferred alternative, USDA APHIS will not burn the vegetation as part of its eradication program.

The program will apply ground (not aerial) herbicide treatments using tractors or manual equipment. Therefore, air impairment from herbicide drift is unlikely.

With regard to methyl bromide, it is used in the Quarantine Alternative mainly for the fumigation of regulated articles (e.g., soil) that cannot be steam-cleaned or washed with pressurized water (7 CFR § 301.80). It is also used in the Eradication Alternative for the soil fumigation in order to devitalize witchweed seeds.
Methyl bromide is a colorless and odorles gas that is highly reactive (reaction with ozone in the upper atmosphere can destroy the ozone layer), very volatile (easily evaporates causing air pollution), and lethal (harmful or deathly); it is considered a hazardous air pollutant under the CAA in part due to its deleterious effects on the nervous system upon inhalation

[19] Tarpaulin: hard surface or heavy-duty waterproof cloth, originally of tarred canvas.

(USEPA, 2015a). While methyl bromide would be used on farms (not in public places), program personel fumigating fields are the most likely to be exposed. However, methyl bromide and other herbicides used by the program will be applied only by USDA-certified pesticide applicators following the program safety measures and the label directions. Fumigation is usually conducted under tarpaulins (hard surfaces) or other gas impervious materials in a manner prescribed by USDA.

f. Historic Properties

In November 2018, APHIS researched and identified all historic properties in the "Areas of Potential Effect (APE)" (appendices B and C). APHIS found that the effects of herbicide treatment on historic resources (buildings and plantations) were unlikely. APHIS submitted its analysis and associated supporting documentations to the North Carolina and the South Carolina State Historic Preservation Offices (SHPOs) for their reviews. These offices concurred with the agency's finding of no effect of the proposed action on historic properties.

g. Human Environment

The consequences of APHIS action (eradication alternative) on the human environment are analyzed below relative to (1) human health risks and (2) environmental justice and safety risks to children.

(1) Human Health Risks

The witchweed program will take place mainly in rural areas, particularly on farms and fields where APHIS personnel and cooperators will apply herbicides in a way that minimizes significant impacts on human health. Human health risks could depend on the way herbicides are applied: soil-applied and foliar-applied herbicides.

Soil-Applied Herbicides

The program applies three soil-applied herbicides (ethylene, methyl bromide, and trifluralin), and their potential risk to human health are presented below as follows:

(a) Ethylene

Ethylene is a colorless gas used in the manufacture of many organics and plastics. It is a plant growth regulator, which is used commercially to accelerate the ripening of various fruits. USDA Agricultural Marketing Service (AMS) (2007) indicates that exposure to ethylene gas could cause dizziness and suffocation. According to the National Institute of Health (NIH), human exposure to ethylene for a prolonged amount of time may result in marked memory disturbances and loss of consciousness. Also, a prolonged inhalation of 85 percent ethylene in air is slightly toxic, while 94 percent ethylene in oxygen is fatal (NIH, 2017). In fatal human intoxication, ethylene affects the respiratory center of the brain and kills by suffocation. Symptoms in workers who have been exposed to ethylene include decreased arterial pressure, slower pulse, visual-motor disorder, hearing troubles, and tension of the thermoregulatory organ. It is not considered carcinogenic (NIH, 2017).

Program use of ethylene could result in exposure of eyes, skin (hand), and the lungs. Occupational workers have the greatest potential for exposure while handling ethylene prior and during application, although the general public may also be exposed.

Adherence to label requirements with proper personal protective equipment (PPE) and general safety hygiene practices would reduce the potential for exposure and risk. The program personnel applying ethylene will follow all necessary precautionary measures, including wearing a longsleeved shirt, long pants, boots, goggles, and chemical-resistant gloves while handling cylinders or any application equipment under pressure. They will also avoid breathing vapors or entering unventilated treatment areas unless wearing a respirator approved by the National Institute for Occupational Safety and Health (NIOSH) and Mine Safety and Health Administration (MSHA).

(b) Methyl Bromide

Methyl bromide is moderately toxic to mammals from oral exposure (an oral LD_{50} of 86 mg/kg), and, from inhalation exposure (an estimated LC_{50} of 780 ppm). A common toxic effect for methyl bromide inhalation exposure is neurotoxicity. Neurotoxic effects include decreased activity, tremors, ataxia, limb paralysis, degenerative changes in the cerebellum, lethargy, right side head tilt, and decreased motor activity. Other toxic effects include failure of gallbladder development, and increased incidence of fused sternebrae (USEPA, 2008).

APHIS uses methyl bromide as a soil fumigation that forms gas when applied to soil. Methyl bromide is a restricted use pesticide avaible only to certified pesticide applicators or those working under the direct supervision of a certified applicator (USEPA, 2008). Occupational workers have the greatest potential for exposure while handling methyl bromide from acute inhalation exposure as a result of off-gasing, as well as from direct fumigant exposure during applications, tarp perforation/removal activities, and re-entry to the treated area shortly after fumigation or tarp perforation. Adherence to label requirements for mitigation measures will reduce the potential for exposure and risk. The mitigation measures include fumigant management plans, restrictions on the timing of perforating and removing tarps, entry-restricted period, application method/practice restrictions with proper PPE on respiratiory protection and air monitoring, and good agricultural practices. The general public who lives or works in the vicinity of a fumigation site is at potential risk from acute inhaltion exposure from off-gasing. Adherence to label requirements for mitigation measures (e.g., buffer zone and posting to prevent off-site migation) will reduce the potential for exposure and risk.

Methyl bromide is classified as a “Class I” ozone-depleting substance due to its high ozone depletion potential; this poses indirect chronic health risks, such as skin cancer. Methyl bromide treatment is usually conducted under a tarpaulin or other gas-impervious material in a manner prescribed by USDA, under the supervision of a certified pesticide applicator, and in accordance with the label directions. Application is not likely to adversely affect the water quality given that water is not included in regulatory fumigation treatments; safety precautions (related to the application methods) would prevent any potential accidental release or disposal of the fumigant into nearby ponds, creeks, or other water sources.

(c) Trifluralin

Trifluralin has low acute oral, dermal, and inhalation toxicity with an acute oral median lethality dose (LD_{50}) of >5000 mg/kg (rat), an acute dermal LD_{50} of >2000 mg/kg (rat and rabbit) or >5000 mg/kg (rabbit), and an LC_{50} of 4.66 mg/L (rat) (USEPA, 2018a). Trifluralin is not an eye or skin irritant, but is considered a skin sensitizer in guinea pigs. The primary target organs of trifluralin are the kidney and the liver in rats and dogs. The 21-day dermal toxicity studies in rat and rabbit found no systemic toxicity at 1,000 mg/kg/day, but observed dermal effects, such as sub-epidermal inflammation and ulcerations at 200 mg/kg/day in rat, and erythema and edema at 100 mg/kg/day in rabbit. A 30-day inhalation exposure of trifluralin to rats found increased methemoglobin and bilirubin, and shortness of breath at 1,000 mg/m3. A two-generation reproduction toxicity study in rats reported a no observable adverse effects level (NOAEL) of 200 mg/kg-diet (10 mg/kg/day), and a lowest observable adverse effects level (LOAEL) of 650 mg/kg-diet (32.5 mg/kg/day) with reduced body weight and litter sizes. Trifluralin is not a neurotoxicant. There are no studies available that indicate that it is immunotoxic. USEPA classifies trifluralin as a “Group C, Possible Human Carcinogen.” Trifluralin is neither mutagenic nor genotoxic (USEPA, 2018a). USEPA’s recent Tier I review of human incidents and epidemiology (USEPA, 2018c) concluded:

- at this time, there is no concern based on the steadily declining incident trends for trifluralin in both Incident Data System (USEPA Office of Pesticide Programs) and Sentinel Event Notification System for Occupational Risk-Pesticides (the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health) databases, and the low severity of the majority of cases; and

- there is no adequate epidemiological evidence from the Agricultural Health Study to conclude a clear associative or causal relationship between trifluralin exposure, and carcinogenic and non-carcinogenic health outcomes assessed in the reported studies. USEPA’s evaluations of risks to different human population subgroups, including occupational exposure, indicate that trifluralin risks do not exceed USEPA’s levels of concern (USEPA, 2018c).

APHIS uses trifluralin formulations (e.g., Treflan® 5G) to control witchweed using soil incorporation. Occupational workers have the greatest potential for exposure while handling trifluralin prior to application and during application, as well as post-application when re-entering treated fields. Adherence to label requirements with proper PPE and general safety hygiene practice will reduce the potential for exposure and risk. The potential exposure of trifluralin in air for the general public in the vicinity of treated fields is low using a soil incorporation application. The potential for human dietary exposure to trifluralin in food is not expected because it is not applied directly to growing crops, and is unlikely to be readily transported throughout plants through xylem and phloem (USEPA, 2018a). The potential for human exposure to trifluralin in drinking water is also not expected because trifluralin is immobile and strongly adsorbed to soil and organic matter. It is not soluble in water and has a low propensity to leach in soil.

Foliar-Applied Herbicides

Other herbicides used by the program are foliar-applied (e.g., paraquat, oxyfluorfen, sethoxydim, DCPA, pendimethalin, 2,4-D, and glyphosate). Their potential human health risks are presented below as follows:

(a) Paraquat

Paraquat is highly acute toxic via inhalation and dermal exposure routes (an inhalation LC_{50} of 1 µg/L (males/females), and a dermal LD_{50} of 174 mg/kg (males), respectively), and toxic via an oral route (an oral LD_{50} of 189 mg/kg (males) or 125 mg/kg (females)) in testing mammals. Paraquat is an eye and skin irritant, but is not a skin sensitizer (USEPA, 2014a).

The primary affected organ of paraquat is the lung. Lung toxicity effects in the respiratory tract observed in the toxicity studies included lung inflammation, scarring, and compromised lung function. Inhalation was a more sensitive route of exposure than the oral route. There were other observed toxicity effects in testing animals with increasing durations of exposure, such as liver inflammation and necrosis, inflammation and necrosis of the kidneys, and lenticular changes in the eyes. The observed developmental toxicity (e.g., reduced body weight/gain and delayed skeletal ossification) occurred in the presence of maternal toxicity (e.g., respiratory distress, reduced body weight, and lesions in the lungs and kidneys) with lesser severity. There was no evidence for paraquate to cause reproductive toxicity, neurotoxicity, or immunotoxicity (USEPA, 2014a).

Paraquat is classified as a Group E, evidence of non-carcinogenicity in humans based on animal studies. Mutagenicity studies showed that paraquat was not mutagenic in the Salmonella typhimurium assay; not genotoxic in the unscheduled DNA synthesis assay in vitro or in vivo; negative for chromosomal aberration in the bone marrow test; and no evidence for suppressed fertility or dominant lethal mutagenicity in mice. However, paraquat was weakly positive in the mouse lymphoma assay and human lymphocyte cytogenetic assay, and was positive in the sister chromatid exchange assay (USEPA, 2014a).

Paraquat is highly toxic to humans. Even a small ingested amount (1.5 teaspoons) can cause death without a known antidote. Since 2000, there have been 17 reported deaths as a result of accidental ingestion of paraquat due to illegally transferring this chemical into beverage containers and later mistakenly drinking it. Three deaths and a high number of severe injuries have resulted from paraquat contact with skin or eyes of occupational workers. USEPA implemented new packaging requirements to prevent the illegal transfer of paraquat to beverage containers, as well as necessary risk mitigation measures, such as label changes, emphasizing paraquat toxicity and supplemental warning materials, and targeted training materials for paraquat users (USEPA, 2017).

APHIS uses paraquat as postemergence directed or postemergence overtop. An occupational worker (certified applicator) has the greatest potential for exposure while handling paraquat prior to (or during) the application, as well as post-application when re-entering treated fields. As a restricted use pesticide, only a certified applicator, or under the direct supervision of a certified applicator, can use the product, and only protected handlers may be in the area during application. Adherence to label requirements with proper PPE and general safety hygiene practices will prevent severe injury and/or death from ingestion, skin or eye exposure, and reduce the potential for risks. The potential exposure to paraquat for the general public in the vicinity of treated fields is low given this is a spot-directed (foliar-applied) herbicide. The potential for human dietary exposure to paraquat in food is not expected because paraquat is not applied directly to growing crops. The potential for human exposure to paraquat in drinking water is also unlikely because paraquat is immobile and adsorbs to soil clay particles resulting in a very low leaching potential.

(b) Oxyfluorfen

Oxyfluorfen has low acute oral, dermal, and inhalation toxicity in mammals with an LD_{50} of >5000 mg/kg, an acute dermal LD_{50} of >2000 mg/kg or >5000 mg/kg, and an LC_{50} of >3.71 mg/L (rat). Oxyfluorfen is a slight eye and skin irritant, but is not a skin sensitizer in guinea pigs (USEPA, 2002b).

The primary target organ of oxyfluorfen is the liver, with effects such as increased liver weights and increased liver enzymes (USEPA, 2002b; 2014b). There were other observed toxicological effects such as decreased body weights, increased urine production and water consumption, slight anemia, and increases in kidney weights. The 90-day oral toxicity study in mice observed liver toxicity and anemia at the LOAEL of 32 mg/kg/day. The 90-day oral toxicity study in rats observed liver and kidney toxicities at the LOAEL of 71 mg/kg/day. Oral subchronic studies observed mortality at the highest tested dose. Chronic dietary toxicity studies found a NOAEC of 3.0 mg/kg/day with liver toxicity occurring in dogs and mice at the LOAEL of 200 ppm in male (33.0 mg/kg/day) and female (42.0 mg/kg/day) mice. Chronic studies in dogs and carcinogenicity studies in mice found a NOAEL of 3.0 mg/kg/day with liver toxicity occurring observed at the LOAEL of 18 mg/kg/day in dogs and 33 mg/kg/day in mice. A developmental study in rabbits found a NOAEL of 30 mg/kg/day, with abortions and clinical signs observed at maternal LOAEL of 90 mg/kg/day. USEPA's review of the developmental and reproductive toxicity studies did not find any increased susceptibility in animals due to pre- or postnatal exposure to oxyfluorfen. Neurotoxicity studies were not performed for oxyfluorfen. The available literature did not indicate neurotoxicity. Oxyfluorfen is not immunotoxic based on a NOAEL of 153.5 mg/kg/day without observed a LOAEL in a USEPA guideline immunotoxicity study. USEPA (2014b) waived an inhalation study, as well as acute and subchronic neurotoxicity studies, but required a subchronic dermal study based on Hazard and Science Policy Council conclusions.

Oxyfluorfen is classified as "Likely to be Carcinogenic to Humans" based on the occurrence of treatment-related hepatocellular tumors in male mice, and the lack of an adequate carcinogenicity study in a second species (USEPA, 2014b). The Cancer Peer Review Committee recommended retaining a linear low-dose extrapolation for a cancer toxicity, with a cancer potency or slope factor of 7.32×10^{-2} $(mg/kg/day)^{-1}$ in human equivalents, based on combined hepatocellular adenomas and carcinomas from a mouse carcinogenicity study (EPA, 2014b).

Oxyfluorfen is rapidly absorbed through an oral exposure route, extensively metabolized, and rapidly eliminated. Most of the compound was eliminated in the feces; females eliminated more in the urine than did male mice (USEPA, 2002b). A dermal absorption study in rats found a dermal absorption factor of 18 percent (USEPA, 2002b).

USEPA's Tier I review of human incidents (USEPA 2014c) found a low frequency of incidents involving oxyfluorfen reported to Incident Data System (USEPA Office of Pesticide Programs) and Sentinel Event Notification System for Occupational Risk-Pesticides (the Centers for Disease Control and Prevention/ National Institute for Occupational Safety and Health). In contrast, there was a relatively large proportion of Ortho Fence & Grass Edger Formula II (Registration No. 239-2516) incidents (USEPA, 2014c).

APHIS uses Goal® 2XL (22.3 percent oxyfluorfen as active ingredient) with a shielded sprayer as post-emergence control of witchweed in corn (USDA APHIS, 2019a). An occupational worker has the most potential for exposure while handling oxyfluorfen prior to application and during application, as well as post-application when re-entering treated fields. The label required restricted entry interval for oxyfluorfen is currently set at 24 hours (USEPA, 2013). Adherence to label requirements with proper PPE to oxyfluorfen and general safety hygiene practice will prevent severe injury and/or death from ingestion, skin or eye exposure, and reduce the potential for risk. Potential inhalation exposures for the post-application worker scenarios are not anticipated because of the low vapor pressure of oxyfluorfen (2.0^{-07} torr at 20° C) (USEPA, 2002b). The potential exposure of oxyfluorfen for the general public in the vicinity of the treated field is low using a shield sprayer. The potential for human dietary exposure to oxyfluorfen in food is not expected because oxyfluorfen is not applied to the edible portions of growing crops (USEPA, 2002b). For example, Goal® 2XL is applied by directed spray to the base of corn plants to prevent leaf contact and injury. This application is unlikely to be transported throughout the corn plant tissues. There is low potential for human exposure to oxyfluorfen in drinking water because the label requires a 25-foot vegetative buffer strip maintained between the treated area of oxyfluorfen and any surface water body; this compound is not expected to migrate or drift that distance (USEPA, 2013).

(c) Sethoxydim

Sethoxydim has low acute oral, dermal, and inhalation toxicity in rats with an LD_{50} of 2,676 (female)/3,125 (male) mg/kg, an acute dermal LD_{50} of >5,000 mg/kg, and an acute inhalation LC_{50} of 6.03 (male)/6.28 (female) mg/L. Sethoxydim is not an eye or skin irritant. It is not a skin sensitizer in guinea pigs treated with Poast® and a dermal sensitization study with the technical compound in guinea pigs was waived (USEPA, 2000).

The primary target organ of sethoxydim is the liver in rats, mice, and dogs, with effects such as increased liver weight; hypertrophy; fatty degeneration; hepatocyte swelling; increased serum bilirubin, alkaline phosphatase, aspartate aminotransferase, and alanine aminotransferase levels; focal granulomatous inflammation; and eosinophilic foci (USEPA, 2005). Liver toxicity was observed by exposure through the oral and inhalation routes, but dermal toxicity was not observed. A 21-day dermal study in rabbits did not observe dermal toxicity at 1,000 mg/kg/day. A subchronic oral toxicity study in mice observed liver toxicity (increased liver weight in both sexes and swollen liver cells in males) at 137 mg/kg/day with a NOAEL of 46 mg/kg/day. A subchronic rat inhalation study found increased liver weight, serum total bilirubin, and increased incidence of slight centrilobular hepatocyte swelling at 2.4 mg/L (NOAEL = 0.3 mg/L). Other toxicity effects were also found. A subchronic oral toxicity study in rats observed decreases in body weight, body weight gain, and food efficiency at 196 mg/kg/day (NOAEL = 60 mg/kg/day). A chronic oral toxicity study in dogs found increased hemosiderosis in the spleen, and depressed myeloid erythropoiesis in the sternal bone marrow at 110 mg/kg/day (NOAEL = 18 mg/kg/day). The chronic toxicity/carcinogenicity study in rats observed interstitial fibrosis and heart failure cells in lungs in female rats at 143 mg/kg/day (NOAEL = 48 mg/kg/day). A developmental rat study observed maternal toxicity, such as an irregular gait, decreased activity, and excessive salivation at 650 mg/kg/day (NOAEL = 180 mg/kg/day). At the same dose as maternal toxicity, developmental toxicity, such as decreased fetal weights, filamentous tail and lack of tail due to the absence of sacral and/or caudal vertebrae, and delayed ossification in the hyoids occurred. Maternal toxicity was not found in rabbits at 400 mg/kg/day, and developmental toxicity had an increase in the incidence of incompletely ossified 6th sternebrae was noted at 400 mg/kg/day (NOAEL = 320 mg/kg/day). The reproduction study observed no parental or reproductive toxicity at 150 mg/kg/day (highest dose tested), but offspring toxicity (decreased pup weight in the F1a, F1b, and F2b generation during lactation) was noted at this dose (NOAEL = 30 mg/kg/day). The available neurotoxicity studies found no evidence of neurotoxicity or neuropathology. USEPA (2015) waived acute neurotoxicity test and immunotoxicity test for sethoxydim.

Sethoxydim is classified as "Not Likely to be Carcinogenic to Humans" based on no evidence of increased tumor incidence in the rats and mice carcinogenicity studies, and no evidence of genotoxicity in the mutagenicity battery.

Sethoxydim is extensively absorbed through an oral exposure route, and excreted within 48 hours. The compound was excreted mostly in the urine (78.5 percent of administered dose (AD)) and partially in feces (20.1 percent AD) with negligible tissue accumulation (<2 percent of AD). The excreta contains mainly metabolites of three sulphoxy compounds and only negligible amount of the parent compound. USEPA (2003) waived a dermal absorption factor based on lack of toxicity in the rabbit dermal toxicity study at the highest dose tested and a low concern for advance findings in fetuses, offspring, and reproduction.

USEPA's Tier I review of human incidents (USEPA 2014d) found a low frequency and low severity of incidents involving sethoxydim reported to Incident Data System (USEPA Office of Pesticide Programs) and Sentinel Event Notification System for Occupational Risk-Pesticides (the Centers for Disease Control and Prevention/ National Institute for Occupational Safety and Health).

APHIS uses Poast® (USEPA Registration No. 7969-58, 18 percent sethoxydim as an active ingredient) as post-emergence overtop control of witchweed in Poast® protected hybrids or Poast®-protected sweet corn (USDA APHIS, 2019a). Poast® is applied to actively growing grass weeds by aerial or ground applications at the label specified rates and timing. An occupational worker has the most potential for exposure while handling sethoxydim prior to application and during application, as well as post-application when re-entering treated fields. The label required restricted entry interval for sethoxydim is currently set at 12 hours. Adherence to label requirements with proper PPE for sethoxydim application and general safety hygiene practices will prevent injury from direct contact exposure and reduce the potential for risk. The potential exposure of sethoxydim to the general public in the vicinity of the treated field is low because only protected handlers are in the area during application. Drift is minimized by following label spray drift management requirements. The potential risk for human dietary exposure to sethoxydim in food is not expected because sethoxydim is not applied to the edible portions of growing crops. For example, Poast® is applied by over-the-top application in Poast®-protected field corn after emergence, but not after pollination (USEPA, 2019). USEPA (2015) chronic dietary (food and water) risk estimates for the registered uses of sethoxydim did not exceed the health effects division's level of concern for the general U.S. population or any population subgroup. There is low potential for human exposure to sethoxydim in drinking water because the label requires to apply the product only when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, or nontarget crops) is minimal and when wind is blowing away from sensitive areas to prevent impacts to any surface water body (USEPA, 2019).

(d) DCPA

DCPA has low acute oral, dermal, and inhalation toxicity in mammals with an acute oral LD_{50} of >5,000 mg/kg, an acute dermal LD_{50} of >2,000 mg/kg, and an acute inhalation LC_{50} of >4.48 mg/L. DCPA is a mild eye and skin irritant, but is not a skin sensitizer (USEPA, 2002a; 2011a).

The primary affected organs are the liver and thyroid. Liver toxicity in longer term studies included increased liver weight, elevated liver enzyme activity, increased cholesterol, and liver hypertrophy. Thyroid toxicity includes decreased levels of thyroid hormone, microscopic thyroid changes, and increased thyroid weight. The liver effects appear to be precursor events to the thyroid effects. The increased metabolism of thyroid hormone by the liver causes a compensatory stimulation of the thyroid. There were other observed toxicity effects such as anemia, pneumonitis, and kidney toxicity. Kidney toxicity effects include increased kidney weight, increased incidences of chronic nephropathy, and changes in clinical pathology (USEPA, 2011a).

DCPA is classified a Group C, possible human carcinogen, with a cancer potency factor of 1.5×10^{-3} $(mg/kg/day)^{-1}$ based on liver tumors in female rats. Mutagenicity studies showed no mutagenicity concerns for DCPA. However, there were thyroid follicular cell adenomas/carcinomas, hepatocellular adenomas/carcinomas, and hepatocholangiocarcinomas found in rats; and hepatic adenomas found in mice (USEPA, 2011a).

Metabolism studies showed that most DCPA was eliminated. Most of the compound was eliminated in the urine at low doses and the feces at high doses (USEPA, 2002a). A dermal absorption study in rats found a dermal absorption factor of 14.9 percent (USEPA, 2002a).

USEPA's review of human incidents (USEPA, 2011b) found a low frequency and severity of incidents involving DCPA reported to Incident Data System (USEPA Office of Pesticide Programs) and Sentinel Event Notification System for Occupational Risk-Pesticides (the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health).

APHIS uses Dacthal® Herbicide as pre-emergence surface applied, post-emergence overtop, or post-emergence directed control of witchweeds in corn (USDA APHIS, 2019a). An occupational worker has the most potential for exposure while handling DCPA prior to application and during application, as well as post-application when re-entering treated fields. Adherence to label requirements with proper PPE for DCPA applications and general safety hygiene practices will prevent adverse health effects from direct contact exposure, and reduce the potential for risk. The potential exposure of DCPA for the general public in the vicinity of the treated field is low because only protected handlers are in the area during application. Drift is minimized by following label spray drift management requirements. The potential for human dietary exposure to DCPA in food is not expected because DCPA will be applied in accordance with label-specific information requirements and not to the edible portions of growing crops. DCPA is absorbed by roots instead of foliage, and is nonsystemic, so it does not translocate in the plant (USEPA, 2009). This application is unlikely to be transported throughout the corn plant tissues. There is low potential for human exposure to DCPA in drinking water if used in accordance with the label required protections to sensitive areas.

(e) Pendimethalin

Pendimethalin has low acute oral, dermal, and inhalation toxicity in mammals, with an acute oral LD_{50} of 1,250 (males)/1,050 (females) mg/kg, an acute dermal LD_{50} of >5000 mg/kg, and an acute inhalation LC_{50} of >320 mg/L. Pendimethalin is not a primary eye or skin irritant, and is not a skin sensitizer in guinea pigs (USEPA, 1997; 2017).

The target organ of pendimethalin is the thyroid with effects including alterations in thyroid hormones (decreased total T4 and T3 and increased percent of free T4 and T3), increased thyroid weight, and microscopic thyroid lesions (including increased thyroid follicular cell height, follicular cell hyperplasia, as well as follicular cell adenomas) (USEPA, 2017b). The chronic and subchronic oral studies in rats found hormonal and histopathological changes in the thyroid at a LOAEL of 31 mg/kg/day. The subchronic dermal study in rats shows that pendimethalin is not dermal toxic (a NOAEL of 1,000 mg/kg/day without a LOAEL). There is no evidence of developmental or reproductive toxicity in test animals. Developmental studies in rabbits and rats found maternal and developmental NOAEL values of 60 mg/kg/day and 500 mg/kg/day without a LOAEL. The two-generation rat reproductive study reported a LOAEL of 125–172/216 (M/F) mg/kg/day (NOAEL of 25–34/43 (M/F) for offspring reproductive effects of decreases in the number of pups born and pup weights, and for parental systemic effects of decreased body weight gain and food consumption. The three-generation rat reproductive study reported a LOAEL of 250 mg/kg/day for offspring effects of decreased pup body weight gain, and possible decreased pups born alive and pup survival, and for parental systemic effects of decreased body weight. USEPA’s review of the developmental and reproductive toxicity studies did not find any increased susceptibility in young animals due to pre- or postnatal exposure to pendimethalin. Pendimethalin is not neurotoxic. The acute neurotoxicity study reported reduced motor activity for males and females on Day 0 at a LOAEL of 300 mg/kg (NOAEL of 100 mg/kg). The subchronic neurotoxicity study reported a NOAEL of 386.8/423.1 mg/kg/day without a LOAEL. Pendimethalin is not immunotoxic based on a NOAEL of 276 mg/kg/day without a LOAEL (USEPA, 2012a).

Pendimethalin is classified as "Group C, Possible Human Carcinogen" (USEPA, 2017b).

Pendimethalin is absorbed, metabolized, and eliminated within 24 hours. Most (70 percent) of the compound was eliminated in the feces and 20 percent in urine; the dermal absorption factor is 3 percent (USEPA, 2012a).

USEPA’s review of human incidents (USEPA, 2012b) found a low frequency and severity of incidents involving pendimethalin reported to the Incident Data System (USEPA Office of Pesticide Programs) and Sentinel Event Notification System for Occupational Risk-Pesticides (the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health). The epidemiology review found overall little substantive evidence to suggest a clear associative or causal relationship between exposure to pendimethalin and the health outcomes investigated in the agricultural health study reported here.

APHIS uses Prowl® H_2O Herbicide (USEPA Registration No. 241-418, 38.7 percent pendimethalin as an active ingredient) as pre-plant or post-emergence incorporated control of witchweeds in corn (USDA APHIS, 2019a). An occupational worker has the most potential for exposure while handling pendimethalin prior to application and during application, as well as post-application when re-entering treated fields. The label required restricted entry interval for pendimethalin is currently set at 12 hours. Adherence to label requirements with proper PPE for pendimethalin application and general safety hygiene practices will prevent adverse health effects from direct contact exposure, and reduce the potential for risk. The potential exposure of pendimethalin for general public in the vicinity of the treated field is low because only protected handlers are in the area during application. Drift is minimized by following label spray drift management requirements. The potential for human dietary exposure to pendimethalin in food is not expected because pendimethalin will be applied in accordance with label crop-specific information requirements and not to the edible portions of growing crops. USEPA (1997) chronic dietary (food and water) risk estimates for the registered uses of pendimethalin did not exceed the health effects division's level of concern for the general U.S. population or any population subgroup. There is low potential for human exposure to pendimethalin in drinking water because the label requires application of the product only when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, or nontarget crops or plants) is minimal, and when wind is blowing away from sensitive areas to prevent impacts to any surface water body (USEPA, 2018b).

(f) 2,4-D

The 2,4-D registration case contains 2,4-D acid, salts, and ester forms. USEPA (2005; 2016a) selected 2,4-D acid to be representative of all members of the case because the effects and relative toxicities of the 2,4-D salt and ester forms are generally quite similar to those of the 2,4-D acid.

2,4-D generally has low acute oral, dermal, and inhalation toxicity in mammals with an acute oral LD_{50} ranging from 639 to 1,646 mg/kg, an acute dermal LD_{50} ranging from 1,829 mg/kg to >2,000 mg/kg, and an acute inhalation LC_{50} ranging from 0.78 mg/L to >4.97 mg/L. 2,4-D is not a skin irritant, nor a skin sensitizer (USEPA, 2005). The 2,4-D ester forms are not eye irritants, however, the acid and salt forms are severe eye irritants (USEPA, 2005).

2,4-D is actively secreted by the proximal tubules in the kidney, which is similar to other phenoxy acids. The primary targeted organs are the kidney, thyroid, liver, adrenals, eye, and ovaries/testes in rats from subchronic oral exposure at a 2,4-D dose level above the saturation threshold for renal clearance, and also following exposure to the amine salts and esters of 2,4-D. Systemic toxicity was not observed in a subchronic dermal toxicity study in rabbits. Maternal and developmental toxicities were observed at high doses exceeding the saturation threshold of renal clearance. Reproductive toxicity resulting in an increase in gestation length was observed from exposure to 2,4-D at a dose level above the threshold of saturation of renal clearance. There was neurotoxicity observed from exposure to 2,4-D at the high dose in the rat acute neurotoxicity study. An extended one-generation reproductive toxicity study in rats did not observe reproductive toxicity, developmental neurotoxicity, or immunotoxicity (USEPA, 2005; 2016a).

2,4-D is classified as a Group D, Not Classifiable as to Human Carcinogenicity. There were some cytogenic effects observed, however, the overall pattern of responses observed in both in vitro and in vivo genotoxicity tests indicated that 2,4-D was not mutagenic (USEPA, 2016a).

2,4-D is absorbed (85 percent–94 percent) through the oral route, undergoes limited metabolism, and is eliminated quickly from the body by active saturable renal transport. Most of the 2,4-D (73 percent–91 percent) in the urine is unchanged (USEPA, 2016a).

EPA's review of human incidents (USEPA, 2016b) found acute health effects incidents involving 2,4-D reported to the Incident Data System (IDS) (USEPA Office of Pesticide Programs), the National Poison Control Centers (NPIC), SENSOR-Pesticides and the California Pesticide Illness Surveillance Program (PISP). Neurological, respiratory, dermal, and gastrointestinal effects are the primary health effects that are generally mild/minor to moderate and resolve rapidly. The most commonly reported exposure scenario in IDS is residential application followed by residential postapplication exposure. Most of the reported 2,4-D incidents from NPIC, SENSOR-Pesticides and California PISP involve off-target drift exposure.

APHIS uses 2,4-D herbicide as a post-emergence directed control of witchweed in corn (USDA APHIS, 2019a). An occupational worker has the most potential for exposure while handling 2,4-D prior to application and during application, as well as post-application when re-entering treated fields. Adherence to label requirements with proper PPE for 2,4-D applications and general safety hygiene practices will prevent adverse health effects from direct contact exposure and reduce the potential for risk. The potential exposure of 2,4-D for general public in the vicinity of a treated field is low because only protected handlers are in the area during application. Drift is minimized by following label spray drift management requirements. The potential for human dietary exposure to 2,4-D in food is not expected because 2,4-D will be applied in accordance with label specific requirements and is not applied to the edible portions of growing crops. This application is unlikely to be transported throughout corn plant tissues. There is low potential for human exposure to 2,4-D in drinking water if used in accordance with the label required protection for sensitive areas.

(g) Glyphosate

Glyphosate exhibits low acute toxicity to mammals in oral, dermal, and inhalation exposures with LD_{50} values >5,000 mg/kg. It is a mild eye irritant and a slight skin irritant. It is not a dermal sensitizer. Effects typically occur at doses equal to or exceeding 1,000 mg/kg/day (USEPA, 2017a; ATSDR, 2019). Gastrointestinal effects (e.g., nausea, vomiting, abdominal pain, sore throat, and mucosal damage in the mouth and esophagus) are the most sensitive noncancer effects observed in acute, intermediate, and chronic studies (ATSDR, 2019). Other effects such as decreases in body weights, and minor indicators of toxicity to the eye, liver, and/or kidney have been reported in intermediate and chronic studies at doses higher than gastrointestinal effects (USEPA, 2017a, ATSDR, 2019). Glyphosate is not a neurotoxic or immnotoxic (USEPA, 2017a)

USEPA classifies glyphosate as “not likely to be carcinogenic to humans” based on a weight-of-evidence review of all relevant data including various technical documents supporting registration of glyphosate, and studies that evaluated the carcinogenic potential of glyphosate (USEPA, 2017c). The International Agency for Research on Cancer (IARC), however, classified glyphosate as “probably carcinogenic to humans (Group 2A)” based on the idea that the evidence for carcinogenicity was limited as it relates to humans but was sufficient when evaluating the potential for carcinogenicity using laboratory animals (IARC 2015). The Agency for Toxic Substances and Disease Registry summarized the carcinogenicity classification from several other regulatory agencies and found that they are consistent with the determination from the USEPA (ATSDR, 2019). Benbrook (2019) and the USEPA (2017c) summarized reasons for the disparity in the classification of the carcinogenicity potential between the USEPA and IARC. Consideration of non-mammalian data in the IARC report, as well as additional literature, were listed as some of the reasons for the difference in classification between IARC and the USEPA.

APHIS uses glyphosate through postemergence overtop and postemergence directed foliar applications. Occupational workers have the greatest potential for exposure while handling and applying glyphosate in the fields. However, precautionary measures (e.g., the adherence to label requirements with proper use of PPE, and general safety hygiene practices) normally reduce the potential for human health risk and protect handlers/workers from occupational exposure. The potential exposure to glyphosate by the general public in the vicinity of treated farms is low for the spot foliar spray application, and the program does not expect any potential for human dietary exposure because glyphosate is applied directly to foliage of witchweed plants (not to growing crops). Its potential for human exposure through drinking water is also not expected because glyphosate sorbs strongly to soil, which eliminates the potential for leaching to groundwater or transport to surface water at high levels through dissolved runoff. The glyphosate method of application by using a large droplet size device under low pressure contributes even more to the limitation of any potential drift and human exposure through drinking water (USDA APHIS, 2019a).

(2) Environmental Justice and Safety Risks to Children

The program's chemical application and human health risks are assessed in this subsection to address potential impacts on minority and/or low income communities (environmental justice), as well as safety risks to children.

Environmental Justice in Minority and/or Low Income Populations

Federal agencies are required by law to identify and address any disproportionately high and adverse human health and environmental effects of its proposed activities, as described in the Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." In conformity with this EO, APHIS will engage any minority and/or low-income communities potentially impacted by its action. According to estimates by the U.S. Census Bureau, American Community Survey (2012–2016), the total population in the witchweed regulated quarantine counties is 926,814 of which 423,701 (46 percent) constitute a minority group. In this minority category, Blacks are nearly 246,813 (27 percent), American Indians 60,593 (7 percent), Asians 12,736 (1 percent), and "some other race" 30,300 (3 percent). The total Hispanic population in the program area is 9 percent, and the percentage of non-English speakers is also 9 percent. Income-wise, approximately 20 percent of people in the program area make less than $25,000 annually (17 percent making under $15,000), and 37 percent rent a place to live versus owning a home. The breakdown of this minority demography is shown in table 10. A range of 15 to 28 percent of the minority populations are identified in the "poverty" category. To meet the needs of minority individuals that could be affected by the witchweed program, USDA APHIS will ensure that any notifications related to the time and place of herbicide treatments (e.g., Stay Away from Treated Areas) be sent or posted in English, as well as other languages.

Safety Risks to Children

USDA APHIS complies with EO 13045, "Protection of Children from Environmental Health Risks and Safety Risks". Based on the U.S. Census Bureau, American Community Survey (2012–2016), the population of children (under 18) in the witchweed program area is 277,871 (30 percent). The agency's chemical program to eradicate witchweed does not pose any disproportionate adverse effects to children because herbicides will be applied primarily to witchweed-infested farms and fields, not in public places or child-occupied areas or facilities (e.g., parks, playgrounds, schools, or other outdoor community centers). All herbicide applications are normally done (or supervised) by USDA certified pesticide applicators, and safety precautions will be taken to minimize any potential risks to children.

Overall, USDA APHIS does not expect the program to pose any disproportionately high and adverse effects to minority and/or low income communities, or any safety risks to children.

Table 10. Minority Population Demographics in the Witchweed Quarantine Area as of July 1, 2017[20]

County	Total Population	Minority	Blacks	American Indians and Alaska Natives	Asians	2 or more races	Native Hawaiian and other Pacific Islanders	Hispanic or Latino ethnic	Poverty
		%	%	%	%	%	%	%	%
Bladen, NC	33478	39.3	34.3	3	0.3	1.7	no data	7.9	26.4
Cumberland, NC	332546	48.2	38.6	1.8	2.8	4.6	0.4	11.6	18.8
Robeson, NC	132606	68.8	23.9	41.3	0.7	2.7	0.2	8.9	27.8
Sampson, NC	63430	33	26.6	3.3	0.6	2.2	0.3	19.8	19.6
Pender, NC	60958	19.1	15.4	0.9	0.6	2.1	0.1	7.3	15
Marion, SC	31293	59.7	56.9	0.7	0.7	1.4	no data	2.9	25.2
Horry, SC	333268	17.4	13.3	0.6	1.3	2	0.2	6	15

2. Cultural Control

Some perspectives of the cultural control practices (e.g., roguing, tillage, disking, crop rotation, and planting of false hosts) have been presented in previous chapters including, among other benefits, weed suppression, soil aeration, and pesticide activation. For instance, when farmers till the ground immediately after harvest of corn, they destroy grasses, weeds, and nematodes (APHIS BRS, 2011). Roguing and disking, and rotating crops in space (between grain crops and broadleaf crops) and in time (seasonally or per growing cycle) make it hard for witchweed and weed hosts to adapt to any given management technique. Also, planting false hosts (e.g., cotton, cowpea, soybean, pearl millet, sunflowers, linseed, and others

[20] Quickfact data available on US Census online at https://www.census.gov/quickfacts/fact/table/US/PST045218, accessed 11/01/18

listed in table 6) stimulates the germination of witchweed seedlings without providing witchweed with necessary resources that allow the pest to live long (APHIS BRS, 2011; SCDA, 2015; CABI, 2017). Some potential impacts of cultural practices on the environment exist and are analyzed as follows:

a. Soil

The witchweed program uses disking for preplant incorporated herbicide applications before the crop is planted or transplanted. Disking soil multiple times per growing season with mechanical equipment can cause soil erosion and possibly impact soil fertility (e.g., loss of phosphorus and potassium from the topsoil). According to Iastate (2004), soil tillage may reduce ground cover or crop residues, and eventually lead to a "hardpan[21]". This situation may cause growers to acquire more fertilizers in order to offset the loss of soil fertility and, therefore, cause other pollution issues.

USDA APHIS applies disking for foliar-applied herbicides such as Treflan® (trifluralin). The program uses double cross disking and PTO-driven rotary cultivators for the mixing of Treflan® and topsoil. Unlike the conventional tillage that is often erosion-causing due to multiple and intensive plowing, the program's disking only applies to the top 1–3 inches of the ground for the Treflan® mixing with soil. Potential disruptions of soil microbial populations exist (Adomako and Akyeampong, 2016), but such effects are very limited, with no significant adverse impact to any unique soil conditions. The USDA APHIS preferred action would lead to greater gains (e.g., witchweed seed bank suppression from infested lands, soil aeration, and nutrient availablity to desired crops).

b. Vegetation and Wildlife

Cultural practices associated with multiple and intensive plowing (e.g., conventional tillage) may reduce the vegetation cover causing erosion, loss of habitat and food for wildlife, among other impacts. Alternatively, practices that keep vegetation materials (e.g., crop residues) in the field after harvest may also cause certain diseases and pest challenges (USDA APHIS, 2011). Such practices are not proposed in this EA.

Under the preferred alternative proposed in this EA, the program will apply soil disking in areas used for farming (e.g., cornfields) for the purpose of mixing soil-applied herbicides. USDA APHIS will not spray chemicals in wild areas covered with natural vegetation and that are

[21] Hardpan: impervious layer, typically of clay, occurring in or below the soil and impairing drainage and plant growth.

inhabited by wildlife. Therefore, the withweed program is not expected to significantly negatively impact the natural vegetation and wildlife cover.

c. Agriculture

USDA APHIS program considers several witchweed control practices according to herbicide labeled uses (e.g., use of false host, fallow land, non-cropland, no-till, preharvest, etc.) and the planting method of the crop in the rotation[22] with corn (e.g., soybean). The program manual (SCDA, 2015) indicates that when soybeans are planted no-till or broadcasted with no land preparation (that is, no erosion risk) weed control may be less effective relative to when land is prepared and soybeans are drill planted in freshly tilled soil (that is, erosion potential)

False host planting (e.g., cotton, cowpea, soybean, pearl millet, sunflowers, and linseed) is considered by the program as a control technique that stimulates the germination of witchweed seedlings without providing the pest with necessary resources to survive. The effectiveness of this system varies according to the type of false hosts planted (see effectiveness for various types in table 6).

USDA APHIS does not anticipate any significant negative impacts on agriculture as a result of crop rotation, planting of false hosts, or any agricultural practices used by the program to control witchweed.

d. Water Quality

USDA APHIS considers impacts to water resources as significant if they exceed Federal or State water quality standards. The APHIS program will not intensively till soil (conventional tillage) or apply any cultural activities that would adversely erode lands and affect water quality (e.g., increased levels of sediments, nutrients, temperature, turbidity, etc.). The program areas are mainly farmlands, whict are flat in general, and are where disking for preplant-incorporated Treflan® treatment is usually limited to the top 1–3 inches of soil. Likewise for disking, the program's application of false hosts, crop rotation, roguing/handpulling, etc. are not expected to cause any significant adverse impacts on the water quality.

e. Air Quality

USDA APHIS considers impacts to air resources as significant if they exceeded the NAAQS for particulate matter, ozone precursors, and greenhouse gas emissions. The cultural control activities of the program are not expected to cause any adverse impacts on air quality.

[22] Rotation: successive planting of different crops on the same land.

f. Historic Properties

In November 2018, APHIS researched and identified all historic properties in the "Areas of Potential Effect (APE)". USDA APHIS found that its eradication program would have no significant adverse impact on historic resources (buildings and plantations). USDA APHIS submitted this analysis and associated documentations to the North Carolina and South Carolina SHPOs for their reviews. These offices concurred with the agency's finding of no effect of the proposed action on historic properties.

g. Human Health

Farming practices (e.g., rotation, use of false hosts, roguing, etc.) as methods for controlling witchweed will likely pose no significant impact to human health. However, Sieczka (1989) notes that some of these practices (e.g., use of fallow fields in crop rotation) lead to decreased yield and lower income for farmers, and possibly to some financial stress or anxiety. However, long term gains from such practices could outweigh the above-mentioned short term negative effect (e.g., letting a part of field lie fallow).

Overall, USDA APHIS does not anticipate its proposed action (including cultural practices) would pose any significant adverse impact on human health.

V. Other Environmental Review Considerations

In this chapter, APHIS analyzes other pertinent environmental issues to ensure its compliance with related statutes and EOs. These considerations include Endangered Species Act, Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act, and Potential Cumulative Effects.

A. Endangered Species Act

Section 7 of the Endangered Species Act (ESA) and ESA's implementing regulations require Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of federally listed T&E species or result in the destruction or adverse modification of critical habitat.

According to the biological assessment completed in the witchweed-quarantine counties (USDA APHIS, 2019b), twenty-three federally listed T&E species occur in the counties regulated for witchweed. The program determined its witchweed eradication activities will have no effect on 18 of these species or designated critical habitats. This is mostly due to the lack of proximity of witchweed-infested agricultural fields to the species and their habitats. The program found it may affect, but is not likely to adversely affect, nine species or designated critical habitats. These species are clams (Atlantic pigtoe *Fusconaia masoni and* yellow lance *Elliptio lanceolate*); fish (Waccamaw silverslide *Menidia extensa*); and plants (American chaffseed *Schwalbea americana*; Canby's dropwor *Oxypolis canbyi*; Cooley's meadowrue *Thalictrum cooleyi*; golden sedge *Carex lutea*; Michaux's sumac *Rhus michauxii*; and rough-leaved loosestrife *Lysimachia asperulaefolia*) (USDA APHIS, 2019b).

The program applies herbicides to agricultural fields with witchweed (and to some extent to road edges, home gardens, and yards). Most of these areas are not in the proximity of listed species or their designated critical habitats. Also, the ecological risk assessment by USDA APHIS (2019a) indicates that herbicides used by the program are in general non-toxic to terrestrial mammals and most invertebrates; they are non-toxic to moderately toxic to birds; but that some of these chemicals may have some toxicity to fish and aquatic invertebrates. However the risk of direct and indirect exposure of T&E species and their critical habitats is not likely due to the Program's use pattern, label requirements and, in most instances, a lack of overlap between the species location/habitat and the program's treatment area.

B. Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. 668–668c) prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. The Act provides criminal penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof." The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb."

The bald eagle (*Haliaeetus leucocephalus*) is present in the lower 48 States and Alaska. Although it was officially removed from the List of Endangered and Threatened Species as of August 8, 2007 due to recovery. After near disappearance decades ago, bald eagles continue to be protected under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA).

The bald eagle's preferred habitats are undisturbed forests with tall canopies near water bodies. Nest sites typically include at least one perch with a clear view of water bodies or areas where the eagles usually forage (FWS, 2018). There are currently three documented bald eagle nests in Marion County, and six bald eagle nests in Horry County. These nests are not in or near treatment areas, which are mostly cornfields and fallow fields (Carl Lightfoot, pers. comm.)
The golden eagle (*Aquila chrysaetos*) is a rare winter resident in the eastern United States, although a few individuals have been observed along the Appalachian Mountains, and occasionally on the coastal plain of South Carolina. For instance golden eagles were identified in the Savannah River forest during the winters of 2014 and 2015, where they typically scavenged on animal carcasses (Vukovich et al., 2015). However, no eagle or nests have been found in the witchweed-infested farms or program area (Joe Beckwith, pers. comm.)

In the event bald or golden eagles are possibly found eating live prey or scavenging on dead animals in flatwoods or floodplains in the vicinity of the program area, and assuming that the scavenged prey has been exposed to witchweed-treated fields, chances that the eagles would be harmed remain very unlikely because (1) the program applies these herbicides carefully following the manufacturer's labels, and (2) major herbicides used do not bioaccumulate, nor do they persist in the environment (USDA APHIS, 2019a). Also, the disturbance of eagles is unlikely to occur because eradication activities in witchweed-infested fields and farms would not differ significantly from activities that normally occur on such properties. Therefore, it is unlikely that the witchweed program would have any impact on bald or golden eagles. If program personnel discover the presence of any bald or golden eagle nests in the witchweed-infested farms and fields, this information will be reported to the State wildlife program manager who would assist APHIS program personnel in minimizing any potential project impacts to the eagles following the National Bald Eagle Management (NBEM) Guidelines (FWS, 2018). FWS usually recommends buffer zones around active nests, and APHIS program personnel will carefully follow such recommendations whenever possible.

C. Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (16 U.S.C. 703–712) established a Federal prohibition, unless permitted by regulations, to intentionally pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird or any part, nest, or egg of any such bird.

North Carolina and South Carolina occur in the Atlantic Flyway, a bird migration route that generally follows the Atlantic Coast of North America and the Appalachian Mountains. Several hundred migratory bird species use this flyway each year (FWS, 2013), including American goldfinch (*Spinus tristis)*, American tree sparrow (*Spizella arborea)*, Baltimore oriole (*Icterus galbula)*, black-capped chickadee (*Poecile atricapillus)*, blue grosbeak *(Passerina caerulea)*, blue jay (*Cyanocitta cristata)*, brown thrasher (*Toxostoma rufum)*, chipping sparrow (*Spizella passerina)*, common redpoll (*Acanthis flammea)*, dark-eyed junco (*Junco hyemalis)*, eastern bluebird (*Sialia sialis)*, eastern meadowlark (*Sturnella magna)*, eastern towhee (*Pipilo erythrophthalmus)*, evening grosbeak (*Coccothraustes vespertinus)*, field sparrow (*Spizella pusilla)*, hermit thrush (*Catharus guttatus)*, housefinch (*Haemorhous mexicanus)*, northern cardinal (*Cardinalis cardinalis)*, northern flicker (*Colaptes auratus)*, orchard oriole (*Icterus spurius)*, pine grosbeak (*Pinicola enucleator)*, pine siskin (*Spinus pinus)*, pine warbler (*Setophaga pinus)*, purple finch (*Haemorhous purpureus)*, red-breasted nuthatch (*Sitta canadensis)*, red-winged blackbird (*Agelaius phoeniceus)*, ruby-crowned kinglet (*Regulus calendula),* ruby-throated hummingbird (*Archilochus colubris)*, song sparrow (*Melospiza melodia)*, white-throated sparrow (*Zonotrichia albicollis)*, and yellow-rumped warbler (*Setophaga coronata)*.

According to NCDNCR (2017), over 460 migratory bird species are documented to date flying through North Carolina, of which about half of that population may breed in that State. Among these migrant birds are Tundra swan (*Cygnus columbianus*), snow goose (*Chen caerulescens*), and over 20 duck species visiting from the Canadian arctic coastal plain. These birds are found to overwinter in the coastal plain national wildlife refuges and barrier islands. Program activities take place on farmlands, and usually not in the winter. In September and October, northern gannet (*Morus bassanus*) and many other fall migrators use the Outer Banks feeding on insects before flying to wintering grounds in the Caribbean and South America. On the other hand, the spring migration (March–May) is dominated by songbirds, wood warblers, vireos, thrushes, and flycatchers, usually enroute to breeding territories in the northern United States and Canada, not in the cornfields within the quarantine counties. Similarly, hawk and other raptors migrate to the western part of North and South Carolina due to the rocky outcroppings and mountain ridgelines.

Some migratory birds use the Carolina inlets as rest stops during migrations. According to the North Carolina Coastal Federation (NCCF, 2016), large flocks of red knot (*Calidris canutus*), semipalmated plover (*Charadrius semipalmatus*) and semipalmated sandpiper (*Calidris pusilla*), for example, appear at North Carolina inlets by hundreds in the months of April and May. Some of these birds lay at inlets as they require open, sandy areas for nesting, as well as natural/unstabilized spits usually found at inlets (NCCF, 2016).

As indicated above, migratory birds more likely use winter grounds in the national wildlife refuges, outer banks, barrier islands (shore birds and other waterfowl) as well as mountain areas (hawks and other raptors). Historically, these birds have not been observed in the witchweed-infested fields and farms where the program activities will take place. Therefore, it is unlikely that the witchweed eradication program would cause any harm to migratory birds.

If APHIS notices any presence of migratory bird nests in the program areas, the program personnel will try, as possible, to avoid or minimize impacts to birds or nests (for example, by establishing a buffer zone around such nests or ground-nesting breeding birds) until nestlings have fledged or breeding behaviors are no longer observed. State agencies may also establish site-specific migratory bird conservation measures, as needed, that the program personnel would follow prior to beginning program activities. As indicated in previous chapters, herbicides used in the witchweed program do not accumulate in animal tissues, nor do they persist in the environment (USDA APHIS, 2019a). APHIS program personnel will apply safety precautions as recommended by the manufacturers on labels, and will follow any mitigation measures set by Fish and Wildlife Service (whenever applicable) to avoid or minimize impacts on potential migratory bird nest sites.

D. Potential Cumulative Effects

Cumulative effects are those impacts on the environment that result from the incremental impact of a proposed 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 (CEQ NEPA Regulations, Part 1508). Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. This section discusses the potential cumulative effects relative to the three alternatives presented in chapter 2.

1. No Action Alternative

Given that State and Federal Governments will apply no herbicide in the witchweed-infested quarantines, or take any witchweed management action in such affected areas under this alternative, the program does not expect any cumulative effects to occur.

2. Quarantine Alternative

Likewise for the no action alternative, no cumulative effects resulting from the witchweed program are expected under the quarantine alternative because State and Federal Governments will apply no herbicide or witchweed management activities in infested farms and fields within the quarantine counties. The quarantine alternative only helps prevent the human spread of witchweed through the transport of contaminated materials across regions in North and South Carolina, although the possibility of natural (but not human) spread of witchweed within and beyond the quarantine could remain possible.

3. Eradication Alternative (Preferred Alternative)

Through this alternative, the State and Federal Governments propose to eradicate witchweed in infested areas using herbicides and farming management described in the previous chapters. Potential cumulative effects on the environment due to the proposed action are analyzed under this alternative.

In the previous chapter (Environmental Consequences), it is indicated that environmental impacts to natural resources (soil, water, air, vegetation, and wildlife), agriculture, historical properties, and human environment are not expected to be significant under the current proposed action. However, these impacts could increase when added to effects related to other ongoing projects in the witchweed quarantine area. Examples of such projects could be agricultural-related (e.g., USDA APHIS cogongrass control program in South Carolina) or from development (e.g., housing and road construction by other Government agencies in the quarantine areas).

In North and South Carolina, where *Imperata cylindrical* (L.) Beauv. (commonly known as cogongrass) is reported to cause damages in annual and perennial crops, the cogongrass program may (or may not) become active in some of the witchweed-regulated counties (Anne Lebrun, pers. comm.) In case it becomes active and expands to North Carolina, both witchweed and cogongrass program areas may overlap in this State particularly in Sampson and Pender Counties (Figure 8), where cogongrass is being treated with imazapyr[23] and/or glyphosate. In the witchweed-cogongrass overlapping areas (Sampson and Pender Counties), there is a possibility that both programs would cause cumulative environmental effects on resources. However, this eventuality is expected to be minimal given the mitigation measures applied by both programs, including the use of specific formulations that cause no or negligible runoff drift; use of buffers that prevent potential pollution of water systems; chemical uses applied (or supervised) by certified USDA personel; use of PPE and careful followup of manufacturer's labels and USEPA's precautionary recommendations. Therefore, potential cumulative effects to terrestrial and human environment are expected to be minor.

Potential cumulative effects to aquatic resources are also negligible because herbicides are soil-applied or foliar-applied, that is these are not sprayed on surface waters or aquatic resources; the program workers will apply buffers, among other measures listed earlier, if treated farms and fields are near water systems.

The cumulative impacts from the proposed action, relative to the current baseline and to past, present, and future activities in the regulated counties, constitute a small incremental change in the environment. Other past and present USDA APHIS activities in the southeastern United States in general include the boll weevil eradication program, the imported fire ant program, and activities such as wildlife damage control. Overall USDA APHIS expects cumulative impacts from these programs to be more positive (e.g., suppression of witchweed and ecosystem improvement) than negative (if any). USDA APHIS programs minimize potential negative cumulative impacts under their proposed actions by following mitigation measures such as those listed above.

Under the Eradication Alternative (preferred alternative), USDA APHIS would have incrementally no significant effects on the environment.

[23] Imazapyr is a non-selective herbicide used for the control of a broad range of weeds including annual and perennial grasses, broadleaved herbs, woody species, and riparian and emergent aquatic species.

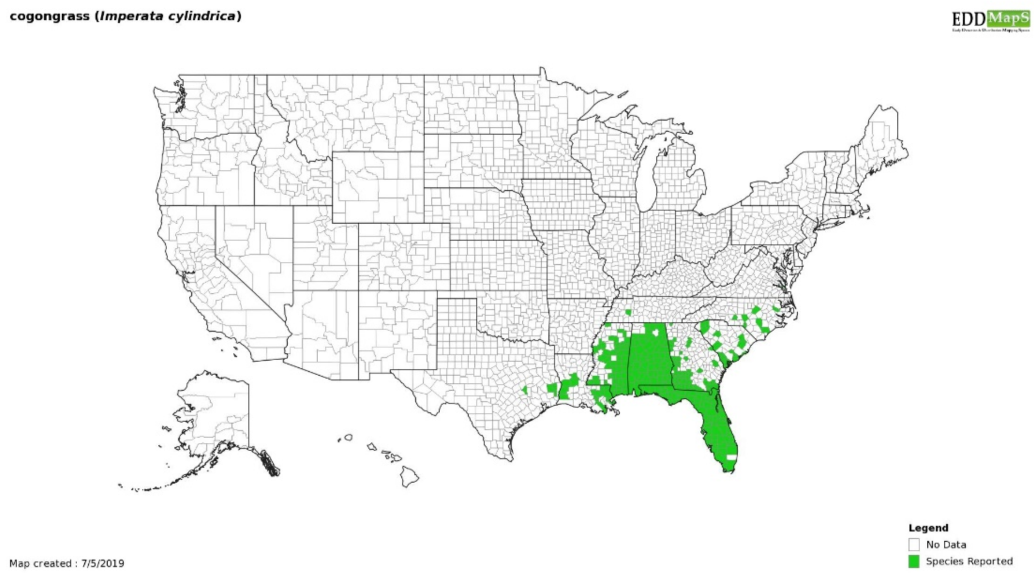

Figure 8. Distribution of cogongrass *Imperata cylindrica* (L.) in the United States (Source: EDDMapS. 2019. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed July 5, 2019)

VI. Listing of Persons and Agencies Consulted

The USDA APHIS witchweed program is a cooperative effort with affected States (North and South Carolina). State inspectors cooperate with APHIS inspectors in witchweed surveys. State personnel also assist in the treatment and certification of regulated articles transported outside the quarantine areas.

USDA APHIS has consulted with several people and other agencies to gather, exchange, and review the information included in this environmental assessment. These are:

Joe Beckwith
State Plant Health Director - North Carolina
USDA APHIS
920 Main Campus Drive, Suite 150
Raleigh, NC 27606

Renee Gledhill-Earley
State Historic Preservation Office
109 E Jones Street, Room 258
Raleigh, NC 27601

Joy A. Goforth
Plant Pest Administrator
NCDA & Cultural Resources
Plant Industry Division
216 W Jones Street
Raleigh NC 27603

Jonathan M. Jones
APHIS PPQ PHP Pest Management
4700 River Rd. Unit 137
Suite 4C-01.62
Riverdale, MD 20737

Anne LeBrun
USDA PPQ
National Policy Manager Pest Management
Plant Health Programs
4700 River Rd. Unit 137
Suite 4A-03.26
Riverdale, MD 20737

Carl Lightfoot
APHIS PPQ PHP
State Plant Health Director
4600 Goer Dr., Suite 104
Charleston, SC 29406

Carol Motloch
Acting National Operations Manager
APHIS PPQ
903 San Jacinto Blvd., Ste. 270
Austin, TX 78701

North Carolina Department of Agriculture and
Consumer Services Plant Industry Division
2 West Edenton St.
Raleigh, NC 27601

North Carolina Department of Natural and Cultural Resources
Natural Heritage Program, Nature Research Center
121 Jones St.
1651 Mail Service Center
Raleigh, NC 27699

Judith Ratcliffe, Zoologist
North Carolina Natural Heritage Program
121 Jones St.
MSC 1651
Raleigh, NC 27699

Renee Shearin
State Historic Preservation Office
Division of Historical Resources
Office of Archives and History
North Carolina Department of Natural and Cultural Resources
109 Jones St.
MSC 4617
Raleigh, NC 27699

U.S. Department of Agriculture
APHIS PPD Environmental Risk and Analysis Services
4700 River Road, Unit 149
Riverdale, MD 20737

U.S. Department of Agriculture
APHIS PPQ PHP-Pest Management
4700 River Road, Unit 26
Riverdale, MD 20737

VII. References

Adomako, M.O., and S. Akyeampong, 2016. Effects of some commonly used herbicides on soil microbial population. Journal of Environment and Earth Science 6:30-38.

Anatra-Cordone, M., Cynthia King, Julie Klotzbach, Patrick R. Durkin, 2005. Oxyfluorfen - Human Health and Ecological Risk Assessment. SERA TR 05-43-26-03b.

APHIS BRS, 2011. Dow AgroSciences Petition (09-233-01p) for Determination of Nonregulated Status of HerbicideTolerant DAS-40278-9 Corn, Zea mays, Event DAS40278-9. Draft Environmental Assessment, October 2011. https://www.aphis.usda.gov/brs/aphisdocs/09_23301p_dea.pdf

APHIS PPQ, 1986. Witchweed environmental assessment. Hard copy available in APHIS PPD ERAS Reading Room (PPQ-9).

APHIS PPQ, 2011. Witchweed: A parasitic pest; Plant Protection and Quarantine factsheet. https://www.aphis.usda.gov/publications/plant_health/2011/witchweed_parasitic_pest.pdf

APHIS PPQ, 2015. Plant Protection and Quarantine [PPQ] strategic plan 2015-2019. Available online at https://www.aphis.usda.gov/plant_health/downloads/PPQ-Strategic-Plan-2019.pdf [Last accessed: April 2018]

ATSDR, 2019. Toxicological profile for glyphosate - Draft for public comment. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. Atlanta, Georgia.

Benbrook, C.M., 2019. How did the USEPA and IARC reach diametrically opposed conclusions on the genotoxicity of glyphosate-based herbicides? Environmental Sciences Europe 31:2.

CABI, 2017. *Striga asiatica* (witchweed), Datasheet
Available online at https://www.cabi.org/isc/datasheet/51786. [Last accessed: April 2018]

Csurhes, S., A. Markula, and Y. Zhou, 2016. Witchweed (*Striga* spp.)
Invasive plant risk assessment, Department of Agriculture and Fisheries Biosecurity Queensland. Available online at https://www.daf.qld.gov.au/__data/assets/pdf_file/0009/67644/Witchweed-risk-assessment.pdf [Last accessed: April 2018]

Durkin, P.R., 2011. Trifluralin human health and ecological risk assessment. SERA TR-052-26-03a, Final Report, Sept. 2011. Available online at https://www.fs.fed.us/foresthealth/pesticide/pdfs/Trifluralin_SERA_TR-052-26-03a.pdf [Last accessed Sept. 2019]

Gade, Ole; Arthur B. Rex; James E. Young; with L. Baker Perry, 2002. North Carolina: People and environments, 2nd Edition. Parkway Publishers, Inc., Boone, NC, 2002, 602 pp., available online at https://geo.appstate.edu/department-resources/nc-people-and-environments [Last accessed: April 2018]

Gagnon, J., 2011. You ain't from around here! Exotic invasive of the quarter: Witchweed (*Striga asiatica*). Virginia Forest Landowner Update Vol. 25 No. 2, spring, 2011.

IARC, 2015. Some organophosphate insecticides and herbicides. IARC Monographs.
Johnson, P.D., 2003. Freshwater mollusks [Online]. Georgia Humanities and the University of Georgia Press. Available: https://www.georgiaencyclopedia.org/articles/geography-environment/freshwater-mollusks [Last accessed July 3, 2019].

Iastate—See Iowa State University

Iowa State University, 2004. A technical assessment of nonpoint pollution in Iowa. College of Agriculture, Iowa State University, pp. 78-79 of the IC-492(13)

Iverson, Richard. D., Randy G. Westbrooks, Robert E. Eplee, and Alan V. Tasker, 2011. Overview and status of the witchweed (Striga asiatica) eradication program in the Carolinas. Invasive Plant Management Issues and Challenges in the United States: 2011 Overview, Chapter 6, pp 51–68. *ACS Symposium Series*, Vol. 1073; Online Publication on September 16, 2011 at https://pubs.acs.org/doi/pdf/10.1021/bk-2011-1073.ch006 [Last accessed: April 2018]

Jones, P., 2011. Successful quarantine efforts contain witchweed to five counties. Available online at http://info.ncagr.gov/blog/2011/08/15/successful-quarantine-efforts-contain-witchweed-to-five-counties/ [Last accessed: April 2018]

Lassiter, B., 2015. Witchweed eradication project; plant industry - Plant Protection Section. A cooperative project between NCDACS, SCDPI, and APHIS PPQ. Available online at http://www.ncagr.gov/PLANTINDUSTRY/plant/weed/witchnc.htm [Last accessed: April 2018]

Lassiter, B., 2018. Witchweed eradication project; Plant Industry - Plant Protection Section. A cooperative project between NCDACS, SCDPI, and APHIS PPQ. Available online at http://www.ncagr.gov/PLANTINDUSTRY/plant/weed/witchnc.htm [Last accessed: October 2019]

Nagoya University Institute of Transformative BIO-Molecules (ITbM), 2015. Fluorescent turn-on probe identifies the 'wake-up protein' in witchweed seeds. Available online at August 21, 2015, https://phys.org/news/2015-08-fluorescent-turn-on-probe-wake-up-protein.html#jCp. [Last accessed: May, 2019]

Nail, K., Kriticos, D.J., Scott, J.K., Yonow, T., and Ota, N., 2014. *Striga asiatica* pest geography. St. Paul, MN: InSTePP-HarvestChoice. Available online at http://www.instepp.umn.edu/sites/default/files/product/downloadable/Striga%20asiatica.pdf [Last accessed: May 29, 2019]

NCCF—See North Carolina Coastal Federation

NCDEQ—See North Carolina Department of Environmental Quality

NCDNCR—See North Carolina Department of Natural and Cultural Resources

NIH—See National Institute of Health

North Carolina Coastal Federation, 2016. Migratory birds use North Carolina inlets as rest stops. https://www.nccoast.org/2016/05/migratory-birds-use-north-carolina-inlets-rest-stops. [Last accessed: May 2019]

North Carolina Department of Environmental Quality, 2016. Available online at https://deq.nc.gov/press-release/air-quality-officials-issue-health-notice-eastern-north-carolina [Last accessed: April 2018]

North Carolina Department of Natural and Cultural Resources, 2017. North Carolina's Must-See Bird Migrations. https://www.ncdcr.gov/blog/2017/05/11/north-carolinas-must-see-bird-migrations [Last accessed: May 2019]

National Institute of Health, 2017. Ethylene. CASRN: 74-85-1, UNII: 91GW059KN7 Reviewed by SRP 9/14/2017. Available online at https://toxnet.nlm.nih.gov/cgi-bin/sis/search2/r?dbs+hsdb:@term+@rn+@rel+74-85-1 [Last accessed August 2019]

SCDA—See South Carolina Department of Agriculture

SCDNR—See South Carolina Department of Natural Resources

Sieczka J.B., 1989. Some negative aspects of crop rotation. In: Vos J., Van Loon C.D., Bollen G.J. (eds) Effects of Crop Rotation on Potato Production in the Temperate Zones. Developments in Plant and Soil Sciences, vol 40. Springer, Dordrecht. Available online at https://link.springer.com/chapter/10.1007%2F978-94-009-2474-1_23

South Carolina Department of Agriculture, 2015. South Carolina Department Witchweed Eradication Operations Manual. Revised January 2015, Mullins, SC.

South Carolina Department of Natural Resources, undated. Coastal plain vegetation and wildlife. Available online at http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainhabitat.pdf [Last accessed: April 2018]

Spallek, T., Musembi Mukutu, and Ken Shirasu, 2013. The genus *Striga*: a witch profile. Molecular Plant Pathology (2013) 14(9), 861–869. Available online at https://onlinelibrary.wiley.com/doi/epdf/10.1111/mpp.12058 [Last accessed: April 2018]

Stringer, Christina E.; Krauss, Ken W.; Latimer, James S., eds., 2016. Headwaters to estuaries: advances in watershed science and management - Proceedings of the Fifth Interagency Conference on Research in the Watersheds. March 2-5, 2015, North Charleston, South Carolina. e-Gen. Tech. Rep. SRS-211. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 302 p. Available online at https://www.georgiaencyclopedia.org/articles/science-medicine/coastal-plain-geologic-province [Last accessed: August 2019]

USDA—See U.S. Department of Agriculture

U.S. Department of Agriculture AgCensus, 2012. Census of Agriculture, Census Publications, State and County Profiles, North Carolina (https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/North_Carolina/) and South Carolina (https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/South_Carolina) [Last accessed: April 2018]

U.S. Department of Agriculture, Agricultural Marketing Service, 2007. Ethylene Crops Identification; NOSB Materials Database, CAS Number 74-85-1. Available online at www.ams.usda.gov/sites/default/files/media/Ethylene%201%20TR%202007.pdf [Last accessed: June 2019]

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2007. Witchweed quarantine regulations; regulated areas in North Carolina and South Carolina. Federal Register Vol. 72, No. 35 (pp. 7923-7926).
Available online at https://www.govinfo.gov/content/pkg/FR-2007-02-22/pdf/E7-3013.pdf [Last accessed: July 31, 2019]

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2011. Dow AgroSciences petition (09-233-01p) for determination of nonregulated status of herbicide-Tolerant DAS-40278-9 Corn, Zea mays, Event DAS40278-9
OECD Unique Identifier: DAS-40278-9; Draft environmental assessment. Available online at https://www.aphis.usda.gov/brs/aphisdocs/09_23301p_dea.pdf
[Last accessed: August 2019]

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2019a. Witchweed eradication in North and South Carolina. ecological risk assessment for pesticide uses.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2019b. Biological assessment for a program to eradicate witchweed (*Striga asiatica*) from Areas in North Carolina and South Carolina; May 2019.

U.S. Department of Agriculture, OBPA—See U.S. Department of Agriculture, Office of Budget and Program Analysis

U.S. Department of Agriculture, Office of Budget and Program Analysis, 2018. APHIS' 2019 President's Budget notes. Available online at https://www.obpa.usda.gov/20aphis2019notes.pdf [Last accessed: April 2018]

USEPA—See U.S. Environmental Protection Agency

U.S. Environmental Protection Agency, 1997. Reregistration eligibility decision (RED) Pendimethalin, EPA 738-R-97-007, dated June 1997, 264 pp.

U.S. Environmental Protection Agency, 2000. Notice of filing a pesticide petition to establish a tolerance for certain pesticide chemicals in or on food; FR Vol. 5, No. 11, [2612-2617]. Available online at https://www.govinfo.gov/content/pkg/FR-2000-01-18/pdf/00-1064.pdf

U.S. Environmental Protection Agency, 2002a. Memorandum - HED Human health risk assessment for DCPA to support new uses on California parsley and other minor crops (D281320), dated July 8, 2002. Available online at https://www3.epa.gov/pesticides/endanger/litstatus/effects/redleg-frog/dcpa/appendix-f.pdf

U.S. Environmental Protection Agency, 2002b. Memorandum - Oxyfluorfen: Second revised occupational and residential non-cancer and cancer exposure and risk assessments for the reregistration eligibility decision
(RED) document [Case # 819447, PC Code 111601, DP Barcode D281831], dated May 1, 2002, 103 pp.

U.S. Environmental Protection Agency), 2004. Poast herbicide. BASF, the Chemical Company. Available online at https://www3.epa.gov/pesticides/chem_search/ppls/007969-00058-20041208.pdf_ [Last accessed August 2019]

U.S. Environmental Protection Agency, 2005. Reregistration eligibility decision for 2,4-D, EPA 738-R-05-02, June 2005, 320 pp.

U.S. Environmental Protection Agency, 2008. Reregistration eligibility decision (RED) for methyl bromide (soil and nonfood structural uses). EPA 738-R-08-005, July 2008, 118 pp.

U.S. Environmental Protection Agency, 2009. Risks of DCPA Use to Federally Threatened California Red-legged Frog (Rana aurora draytonii): Pesticide Effects Determination; February 19, 2009. Available online at https://www3.epa.gov/pesticides/endanger/litstatus/effects/redleg-frog/dcpa/analysis.pdf [accessed October 15, 2019].

U.S. Environmental Protection Agency, 2011a. Memorandum - DCPA. (Chlorthal dimethyl). Human health assessment scoping document in support of registration review, dated May 27, 2011, 23 pp.

U.S. Environmental Protection Agency, 2011b. Memorandum - DCPA: Review of human incidents, dated March 1, 2011.

U.S. Environmental Protection Agency, 2012a. Memorandum - Pendimethalin: Human health assessment scoping document in support of registration review.

U.S. Environmental Protection Agency, 2012b. Memorandum - Pendimethalin: Review of human incidents, dated July 10, 2012, 5 pp.

U.S. Environmental Protection Agency, 2013. Label amendment for product name: Goal 2XL herbicide, EPA Registration Number: 62719-424, Application Dated: July 31.2012.

U.S. Environmental Protection Agency, 2014a. Memorandum - Oxyfluorfen: Human health assessment scoping document in support of registration review.

U.S. Environmental Protection Agency, 2014b. Memorandum - Oxyfluorfen: Tier I review of human incidents, dated July 17, 2014, 5 pp.

U.S. Environmental Protection Agency, 2014c. Memorandum - Oxyfluorfen: Tier I review of human incidents, dated July 17, 2014, 5 pp.

U.S. Environmental Protection Agency, 2014d. Memorandum - Sethoxydim: Tier I review of human incidents, dated October 23, 2014, 4 pp.

U.S. Environmental Protection Agency, 2015. Prowl H20 Herbicide: EPA registration number: 241-418; Available online at https://www3.epa.gov/pesticides/chem_search/ppls/000241-00418-20150129.pdf [Last accessed September 23, 2019]

U.S. Environmental Protection Agency, 2015. Memorandum - Sethoxydim: Human health risk assessment for registration review and to support the section 3 registration of proposed uses on high bush blueberry and fine fescue grasses, dated February 3, 2015, 70 pp.

U.S. Environmental Protection Agency, 2015b. Prowl H20 Herbicide: EPA registration number: 241-418; Available online at https://www3.epa.gov/pesticides/chem_search/ppls/000241-00418-20150129.pdf [Last accessed September 23, 2019]

U.S. Environmental Protection Agency, 2015a. Methyl bromide use. Notice pursuant to 40 CFR Part 54 Prior to Filing of Civil Action under 42 U.S .C. § 7604(a) (2) for Failure to Take Nondiscretionary Actions. Available online at https://www.epa.gov/sites/production/files/2015-09/documents/vr_noi_08062015_0.pdf
[Last accessed October 1st, 2019]

U.S. Environmental Protection Agency, 2016. Methyl bromide (Bromomethane). Production file # 74-83-9. Available online at
https://www.epa.gov/sites/production/files/2016-09/documents/methyl-bromide.pdf [Last accessed October 1st, 2019]

U.S. Environmental Protection Agency, 2016a. 2.4-D. Human health risk assessment for registration review, dated June 21, 2016, 128 pp.

U.S. Environmental Protection Agency, 2016b. Memorandum - 2,4-D: tier II incident report, dated June 28, 2016, 46 pp.

U.S. Environmental Protection Agency, 2017. Paraquat dichloride human health mitigation decision notice of availability; Federal Register/Vol. 82, No. 1. Available online at https://www.federalregister.gov/documents/2017/01/03/2016-31832/paraquat-dichloride-human-health-mitigation-decision-notice-of-availability [Last accessed August 2019]

U.S. Environmental Protection Agency, 2017a. Memorandum: glyphosate draft human health risk assessment in support of registration review. U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention. Washington, D.C.

U.S. Environmental Protection Agency, 29017c. Revised glyphosate issue paper: evaluation of carcinogenic potential. U.S. Environmental Protection Agency, Office of Pesticide Programs.

U.S. Environmental Protection Agency, 2017b. Memorandum – pendimethalin – draft human health risk assessment to support registration review, dated June 26, 2017, 21 pp.

U.S. Environmental Protection Agency, 2018. Label amendment – incorporating supplemental labels for product name: Prowl H2O Herbicide, EPA Registration Number: 241-418, Application Dated: September 29, 2017. Decision Number: 534826. 43 pp.

U.S. Environmental Protection Agency, 2018a. Memorandum - trifluralin: human health draft risk assessment for registration review and a proposed section 3 use of trifluralin on rosemary, dated June 28, 2018, 63 pp.

U.S. Environmental Protection Agency, 2018b. Memorandum - trifluralin: preliminary ecological risk assessment for registration review, dated May 10, 2018, 85 pp.

U.S. Environmental Protection Agency, 2018c. Memorandum - trifluralin: tier I review of human incidents and epidemiology for draft risk assessment, dated May 15, 2018, 47 pp.

U.S. Environmental Protection Agency, 2019. Label amendment – incorporating supplemental label for product name: Poast, EPA Registration Number: 7969-58, Application Dated: February 2, 2018, Decision Number: 542318, 45 pp.

USFWS—See U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service, 2013. General provisions; revised list of migratory birds. Federal Register Vol. 78, No. 212, pp. 65843-65864 Available online at https://www.fws.gov/migratorybirds/pdf/policies-and-regulations/MBTAListofBirdsFinalRule.pdf [Last accessed May 28, 2019].

U.S.Fish and Wildlife Service, 2018. Federally endangered, threatened, and candidate species in Mississippi. USFWS Mississippi Field Office. Available online at www.fws.gov/mississippiES/_pdf/MS_Species_Habitat_Descriptions_2018final.pdf [Last accessed October 1, 2018]

Vukovich, Mark, Kelsey L. Turner, Tracy E. Grazia, Thomas Mims, James C. Beasley, and John C. Kilgo, 2015. Wintering golden eagles on the coastal plain of South Carolina. J. Field Ornithol. 86(4):337–344. Available online at https://www.researchgate.net/publication/285580778/download [Last accessed: September 2018]

Appendix A: Witchweed (*Striga asiatica*) and Other Weed Species of the Genus *Striga* and the Family Orobanchaceae (Csurhes et al., 2016)

Striga species	Authority	Distribution
S. aequinoctialis	Chev. Ex Hutch. & Dalz.	W. Africa
S. angolensis	K.I. Mohamed & L.J. Musselman	Angola
S. angustifolia	(Don) Saldanha	E. Africa, Asia, Indonesia
S. asiatica syn. S. lutea (Asiatic witchweed, red witchweed)	(L.) Kuntz Loureiro	Africa, Arabian peninsula, India, Burma, China, Indonesia, Philippines, Malaysia, New Guinea, USA (introduced)
S. aspera	(Wild) Benth.	Africa
S. bilabiate	(Thunb.) O. Ktze.	Africa
ssp. *barteri*	(Engl.) Heper	
ssp. *bilabiata*	Kuntze	
ssp. *ledermannii*	(Pilger) Hepper	
ssp. *linearifolia*	(Schum. & Thonn.) Mohamed	
ssp. *rowlandii*	(Engl.) Hepper	
S. brachycalyx	Sckan	Africa
S. chrysantha	A. Raynal	Central Africa
S. dalzielii	Hutch.	W. Africa
S. elegans (elegant witchweed)	Benth.	Angola, Malawi, S. Africa, Zimbabwe
S. forbesii (giant mealie witchweed)	Benth.	Africa, Madagascar
S. gastonii	A. Raynal	Chad and Central African Republic
S. gesnerioides syn. *S. orobanchoides* (cowpea witchweed, tobacco witchweed)	(Willd) Vatke Benth.	Africa, Arabian peninsula, India, USA (introduced)
S. gracillima	Melch.	Tanzania
S. hallaei	A. Raynal	Gabon, Democratic Republic of Congo
S. hermonthica syn. *S. senegalensis* (purple witchweed)	(Del.) Benth. Benth.	Senegal to Ethiopia, Democratic Republic of Congo and Tanzania, Angola, Namibia
S. hirsuta	Benth.	Madagascar
S. junodii	Schinz	S. Africa, Mozambique
S. klingii	(Engl.) Skan	W. Africa, Nigeria, Ghana, Cameroon, Togo
S. latericea	Vatke	E. Africa, Ethiopia, Somalia

S. lepidagathidis	A. Raynal	Senegal, Guinea, Guinea Bissau.
S. lutea	Lour.	Sudan, Ethiopia
S. macrantha	(Benth.) Benth.	W. Africa, Nigeria, Ivory Coast, Togo
S. passargei	Engl.	W. & C. Africa, Arabian peninsula (?)
S. pinnatifida	Getachew	Ethiopia
S. primuloides	A. Chev.	Ivory Coast, Nigeria
S. pubiflora	Klotzsch	Somalia
S. yemenica	Musselman and Hepper	Ethiopia

Appendix B: List of Historic Properties in the Witchweed-Regulated Counties in North Carolina

Historic Property Name	Reference Number	Date Listed	Address
Bladen County			
Brown Marsh Presbyterian Church	75001239	9/2/1975	N of Clarkton on SR 1700 off SR 1762, Clarkton
Carver's Creek Methodist Church	08000365	4/30/2008	16904 NC Highway 87 East, Council
John Hector Clark House	87000039	5/20/1987	South Grove St. & East Green St., Clarkton
Clarkton Depot	86003463	12/23/1986	NW corner of Elm and Hester St. junction, Clarkton
Desserette	87001786	10/7/1987	SW corner of SR 1320 near SR 1318 junction, White Oak
Gilmore-Patterson Farm	99000912	07/28/1999	20337 Hwy 87 West, St. Paul, NC 28384
Harmony Hall	72000925	3/24/1972	W of White Oak on SR 1351 & SR 1318 junction, White Oak
Mount Horeb Presbyterian Church and Cemetery	87000695	5/13/1987	SW corner of NC 87 and SR 1712 Junction
Oakland Plantation	72000924	4/25/1972	N of SR 1730, Carvers
Purdie House and Purdie Methodist Church	77000989	7/28/1999	E of Tar Heel, Tar Heel
South River Presbyterian Church	96000563	5/23/1996	NE of NC 210 & SE of junction with U.S. 701
Trinity Methodist Church	89001419	9/14/1989	NW corner Broad & Lower Sts., Elizabethtown
Walnut Grove	75001241	5/29/1975	E of Tar Heel on NC 87, Tar Heel
Cumberland County			
Atlantic Coast Line Railroad Station	82001294	7/7/1982	472 Hay St., Fayetteville
Barge's Tavern	83001843	7/7/1983	519 Ramsey St., Fayetteville
Belden-Horne House	72000955	3/16/1972	519 Ramsey St., Fayetteville
Big Rockfish Presbyterian Church	83001844	7/21/1983	SR 2268, Hope Mills
Brownlea	03000803	8/21/2003	405 Southampton Court, Fayetteville
Camp Ground Methodist Church	83001845	7/7/1983	Camp Ground Rd., Fayetteville
Cape Fear and Yadkin Valley Railway Passenger Depot	83001846	7/7/1983	148 Maxwell St., Fayetteville
Cape Fear Baptist Church	83003816	10/13/1983	SR 2233, Hope Mills

The Capitol	05000376	5/4/2005	126 Hay St., Fayetteville
Carolina Theater	83001847	7/7/1983	443 Hay St., Fayetteville
Confederate Breastworks	81000421	10/7/1981	2300 Ramsey St., Fayetteville
Cool Spring Place	72000956	10/10/1972	119 N. Cool Spring St., Fayetteville
Cool Springs	85002417	9/19/1985	Off SR 1607 at Cumberland, near Carvers Creek
Cross Creek Cemetery No.1	98001209	9/25/1998	Off Raeford Rd (NC 401), Fayette NC 28304
Cumberland County Courthouse	79001696	5/10/1979	Franklin, Gillespie, and Russell Sts., Fayetteville
John Davis House	83001848	7/7/1983	910 Arsenal Ave., Fayetteville
DeVane-MacQueen House	83001849	7/21/1983	NC 87, near Grays Creek
Ellerslie	74001344	8/7/1974	West of Linden on SR 1607 at the junction with SR 1606, near Linden
Evans Metropolitan A.M.E. Zion Church	83001850	7/7/1983	301 N. Cool Spring St., Fayetteville
Falcon Tabernacle	83003814	10/11/1983	West St., Falcon
Fayetteville Downtown Historic District	99000779	7/1/1999	Roughly along Hay, Person, Green, Gillespie, Bow, Old, W. Russell and Cool Spring Sts., Fayetteville
Fayetteville Ice and Manufacturing Company: Plant and Engineer's House	83001851	7/7/1983	436 Rowan St. and 438 Rowan St., Fayetteville
Fayetteville Mutual Insurance Company Building	83001852	7/7/1983	320 Hay St., Fayetteville
Fayetteville Veterans Administration Hospital Historic District	12000799	9/19/2012	2300 Ramsey St., Fayetteville
Fayetteville Women's Club and Oval Ballroom	73001330	2/6/1973	224 Dick St., Fayetteville
First Baptist Church	83001853	7/7/1983	200 Old St., Fayetteville
First Presbyterian Church	76001317	4/30/1976	Ann and Bow Sts., Fayetteville
Gully Mill	83001854	7/7/1983	S.R. 1839, near Fayetteville
Hangars 4 and 5, Pope Air Force Base	90002153	1/16/1991	Bldg. 708, Pope AFB, Fayetteville
Hay Street United Methodist Church	83001855	7/7/1983	Hay St. at Ray and Old Sts., Fayetteville
Haymount Historic District	83001856	8/7/1983	Roughly Hillside Ave, from Bragg Blvd. to Purshing St.; 100-200 blks Bradford Ave., 801 Hay St., 801, 802, 806 Arsenal Ave., Fayetteville
Holt-Harrison House	83001857	7/7/1983	806 Hay St., Fayetteville
Hope Mills Historic District	85001515	7/9/1985	Roughly bounded by Seaboard Coastline RR tracks, Lakeview Rd., Little Creek and Cross St., Hope Mills

Kyle House (Fayetteville)	72000957	6/19/1972	234 Green St., Fayetteville
Liberty Row (Fayetteville)	73001331	8/14/1973	N Side of the first block of Person St., bounded by Market Sq. and Liberty Point, Fayetteville
Long Valley Farm	94000032	6/6/1994	Carvers Creek State Park, near Spring Lake, NC 28390
M & O Chevrolet Company (Fayetteville)	83001858	7/7/1983	412 W. Russell St., Fayetteville
Mansard Roof House (Fayetteville)	73001332	3/20/1973	214 Mason St., Fayetteville
Market House (NHL) (Fayetteville)	70000451	9/15/1970	Market Sq., Fayetteville
Market House Square District (Fayetteville)	83001860	7/7/1983	Hay, Person, Green, and Gillespie Sts., Fayetteville
Massey Hill High School (Fayetteville)	04001387	12/23/2004	1062 Southern Ave., Fayetteville
Maxwell House (Stedman vicinity)	85000380	2/28/1985	Off NC 24, near Stedman,
McArthur-Council House	83001861	7/21/1983	SR 2244, near Grays Creek
McCall House (Arsenal House) (Fayetteville)	83001862	7/7/1983	822 Arsenal Ave., Fayetteville
William McDiarmid House (Fayetteville)	83001863	7/7/1983	330 Dick St., Fayetteville
Henry McLean House (Fayetteville)	83001864	7/7/1983	1006 Hay St., Fayetteville
Nimocks House (Fayetteville)	72000958	1/20/1972	225 Dick St., Fayetteville
North Carolina Arsenal Site (Archaeology) (Fayetteville)	83001865	2/23/1983	Fayetteville, NC (Address Restricted)
Oak Grove (Erwin vicinity)	73001329	2/6/1973	South of Erwin near the junction of NC 82 and SR 1875, near Erwin
John A. Oates House (Fayetteville)	83001866	7/7/1983	406 St. James Sq., Fayetteville
Old Bluff Presbyterian Church (Wade vicinity)	74001345	8/7/1974	4100 Old Bluff Rd., Godwin
Orange Street School (Fayetteville)	87001597	9/22/1987	500 blk. of Orange St., jct. of Orange and Chance Sts., Fayetteville
John E. Patterson House (Gone) (Fayetteville)	83001867	7/7/1983	445 Moore St., Fayetteville
Phoenix Masonic Lodge No. 8 (Fayetteville)	83001868	7/7/1983	221 Mason St., Fayetteville
Edgar Allen Poe House (Fayetteville)	83001869	7/7/1983	206 Bradford Ave., Fayetteville
Pope Air Force Base Historic District (Pope Air Force Base)	90002152	1/25/1991	Bldgs. 300, 302, 306, and Old Family Housing Units, Fayetteville

Prince Charles Hotel (Fayetteville)	83001870	7/7/1983	430 Hay St., Fayetteville
Saint John's Episcopal Church (Fayetteville)	74001343	9/6/1974	302 Green St., Fayetteville
Saint Joseph's Episcopal Church (Fayetteville)	82003447	6/1/1982	Ramsey and Moore Sts., Fayetteville
Sedberry-Holmes House (Fayetteville)	75001252	9/2/1975	232 Person St., Fayetteville
Seventy-First Consolidated School (Fayetteville)	04001388	12/23/2004	6830 Raeford Rd., Fayetteville
Dr. Ezekial Ezra Smith House (Fayetteville)	15000237	5/13/2015	135 S. Blount St., Fayetteville
Frank H. Stedman House (Fayetteville)	02000966	9/14/2002	1516 Morganton Rd., Fayetteville
Robert Strange Country House (Fayetteville)	83001871	7/7/1983	309 Kirkland Dr., Fayetteville
Taylor-Utley House (Fayetteville)	83001872	7/7/1983	916 Hay St., Fayetteville
United States Post Office (Fayetteville)	83001873	7/7/1983	301 Hay St., Fayetteville
Dr. William C. Verdery House (Fayetteville)	07000904	9/5/2007	Morganton Rd & Dobbin Ave., Fayette NC 28305
Waddill's Store (Fayetteville)	83001874	7/7/1983	220 Hay St., Fayetteville
Westlawn (Fayetteville)	80002815	9/22/1980	1505 Fort Bragg Rd., Fayetteville
Robert Williams House (Eastover vicinity)	83001875	7/21/1983	SR 1728, near Eastover

Robeson County

Asbury Methodist Church (Raynham)	09000264	4/30/2009	Raynham; SE. side U.S. Hwy. 301 N., .10 mi. SW. of NC 1154
Ashpole Presbyterian Church	82001302	10/19/1982	Rowland; NW of Rowland of SR 1138
Baker Sanatorium (Lumberton)	98001240	10/8/1998	Roughly Sixth St., Elm St., Fifth St., Chestnut St., Second St., Walnut St., Seaboard Coast Railroad tracks, & Water St., Lumberton
Luther Henry Caldwell House (Lumberton)	78001971	9/18/1978	209 Caldwell St., Lumberton
Carolina Theatre (Lumberton)	81000426	7/9/1981	319 N. Chestnut St., Lumberton
Centenary Methodist Church (Rowland)	07000294	4/10/2007	2585 NC 130 E, jct. with NC 2462, near Rowland
Fairmont Commercial Historic District (Fairmont)	10000163	4/7/2010	Bordered Roughly by Byrd St. on the N., Walnut St. on the E., Red Cross St. on the S., & Alley St. on the W., Fairmont

Humphrey-Williams Plantation (Lumberton vicinity)	73001367 (original) 88002608 (boundary increased)	7/24/1973 (original) 11/16/1988 (boundary increased)	West of Lumberton on NC 211, between SR 1001 and SR 1769, Lumberton
Lumberton Commercial Historic District (Lumberton)	89002131	12/21/1989	Roughly Sixth St., Elm St., Fifth St., Chestnut St., Second St., Walnut St., Seaboard Coast Railroad tracks, & Water St., Lumberton
Flora MacDonald College (Red Springs)	76001336	4/3/1976	College St. and 2nd Ave., Red Springs
Maxton Historic District (Maxton)	99000199	2/12/1999	Roughly bounded by Graham St., Martin Luther King Dr., McCaskill St., and Florence St., Maxton
Kenneth McKinnon House (St. Pauls vicinity)	05001029	9/15/2005	South Side of NC 20, SE corner of NC 20 and NC 1907, near St. Pauls
Old Main (Pembroke State University) (Pembroke)	76001335	5/13/1976	Pembroke; W of jct. of NC 711 and SR 1340
Former Pembroke High School (Pembroke)	95001071	9/1/1995	Pembroke; E of the jct. of Hwy. 711 and NC 1561
Philadelphus Presbyterian Church (Philadelphus)	75001287	10/3/1975	SR 1318 SW of jct. with NC 72, Philadelphus
Planters Building (Lumberton)	87001913	11/3/1987	312 N. Chestnut St., Lumberton
Robeson County Agricultural Building (Lumberton)	12000216	4/16/2012	108 W. 8th St., Lumberton
Rowland Depot (Rowland)	01000511	5/18/2001	W. Main St. and W. Railroad St., Rowland
Alfred Rowland House (Lumberton)	07001411	1/17/2008	1111 Carthage Rd., Lumberton
Rowland Main Street Historic District (Rowland)	04001582	2/2/2005	Roughly bounded by the 100 and 200 blks. of W. Main St., 100 blk. of E. Main St., and Hickory and E and W Railroad Sts., Rowland
W. R. Surles Memorial Library (Proctorville)	09000725	9/16/2009	105 W. Main St., Proctorville
United States Post Office (Federal Nomination)	85000483	3/6/1985	606 N. Elm St., Lumberton
Williams-Powell House (Orrum vicinity)	84002453	4/9/1984	SR 2256, near Orrum

Sampson County

Beatty-Corbett House (Ivanhoe vicinity)	86000549	3/17/1986	SR 701 at SR 1200, near Ivanhoe
Bethune-Powell Buildings (Clinton)	86000580	3/17/1986	118-120 E. Main St., Clinton
Asher W. Bizzell House (Rosin)	86001125	5/21/1986	U.S. 13 and SR 1845, Rosin

Black River Presbyterian and Ivanhoe Baptist Churches (Ivanhoe)	86000550	3/17/1986	SR 1102 E of SR 1100, Ivanhoe
General Thomas Boykin House (Clinton vicinity)	86000551	3/17/1986	SR 1214 SW of SR 1222, near Clinton
Thomas Bullard House (Autryville vicinity)	14000522	8/25/2014	386 Carry Bridge Rd., near Autryville
Marion Butler Birthplace (Moved 1991)	86000552	3/17/1986	NC 242 at SR 1414, near Salemburg
Dan E. Caison Sr. House (Roseboro)	86001124	5/21/1986	Broad St., Roseboro
Cherrydale (Turkey vicinity)	86000554	3/17/1986	SR 1919 at SR 1952, near Turkey
Clear Run (Clear Run)	86000548	3/17/1986	NC 411 at Black River, Clear Run
Clinton Commercial Historic District (Clinton)	02000568	5/30/2002	Roughly bounded by Vance, Elizabeth, Wall, and Sampson Sts., Clinton
Clinton Depot & Freight Station (Clinton)	86000555	3/17/1986	W. Elizabeth St., Clinton
College Street Historic District (Clinton)	86000553	3/17/1986	600-802 College St., Clinton
Dell School Campus (Delway)	86001126	5/21/1986	U.S. 421 and SR 1003, Delway
Delta Farm (J.W. Scott Robinson Farm)	86000556	3/17/1986	SR 1100 N of SR 1105, Ivanhoe
William E. Faison House (Giddensville vicinity)	04001526	1/20/2005	NC 50 at jct. with NC 1757 (10901 Suttontown Rd.), near Giddensville
Graves-Stewart House (Clinton)	83001913	9/8/1983	600 College St., Clinton
Robert Herring House (Clinton)	86000557	3/17/1986	216 Sampson St., Clinton
Troy Herring House (Roseboro)	86000558	3/17/1986	Broad St. S of NC 24, Roseboro
Lewis Highsmith Farm (Harrells vicinity)	86000559	3/17/1986	U.S. 421 S of NC 41, near Harrells
Hollingsworth-Hines Farm (Turkey vicinity)	86000547	3/17/1986	SR 1926 S of SR 1004, near Turkey
Howard-Royal House (Salemburg)	86000561	3/17/1986	202 N. Main St., Salemburg
Howell-Butler House (Roseboro)	86000560	3/17/1986	Broad and McLamb Sts., Roseboro
A. F. Johnson Building (Clinton)	00000459	5/11/2000	102-104 E. Main St., Clinton
Samuel Johnson House and Cemetery (Ingold vicinity)	86000562	3/17/1986	SR 1157 S of SR 1004, near Ingold
James Kerr House (Kerr vicinity)	86000563	3/17/1986	SR 1005 S of SR 1007, near Kerr,

Marcheston Killett Farm (Clinton vicinity)	86000564	3/17/1986	SR 1222 N of U.S. 701, near Clinton
Marshall Kornegay House and Cemetery (Suttontown)	86000565	3/17/1986	SR 1725 and SR 1720, Suttontown
James H. Lamb House (Suttontown)	86000566	3/17/1986	SR 1135 N of NC 411, near Garland
Lovett Lee House (Giddensville vicinity)	86000567	3/17/1986	SR 1725 and SR 1730, near Giddensville
Dr. James O. Matthews Office (Gone)	86000568	3/17/1986	SR 1960 S of SR 1004, near Taylors Bridge
Fleet Matthis Farm (Gone) (Taylors Bridge vicinity)	86000569	3/17/1986	U.S. 421 S of SR 1146., near Taylors Bridge
Jonas McPhail House and Annie McPhail Store (Rosin)	86000571	3/17/1986	U.S. 13 E of SR 1845, Rosin
Murphy-Lamb House and Cemetery (Garlin vicinity)	86000570	3/17/1986	SR 1135 S of U.S. 701, near Garland
Oak Plain Presbyterian Church (Waycross vicinity)	86001127	5/21/1986	SR 1943 S of SR 1945, near Waycross
Livingston Oates Farm (Clinton vicinity)	86000572	3/17/1986	SR 1748 W of NC 403, near Clinton
Owen Family House and Cemetery (House gone)	86000573	3/17/1986	SR 1212 N of SR 1214, near McDaniels
Patrick-Carr-Herring House (Clinton)	92001791	1/14/1993	226 McKoy St., Clinton
Pigford House (Gone) (Clinton vicinity)	86000574	3/17/1986	SR 1751 S of U.S. 701, near Clinton
Pope House (Gone) (Clinton vicinity)	86000575	3/17/1986	SR 1146 N of SR 1145, near Clinton
Francis Pugh House (Clinton vicinity)	86000577	3/17/1986	SR 1751 at NC 403, near Clinton
Pugh-Boykin House (Clinton)	86000576	3/17/1986	306 Elizabeth St., Clinton
Royal-Crumpler-Parker House (Clinton)	86000578	3/17/1986	512 Sunset Ave., Clinton
Dr. John B. Seavey House and Cemetery (Harrells vicinity)	86001128	5/21/1986	SR 1100 S of SR 1007, near Harrells
Dr. David Dickson Sloan House (Garland vicinity)	86000579	3/17/1986	SR 1135 S of U.S. 701, near Garland
Thirteen Oaks (Newton Grove vicinity)	90000879	6/7/1990	Jct. of U.S. 13 and SR 1647, near Newton Grove
West Main-North Chesnutt Streets Historic District (Clinton)	86000546	3/17/1986	Roughly N. Chesnutt, Fayetteville, and Williams Sts. between W. Main and Margaret Sts., Clinton

Isaac Williams House (Boundary Increase)	84002523 (89000467)	3/1/1984 (6/12/1989)	NC 55; also NC 55 at its junction with NC 50, near Newton Grove
John E. Wilson House (Dunn vicinity)	86000545	3/17/1986	SR 1631 at SR 1630, near Dunn

Pender County

Governor Samuel Ashe Grave (Rocky Point vicinity)	01001096	10/12/2001	Farm Ln., from S side of NC 1411, 0.7 miles E of crossing of Pike Creek, near Rocky Point
Bannerman House (Players vicinity)	74001365	5/31/1974	NE of Burgaw off NC 53 on SR 1520, near Burgaw
Beatty-Corbett House (Ivanhoe vicinity)	86000549	3/17/1986	SR 701 at SR 1200, near Ivanhoe
Belvidere Plantation House (Gone) (Hampstead vicinity)	82003495	6/14/1982	Off SR 1565, near Hampstead
Burgaw Depot (Burgaw)	86001910	7/24/1986	102 E. Fremont, Burgaw
Burgaw Historic District (Burgaw)		8/27/1999	Roughly bounded by Cowan St., Fremont St., Dudley St., and Ashe St., Burgaw
Canetuck School	100002520	5/31/2018	6098 Canetuck Rd, Currie
Cape Fear Civil War Shipwreck Discontiguous District	85003195	12/23/1985	Address Restricted
Moore's Creek National Military Park (Boundary Increase)	66000070 (86003649)	10/15/1966 (2/13/1987)	State Rd. 210, Currie
Pender County Courthouse (Burgaw)	79001741	5/10/1979	Wright, Wilmington, Walker, and Fremont Sts., Burgaw
Penderlea Homesteads Historic District (Willard vicinity)	13000803	9/27/2013	Bounded by Sills Cr., Webber, Crooked Run, Lake, Lamb & Raccoon Rds., near Willard
Poplar Grove (Scotts Hill)	79003346	7/16/1979	10200 U.S. Highway 17 North, Wilmington
SS. Peter & Paul's Russian Orthodox Greek Catholic Church (St. Helena)	100000903	4/17/2017	2384 Front Street, St. Helena
Sloop Point (Vista)	72000985	1/20/1972	NE of Vista off SR 1561, near Vista
U.S. Naval Ordnance Testing Facility Assembly Building (Topsail Beach)	93000909	9/14/1993	Jct. of Channel Blvd. and Flake Ave., Topsail Beach
U.S. Naval Ordnance Testing Facility Control Tower (Topsail Beach)	93000909	9/14/1993	SW corner of S. Anderson Blvd. and Flake Ave., Topsail Beach
US Naval Ordnance Testing Facility Control Tower	93000910	9/14/1993	SW corner of S. Anderson Blvd. and Flake Ave., Topsail Beach

U.S. Naval Ordnance Testing Facility Observation Tower 2 (Topsail Beach)	93000911	9/14/1993	1000 blk. S. Anderson Blvd., Topsail Beach

Appendix C: List of Historic Properties in the Witchweed-Regulated Counties in South Carolina

Historic Property Name	Reference Number	Date Listed	Address
Marion County			
A.H. Buchan Company Building	84003817	8/3/1984	Laurel St., Mullins
Dew Barn	84003818	8/3/1984	NW of Zion, near Zion
Dillard Barn	05001101	9/28/2005	719 Virginia Dr., near Mullins
Imperial Tobacco Company Building	84003820	8/3/1984	416 N. Mullins St., Mullins
J.C. Teasley House	01000609	5/30/2001	131 E. Wine St., Mullins
Liberty Warehouse	84003821	8/3/1984	Park St., Mullins
Marion High School	01000631	6/6/2001	719 N. Main St., Marion
Marion Historic District	73001720	10/4/1973	Roughly bounded by E. and W. Dozier, N. Montgomery, W. Baptist, and N. Wilcox Sts. (original), Roughly bounded by Railroad and N. Wilcox Aves., N. Main and W. Dozier Sts., also Wheeler, Lee, and Arch Sts. (increase), Marion
Mt. Olive Baptist Church	00000695	6/15/2000	301 Church St., Mullins
Mullins Commercial Historic District	03000662	7/20/2003	Along portions of Main, Front, and W. Wine Sts., Mullins
Neal and Dixon's Warehouse	84003822	8/3/1984	303 S. Main St., Mullins
Old Brick Warehouse	73001719	3/30/1973	Main and Wine Sts., Mullins
Old Ebenezer Church	73001719	3/30/1973	5 miles south of Latta on South Carolina Highway 38, near Latta
Rasor and Clardy Company Building	82001522	10/29/1982	202 S. Main St., Mullins
Horry County			
H.W. Ambrose House	86002219	8/5/1986	1503 Elm St., Conway
Atlantic Coast Line Railroad Depot	86003839	5/18/1995	N side of U.S. 701, Conway
Beaty-Little House	86002220	8/5/1986	507 Main St., Conway
Beaty-Spivey House	86002223	8/5/1986	428 Kingston St., Conway
Buck's Upper Mill Farm	82003868	3/25/1982	on Waccamaw River off SC 136 & SC 701 intersection, Bucksville
Burroughs School	84002047	8/2/1984	801 Main St., Conway
Arthur M. Burroughs House	86002224	8/5/1986	500 Lakeside Dr., Conway
Conway Downtown Historic District	94000815	8/19/1994	Roughly bounded by Fourth Ave., Kingston St., Third Ave. and Laurel St., Conway
Conway Methodist Church, 1898 and 1910 Sanctuaries	86002225	8/5/1986	Fifth Ave., Conway

Conway Post Office	08000758	9/2/2009	428 Main St., Conway
Conway Residential Historic District	10000166	4/7/2010	Main St. on the east, Fifth Ave. to the south; Beaty and Burroughs Sts. to the west, and Ninth and Tenth Aves. to the north
John P. Derham House	05001154	10/4/2005	1076 Green Sea Rd., Green Sea
Galivants Ferry Historic District	01000321	3/29/2001	Junction of U.S. Route 501, Pee Dee Road, and Galivants Ferry Road, Galivants Ferry
Hebron Church	77001227	5/16/1977	10 miles (16 km) south of Conway off of U.S. Route 701, Bucsville
J.W. Holliday, Jr. House	86002227	8/5/1986	701 Laurel St., Conway
Kingston Presbyterian Church	08000759	9/28/2009	800 3rd Ave., Conway
Kingston Presbyterian Church Cemetery	86002229	8/5/1986	800 3rd Ave., Conway
Myrtle Beach Atlantic Coast Line Railroad Station	96001212	7/22/2002	Junction of Oak St. and Broadway between Jackson St. and 8th, Myrtle Beach
Myrtle Heights--Oak Park Historic District	96001217	10/28/1998	Junction of Oak St., and Broadway between Jackson St. and 8th, Myrtle Beach
Ocean Forest Country Club	96001219	11/7/1996	5609 Woodside Dr., Myrtle Beach
Old Horry County Courthouse	71000785	4/7/1971	Main St., Conway
Pleasant Inn	96001220	11/7/1996	200 Broadway, Myrtle Beach
C. P. Quattlebaum House	86002233	8/5/1986	219 Kingston St., Conway
C. P. Quattlebaum Office	86002235	8/5/1986	903 3rd Ave., Conway
Paul Quattlebaum House	86002231	8/5/1986	225 Kingston St., Conway
Rainbow Court	96001221	11/7/1996	405 Flagg St., Myrtle Beach
Socastee Historic District	02000558	5/22/2002	South Carolina Highway 544, .5 miles (0.80 km) north of the Intracoastal Waterway, Socastee
Waccamaw River Memorial Bridge	94000994	8/26/1994	Main St. (U.S. Route 501) over the Waccamaw River, Conway
Waccamaw River Warehouse Historic District	86002269	8/5/1986	Roughly Main St. between the Waccamaw River and Laurel St., Conway
Waikiki Village Motel	100001076	6/12/2017	1500 S. Ocean Blvd, Myrtle Beach
W.H. Winborne House	86002268	8/5/1986	1300 6th Ave., Conway