

North Carolina Ecosystem Response to Climate Change: DENR Assessment of Effects and Adaptation Measures

DRAFT

Dry Longleaf Pine Communities

Ecosystem Group Description:

Longleaf pine communities are scattered in most of the Coastal Plain and extend into the Piedmont in the south. They were once the most abundant communities in the Coastal Plain, occupying most of the land that was not swamp or pocosin and now occur as scattered remnants. Dry longleaf pine communities range from moist sites to excessively drained coarse sands which produce near desert conditions for plants. A number of variants are recognized within the community types, determined by variation in moisture, soil, and location. These communities have in common a regime of frequent natural fires which once crept across vast areas of the landscape. The structure and composition of these communities at present strongly depends on the extent to which these fires have continued or have been replaced by prescribed fire.

With frequent fire, longleaf pine strongly dominates the canopy, which may range from sparse to fairly dense but is seldom completely closed. The ground cover is dominated by wiregrass and has a variety of other herbs and low shrubs. In the three sandhill community types a sparse midstory of scrub oaks is present, with the species varying with the types and variants. In the Mesic Pine Flatwoods type, oaks are absent and the community has a distinctly two-layered structure of trees and grass. The herb layer is often very diverse. With removal of fire, scrub oaks in the sandhills community types and shrubs and hardwood trees in the flatwoods community types become dense and out-compete the herbs. Piedmont Longleaf Pine Forests are more poorly known. Most existing examples have a mixed canopy of longleaf, loblolly, and shortleaf pine, often mixed with southern red oak and post oak. These communities probably once also had a grassy understory, but it is not known if wiregrass was once dominant.

Ecosystem Level Effects:

Predicted Impacts of Climate Change:

Climate Change Factor:	Likelihood:	Effect:	Magnitude:	Comments:
Wind Damage	High	Neg	Med	
Mild Winters	High	Mix	Low	May include some positive and some negative effects.
Fire	Low	Mix		May include some positive and some negative effects. Effects on plants may be relatively low but for animals, particularly insects, may be severe.

Climate Wizard data for the Sandhills Game Land shows a mid-value annual average temperature increase of 3.7 degrees. There is substantial seasonal variation in this region, with the summer average expected to increase 5.2 degrees. The mid-value rainfall prediction is for no change, but the different models' rainfall

projections in the A1B scenario range from -16 inches to +20 inches (Maurer et al., 2007).

General forecasts suggest an increase in severe storms and in droughts. This may cause more wind damage to canopy trees. Given the excessively drained soils in these systems, most species can readily tolerate dry periods. However, reproduction of plants may depend on wet periods.

Increased drought conditions and increased thunderstorm intensity are likely to produce more wild fires. These systems depend on fire and are often degraded by lack of fire and an increase in wild fires may allow some occurrences to burn in a way that is ecologically beneficial. However, wild fires in drought may be more likely to be too intense or too extensive, and may harm some species. In small, isolated sites, an increase in wildfires may have catastrophic impacts on insects and other animals that depend on a metapopulation strategy for coping with environmental disturbances. For such species, lack of landscape connectivity can prevent restoration of populations through re-colonization from unburned refuges. As a result, there may be a significant increase in local extirpations that may eventually lead to region-wide extirpations or even extinction of certain species.

Mild winters, with decreased cold damage, are likely to allow species from the south to move into North Carolina. In recent years, several longleaf-pine associated insects once thought to be restricted to Florida or the Gulf Coast have been found to be established in North Carolina. Although we lack the historic data to know for sure that these represent recent colonizations, this trend will undoubtedly accelerate with decreasingly cold winters.

Predicted Ecosystem Responses:

Ecosystem Response:	Likelihood:	Effect:	Magnitude:	Comments:
Exotic species invasion	High	Neg	High	<i>Imperata cylindrica</i> ; <i>Dasytus novemcinctus</i> ; <i>Solenopsis invicta</i>
Compositional Change	Low	Mix		Could be some positive effects of adding native species but negative if exotics increase. Some of the insects most highly tied to dry longleaf habitats may be eliminated by increases in wildfires.
Latitudinal Change	Low	Pos	Low	
Structural Change	Med	Neg	Low	

These systems range well to the south of North Carolina. They and their component species are well adapted to warm temperatures, drought, and fire. They should withstand the future climate with less stress than most ecological systems, at least where landscape integrity is still high. In the outer Coastal Plain, where most examples are now small, isolated remnants, increased environmental perturbations, including wildfire, may have devastating effects on major components of the ecosystem.

Increased wind storm damage could affect canopy structure. Because of their slow reproductive rate and long life span, increased wind mortality would reduce average age and might reduce natural canopy density. This would be detrimental to red-cockaded woodpeckers and other species that depend on older longleaf pine trees. However, such effects would be small compared to the widespread similar effects from logging. Longleaf pines are among the least susceptible trees to wind destruction, and it is unclear how significant increased wind will be to them. Increased plant productivity with a longer growing season may partly offset the effect of reduced tree age on structure. However, nutrient and water limitation will likely limit increased productivity in these systems.

These systems are not very susceptible to invasive plants and no invasive exotic plants are currently a problem in these systems in North Carolina. Cogon grass (*Imperata cylindrica*) is a serious invader in states

to the south. It is spreading northward at present, and it is unclear if temperature would limit its invasion of North Carolina at present. But warmer climate is likely to enhance its spread. Fire ants (*Solenopsis invicta*) are already a serious invader in these systems. They are a serious threat to ground nesting birds, reptiles, amphibians, and insects. Warmer temperatures may allow an increase in their abundance or rate of spread. Armadillos (*Dasyus novemcinctus*) are already spreading northward and may already have reached North Carolina. They are likely to expand more rapidly with warming climate. This appears to be a natural spread but, as generalist predators, may have a substantial effect on ground-dwelling species.

There may be direct effects of increased CO2 on plant competitive relations. The dominant grasses in these systems use the C4 photosynthetic pathway. Increased CO2 likely will benefit plants with the C3 pathway more than C4. But this effect may be completely masked by the effects of fire.

Increased temperatures might increase the range of these systems in the northern Coastal Plain and in Virginia. However, the widespread conversion of uplands in this region, the fragmented distribution and lack of seed source for them, and their dependence on fire, make natural expansion very unlikely.

Warmer temperatures may allow some species of longleaf pine systems farther south to move into North Carolina. The limited tendency of most plants in these systems to invade new areas suggests that any such process would naturally be slow and limited. The reduced abundance and fragmented distribution of remnants make it unlikely to happen to any great degree.

Habitat Level Effects:

Natural Communities:

Third Approximation Name:	Comments:
Piedmont Longleaf Pine Forest	
Coastal Fringe Sandhill	
Xeric Sandhill Scrub	The most extreme Xeric Sandhill Scrub, the Sand Barrens, are dry enough that vegetation density is limited. Increase drought may possibly cause plant mortality and reduce vegetation density further. It may also cause Sand Barrens to develop in slightly less dry soils.
Pine/Scrub Oak Sandhill	
Mesic Pine Flatwoods	Because these communities depend on moist conditions, they may be more susceptible to drought effects than the drier sandhills.

LHI Guilds:

Guilds with Significant Concentration in Ecosystem Group:	Comments:
Xeric-Mesic Longleaf Pine and Mixed Oak Woodlands	
Wet-Xeric Longleaf-Wiregrass Woodlands	
Dry-Xeric Mixed Forests, Woodlands, and Barrens	

Three guilds have a high concentration of their habitats within this Ecosystem Group. The Xeric-Mesic Longleaf Pine and Mixed Oak Woodlands contains the species that are the most highly restricted to dry longleaf ecosystems but longleaf generalists belonging to the Wet-Xeric Longleaf-Wiregrass Woodlands

guild also have some of their largest habitat units located within the drier end of the longleaf community spectrum. The same is true for the Dry-Xeric Mixed Forests, Woodlands, and Barrens guild, which also occurs in other types of dry-xeric woodlands. All three guilds appear to be best represented in the state within the dry sandhills habitats located within the Fall-line Sandhills ecoregion.

Species Level Effects:

Plants

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/Extirpation Prone	Status: US/NC	Comments:
<i>Campylopus carolinae</i>	G2/S1S2				FSC/SR-T	
<i>Rhus michauxii</i>	G2G3/S2				E/E-SC	
<i>Schwalbea americana</i>	G2G3/S2				E/E	
<i>Spiranthes eatonii</i>	G2G4/S2				/SR-L	
<i>Paronychia herniarioides</i>	G2G4/S1				/E	
<i>Solidago verna</i>	G3/S3				FSC/T	
<i>Ruellia ciliosa</i>	G3/S2				/SR-P	
<i>Astragalus michauxii</i>	G3/S3				FSC/T	
<i>Crocianthemum nashii</i>	G3?/S1		Yes		/E	
<i>Bulbostylis warei</i>	G3G4/SH				/SR-P	
<i>Cheilolejeunea myriantha</i>	G3G4/SH				/SR-P	
<i>Quercus elliotii</i>	G3G5/S2				/SR-P	
<i>Crataegus munda</i>	G3G5Q/S2?				/SR-T	
<i>Gaylussacia nana</i>	G4/S1				/E	
<i>Warea cuneifolia</i>	G4/S1				/E	
<i>Asclepias pedicellata</i>	G4/S3				/SR-P	
<i>Crocianthemum carolinianum</i>	G4/S1				/SR-P	
<i>Lechea torreyi</i>	G4/S1				/SR-P	
<i>Aristida condensata</i>	G4?/S1				/SR-P	
<i>Chrysoma pauciflosculosa</i>	G4G5/S1				/E	
<i>Eriogonum tomentosum</i>	G4G5/SH				/SR-P	
<i>Galactia mollis</i>	G4G5/S2				/SR-P	
<i>Liatris squarrulosa</i>	G4G5/S2				/SR-P	
<i>Solidago tortifolia</i>	G4G5/S1				/SR-P	
<i>Salvia azurea</i>	G4G5/S2				/SR-P	
<i>Stylisma pickeringii</i> var. <i>pickeringii</i>	G4T3/S3				FSC/E	
<i>Pyxidantha brevifolia</i>	G4T3Q/S3	Yes			FSC/E	
<i>Chamaesyce cordifolia</i>	G5/S1				/SR-P	
<i>Lupinus villosus</i>	G5/S2				/SR-P	
<i>Clinopodium georgianum</i>	G5/S2				/SR-P	
<i>Quercus minima</i>	G5/S1				/SR-P	
<i>Kalmia angustifolia</i>	G5/S1				/SR-P	

Polygonella articulata	G5/SX	/SR-P
Polygala grandiflora	G5?/S2	/SR-P
Carex tenax	G5?/S1	/SR-P
Pityopsis graminifolia var. graminifolia	G5T4/S1	/SR-P
Gaillardia aestivalis var. aestivalis	G5TNR/S2	/SR-P
Aristida tenuispica	G5TNR/S1	/SR-P

Many rare plant species associated with Dry Longleaf Pine communities are at the northern limit of their range in North Carolina. These species are rare in NC, but are considered globally secure, as their habitat is widespread throughout the southeastern United States. Their fate, however, is tied to that of the longleaf pine system, which has been dramatically reduced over the past 200 years.

Terrestrial Animals

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/Extirpation Prone	Status: US/NC/WAP	Comments:
Catocala grisatra	G1G3/S1S2		Yes		/SR/	The Bladen County population -- if it still exists -- is the only one known north of Florida and extreme south Georgia. Given the extremely patchy distribution of the hawthorn habitats that it is associated with, this species is likely to be highly vulnerable to the effects of wildfires and other environmental disturbances.
Heterodon simus	G2/S2				FSC/SC/P	
Agrotis carolina	G2G3/S2S3	Yes			FSC/SR/	May benefit from increases in fire -- has a subterranean larva that appears to survive fires on site better than most other longleaf insect species.
Heliomata infulata	G2G4/S2S3		Yes		/SR/	The population in the Sandhills is widely disjunct from those in the western Piedmont and mountains.
Hesperia attalus slossonae	G2G4T2T3/S2				/SR/	Vulnerable to local extirpation following a fire. Needs high landscape integrity to persist within the region.
Aimophila aestivalis	G3/S3B,S2N				FSC/SC/P	
Callophrys irus	G3/S2		Yes		/SR/	Occurs in North Carolina only as widely scattered populations. The largest may be the one in the Fall-line Sandhills.
Pygarctia abdominalis	G3/S2S3				/SR/	
Ptichodis bistrigata	G3/S2S3				/SR/	
Picoides borealis	G3/S2				LE/E/P	
Doryodes n. sp. 1	G3G4/S3S4	Yes			/W3/	A grass-feeding species thought to be strongly associated with northern wiregrass. Not found in habitats lacking that grass.
Hypomecis buchholzaria	G3G4/S1S2		Yes		/SR/	Recorded from only a few sites in North Carolina.
Heterocampa varia	G3G4/S1S2		Yes		/SR/	Recorded from only a few sites in the North Carolina Coastal Plain.

<i>Acronicta albarufa</i>	G3G4/S1S2	Yes	/SR/	Apart from one historic record from the Piedmont, all North Carolina records are from the Fall-line Sandhills.
<i>Hesperia meskei</i>	G3G4/S3		/SR/	Vulnerable to local extirpation following a fire. Needs high landscape integrity to persist within the region.
<i>Faronta rubripennis</i>	G3G4/S2S3		/W3/	
<i>Erynnis martialis</i>	G3G4/S3		/SR/	
<i>Chytonix sensilis</i>	G4/S3?		/W3/	A fire follower that is likely to benefit from increased fire frequency.
<i>Eucoptocnemis dapsilis</i>	G4/S2S3		/W3/	
<i>Erastria coloraria</i>	G4/SU	Yes	/W3/	Feeds on New Jersey tea, but the only known population in North Carolina is located at Fort Bragg.
<i>Digrammia eremiata</i>	G4/S3?		/W3/	
<i>Cryphia cyanympha</i>	G4/SU		/W3/	
<i>Chaetagnia fergusonii</i>	G4/SU		/SR/	Habitats and range are poorly known. Recorded at Weymouth Woods in the Sandhills.
<i>Catocala messalina</i>	G4/S2?	Yes	/SR/	Appears to be primarily associated with maritime forests but an apparently disjunct population was found at Fort Bragg.
<i>Catocala louiseae</i>	G4/S1S3	Yes	/SR/	The Bladen County population is the only one known north of Florida.
<i>Catocala jair</i>	G4/S1S3		/SR/	
<i>Catocala amestris</i>	G4/S1S2	Yes	/SR/	
<i>Dasychira leucophaea</i>	G4/SU		/W3/	
<i>Nemoria bifilata</i>	G4/S3?		/W3/	
<i>Schinia jaguarina</i>	G4/S1S3		/SR/	
<i>Schinia bina</i>	G4/S2S3		/W3/	
<i>Feltia manifesta</i>	G4/S2S3	Yes	/SR/	Most NC records are from the Fall-line Sandhills and from similar sandhill habitats in the Outer Coastal Plain. However, there are also records from the mountains although none yet from the Piedmont.
<i>Satyrium edwardsii</i>	G4/S2?	Yes	/SR/	The population in the Fall-line Sandhills appears to be widely separated from those in the mountains.
<i>Gabara pulverosalis</i>	G4/S3?		/W3/	
<i>Grammia phyllira</i>	G4/S2S3		/SR/	
<i>Idaea eremiata</i>	G4/S3S4		/W3/	
<i>Anicla lubricans</i>	G4G5/S3?		/W3/	
<i>Melanoplus strumosus</i>	G4G5/SU		/W3/	
<i>Tantilla coronata</i>	G5/S3S4		//P	
<i>Bufo quercicus</i>	G5/S3		/SR/P	Thought to be declining due to invasion of fire ants. Decreases in cold winters may lead to higher densities of fire ants, with consequent decreases in oak toads and many other species of ground-

				dwelling animals.
<i>Callophrys augustinus</i>	G5/S4	Yes	//	While fairly widely distributed in the mountains, it occurs in only a few scattered locations in the Fall-line Sandhills and Piedmont.
<i>Micrurus fulvius</i>	G5/S1		/E/P	
<i>Caprimulgus carolinensis</i>	G5/S5B		//P	
<i>Cemophora coccinea</i>	G5/S3		/W1,W5/P	
<i>Megathymus yuccae</i>	G5/S3S4		/W2/	
<i>Masticophis flagellum</i>	G5/S3		/SR/P	
<i>Ulolonche modesta</i>	G5/SU		/W3/	
<i>Idaea ostentaria</i>	GNR/S3?		/W3/	
<i>Hemeroplanis n. sp.</i>	GNR/S2S3		/SR/	The population in the Sandhills is widely disjunct from those in the western Piedmont and mountains. The overall range of this species is not yet known.
<i>Hyperstrotia aetheria</i>	GNR/S1S2	Yes	/SR/	Previously not recorded north of Florida. Belongs to a species complex that has yet to be sorted out taxonomically.
<i>Apoda rectilinea</i>	GNR/S1S3		/W3/	
<i>Schinia siren</i>	GNR/SU		/W3/	
<i>Lobocleta peralbata</i>	GNR/SU		/W3/	
<i>Bleptina sangamonia</i>	GU/S1S2	Yes	/SR/	Very few occurrences are known for this species rangewide. May represent a species complex.

Two moths, *Agrotis carolina* and *Doryodes n. sp. 1*, appear to be endemic to longleaf pine habitats in North Carolina and adjoining South Carolina. Both of these species occur, however, in fairly mesic flatwoods in addition to dry sandhills. Fourteen other lepidoptera either have their only North Carolina records from habitats represented by this theme or have populations in these habitats that are widely separated from other populations in the state.

Insects associated with these habitats almost all rely on a metapopulation structure for coping with environmental disturbance, particularly fire (*Agrotis carolina* and *Chytonix sensilis* being perhaps the only exceptions). Populations remaining in small, fragmented sites are thus highly vulnerable to extirpation following even single disturbance events that affect their entire habitat unit.

In addition to the insects, this theme contains habitat used by a large proportion of the state's rare reptiles, particularly snakes. The main threat to these species is conversion of their habitats, but the spread of fire ants and potentially the invasion of the state by armadillos (which feed on eggs and immature snakes and other ground-nesting vertebrates), are significant threats that may be exacerbated by the increasingly mild winters associated with climate change.

Combined Threats and Synergistic Impacts:

Importance of Climate Change Factors Compared to Other Ecosystem Threats:

Threat:	Rank Order:	Comments:
Development	1	
Logging/Exploitation	2	
Conversion to agriculture/sylvicu	2	The threat of agricultural conversion has reduced in recent years (having greatly reduced habitat historically), but pine plantation conversion continues.
Fire	3	Inadequate fire is an ongoing threat at many sites. For small, isolated habitat remnants, wildfires can cause permanent extirpation of insect and other animal populations. This is a problem at most unprotected examples and is the greatest threat to protected examples.
Climate Change	4	

The greatest threats to this system do not come from climate change. With their adaptation to dry conditions, fire, wind, and their range well to the south, these may be the most resilient systems to warming climate.

Currently, the greatest threat comes from development pressure. Historically, conversion and exploitation destroyed most of this once extensive system, and these forces continue to consume the remnants. Among protected examples, inadequate fire and its consequences are the greatest ecological threat. For particular species, especially insects, too frequent or too extensive burning (whether by wildfire or prescribed burns) can have major effects when coupled with loss of landscape integrity resulting from habitat loss.

Climate change may exacerbate some of these problems. These systems occur on some of the highest lands in the outer Coastal Plain, where development may become even more concentrated as sea level rises. In the current settled landscape, they depend on prescribed burning for the fire they need. Increased difficulty burning may lead to further deterioration. In addition, severe wild fires in droughts, burning in excessive fuel loads, may cause ecological damage.

Recommendations for Action:

Interventive Measures:

Intervention:	Importance:	Feasibility:	Comments:
Conduct Prescribed Burns	High	High	
Control Invasive Species	High	High	Need to watch for arrival of cogon grass. Suppression of fire ant colonies -- particularly where multi-queen colonies have developed -- should be a high priority for all protected natural areas
Restore/Maintain Landscape Connections	High	Medium	Restoration of landscape integrity is a high priority for protecting insect populations associated with longleaf pine habitats
Protect/Expand Remaining Examples	High	High	

Prescribed burning is crucial for retaining these systems in both the present and the expected climate. It is important in preparing for climate change because excess fuel loads increase the risk of destructive wild fire during droughts. Beginning prescribed burning programs in moist periods is important, as reducing fuel loads safely while avoiding ecological damage takes time. Sites that have had regular fire will be safer from wild fire, will make it easier to control wild fire, and will allow prescribed burning to continue into drier conditions. Regular burning will also promote healthy, diverse communities and species, which will allow the best potential for communities to adapt to changing climate. To protect sensitive insect populations, prescriptions should include setting aside unburned refugias in every burn and preferably following a three year burn rotation among three different burn units.

Because so few examples remain, protecting and expanding remaining examples is crucial with or without climate change. Because these systems are likely to withstand the stresses of changing climate well, restoring more of them in the near future would produce more resilient natural landscapes.

Protecting and restoring landscape connections is important to allow movements of mobile species and to improve the viability of small populations. The need for this is particularly important for disturbance-maintained habitats such as longleaf pine ecosystems and will increase with the stresses of a changing climate.

Suppression of fire ants is already an urgent priority within protected examples of longleaf pine ecosystems. Although no invasive exotic plants are a serious problem in these systems now, early detection and control of invasive exotic species (such as cogon grass) will reduce the ecological damage caused by invasives and the cost of controlling them. Preventative measures such as forbidding sale and transport of invasive species will help reduce the risks and cost.

Ecosystem Group Summary:

Dry longleaf pine communities are likely to be resilient to climate change effects, perhaps more resilient than any of our ecological systems. Most of their component species range well to the south of North Carolina. Species associated with these communities are generally tolerant of drought, fire, and wind, although in some cases, tolerance to disturbance depends on the existence of viable connections between habitat units.

These communities have been drastically reduced by conversion to other uses and degraded by lack of fire. Protection of remaining examples and restoration of degraded sites and landscape-level connections would help the Coastal Plain landscape adapt to future climates, as well as provide benefits to the species under the current climate.

References:

Maurer, E.P, L.Brekke, T.Pruitt, and P.B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. *Eos Trans. AGU*, 88(47), 504.
