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

DRAFT

Wet Pine Savannas

Ecosystem Group Description:

The communities in Wet Pine Savannas are Coastal Plain mineral soil wetlands that under natural conditions were frequently burned. With frequent fire they have an open canopy dominated by longleaf or pond pine over a grassy herb layer. Shrubs are short and sparse with frequent fire, but become dense if fire is suppressed for more than a couple of years.

The Pine Savanna type occurs in flat areas that are saturated or even slightly flooded during the wetter parts of the year. The herb layer is dominated by grasses and sedges and a variety of low shrubs may be present, but are low and open if the savanna is frequently burned. The herb layer usually contains many showy composites, orchids, and insectivorous plants. One of the most notable features of Pine Savanna communities is their tremendous plant diversity at small scales. Sandhill Seeps occur on sloping seepage areas, where the wettest parts are essentially permanently saturated. They share many species with the Pine Savanna type but are more heterogeneous and more bog-like in character. In frequently burned seeps, grassy and sedgy areas can have a high diversity of plants, rivaling the Pine Savannas in species richness at small scales. Wet Pine Flatwoods communities usually occur in flat areas, though sloping areas are possible. They resemble Pine Savannas in general structure, with an open pine canopy over a grassy ground cover with low shrubs. Wiregrass is always the dominant herb. Shrubs become dense if fire is excluded. Unlike Pine Savannas, the herb diversity is low. In many cases, only one to five species may be present in a square meter.

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	
Fire	Low	Mix	High	
Drought	High	Neg	Low	

Climate Wizard data (Maurer et al., 2007) for the Holly Shelter area show a mid-value average annual temperature increase of 3.3 degrees, with a range among models of 2.28-4.79 degrees. Mid-value average rainfall change is a decrease of 2 inches, but the range of model rainfall predictions range from a decrease of 19 inches to an increase of 18 inches.

General forecasts suggest an increase in severe storms and in droughts. Severe storms may cause more wind damage to canopy trees. The effect of drought is less certain. These systems occur mostly in low-lying areas that are unlikely to become extremely dry even in droughts. However, many species may be excluded from them at present by wetness. Many savannas have ditches in or near them. The effects of these ditches on site hydrology and on the ecosystems are not well known. They do not seem to completely dry the sites, but might exacerbate the effects of drought.

Increased drought conditions and increased thunderstorm intensity may lead to more wild fires. These systems depend on fire and are often degraded by lack of fire. 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 extensive and to harm some species. Wild fire is generally easy to control in these systems, but small patches may be completely burned before fires are controlled. Fire fighting often damages savannas, and this damage could increase. Increased drought might make prescribed burning harder, leading to a decrease in fire in protected examples. In particular, many of the best savannas in conservation management are burned using wet pocosins as firebreaks to contain the fire in the savannas. If conditions become drier, this may be less possible. In addition, flammability of pocosins varies with season, and a change in seasonal phenology that makes them flammable earlier in the season would limit prescribed burning in savannas.

Mild winters, with decreased cold damage, may allow species from the south to move into North Carolina.

Predicted Ecosystem Reponses:

Ecosystem Response:	Likelihood:	Effect:	Magnitude:	Comments:
Exotic species invasion	High	Neg	Med	Imperata cylindrica
Compositional Change	Low	Mix	Low	
Latitudinal Change	Low	Pos	Low	Limited opportunity
Structural Change	Med	Neg	Low	Wind damage

These systems range well to the south of North Carolina. They and their component species are well adapted to warm temperatures. Increased temperatures might increase the range of these systems in the northern Coastal Plain and in Virginia. Most plants in these systems have limited dispersal ability even locally, so any influx of native species from the south is likely to be slow. Mobile animals are more likely to be able to move. However, the widespread conversion of potential sites in this region, the fragmented distribution of examples, and their dependence on fire, make natural expansion difficult.

Increased wind storm damage could affect canopy structure. Because of the slow reproductive rate and long life span of longleaf pine, 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. This was observed after Hurricane Hugo in South Carolina in 1989. 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, allowing trees to become large faster. However, nutrient limitation will likely limit increased productivity in these systems.

These systems are not very susceptible to invasive plants currently. 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 currently limits its invasion of North Carolina. But warmer climate is likely to enhance its spread. Fire ants are already a serious invader in these systems. Warmer temperatures may allow an increase in their abundance or rate of spread.

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.

If droughts are frequent enough, species of drier communities that are currently excluded by wet periods may be able to establish in them. However, if wet spells return after drought, this may be offset. While species of dry longleaf pine communities are presumably excluded from wet pine savannas by moisture, most other species are excluded more by frequent fire. If examples can be burned, composition is unlikely to change much.

Habitat Level Effects:

Natural Communities:

Third Approximation Name:	Comments:
Wet Pine Flatwoods	The sandy soils of Wet Pine Flatwoods probably make them more subject to drought than the savannas on finer-textured soils.
Sandhill Seep	Sandhill Seeps are probably more vulnerable than other community types in this group because they depend on movement of shallow ground water. Droughts would dry them up, perhaps enough for plants to experience water stress.
Pine Savanna	

LHI Guilds:

Guilds with Significant Concentration in Ecosystem Group:	Comments:
Wet-Mesic Pine Woodlands	
Savannas and Wet, Sandy, Herbaceous Swales	
Sandhill Seeps and Wet, Sandy Herbaceous Swales	
Herbaceous Peatlands and Pitcher Plant Meadows	

Habitat for two of the guilds, Savannas and Wet, Sandy, Herbaceous Swales and Sandhill Seeps and Wet, Sandy Herbaceous Swales, is completely contained within this Ecosystem Group. Wet Mesic Pine Woodlands, and Herbaceous Peatlands and Pitcher Plant Meadows also have a high concentration of their habitats within this Ecosystem Group, but also occur in association with other types. With the exception of the Herbaceous Peatlands and Pitcher Plant Meadows guild, which has at least some members with a more northerly distribution, most of the members of this guild occur south to Florida and the Gulf Coast and are unlikely to be significantly affected by rising temperatures. As members of fire-dependent communities, they should also benefit to some extent by increasing frequencies of fire, but only where habitats are divided into a sufficient number of burn units, not all of which burn in any one fire, to allow for rescue effects. Increased frequency of droughts may exacerbate the impacts of wildfires, making them more catastrophic in terms of both their severity and overall extent. Drought may also have adverse impacts both on the members of the guilds themselves, all of which are adapted to fairly wet microclimates, and to the herbaceous plant species on which they depend.

Species Level Effects:

Plants

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/ Extirpation Prone	Status: US/NC	Comments:
Scleria sp. 1	G1/S1	Yes			FSC/SR-L	Extremely rare and dependent on combination of wet conditions and frequent fire. Changes in climate that result in changes in habitat could cause extinction.
Ludwigia ravenii	G1G2/S1				FSC/SR-T	
Allium sp. 1	G1G2/S1S2	Yes			FSC/SR-L	Extremely rare and dependent on combination of wet conditions and frequent fire. Changes in climate that result in changes in habitat could cause extinction.
Campylopus carolinae	G2/S1S2				FSC/SR-T	
Carex lutea	G2/S2	Yes			E/E	Extremely rare and dependent on combination of wet conditions and frequent fire. Changes in climate that result in changes in habitat could cause extinction.
Balduina atropurpurea	G2/S1	Yes			FSC/SR-T	Extremely rare and dependent on combination of wet conditions and frequent fire. Changes in climate that result in changes in habitat could cause extinction.
Sporobolus teretifolius	G2/S2	Yes			FSC/T	
Rudbeckia heliopsidis	G2/S1				FSC/E	
Thalictrum cooleyi	G2/S2				E/E	
Packera crawfordii	G2G3/S1				/SR-T	
Calopogon multiflorus	G2G3/S1	Yes			FSC/E	
Cirsium lecontei	G2G3/S2				/SR-P	
Spiranthes longilabris	G3/S1				/T	
Rhynchospora thornei	G3/S2				FSC/E	
Polygala hookeri	G3/S2S3				/SR-T	
Parnassia caroliniana	G3/S2	Yes			FSC/E	
Lysimachia asperulifolia	G3/S3	Yes			E/E	
Dionaea muscipula	G3/S3				FSC/SR-L, SC	
Plantago sparsiflora	G3/S1S2				FSC/E	
Xyris chapmanii	G3/S3				/SR-T	
Xyris scabrifolia	G3/S2				FSC/SR-T	
Helianthus floridanus	G3G4/S1				/E	
Platanthera integra	G3G4/S2				/T	
Solidago leavenworthii	G3G4/S1				/SR-P	
Xyris serotina	G3G4/S1				/SR-P	
Aristida simpliciflora	G3G4/S1S2				/SR-T	

Rhynchospora breviseta	G3G4/S2S3	/SR-P
Agalinis virgata	G3G4Q/S2	/SR-P
Amorpha georgiana var. georgiana	G3T2/S2	FSC/E
Amorpha confusa	G3T3/S3	FSC/T
Pinguicula pumila	G4/S2	/SR-P
Lophiola aurea	G4/S2	/E
Hypoxis rigida	G4/S2	/SR-P
Helenium pinnatifidum	G4/S2	/SR-P
Drosera filiformis	G4/S2	/SR-P
Asclepias pedicellata	G4/S3	/SR-P
Hypoxis sessilis	G4/SH	/SR-P
Carex verrucosa	G4/S2	/SR-P
Scleria baldwinii	G4/S2	/SR-P
Sarracenia minor	G4/S2	/T
Agrostis altissima	G4/S2	/SR-T
Xyris stricta	G4/S1	/SR-P
Rhynchospora divergens	G4/S2	/SR-P
Helenium vernale	G4?/S1	/E
Hypoxis juncea	G4?/S1	/SR-P
Andropogon mohrii	G4?/S2	/SR-P
Arnoglossum ovatum	G4G5/S2	/SR-P
Pinguicula lutea	G4G5/S2	/SR-P
Hypericum suffruticosum	G4G5/SH	/SR-P
Hypericum brachyphyllum	G5/S1S2	/SR-P
Platanthera nivea	G5/S1	/T
Trifolium carolinianum	G5/SH	/SR-O
Tridens strictus	G5/SH	/SR-P
Dichanthelium spretum	G5/S1S2	/SR-D
Cladium mariscoides	G5/S3	/SR-O
Linum floridanum var. chrysocarpum	G5?T3?/S1S2	/SR-T
Rhynchospora pinetorum	G5?T3?/S2	/SR-T
Pityopsis graminifolia var. graminifolia	G5T4/S1	/SR-P
Xyris floridana	G5T4T5/S1	/SR-P

Many rare plant species associated with Wet Pine Savannas are at the northern limit of their range in NC. 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.

Like many wet savanna plants, endemic species such as Golden Sedge (Carex lutea) and Savanna Onion (Allium sp. 1) are dependent on the combination of wet conditions and frequent fire. Changes in climate that reduce frequency of fire or degree of moisture could cause extinction of the rarest species.

Terrestrial Animals

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/ Extirpation Prone	Status: US/NC/ WAP	Comments:
Hemipachnobia subporphyrea	G1/S1?	Yes		Yes	FSC/SR/	Except for a single Maryland population, all known populations are from flytrap-containing savannas in North Carolina. This species appears to be drastically affected by loss of metapopulation structure and is likely to be vulnerable to increases in the severity and extent of wildfires.
Atrytonopsis loammi	G1/SH		Yes	Yes	FSC/SR/	Possibly already extirpated from this region, probably due to loss of metapopulation structure.
Papaipema eryngii	G1G2/S1		Yes	Yes	/SR/	Only a single population is known from the entire Atlantic Slope. May be highly vulnerable to increased environmental perturbations due to near complete loss of metapopulation structure. May, in fact, be already extirpated.
Melanoplus nubilus	G2G3/S2S3	Yes			/SR/	
Spartiniphaga carterae	G2G3/S2S3		Yes		FSC/SR/	
Agrotis carolina	G2G3/S2S3	Yes			FSC/SR/	May be re-synonymized with A. buccholzi, in which case its status changes from Endemic to Major Disjunct
Eotettix pusillus	G2G3/S2?				/SR/	
Amblyscirtes alternata	G2G4/S2				/SR/	
Exyra ridingsii	G2G4/S3?				/W3/	Sandhill populations may have become nearly completely extirpated outside of Fort Bragg, primarily due to loss of metapopulation structure combined with alterations in natural fire frequencies.
Cyclophora n. sp. (culicaria of authors)	G3/S2S3		Yes	Yes	/SR/	Apparently confined to the Boiling Spring Lakes area, either as a disjunct population or possibly a separate taxon.
Ophisaurus mimicus	G3/S2				FSC/SC/P	
Schinia carolinensis	G3/S2S3				/SR/	
Exyra semicrocea	G3G4/S2S3				/SR/	
Amblyscirtes carolina	G3G4/S3S4				/W2/	Should benefit from increased spread of fire-maintained cane meadows.
Acronicta sinescripta	G3G4/S1S3				/SR/	
Amblyscirtes reversa	G3G4/S3				/SR/	Should benefit from increased spread of fire-maintained cane meadows.
Melanoplus decorus	G3G4/S2S3	Yes			/SR/	
Atrytone arogos arogos	G3T1T2/S1		Yes	Yes	FSC/SR/	Extremely vulnerable to wildlfires due to drastic reduction in number of populations and loss of metapopulation structure
Rhadinaea flavilata	G4/S3				/W2/P	

Papaipema appassionata	G4/S2S3		/SR/	Sandhill populations may have become nearly completely extirpated outside of Fort Bragg, primarily due to loss of metapopulation structure combined with alterations in natural fire frequencies.
Argyrostrotis quadrifilaris	G4/S3?		/W3/	
Leptostales laevitaria	G4/SU		/W3/	
Calephelis virginiensis	G4/S2		/SR/	
Eubaphe meridiana	G4/S2S3		/SR/	
Exyra fax	G4/S3?		/W3/	Sandhill populations may have become nearly completely extirpated outside of Fort Bragg, primarily due to loss of metapopulation structure combined with alterations in natural fire frequencies.
Grammia placentia	G4/S2S3		/SR/	
Lagoa pyxidifera	G4G5/S2S3		/SR/	
Gabara distema humeralis	G4T4/S3?		/W3/	
Pseudacris nigrita	G5/S4		//P	
Arphia granulata	G5/S2S4		/W3/	
Hesperotettix viridis brevipennis	G5T5/SU		/W3/	
Tornos cinctarius	GNR/S2?		/SR/	
Apamea mixta	GU/S1S2	Yes	/SR/	Primarily and northern and montane species with disjunct populations in coastal savannas.

Three species of insects are endemics or near-endemics to Wet Pine Savanna habitats in North Carolina. Five others are major disjuncts, with their next nearest populations in New Jersey, Florida, or in the case of Papaipema eryngii, the tallgrass prairies of the Midwest (Apamea mixta appears to have a highly disjunct population in the coastal savannas but also occurs in the Southern Appalachians).

While all of these species are associated with fire-maintained habitats, the majority depend on having a metapopulation structure to cope with fire, as well as other environmental perturbations. Five of these species have substantially lost their metapopulation structure and have become highly vulnerable to the effects of single catastrophic events, including wildfires.

Combined Threats and Synergistic Impacts:

Importance of Climate Change Factors Compared to Other Ecosystem Threats:

Threat:	Rank Order:	Comments:
Development	1	
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.
Logging/Exploitation	2	
Fire	3	Inadequate fire is the greatest threat to protected examples.

The greatest threats to this system do not come from climate change. Conversion and exploitation have destroyed most of this once-extensive system, and continue to consume the remnants. Inadequate fire and it consequences are the greatest ecological threat among protected examples, and continue to threaten unprotected examples (although development, conversion, and logging are greater threats at unprotected sites).

Climate change may exacerbate some of these problems. In the current settled landscape, these systems 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. Because many examples are now fragmented and isolated, uncontrolled fire that burns whole patches is a significant threat to many insect populations.

Recommendations for Action:

Interventive Measures:

Intervention:	Importance:	Feasibility:	Comments:
Restore/Maintain Hydrology	Mediu	High	
Restore/Maintain Landscape Connections	Mediu	Medium	Good restoration is difficult in these systems and will take time and effort.
Control Invasive Species	High	High	Watch for arrival of Imperata and other new invaders and control promptly.
Conduct Prescribed Burns	High	High	Burning is difficult for some examples, but is more feasible than most other interventions.
Protect/Expand Remaining Examples	High	High	

Prescribed burning is crucial for retaining these systems in both the present and the expected future 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 before droughts become severe 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 represent less of a wild fire hazard to adjacent areas, 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.

Because so few examples remain, and many rare species are associated with this habitat, 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 will increase with the stresses of a changing climate. Improving landscape connections would also make them more resilient to the impacts of wild fire.

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. Fire ants are already a serious cause for concern for many of the animal species that inhabit savannas. The development of multi-queen colonies, resulting in greatly increased hive densities, should be regarded as a major threat to savanna ecosystems. High hive densities are already a serious problem along the Gulf Coast and may spread northward aided by decreased winter severity.

Ecosystem Group Summary:

Wet Pine Savannas are likely to be resilient to climate change effects. Most of their component species range well to the south of North Carolina. They are tolerant of drought, fire, and wind. Many have broad tolerance of varying moisture and nutrient conditions. However, they have been drastically reduced by conversion to other uses and degraded by lack of fire. This makes them more vulnerable to loss of species and degradation both by climate change and by other threats. Protection of remaining examples and restoration of degraded examples would help the Coastal Plain landscape adapt to future climates, as well as provide benefits under the current climate. Keeping or restoring fire to these systems, through prescribed burning, is crucial to their long term survival in both the present and any future 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.