Forest Decline in the Southeastern United States: Assessment of the State of the Science

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Workshop Overview, Report, and Summary

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General Forest Health Problem Description and Statement of Basic Issues

In the course of a Department of Defense-sponsored workshop on land management priorities, the land management staff at Fort Benning, GA mentioned their belief that their loblolly pine forest stands, upon which their Red-cockaded Woodpecker recovery program depends, are declining at an alarming rate. If decline continues, the staff believe that their ability to recover the species at their location will be compromised. They, and other installations, want to know if there is a forest health problem that may result in a local or regional decline in function and productivity. The principal concern is that if such a problem were to expand, and extend to longleaf pine plantings, it could have adverse impacts on current ecosystem restoration and endangered species recovery efforts. At broader scales, such a problem would have serious landscape and watershed implications as well as affect local economies that are dependent upon the forest products industry. Based on current forest pathology work, a few observations have been noted: 1) the problem is likely due to the combined effects of multiple stressors that include past and current human use, 2) different pathogens may be involved and have differential physiological effects, 3) mature or maturing plantation pine stands seem to be most susceptible, and 4) different pine pathogens (disease, fungi, insects) may be contributing to the observed tree health problem, but root-borne fungi (blue-stain species) appear to be consistently associated with the observed forest health phenomena.

Forest types that are particularly susceptible include those dominated by loblolly pine and shortleaf pine; however, some longleaf pine forests appear to have forest health issues. The observed problem seems to be more prevalent across the Sandhills physiographic region, which lies between the Piedmont and Coastal Plain provinces. Relative to the Coastal Plain, the Sandhills region is characterized by a greater proportion of unproductive soils. These forests may be sensitive to multiple stressors and disturbances. The Sandhills region is also characterized by several large federal installations (e.g. Fort Bragg, Fort Jackson, Savannah River Site, Fort Gordon, Fort Benning) that have different levels and types of disturbances, but most have similar land histories and land management objectives. Potential threats to forest health are therefore of concern to the federal agencies that operate installations in this region, particularly the Departments of Defense and Energy.

If such a forest health problem exists, then several underlying questions must be asked, including:

1) What is the forest health/decline problem and how widespread is it (scope/scale/magnitude)?
   a. Is the current forest health problem new, cyclic, or climate related?
   b. Are we being unrealistic in not accepting these losses as within the normal range?
   c. Why do commercial timber producers not report this as an important matter?
   d. Where are the places/species/systems in which these symptoms are experienced?
   e. Is this the same as a “little leaf?”
   f. Is this the same as “loblolly decline?”

2) What are the underlying causes and do these causes differ across the region?
   a. How may we characterize the suite of possible causes and influencing factors?
   b. What early detection techniques are currently available (e.g. remote sensing) and how accurate are these techniques?
   c. Is it possible to construct a diagnostic flow diagram that can then be used in assessing forest health?
   d. With forest health in mind, what is the relationship between past land use and combinations of current management techniques: what disturbance (natural, forest...
management, army training) combinations increase or accelerate the observed forest health problem; are there relationships to military mission activities?
e. Independent of land history and current land management, do some systems and locales have greater susceptibility/resistance/resilience than others?
f. What is the likelihood that forest decline is primarily caused by an invasive fungal species: physiologically and biochemically, what does a *Leptographium* fungal infection do that results in the expressed symptoms and would a better understanding of these relationships help in identifying site susceptibility?
g. What interaction effects exist between fungal infections and other forest pests (beetles, etc.)?

3) Are there management actions that can be taken immediately that would help minimize the impact of a potential forest health problem?
   a. Assuming a “worse case scenario” forest health situation, what management opportunities exist to minimize the impact to achieving desired future conditions such as red cockaded woodpecker recovery, sustainable forests, etc?
   b. What actions can be taken to reduce the risk of a forest health problem and its implications?
   c. Based on the existing landscape, are our land management goals and expectations unrealistic and “out of sync” with the existing ecological capacity (i.e. can today’s post-agriculture conditions meet our expectations or should forest health problem be expected)?

4) How would a significant forest health problem affect achievement of long term plans (desired future conditions, red cockaded woodpecker recovery, troop readiness, etc.)?
   a. Can or should the consequences of forest decline be prioritized, and if so on what basis?
   b. Do the consequences affect mission fitness and troop training capability?
   c. If there is a “point of no return,” how far are we from it and how rapidly are we progressing toward it?
   d. If the problem continues to progress, what will the future economic and planning impacts be?
   e. Including regeneration, what are the implications as related to longleaf pine recovery and desired future condition expectations?

**Project Plan**

The Science Programs Office of the Ecological Society of America (ESA), which has access to a wide range of expertise on ecosystem services and forest ecology through the 10,000 members of ESA, was tasked by the Department of Defense’s Strategic Environmental Research and Development Program (SERDP) with preparing an assessment of the state of knowledge regarding forest decline in the Southeast, summarizing the current science, identifying and prioritizing gaps in knowledge, and providing guidance to resource managers to address the issue. To meet these goals, ESA coordinated the following:

- an initial kickoff meeting at Fort Benning, Georgia to receive input from local experts on their needs to address the forest health issues.
• a workshop of 44 researchers and managers to exchange information and determine the degree of consensus on the nature and extent of the problem

• preparation of a set of white papers by a subset of those involved in the workshop, addressing five basic questions:
  o What is the problem?
  o What are the cause(s) of the problem?
  o How widespread is the problem?
  o What actions should environmental managers and researchers take immediately?
  o What actions should be taken over the long term?

• a site visit to Fort Benning, Georgia, so that participants can gain an immediate appreciation for the concerns of environmental managers in the field

• preparation of a nontechnical summary, in language accessible to nonscientists, for distribution to decision makers, legislators, and the general public

This general approach was refined in consultation with the U.S. Army to work out such details as design and timing of the workshop, identification of participants and the lead authors, content, and format of white papers.
Workshop Summary

Background

Workshop presenters summarized the concern seen at Fort Benning regarding the function of the forests in supporting endangered species, particularly the Red Cockaded Woodpecker (RCW). At Fort Benning, a majority of the RCW cavities use loblolly pine, and anecdotal observations suggest that too many mature loblolly pines are dying. Possible explanations for the health problem being seen at Fort Benning include:

- Pre-military land use history – agriculture (loss of topsoil, row crop farming on poor soils, nutrient depletion), commercial logging and railroads
- Military training disturbance – soil compaction and/or continuous “churning”
- Loblolly pine decline/littleleaf disease of shortleaf pine – the symptoms seem to match but the causes may not be identical
- Beetle infestation and pathogen outbreak
- Poor soil quality – inadequate soil nutrients may not support growth of mature trees
- Carbon loss in un checked fires – carbon and nitrogen lost to atmosphere in too frequent fires

Current data sources on the state of the forest at Fort Benning include research projects, a plot monitoring program, and an ongoing forest inventory (started in late 2005 with approximately 48,000 acres inventoried to date, mostly of the upland acres.). Information is lacking on how quickly trees are moving from fair to poor crown vigor, the rate of mortality, and what would be considered “normal age and mortality conditions” at Fort Benning. Currently the mean stand age is 54 years and 5.4% of the total trees tallied were dead.

In the early to mid 1990s, Fort Benning management began to focus on longleaf pine restoration the best forest system for military needs at Fort Benning to support RCW recovery. They are on a on a 2 to 3 year burning cycle to support longleaf and benefit military training. The current condition is still mostly loblolly. There is a higher representation of longleaf where military impact areas, which have seen a history of regular fire (1-2 year intervals), are located.

Much of the industry-owned land south of Fort Benning sees shorter crop rotations based on tree harvesting; thus the land managers have not been aware of the forest health problems. Most industry has also ceased to use prescribed burning as a tool, so there are different understory conditions. Industry is not managing for habitat and old growth.

Longleaf pine ecosystem restoration challenges include legacy land use (agriculture and erosion, and resulting regional soil attributes and characteristics), past and present fire regimes, urban development, smoke management, spatial constraints (density and competition), infestations (pathogens and beetles), and military training (fire regimes, root damage). For management of RCW, the greatest risk is loss of sustainability and flexibility. Risks to military training would limit future land-use opportunities.

There still remains the question of whether this is a regional forest health problem rather than a local problem. Sporadic occurrences have been seen in Piedmont, Sandhill, and Appalachian plateaus (SE Arkansas to Alabama and North Carolina). The compacted, finer-textured soils that are the original habitat of the loblolly pine have the likelihood of greater problems. Shortleaf pine and loblolly are the most impacted, with some occurrences in longleaf pine stands. Some reports suggest “fading” of longleaf pine stands planted on abandoned farm land. Coastward reports are limited, which is
potentially due to differences in: soil texture and productivity, weather pattern differences including salt deposition, differences in land-use legacies, or management activities (burning, harvest, herbicides).

What are the consequences of forest decline?
- Change in forest structure & composition
  - Potential impacts:
    - Rate of RCW recovery
    - Other cavity-users associated with pine habitats
    - Mission training flexibility
    - Loss of fuel for fire may be an issue for low basal area stands
    - Undesirable forest age structure
  - Desired future conditions not greatly affected
  - Accelerated longleaf restoration could decrease Gopher Tortoise habitat

Implications of longleaf decline
- Desired future conditions cannot be achieved for affected stands
- Long term RCW recovery would be uncertain
- Training conditions would be altered
- Mission flexibility would be compromised

**Breakout Reports**

**Breakout Topic #1: What is the forest health/decline problem and how widespread is it (scope/scale/magnitude)?**

Participants discussed the forest health/decline problem and how widespread it is (scope/scale/magnitude). Two main themes emerged: 1) Is this health problem new, cyclic, or climate-related? and 2) Where are the places/species/systems with these problems?

**Is this health problem new, cyclic, or climate-related?**
1) Better quantitative information is needed to address this question regionally and at other locales.
2) We suspect that the forest health problem arises from a novel set of stressors derived from legacy, current management, and/or cultural activities.
3) Climate change and cycles may be exacerbating the forest health problem.
4) Management of forest health may be limited by new environmental policies and land-use demands.

**Where are the places/species/systems with these problems?**
1) The potential problem may need elevated monitoring and feedback to improve/refine research questions.
2) Differential tree species mortality may be a critical component in interpreting the question.
3) The forest health question associated with loblolly pine and shortleaf pine may be a time-progression bottleneck related to stand development and RCW habitat.
Identified needs/Recommendations:
1) Assess monitoring needs, frequencies, and intensities with improved integration and model development.
2) Monitoring should be regionally integrated with established FIA/FHM and Eastern Forest Threat programs.
3) Effective use of remote sensing tools is needed.
4) Evaluate management techniques, protocols, and implementation to reduce presumed stressors.
5) Quantification of flexibility of desired management “end points” and capacity to meet objectives.
6) Interaction study of management related effects on resources may be needed.
7) Management response thresholds are needed to determine when to initiate actions.
8) Determine if there is a new local or regional problem associated with an exotic *Leptographium* spp. on longleaf pine.
9) A better understanding of longleaf pine physiological response to interacting stresses (particularly climate induced).
10) Well developed list of geographic locales and health problems.
11) Develop scale-appropriate remote sensing technology that can be integrated with field monitoring information using GPS/GIS.
12) Expanded understanding of the spatial pattern, mortality spread rate and infection of tree species, and their relationships with local and regional stressors/conditions.

Breakout Topic #2: What are the underlying causes and do these differ across the region?
Participants discussed the underlying causes of the forest decline and how these differ, if they do, across the region. Stress was a common theme and possible causes and influences include:
- Agriculture, soil erosion, similar land use histories/land disturbance with different variations
- Change in soil characteristics, composition and nutrient balance
  - May affect root architecture
- Changes in duff layer characteristics
- “Exotic ecosystem”

It was determined that interacting factors must be considered, no single approach will work. Additional research data is needed to determine causality and mortality patterns (locally and regionally). There may be a need to conduct surveys to determine the extent and species affected. Climate also affects present conditions and is not manageable.

The likelihood that the “decline” is primarily caused by an invasive species was discussed and requires further research. *Leptographium* has been found in longleaf roots but not clear if it causes longleaf mortality. Other pathogens, insects, and factors need to be considered.

Identified needs/Recommendations:
1) Data on the extent and rate of this decline is needed to evaluate its severity.
2) Identify the questions.
   a. Is it that off-site pine is declining as expected OR is off-site pine declining faster than expected? Is there decline in loblolly that occur on their original, ‘natural’ sites?
   b. Is longleaf also declining/affected? Should be studied in conjunction with loblolly pine
c. Are there any data to relate the decline symptoms to fire? To military training exercises? To weather and climate phenomena? To other stressful situations?

3) Use preventative measures (best management practices) to reduce introduction/spread of other pathogens and insects (e.g. borax on stumps, sanitation).

4) Determine causality of mortality.

5) Need site specific manipulative studies (e.g. inoculation experiments, determine what combinations of stressors are at higher risk of causing mortality).

6) Determine if the system in which the trees are now growing so stressed, and so different from the original that the deaths represent normal senescence, and no intervention will likely succeed.

**Breakout Topic #3: Are there management actions that can be taken immediately that would help minimize the impact of a potential forest health problem?**

Participants discussed short term management actions that could help minimize the impact of a potential forest health problem.

**Identified needs:**

Before short-, medium-, and long-term management actions can be identified, the following are necessary:

1. Characterization of decline.
   a. Spatial and within stand and across the landscape, and within other military installations.
   b. Potential influential variables (e.g. slope, aspect, land-use history, mortality, pathogens, burn regime), baseline or acceptable mortality rates for each species in decline.
   c. Values and data for (b) above.

2. Integrated stand management unit database. A one-stop shop that will integrate stand history and management. Vital information is needed before triage can be done. This database needs to be invested in before other medium and long term goals can be undertaken. Eglin Air Force Base has one of these, and perhaps that can be used as a template. One essential short-term solution is the need to hire a fire restoration ecologist to critically think about, design, and publish the results of the longleaf pine/RCW restoration program and to take ownership of the database onsite.

3. For Fort Benning we need to bridge the gap for RCW populations:
   a. Decrease the mortality rate of colony trees using adaptive fire management (e.g., decrease the intensity, don’t conduct warm season burns, and perhaps decrease the frequency of fires). Decreasing fire frequency won’t help restore longleaf pine, though. On Fort Benning, the best RCW/longleaf pine habitat (as defined by the matrix) is in the impact zones where fires are regular and disturbance is the norm.
   b. Increase the suitability of longleaf pine host trees for RCW colonies: place artificial cavities in younger trees, inoculate trees with heart-rot fungus.
   c. Relocate the RCW colonies to off-site forest stands that are suitable.

Once causal agents are correctly identified, actions include:

a. Fire
b. Harvesting (clear cutting, thinning)
An Adaptive Management approach is necessary. Factors change: fire regime, pests – timing of management, regeneration, harvesting, herbicide application, etc.

**Recommendations:**
If RCW clusters start to die off, the first priority is to move the clusters to healthy habitat (e.g., move them off-site, stop-gap measure or “organized retreat”).

a. On-base mitigation—loss of habitat and clusters in training areas offset the clusters within the impact area; move RCW populations to other restored areas on the base.

b. Off-base mitigation—purchase land (fee simple) adjacent to base to provide a buffer for encroaching urban and suburban land use-land change (LULC); conservation easement; move RCW off site and/or purchase mitigation credits.

If clusters are not immediately at risk, then several opportunities exist to improve forest health, (adaptive management approach “plan>act>measure/monitor>adjust>repeat) including:

a. Decrease the intensity of fire in the loblolly pine stands, or burn in the cooler season in “weakened” stands.

b. In the “weakened” stands although they are using the 1-3 year return interval to restore longleaf pine, maybe they should use 3-5 yr return interval (which is the burn interval for loblolly)... This solution may be less desirable than the intensity issue because of fuel buildup over 5 years may cause more intense fires even if they are in the winter.

c. In the “weakened” stands, decrease the root/soil disturbance—use cut-to-length harvesting operation only.

d. Bring more habitat online — To jump-start the longleaf pine savanna structure, use mechanical and herbicidal treatments to restore the structure in stands that don’t have the structure yet... then use burning to maintain that structure.

e. Increase the longleaf pine regeneration effort: put cavities in smaller trees, inoculate trees with heart-rot fungus.

f. *Annosum* identify high hazard areas based on soils and species (loblolly on sandy soils) if you thin those sites then do it in the summer and also treat the stumps with sporax by hand. *Hylastes* is most active in April-May, so you don’t want to thin during this time. Considering multiple pest interactions, might be best to thin during the winter and treat stumps.

**Breakout Topic #4: How would a significant forest health problem affect achievement of long term plans (desired future conditions, red cockaded woodpecker recovery, troop readiness, etc.)?**
Participants discussed long term management action plans that are affected by a forest health problem.

The effects on mission fitness and troop training capability if there is forest decline are not direct, since low basal area stands are desirable for training; however, indirect consequences due to loss of flexibility because of restrictions associated with declining RCW will occur. Also, accelerated longleaf restoration could reduce training land base...
If there is a “point of no return,” how far are we from it and how rapidly are we progressing toward it?

- With respect to RCWs “points of no return” are (a) population below viable size and (b) managed stability foraging habitat standard for the territory.
- At the territory scale distance to point of no return is uncertain.
  - There may be a point of no return for RCWs at the territory level, a point at which basal area falls to a sufficiently low level that territory sizes expand.
  - Identifying this point at a territory level is a research need
- At the population scale not likely to get to point of no return.
- Cannot say for affected stands
- To answer the question these are the information needs:
  - Identifying patterns of mortality within and between stands (which trees are dying, where & how fast)
  - Using that to develop a stand dynamics model (e.g., as Eglin has done)
  - This will require identifying appropriate baseline mortality patterns against which to compare across the region.

If the problem continues to progress, what will the future economic and planning impacts be?

- There could be a period of RCW decline, leading to a loss of mission flexibility.
- There may be an undesirable effect on the age structure of the forest which could affect the economics of the timber program as well as mission flexibility.
- Pace of longleaf conversion
  - Short term: increase in underplanting at current rate of tree mortality
  - Long term: increase in stand conversion at accelerated rate of tree mortality
- Ability to plan for addressing the effects of forest decline is limited.
- An appropriate planning tool that incorporates inventory and monitoring data, and constraints such as limits on the amount of training land that can be tied up in longleaf regeneration, is needed.
- The need for additional planning efforts may increase if mortality rate increases.

Including regeneration, what are the implications as related to longleaf pine recovery and desired future condition expectations?

- Few long term implications:
  - desired end state can still be achieved despite the forest health problem, although the methods may change.
- The long term objective is unaffected.

Identified needs/Recommendations:

- Understanding potential vulnerability of longleaf to the forest health issue.
- For loblolly pine:
  - Identifying patterns of mortality with comparison to appropriate baseline.
  - Develop a stand dynamics model.
- For RCW:
  - Determine how fitness, territory size, and territory loss are related to changes in forest structure and composition.
- Planning tools that integrate inventory data, monitoring data, modeling, and restoration strategies.
- Synthesizing state of knowledge about causes of forest health decline.