Recent Literature and Resources: Forest Management on Public Lands

by
Stacy M. Seamans[a] and Melinda G. Knutson[b]

[a]U.S. Geological Survey, Upper Midwest Environmental Sciences Center
[b]U.S. Fish and Wildlife Service, National Wildlife Refuge System, Biological Monitoring Team

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A research needs assessment conducted in 2006 by the U.S. Fish and Wildlife Service, National Wildlife Refuge System (NWRS) in Regions 3 (Midwest) and 5 (Northeast) indicated that there is a high priority need for refuge managers. The need is to collect better information about setting priorities and monitoring the effects of management on forests. Funds were allocated by the U.S. Geological Survey to issue a call for adaptive management research proposals focusing on high priority management needs identified by the NWRS. In response to these events, a workshop, *Forest Management for National Wildlife Refuges*, was planned and held at Big Oaks NWR, Madison, Indiana on August 8-10, 2006. NWRS project leaders, biologists, and foresters from the Midwest and Northeastern U.S. as well as scientists from USGS and academia attended. The objectives of the workshop were:

1. Gain an understanding of the current status of forest management on refuges.
2. Review the science of forest management on conservation lands.
3. Increase understanding of how adaptive management and modeling can be applied to improve forest management on refuges.
4. Inform the call for proposals from USGS and set the stage for designing an adaptive management research project.
    a. Define problem(s) and identify threats with regard to forest management on refuges.
    b. Identify information needs for setting or achieving forest management objectives on refuges; identify obstacles that make it difficult to set or achieve management objectives.
    c. Use Refuge Management Scenarios to share ideas and explore the thought process that is required for setting measurable forest management objectives (desired future conditions) and identify metrics that could be monitored by refuges.
    d. Use a Regional Forest Management scenario to share ideas for setting measurable *Regional* forest management objectives (desired future conditions) for the Refuge System.
    e. Explore possible themes for a multi-refuge project to work on with USGS, with a focus on forest management, including identifying metrics that could be monitored by multiple refuges.

This list of recent literature and resources provides a brief introduction to forest management and monitoring for public land managers. A companion database (Forest Management Literature Database) with approximately 400 papers, books, and websites was also developed as a resource for NWRS staff searching for literature on forest management. The Procite database and an M.S. Excel version are posted on the Biological Monitoring Team's website: https://intranet.fws.gov/Region3/ScienceExcellenceandLandscapeConservation/bio_monitoring.html. In addition, a glossary of terms is provided by the U.S. Forest Service, North Central Region based on *The Dictionary of Forestry* at this website: http://www.ncrs.fs.fed.us/fmg/nfmg/glos.html. The words and terms in this glossary are used to describe aspects of forest management. A clear definition of each term will help resource managers use common language to communicate with forestry professionals.

The papers or resources selected below are interesting, relatively recent, and are written by reputable forest ecologists in the United States and elsewhere. They are divided into categories: forest ecology, threats, silviculture, wildlife, metrics, and adaptive management. There is a brief introduction for each section and the abstracts are included, if available. The selected resources provide specific information on forest management, but they are by no means comprehensive. The companion database lists several textbooks that provide more comprehensive and in-depth treatment of the practice of forest management.

Forest Ecology

Forest ecology is the study of the relationships between forest organisms and their environment. This is a broad topic and hundreds of papers and books have been written about it. The difficulty for public land managers is that they typically manage several different habitat types and they can't be experts in the ecology and management of all of them. They need resources to help them make good management decisions when time is limited. The following resources will be helpful to managers in the Midwest and Northeastern United States.

Manomet Center for Conservation Sciences:
http://www.manometmaine.com/default.asp

U.S. Forest Service, North Central Research Station:
http://www.ncrs.fs.fed.us/
http://www.ncrs.fs.fed.us/pubs/

U.S. Forest Service, National Forest Health Monitoring:
http://fhm.fs.fed.us/

U.S. Forest Service, Northeastern Area, Forest Health Protection:
http://www.na.fs.fed.us/fhp/index.shtm

U.S. Forest Service, Forest Inventory and Analysis National Program:

http://www.fia.fs.fed.us/

Great Lakes Ecological Assessment:
http://www.ncrs.fs.fed.us/gla/

Cleland, D.T., L.A. Leefers, and D.I. Dickmann. 2001. Ecology and Management of Aspen: A Lake States Perspective. Proceedings of a Conference - Sustaining Aspen in Western Landscapes.

Aspen has been an ecologically important, though relatively minor, component of the Lake States (Michigan, Wisconsin, and Minnesota) forests for millennia. General Land Office records from the 1800s indicate that aspen comprised a small fraction of the region's eastern forests, but was more extensive on the western edge. Then Euro-American settlement in the 1800s brought land clearing, timber harvesting, and subsequent widespread wildfires that increased aspen-birch acreages considerably. Though aspen-birch acreage has declined since the 1930s, it remains the region's second most prevalent forest type. Aspen management is probably the most contentious issue confronting forest managers in the Lake States.

Hodges, J.D. 1997. Development and ecology of bottomland hardwood sites. Forest Ecology and Management 90:117-25.

A basic knowledge of the origin, development, and ecology of bottomland hardwood sites is important for assessing harvesting impacts on those sites. This paper presents an overview of the geologic origin and development of hardwood sites, species-site relationships and the natural patterns of ecological succession on those sites, and the implications of that information for forest management. Bottomland hardwoods occur on floodplain sites primarily in the Atlantic and Gulf Coastal Plains. Past geologic events led to the formation of broad stream valleys in those areas because of the erodible, sedimentary geologic materials. Natural patterns of ecological succession on floodplain sites are influenced by autogenic and alloginc processes in that the sites may undergo constant change because of deposition. Three natural patterns of succession are recognized for floodplain sites of major river bottoms - those occurring on permanently flooded sites, those on low elevation wet sites, and those on higher elevation, better drained sites. Floristic composition and successional patterns are strongly influenced by the hydrologic events on the sites and particularly by rates and types of deposition.

Simberloff, D. 1999. The Role of Science in the Preservation of Forest Biodiversity. Forest Ecology and Management 115(2-3):101-11.

Forest management must change radically to maintain biodiversity. 'Biodiversity' has many components, but only one has been measured unambiguously - species richness - although there is recently much emphasis on structural, process, and functional diversity. So we must determine exactly what aspects of biodiversity to seek, and why. A battery of suggestions about how to achieve this re-focus on biodiversity (e.g., ecosystem management and the 'new forestry') are catchwords rather than guides on how to manage forests on the ground. These suggestions stem from an ill-defined concept of 'forest health,' which can be seen variously depending on the desired role and state of a forest. Ecosystem management for some versions of forest health may even decrease some forms of biodiversity. A decline in species richness need not lead to a decline in the process diversity or rates. Evidence that species richness contributes to ecosystem maintenance and function is scant. Thus, effective management for biodiversity (generally species richness) entails a frank commitment to maintain biodiversity as an end, not as a means. Some suggestions to maintain forest biodiversity while still allowing timber production, such as uneven-aged stand management and various burning regimes, are focused squarely on species richness per se, but they are hypotheses, not scientifically validated procedures. Existing empirical measurements on such techniques are usually on the amount and sustainability of timber harvest, not on how well they maintain species richness. A wealth of scientific research is needed, involving landscape-level field manipulations and careful natural historical observations on the effects on various species. The idea that forests can always serve multiple uses, including wood production and maintenance of all species, is an untested hypothesis. It may be incorrect; maintaining some species may require extensive pristine tracts. The major requirement for almost all research needed to manage forests for biodiversity is extensive and intensive monitoring. The concepts of umbrella and indicator species as management shortcuts are barely tested. Their utility can be validated only by intensive field study. Valuable umbrellas and/or indicators may exist for some forest systems. However, management procedures should not evolve towards management of indicator species, as the indicator might cease to indicate the status of other species. By contrast, managing an umbrella species is not an inherent contradiction in terms, but different umbrella species may shelter different sets of species, so management for one might be inimical to the other. The concept of keystone species may be useful in forest management. If the fates of particular species determine those of many others, managing for such keystones may effectively maintain species richness. But recognition of a keystone species requires well-designed experiments.

Slosser, N.C., J.R. Strittholt, D.A. DellaSala, and J. Wilson. 2005. The landscape context in forest conservation: integrating protection, restoration, and certification. Ecological Restoration 23(1):15-23.

No abstract

Threats

Forest communities must be managed properly to maintain their ecological integrity. An unhealthy or poorly managed forest may lose the ability to produce the proper resources for wildlife leading to an ecological “sink” or loss of habitat for many species of wildlife.

The identification of ecological problems leads to the important step of determining appropriate management strategies to overcome them. Proper forest management practices will create healthy forest communities that can sustain the necessary forest processes for wildlife habitat and plant communities.

Increasing fragmentation, disturbance and climate change increase opportunities for invasive species to become established in U.S forest ecosystems. The National Commission on Science for Sustainable Forestry (NCSSF; 2005) estimated monetary losses of U.S. forest products due to invasive species to be over $2 billion annually. They identified non-native species significant to forest health in the United States: Nun moth (*Lymantria monacha*), Sirex woodwasp (*Sirex noctilio*), Emerald ash borer (*Agrilus planipennis*), Sudden oak death (*Phytophthora ramorum*), Dutch elm disease (*Ophiostoma ulmi*), Hemlock woolly adelgid (*Adelges tsugae*), Balsam woolly adelgid (*Adelges piceae*), Chestnut blight (*Dryphonectria parasitica*), White pine blister rust (*Cronartium ribicola*), European gypsy moth (*Lymantria dispar*), Japanese honeysuckle (*Lonicera japonica*).

Northeastern area forest stressor report - 2001:

http://www.fs.fed.us/na/durham/foresthealth/text/stressor_report/stressor_report.shtml

U.S. Forest Service, Northeastern Area, Forest and Tree Health Publications for Pests:

http://na.fs.fed.us/pubs/palerts.shtm

Augustine, D.J., and D. Decalesta. 2003. Defining Deer Overabundance and Threats to Forest Communities: From Individual Plants to Landscape Structure. Ecoscience 10(4):472-86.

Changes in habitat and reduction in predation and hunting pressure are two primary causes of high-density populations of white-tailed deer (*Odocoileus virginianus*) in many areas of eastern North America. Despite increasing recognition of the major effects deer exert on forest communities, deciding when deer are overabundant remains a major challenge to managers charged with conserving native plant communities. In this context, we define overabundance as a condition where deer are causing the local extinction of a native plant species. Because this definition is difficult to apply from a management perspective, we outline an approach using native understory forbs. Indicator species are selected based on combined criteria of palatability to deer, leaf and flower morphology, and demographic characteristics. Four indices related to plant population viability are derived from understory survey data: flowering rate, mean stem height, stage-class distribution, and deer browsing pressure. We apply this analysis to Trillium populations from forests in Minnesota (highly fragmented agricultural landscape with varying deer densities), Pennsylvania (forested and fragmented landscape with long-term high deer densities), and New York (forested and fragmented landscape with long-term low deer densities). We observed two distinct types of deer-affected plant populations. In sites with moderate or recent increases in deer density, Trillium populations were characterized by low mean plant size, high browsing rates, intermediate flowering rates, and a size class distribution lacking large, reproductive plants. Sites affected by long-term high deer densities exhibited low browsing rates on Trillium, low Trillium flowering rates, a population structure lacking both large and small plants, and high summer browsing pressure on woody saplings. We suggest these combined indices be used to assess deer browsing impact, and we discuss the role of landscape structure and deer density in defining deer overabundance.

Brockerhoff, E.G., A.M. Liebhold, and H. Jactel. 2006. The Ecology of Forest Insect Invasions and Advances in Their Management. Canadian Journal of Forest Research 36(2):263-268.

Invasions by nonindigenous forest insects can have spectacular effects on the biodiversity, ecology, and economy of affected areas. This introduction explores several critical issues that are generally relevant to invasions by forest insects to provide an extended background for this special issue of the Canadian Journal of Forest Research and highlights the key findings of the papers included in the issue. The topics covered address new information about (1) the role of cargo shipments as invasion pathways for the arrival of insects such as wood borers and bark beetles, (2) biogeographical effects that can influence the ecological and economic impact of insects feeding on exotic tree species, (3) the influence of biodiversity on impacts of forest insects and on the invasibility of ecosystem, and (4) recent advances in the detection, monitoring, and management of invasive species and native pests, including DNA barcoding for identification, the use of pheromones for monitoring and mating disruption, and biological control. These findings are likely to become even more important with elevated prevalence of invasions as a result of increasing global trade and international travel. Avenues of international communication and cooperation among scientists should be encouraged to enhance the sharing of information about biological invasions and to find solutions to this alarming problem.

Gobster, P.H. 2005. Invasive Species as Ecological Threat: Is Restoration an Alternative to Fear-Based Resource Management? Ecological Restoration 23(4):261-270.

Invasive species is a hot topic in the USDA Forest Service these days. Along with wildfire, land conversion and unmanaged recreation, Chief Dale Bosworth has called invasive species one of the "Four Threats" needing the attention of Forest Service land managers and researchers (USDA Forest Service 2004). My unit of the Forest Service, the North Central Research Station, has responded to the call by focusing a portion of our research capacity on invasives. As a social scientist, I began looking for my niche in the issue by searching the literature for what had been done on the social aspects of invasive species. Not much, I soon concluded. Most work tends to focus on risk assessment and economic impact analysis or the ethics of exotic species removal. There are also some general outlines, done mostly by ecologists, documenting the human causes and consequences of introductions. Few social scientists, however, have looked at invasives within the context of questions considered of central importance to understanding the human dimensions of natural resource management - how people perceive, value and act toward nature, and what these imply for programs and policies. A few years ago, I began looking at these questions as they applied to ecological restoration projects, and now thought it might be worthwhile to do the same for invasives. What I have been finding is that while ecological restoration and the science and management of invasive species share many of the same goals and concerns, there is a fundamental difference in how the two fields are conveyed to the public. This difference relates to the use of fear as a mechanism for gaining public support and motivating behavioral change. In the pages that follow, I attempt to identify the dimensions of this difference and suggest what it might mean for talking about and dealing with invasives in the context of restoration programs, with the goal of improving the success of these programs with people in mind.

Miller, K.E., and D.L. Gorchov. 2004. The Invasive Shrub, *Lonicera Maackii*, Reduces Growth and Fecundity of Perennial Forest Herbs. Oecologia 139(3):359-357.

Effects of invasive plant species on native plant species are frequently assumed or inferred from comparisons, but rarely quantified experimentally. Such quantification is important to assessing risks and impacts of invasives. We quantified the effects of *Lonicera maackii*, an exotic shrub invasive in many eastern North American forests, on survival, growth, and reproduction of three perennial herbs: *Allium burdickii*, *Thalictrum thalictroides* , and *Viola pubescens*. We predicted that the spring ephemeral, *A. burdickii* , would be most impacted, due to early leaf expansion of *L. maackii*. Field experiments were carried out in two deciduous forest stands, one (Gregg's Woodlot, GW) disturbed and the other (Western Woods, WW) relatively undisturbed. In each stand, individual herbs were transplanted into a blocked design of 60 plots where *L. maackii* was present, absent, or removed, and monitored for 5 growing seasons. *Lonicera maackii* did not affect survival of transplants, but reduced growth and final size of individuals of all three species. For two of the species, *A. burdickii* and *V. pubescens*, *L. maackii* reduced the proportion of live plants flowering in both stands, and reduced the seed or fruit number per flowering individual in GW. For *T. thalictroides* the proportion flowering was not affected, but seed number per flowering plant was reduced by *L. maackii* in both stands. For all three species, cumulative seed production over the course of the study was reduced by *L. maackii*. Overall, effects on the spring ephemeral, *A. burdickii*, were similar to effects on the other herbs. Because mortality of these established individuals was not affected, short-term studies might conclude forest herbs are unaffected by invasive shrubs. However, the growth and reproduction impacts documented here suggest that populations are impacted in the long-term.

NCSSF. 2005. Science Biodiversity and Sustainable Forestry: A Findings Report of the National Commission on Science for Sustainable Forestry (NCSSF) Washington, DC.

No abstract.

Tremblay, J., A. Hester, J. Mcleod, and J. Huot. 2004. Choice and development of decision support tools for the sustainable management of deer-forest systems. Forest Ecology and Management 191:1-16.

Situations where a natural resource is both an asset, as well as a threat, to the integrity of ecosystem function and biodiversity are difficult to manage sustainably. One such situation happens when native deer populations, which are managed for sport are overexploiting forests to a point where they severely compromise natural forest regeneration. Managers facing those situations need support from the scientific community to analyze and synthesize information on deer-forest relationships and thus help to predict the potential outcomes of different management options for both the deer and the forests. Research scientists are increasingly expected to provide expertise and support into the decision-making process. One way to achieve this is to develop decision support tools (DSTs) based upon sound, scientific understanding of the deer-forest systems. Our objective is to explore a range of approaches that have been used for the development of DSTs for deer-forest management and to propose criteria for selecting a specific approach or combination of approaches for specific situations. DST and research-oriented models were catalogued according to two modeling paradigms: bottom-up models, which simulate systems through inductive inference, by scaling up from fundamental processes to the inherent behavior of the system-the best known applications are forest gap and individual-based models; and top-down models which proceed by deductive, rule-based inference-they include expert systems, qualitative simulation models, frame-based models, Markovian process models and Bayesian networks. Uncertainty assessment in both modeling paradigms is discussed. The analysis is put in the context of two very different examples of deer-forest systems currently requiring DST development to guide their management: (1) the upland red/roe deer-fragmented temperate/boreal forest system of Scotland; and (2) the white-tailed deer-eastern boreal forest system of Anticosti Island, Quebec, Canada. We conclude that a top-down approach with explicit uncertainty assessment should be aimed for, as a deliverable product to the end-users, keeping in mind that simulation models from the bottom-up family may be required to gain insights about the underlying mechanisms.

Silviculture

Silviculture is the practice of controlling the establishment, composition, and development of stands of trees to achieve the objectives of management. Silviculturists manipulate forest vegetation to accomplish a specified set of objectives. They control forest establishment, composition, and growth by means of regeneration, thinning, clear-cutting, seed tree retention, shelterwood maintenance, and selection. Understanding how silvicultural practices affect forest ecological integrity is essential for developing a plan to manage forests on NWRS.

Albrecht, M.A., and B.C. McCarthy. 2006. Effects of Prescribed Fire and Thinning on Tree Recruitment Patterns in Central Hardwood Forests. Forest Ecology and Management 226(1-3):88-103.

> Second-growth oak forests in the central hardwoods region are considered compositionally unstable in the absence of large-scale disturbances. While prescribed burning and mechanical thinning treatments are potential options for managing succession in mixed-oak forests, few studies have adequately studied tree successional patterns in mature (> 100-year old) stands following application of these anthropogenic disturbances. In a randomized block factorial design, we studied tree recruitment patterns (stems < 10 cm dbh) in three mature southern Ohio forests that contained stands divided into four treatment units (each approximately 30 ha): control, prescribed fire, mechanical thinning, and mechanical thinning followed by prescribed fire. Treatments were applied in the dormant season of 2001. A single prescribed fire reduced seedling and sapling densities of *Acer rubrum*, the understory dominant in these forests. *A. rubrum* rapidly recovered to pre-treatment levels in all treatment units four growing seasons following the disturbances, largely by colonizing from seed and resprouting from top-killed sapling regeneration. Mechanical thinning treatments accelerated understory recruitment of early-successional, shade-intolerant tree species that regenerated from seed (e.g., *Liriodendron tulipifera*) and resprouted from a seedling bank (e.g., *Sassafrass albidum*). Oak (*Quercus* spp.) seedlings < 140 cm tall densities were unresponsive to all treatments over the 4-year study period, although densities were dynamic through time. Seedling densities of *Q. alba* and *Q. prinus* declined in all treatments over the 4-year study period, while seedling densities of *Q. velutina* increased in all treatments. Oak seedling sprouts were not released from growth suppression in silviculturally thinned or burned forests. Four growing seasons following treatment application, oak regeneration remained at a competitive disadvantage with high densities of early-successional species present in xeric and intermediately moist portions of thinned stands. To maintain adequate oak recruitment in these forests, our data suggest that prescribed fire may need to be applied several years following a mechanical thinning treatment. Periodic fires are predicted to control the strong resprouting response of *A. rubrum* and fast-growing opportunistic tree species.

Haeussler, S., L. Bedford, A. Leduc, Y. Bergeron, and J.M. Kranabetter. 2002. Silvicultural disturbance severity and plant communities of the southern Canadian boreal forest. Silva Fennica 36(1):307-327.

Boreal forest ecosystems are adapted to periodic disturbance, but there is widespread concern that conventional forest practices degrade plant communities. We examined vegetation diversity and composition after clearcut logging, mechanical and chemical site preparation in eight 5- to 12-yr old studies located in southern boreal forests of British Columbia and Quebec, Canada to find useful indicators for monitoring ecosystem integrity and to provide recommendations for the development and testing of new silvicultural approaches. Community-wide and species-specific responses were measured across gradients of disturbance severity and the results were explained in terms of the intermediate disturbance hypothesis and a simple regeneration model based on plant life history strategies. Species richness was 30 to 35% higher 5 to 8 years after clearcut logging than in old forest. Total and vascular species diversity generally peaked on moderately severe site treatments, while non-vascular diversity declined with increasing disturbance severity. On more-or-less mesic sites, there was little evidence of diversity loss within the range of conventional silvicultural disturbances; however, there were important changes in plant community composition. Removing soil organic layers caused a shift from residual and resprouting understory species to ruderal species regenerating from seeds and spores. Severe treatments dramatically increased non-native species invasion. Two important challenges for the proposed natural dynamics-based silviculture will be 1) to find ways of maintaining populations of sensitive non-vascular species and forest mycoheterotrophs, and 2) to create regeneration niches for disturbance-dependent indigenous plants without accelerating non-native species invasion.

Lockaby, B.G., J.A. Stanturf, and M.G. Messina. 1997. Effects of silvicultural activity on ecological processes in floodplain forests of the southern United States: a review of existing reports. 90:93-100.

Activities associated with timber harvesting have occurred within floodplain forests in the southern United States for nearly two hundred years. However, it is only in the last ten years that any information has become available about the effects of harvesting on the ecological functions of this valuable resource. Hydrology is the driving influence behind all ecological processes in floodplains, and timber harvesting alone usually has little long-term effect on hydroperiod. However, logging roads, built in association with harvest sites, can sometimes alter hydroperiod to the extent that vegetation productivity is raised or lowered. There is no evidence that harvesting followed by natural regeneration represents a threat to ground or surface water quality on flood plain sites, as long as “best management practices” are followed. Harvested floodplains may increase or have little effect on decomposition rates of surface organic matter. The nature of the effects seems to be controlled by site wetness. Data from recently harvested sites (i.e. within the last ten years) suggest that vegetation productivity is maintained at levels similar to those observed prior to harvests. During the early stages of stand development, tree species composition is heavily influenced by harvest method. Similarly, amphibian populations (monitored as bioindicators of ecosystem recovery) seem to rebound rapidly following harvests, although species composition may be different from that of unharvested stands.

Rauscher, H.M. 1999. Ecosystem management decision support for federal forests in the United States: A review. Forest Ecology and Management 114:173-197.

Ecosystem management has been adopted as the philosophical paradigm guiding management on many federal forests in the United States. The strategic goal of ecosystem management is to find a sensible middle ground between ensuring long-term protection of the environment while allowing an increasing population to use its natural resources for maintaining and improving human-life. Ecosystem management has all the characteristics of 'wicked' problems that are tricky, complex, and thorny. Ambiguities, conflicts, internal inconsistencies, unknown but large costs, lack of organized approaches, institutional shock and confusion, lack of scientific understanding of management consequences, and turbulent, rapidly changing power centers all contribute to the wickedness of the ecosystem management paradigm. Given that ecosystem management, like human survival and welfare, is a wicked problem, how can we proceed to tame it? Mangers need to use the same tools that people have always used for handling such problems – knowledge, organization, judicious simplification, and inspired leadership. The generic theory of decision support systems development and application is well developed. Numerous specific ecosystem management decision support systems (EM-DSS) have been developed and are evolving in their capabilities. There is no doubt that given a set of ecosystem management processes to support and adequate time and resources, effective EM-DSS can be developed. On the other hand, there is considerable doubt that sufficiently detailed, explicitly described and widely accepted processes for implementing ecosystem management can be crafted given the current institutional, educational, social and political climate. A socio-political climate in which everyone wants to reap the benefits and no one wants to pay the costs incapacitates the federal forest management decision making process. Developing a workable ecosystem management process and the decision making tools to support it is probably on of the most complex and urgent challenges facing us today. This paper offers a concise review of the state of the art of decision support systems related to implementing ecosystem management. A conceptual model of the context in which ecosystem management is expected to function is presented. Next, a candidate for an operational ecosystem management process is described and others are referenced. Finally, a generic ecosystem management decision support system is presented and many existing systems briefly described.

Wood, P. B., J.P. Duguay, and J.V. Nichols. 2005. Cerulean Warbler Use of

Regenerated Clearcut and Two-Age Harvests. Wildlife Society Bulletin 33(3):851-858.

> We examined use of 2 silvicultural treatments (clearcut and two-age harvests), 15-18 years post-harvest by cerulean warblers (*Dendroica cerulea*) in mixed mesophytic and northern hardwood forests of the Allegheny Mountain region in West Virginia. Cerulean warbler abundance and occurrence were greater in 70-80-year-old mature forests than in 15-18-year-old clearcuts. Although abundance did not differ statistically between clearcut and two-age treatments, it was almost 5 times greater in the two-age treatments, likely because they provided a more complex canopy structure. Abundance of cerulean warblers in unharvested periphery stands adjacent to clearcut and two-age harvests was similar to that in unharvested control stands, suggesting that small harvests within mature forest do not negatively impact cerulean warbler abundance in the remaining forest, only within the clearcut harvests themselves.

Wildlife

There are various approaches to the management of forests for wildlife. Managing for biodiversity generally leads to the identification of one or more focal species that are rare, declining, or representative of a particular habitat type or stage of forest succession. Often, it is assumed that managing for focal species with restrictive habitat requirements will also provide the necessary habitat for a suite of other species with similar habitat affinities but less restrictive habitat requirements. This assumption continues to be debated and studied. Some species management goals lead to an increase in population size, management of a species after removal by harvest, or to simply stabilize an existing population.

Third International Partners in Flight Conference 2002:

> http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/

Drapeau, P., A. Leduc, J.F. Giroux, J.P.L. Savard, Y. Bergeron, and W.L. Vickery. 2000. Landscape-scale disturbances and changes in bird communities of Boreal mixed-wood forests. Ecological Monographs 70(3):423-444.

> Bird community response to both landscape-scale and local (forest types) changes in forest cover was studied in three boreal mixed-wood forest landscapes modified by different types of disturbances: (1) a pre-industrial landscape where human settlement, agriculture, and logging activities date back to the early 1930s, (2) an industrial timber managed forest, and (3) a forest dominated by natural disturbances. Birds were sampled at 459 sampling stations distributed among the three landscapes. Local habitat and landscape characteristics of the context surrounding each sampling station (500-m and 1-km radius) were also computed. Bird communities were influenced by landscape-scale changes in forest cover.

The higher proportion of early-successional habitats in both human-disturbed landscapes resulted in significantly higher abundance of early-successional bird species and generalists. The mean number of mature forest bird species was significantly lower in the industrial and pre-industrial landscapes than in the natural landscape. Landscape-scale conversion of mature forests from mixed-wood to deciduous cover in human-disturbed landscapes was the main cause of changes in mature forest bird communities. In these landscapes, the abundance of species associated with mixed and coniferous forest cover was lower, whereas species that preferred a deciduous cover were more abundant. Variation in bird community composition determined by the landscape context was as important as local habitat conditions, suggesting that predictions on the regional impact of forest management on songbirds with models solely based on local scale factors could be misleading. Patterns of bird species composition were related to several landscape composition variables (proportions of forest types), but not to configuration variables (e.g., interior habitat, amount of edge). Overall, our results indicated that the large-scale conversion of the southern portion of the boreal forest from a mixed to a deciduous cover may be one of the most important threats to the integrity of bird communities in these forest mosaics. Negative effects of changes in bird communities could be attenuated if current forestry practices are modified toward maintaining forest types (deciduous, mixed-wood, and coniferous) at levels similar to those observed under natural disturbances.

Holthausen, R., R.L. Czaplewski, D. DeLorenzo, G. Hayward, W.B. Kessler, P. Manley, K.S. McKelvey, D.S. Powell, L.F. Ruggiero, M.K. Schwartz, B. Van Horne, and C.D. Vojta. 2005. Strategies for Monitoring Terrestrial Animals and Habitats. USDA, Forest Service, Rocky Mountain Research Station. RMRS-GTR-161.

This General Technical Report (GTR) addresses monitoring strategies for terrestrial animals and habitats. It focuses on monitoring associated with National Forest Management Act planning and is intended to apply primarily to monitoring efforts that are broader than individual National forests. Primary topics covered in the GTR are monitoring requirements; ongoing monitoring programs; key monitoring questions and measures; balancing three necessary and complementary forms of monitoring (targeted, cause-and-effect, and context); sampling design and statistical considerations; use of the data that result from monitoring; and organizational and operational considerations in the development and implementation of monitoring programs. The GTR concludes with a series of recommendations for the ongoing improvement of monitoring of terrestrial animals and their habitat.

Miller, D.A., E.B. Arnett, and M.J. Lacki. 2003. Habitat management for forest-roosting bats of North America: a critical review of habitat studies. Wildlife Society Bulletin 31(1): 30-44.

Public and private land managers increasingly are being asked to consider habitat needs of bats (Chiroptera) when planning forest management activities. However, reliability of current data on which to base management of forest-roosting bats is uncertain. Therefore, we surveyed peer-reviewed manuscripts pertaining to habitat ecology of forest-roosting bats for the period 1980-2001. We found that there were limited data upon which to base habitat management for forest-roosting bats because relatively few studies (56 over 21 years) have been conducted, most have occurred primarily in older-aged forests with little to no active forest management, and current research has primarily focused on roost-site selection to infer habitat relationships and response to habitat change. Limited sample sizes and pseudo-replication were prevalent, and management recommendations often were made without regard to inferential bounds of collected data. We contend that studies using bat detectors have limited ability to infer habitat selection per se, and recommend that studies incorporating detectors define more appropriate objectives regarding habitat associations. The best use of bat detectors may be generation of hypotheses of habitat selection to be tested with more appropriate techniques. There also is a need to conduct more long-term, holistic, experimentally designed research, to focus habitat research on 1-2 focal species per study, and to expand habitat research to include a wider diversity of forest types and management regimes. We suggest that cooperative research efforts be developed to secure sufficient funding and logistical support for such studies. We also recommend that authors clearly state the objectives of their study, including sampling assumptions and limitations; define inferential space; ensure that results are interpreted within inferential bounds of their data, especially at the proper spatial scale; and use consistent terminology when articulating concepts and results of their work.

Sallabanks, R., E.B. Arnett, and J.M. Marzluff. 2000. An evaluation of research on the effects of timber harvest on bird populations. Wildlife Society Bulletin 28(4):1144-1155.

We reviewed 95 studies (published from 1972 to 1997) that examined relationships between timber harvest and populations of songbirds and cavity-nesting birds. We critique the way in which studies have been conducted, evaluate their usefulness to forest managers, and suggest new directions of study. The number of bird-forestry studies conducted increased throughout our review period and most appeared in The Journal of Wildlife Management (24%) and U.S. Department of Agriculture Forest Service technical publications (19%). More studies (32%) have occurred in the northeastern United States than elsewhere and most have examined effects of clearcutting (53%). Researchers typically collect data on all bird species, especially songbirds (78%), using common sampling protocols such as point-count surveys, line transects, and spot mapping techniques to assess relative abundance (55%) and density (32%). Few studies (13%) measured avian demographic parameters such as nest success or survivorship. Most studies (68%) lasted only 1-2 years; only 7 (7%) lasted >4 years. Most studies (27%) had only one replicate/treatment. Research on effects of timber harvest on bird populations has been limited to mensurative (observational) studies in which treatment effects cannot be inferred statistically. Most research is correlational (84%) and does not address cause-and effect relationships. Incorporating experimental treatments to provide pre- and post- timber harvest comparisons is rare (16%). Future research should: 1) be more long term; 2) incorporate rigorous experimental designs in which treatments are assigned randomly and better replicated; and 3) although difficult, measure parameters related to avian fitness and population viability. Rather than only documenting observed patterns, researchers need to focus on identifying causal mechanisms that can be translated into meaningful management recommendations to enhance conservation of forest avifauna.

Thompson, F.R. III. 2005. Landscape level effects on forest bird populations in eastern broadleaf forests: principles for conservation. USDA, Forest Service, Pacific Southwest Research Station. PSW-GTR-191.

Forest fragmentation, urbanization, and forest management are important issues for bird conservation in the eastern broadleaf forest of North America. Fragmentation of forest by agricultural and developed land uses increases the numbers of Brown-headed Cowbirds (*Molothrus ater*) and nest predators in the landscape, which results in decreased productivity of songbirds. Reproductive success is so low in some Midwestern landscapes that the only way populations could persist is through immigration, which provides circumstantial evidence that populations are structured as sources and sinks. Recent hypotheses that put nest-site factors in a habitat context, habitat or local factors in a landscape context, and landscapes in a geographic context provide guidance for conservation planning. At a landscape scale conservation efforts should focus on providing necessary habitats, conserving existing large-contiguous landscapes, and reducing fragmentation in moderately fragmented landscapes. Minimizing habitat fragmentation at a landscape scale may be the best approach to addressing local effects such as edge and patch size effects.

Thompson, F.R. III., J.D. Brawn, S. Robinson, J. Faaborg, and R.L. Clawson. 2000. Approaches to investigate effects of forest management on birds in eastern deciduous forests: How reliable is our knowledge? Wildlife Society Bulletin 28(4):1111-1122.

We review some key features of scientific inquiry and experimental design and apply them to studies of the effects of forest management on songbirds. We use examples from contemporary studies in eastern deciduous forests. Scientific methods, observational versus experimental studies, replication and randomization, choice of factors and models, and response variables are important elements in designing research approaches that address effects of forest management. There are significant gaps in our knowledge on the effects of forest management on birds. Many studies have addressed effects of management on species abundance, but we can make only limited inferences from most of these. The design of studies is complicated because of the range of forest management practices, variation in bird species responses, differences among forest types, and the effects of confounding factors such as landscape effects. Few studies have addressed effects of forest management on the reproductive success of forest songbirds. We believe the reliability of our knowledge in this area will be improved most quickly if we use current knowledge to generate hypotheses, use a mix of well-designed observational and manipulative experiments to test them, and more frequently measure reproductive success in addition to bird abundance.

Twedt, D. J. 2005. An objective method to determine an area's relative significance for avian conservation. USDA, Forest Service, Pacific Southwest Research Station. PSW-GTR-191.

Land managers are often concerned with providing habitat that affords the "best habitat for songbirds". However, unless management simply is directed at rare species, it may not be clear which habitats or management options are best. A standard, quantifiable measure to compare the significance of different tracts of land or competing management techniques for avian conservation would benefit managers in decision making. I propose a standard measure that is based on the relative density of each species within a finite area and their respective regional Partners in Flight concern scores. I applied this method to >100 reforested sites in the Mississippi Alluvial Valley that ranged in age from 2 to 32 years. The objectively determined avian conservation significance for each of these reforested sites was correlated with stand age and with my subjective assessment of "habitat quality". I also used this method to compare the avian conservation significance of forested habitats before and after selective timber harvest. Sites with high significance for avian conservation provided habitat for species of conservation concern. I recommend application of this methodology to other sites, and areas under different management, to determine its usefulness at predicting avian conservation significance among habitats and at various avian densities.

Welsh, H. H., and S. Droege. 2001. A Case for Using Plethodontid Salamanders for Monitoring Biodiversity and Ecosystem Integrity of North American Forests. Conservation Biology 15(3):558-569.

Terrestrial salamanders of the family Plethodontidae have unique attributes that make them excellent indicators of biodiversity and ecosystem integrity in forested habitats. Their longevity, small territory size, site fidelity, sensitivity to natural and anthropogenic perturbations, tendency to occur in high densities, and low sampling costs mean that counts of plethodontid salamanders provide numerous advantages over counts of other North American forest organisms for indicating environmental change. Furthermore, they are tightly linked physiologically to microclimatic and successional processes that influence the distribution and abundance of numerous other hydrophilic but difficult-to-study forest dwelling plants and animals. Ecosystem process such as moisture cycling, food-wed dynamics, and succession, with their related structural and microclimatic variability, all affect forest biodiversity and have been shown to affect salamander populations as well. We determined the variability associated with sampling for plethodontid salamanders by estimating the coefficient of variation (CV) from available time-series data. The median coefficient of variation indicated that variation in counts of individuals among studies was much lower in plethodontids (27%) than in lepidoptera (93%), passerine birds (57%), small mammals (69%), or other amphibians (37-46%), which means plethodontid salamanders provide an important statistical advantage over other species for monitoring long-term forest health.

Wigley, T.B., T.H. Roberts. 1997. Landscape-level effects of forest management on faunal diversity in bottomland hardwoods. Forest Ecology and Management 90(2-3):141-154.

Forest management activities potentially influence ecosystems at many spatial scales. For most forest systems, influences at the stand level have been most intensively studied and are best understood. Management impacts at the larger, landscape scale are poorly understood and many hypotheses regarding landscape-level effects remain untested. This lack of knowledge is particularly acute in bottomland hardwood forest (BLH) ecosystems. Most hypotheses regarding landscape-level impacts were derived from theories about island biogeography and metapopulations. Thus, species presence and productivity sometimes are viewed as functions of patch characteristics such as size, shape, amount of edge, degree of isolation from larger, similar habitats, time since isolation, and dispersal, immigration, and extinction rates. Recommendations for mitigating fragmentation effects often include maintenance of reserves, increasing patch size, reducing edges, and enhancing connectivity through the use of corridors. While many of these theories are intuitively sound, there are few data to demonstrate their effectiveness in landscapes dominated by managed forests, including BLH forests. We suggest that high priority be given to using adaptive management to simultaneously test hypotheses about how biotic communities function in managed, BLH landscapes. Such information would help managers understand the consequences of their activities, provide them with more flexibility, and improve their ability to protect biological diversity while also meeting society's needs for forest resources.

Wood, P. B., J.P. Duguay, and J.V. Nichols. 2005. Cerulean Warbler Use of Regenerated Clearcut and Two-Age Harvests. Wildlife Society Bulletin 33(3):851-858. (See Silviculture section for abstract)

Metrics

The use of ecological indicators is very appealing to managers because they provide a cost and time efficient way to assess the impacts of environmental disturbances on an ecosystem and can provide information on the effectiveness of management strategies.

Forest Mosaic Science Notes from Manomet

> **A process for identifying species at risk in forested landscapes**
> **LS index: Northern hardwood Forest**
> **LS index: Upland Spruce-fir Forest**
> http://www.manometmaine.com/publications.html

Alexander, S.A., and C.J. Palmer. 1999. Forest health monitoring in the United States: first four years. Environmental Monitoring and Assessment 55(2):267-77.

> To address the need for more effective methods for evaluating and assessing forest ecosystem health, the USDA-Forest Service and the US Environmental Protection Agency through its Environmental Monitoring and Assessment Program developed the Forest Health Monitoring program. The program was initiated in 1990 and by 1994 was present in the major areas of the United States. This paper presents an overview of the program, the indicators and methods developed for the program, and some of the results after four years of monitoring and research.

Allen, R.B., P.J. Bellingham, and S.K. Wiser. 2003. Forest Biodiversity Assessment for Reporting Conservation Performance. Science for Conservation 216:p49.

> There is a need to upgrade the quality of information about the status of indigenous biodiversity so that agencies (e.g. Department of Conservation) can make appropriate conservation management decisions. Methods and indicators for determining changes in indigenous forest biodiversity are developed. Because indicators, and the way they are derived, will change over time, it is most essential that any biodiversity assessment system is based on an enduring set of compositional, structural and functional characteristics. Experience in indigenous forests suggests the following are required for monitoring systems: build on past information while accommodating new developments; pay more attention to sampling design; select indicators that achieve goals; do not focus too much attention on today's specific views and concerns; allow for interpretation of indicators in monitoring designs; and, do not expect an indicator will necessarily return to some pre-disturbance value or trajectory. Six indicators are proposed: forest area and fragmentation as a habitat indicator; tree mortality and recruitment rates for maintenance of structural dominants; community composition as an indicator of species assemblages; exotic weeds as a measure of intactness; indices for introduced animal impact; and, quantity and characteristics of dead wood as a habitat diversity indicator. Many of these indicators are currently best assessed through a network of permanent plots. There is also considerable merit in having

indicators which can be used in predictive models to develop time-frames for management intervention. These indicators are assessed in relation to other national and international initiatives, including the Biodiversity Strategy. Although this report was specifically commissioned for forests, such a system should eventually be established to cover the full range of ecosystems.

Brooks, R.P., T.J. O'Connell, D.H. Wardrop, and L.E. Jackson. 1998. Towards a regional index of biological integrity: The example of forested riparian ecosystems. Environmental Monitoring and Assessment 51(1-2):131-143.

Our premise is that measures of ecological indicators and habitat conditions will vary between reference standard sites and reference sites that are impacted, and that these measures can be applied consistently across a regional gradient in the form of a Regional Index of Biological Integrity (RIBI). Six principles are proposed to guide development of any RIBI: 1) biological communities with high integrity are the desired endpoints; 2) indicators can have a biological, physical, or chemical basis; 3) indicators should be tied to specific stressors that can be realistically managed; 4) linkages across geographic scales and ecosystems should be provided; 5) reference standards should be used to define target conditions; and 6) assessment protocols should be efficiently and rapidly applied. To illustrate how a RIBI might be developed, we show how four integrative bioindicators can be combined to develop a RIBI for forest riparian ecosystems in the Mid-Atlantic states: 1) macroinvertebrate communities, 2) amphibian communities, 3) avian communities, and 4) avian productivity, primarily for the Louisiana waterthrush (*Seirius motacilla*). By providing a reliable expression of environmental stress or change, a RIBI can help managers reach scientifically defensible decisions.

Carignan, V., and M.A. Villard. 2002. Selecting indicator species to monitor ecological integrity: A review. Environmental Monitoring and Assessment 78(1):45-61.

We review critical issues that must be considered when selecting indicator species for a monitoring program that aims to maintain or restore ecological integrity. First, we examine the pros and cons of different management approaches on which a conservation program can be based and conclude that ecosystem management is most appropriate. We then identify potential indicators of ecological integrity at various levels of the ecosystem, with a particular emphasis on the species level. We conclude that, although the use of indicator species remains contentious, it can be useful if (1) many species representing various taxa and life histories are included in the monitoring program, (2) their selection is primarily based on a sound quantitative database from the focal region, and (3) caution is applied when interpreting their population trends to distinguish actual signals from variations that may be unrelated to the deterioration of ecological integrity. Finally, we present and discuss different methods that have been used to select indicator species.

Groebel, P.C., T.C. Wyse, and R.G. Corace III. 2005. Determining reference ecosystem conditions for disturbed landscapes within the context of contemporary resource management issues. Journal of Forestry Oct/Nov pp 351-356.

No abstract

Hagan, J.M., and A.A. Whitman. 2004. Late successional forests: A disappearing age class and implications for biodiversity. Manomet Center for Conservation Sciences. FMSN-2004-2. http://www.manometmaine.com/publications.html

"Late-successional" (L-S) forest is rapidly disappearing from managed forest landscapes in northern New England. L-S stands typically contain some trees 100-200 years old. Despite having a logging history, many L-S stands share species in common with true old-growth. Conservation strategies are needed to help landowners maintain and manage for L-S forest in the landscape.

Hagan, J.M., and A.A. Whitman. 2004. A primer on selecting biodiversity indicators for forest sustainability: simplifying complexity. Manomet Center for Conservation Sciences. FMSN-2004-1. http://www.manometmaine.com/publications.html

Maintaining biodiversity is a primary goal of sustainable forestry. However, maintaining "life in all its forms" can be a seemingly impossible task. 'Biodiversity', as commonly defined, is simply too complex to measure or monitor. The only practical solution is to use indicators. In theory, good indicators are relatively simple to measure and correlate with many other elements of biodiversity so that they too do not have to be measured. All sustainable forestry programs use indicators as the measures of success, yet there is tremendous confusion and frustration among forest managers and forest stakeholders about the usefulness of indicators. Here we explain why indicators can cause such confusion and propose a new framework for selecting biodiversity indicators that will better inform decision makers and stakeholders. What has been lacking for biodiversity indicators in sustainable forestry is not science but a structured, transparent, inclusive process for selecting indicators.

NCSSF. 2005. Science Biodiversity and Sustainable Forestry: A Findings Report of the National Commission on Science for Sustainable Forestry (NCSSF) Washington, DC.

No abstract. Excerpt from paper - The National Commission on Science for Sustainable Forestry (NCSSF) consists of a group of scientists and forest management professionals that collaboratively plan and oversee the NCSSF program. Their mission is to "advance the science and practice of biodiversity conservation in sustainable forestry" (NCSSF). The NCSSF's findings report can be used by various forest and wildlife professionals to develop and apply policies and practices that will conserve biodiversity more effectively. These findings are based on a wide range of sources that have been reviewed and assessed. NCSSF focuses its efforts in filling in gaps that are most crucial to advancing biodiversity conservation in the context of sustainable forestry. Adaptive management techniques and scientific research are used to accomplish the NCSSF's goals. The NCSSF goals are accomplished through four agendas. The initial findings of the report are not comprehensive at this stage. Instead, defining a baseline of current knowledge on management issues is their main focus at this point in time. NCSSF provides summaries and detailed reports for completed projects on their website: http://www.ncssf.org. Currently, more than half of NCSSF's initiatives are still in progress.

Ruiz-Jaen, M.C., and T.M. Aide. 2005. Vegetation structure, species diversity, and ecosystem processes as measures of restoration success. Forest Ecology and Management 218:159-173.

Most restoration projects have focused on recovery of vegetation to assess restoration success. Nevertheless if the goal of a restoration project is to create an ecosystem that is self-supporting and resilient to perturbation, we also need information on the recovery of other trophic levels and ecosystem processes. To provide an example on how to assess restoration success, we compared four measures of vegetation structure, four measures of species diversity, and six measures of ecosystem processes among pre-reforested, reforested, and reference sites. In addition, we described how Bray Curtis Ordination could be used to evaluate restoration success. Vegetation structure recovered rapidly due to the increase in vegetation height and the decrease in herbaceous cover. Other measures such as litter cover, number of litter layers, and DBH size class values are recovering at slower rates, but they also have increased vegetation heterogeneity in the reforested site. Species diversity recovered rapidly. The increase in vegetation structure changed the local conditions in the reforested site facilitating the colonization of woody seedlings, ants, reptiles, and amphibians. Ecosystem processes, particularly litter production and turnover, have enhanced the incorporation of nutrients and organic matter in the soil. By including vegetation structure, species diversity, and ecosystem processes measures we have better information to determine the success of a restoration project. Moreover, the Subjective Bray Curtis Ordination is a useful approach for evaluating different restoration techniques or identifying measures that are recovering slowly and would benefit from additional management.

U.S. Department of Agriculture, U.S. Forest Service. 2004. National Report on Sustainable Forests - 2003. FS -766.

Prologue- A new century has dawned. With it has come increased demand for goods, services, and amenities from the private and public forests of the United States. Increasing population and increasing urban centers are creating demands on our forests that were not envisioned a century ago. Today, 270 percent more U.S. citizens are being supported by essentially the same forest land area – 749 million acres – as existed in 1900. Certainly we are closer to the limits of our forests' capability to provide the things people want today than we were in 1900. Since 1900, a few national assessments and reports have made critical contributions to the development of U.S. forests. By informing public discussion about U.S. forests, the reports shaped the policy choices and pathways taken to mange American forests. On such example is *Forest Taxation in the United States*, which provided new options for forest taxation that eliminated the confiscatory nature of previous tax laws and made it possible for private landowners to invest in reforestation and stand management activities. More recently, the *2000 RPA Assessment of Forests and Rangelands and the Southern Forest Resource Assessment* influenced public discussion of domestic forest management policies from a national and a regional perspective.

This report presents a fresh analysis of the available data on the condition of forests in the United States. It uses the criteria and indicators of sustainable forest management endorsed by the Montreal Process of which the United States is a member country. The report also identifies data gaps and makes recommendations for next steps to move forward the stat of the art for analysis of sustainable forest management in the United States. A supporting document, "*Data Report – Technical Document Supporting the 2003 National Report on Sustainable Forests*", is available at http://www.fs.fed.us/research/sustain/. Thus, this report represents a significant step forward in providing an analysis of data that is consistent and comparable with analysis of data by other Montreal Process countries. The collective hope of the team of experts who assembles this report is that the reader will gain a better understanding of what available data can tell us about the status, condition, and trends in U.S. forests. The further identification of data gaps and analysis possibilities will better equip the reader to participate in the public dialog about America's forests and to help shape future policies.

"Better data leads to better dialog, which leads to better decisions" – it has been our mantra. Richard W. Guldin and H. Fred Kaiser.

Whitman, A.A., and J.M. Hagan. 2004. A rapid-assessment late-successional index for northern hardwoods and spruce-fir forest. Manomet Center for Conservation Sciences. FMSN-2004-3. http://www.manometmaine.com/publications.html

Late-successional forest typically has grown beyond silvicultural or financial maturity, and yet forest in this age class appears to be important for maintaining biodiversity. Maintaining and managing for late-successional forest therefore is an important consideration for sustainable forestry. A key step in developing management and conservation strategies for late-successional forest is having the ability to recognize it. Here we present the LS index, a simple, fast (<30 minutes), science-based tool that foresters can use to identify late-successional forest. Although built from a large number of variables, the LS index relies only on the density of large-diameter trees (>16", 40cm, alive or dead) and the density of three easily-identified lichen species. The LS index was designed for foresters. With the LS index, new opportunities for conservation, management, and quantification of LS forest are possible.

Adaptive Management

Adaptive management is an iterative approach to managing ecosystems that combines management, research, and monitoring of resources. Adaptive management helps managers evaluate the outcomes of alternative management decisions for purposes of improving future decisions. Management strategies may change over time as experience is gained.

Kershner, J. L. 1997. Monitoring and adaptive management. Watershed Restoration: Principles and Practices 116-137.

By now the reader should be convinced that restoring degraded watersheds is important. Millions of dollars have been spent to reclaim our aquatic and riparian resources and millions more probably will be. Intuitively, we know that restoration can improve these resources, but clearly restoration dollars must be spent wisely. Monitoring is the measure of success of any restoration. Well-designed monitoring should (1) indicate whether the restoration measures were designed and implemented properly, (2) determine whether the restoration met the objectives, and (3) give us new insights into ecosystem structure and function. Monitoring should help us reexamine our understanding of aquatic and riparian ecosystems and provide information needed to adapt the goals for restoring those systems. Significantly, as much or more is learned about systems by monitoring and reporting failure as is learned by reporting success. If monitoring is so important, why is so little effective monitoring undertaken in proportion to the number of restoration projects? Probably foremost is the lack of funding for monitoring, an institutional problem that persists.

Moir, W.H., and W.M. Block. 2001. Adaptive management on public lands in the United States: Commitment or rhetoric? Environmental Management 28(2):141-148.

Adaptive management (AM) is the process of implementing land management activities in incremental steps and evaluating whether desired outcomes are being achieved at each step. If conditions deviate substantially from predictions, management activities are adjusted to achieve the desired outcomes. Thus, AM is a kind of monitoring, an activity that land management agencies have done poorly for the most part, at least with respect to ground-based monitoring. Will they do better in the future? We doubt it unless costs, personnel, and future commitment are seriously addressed. Because ecosystem responses to management impacts can ripple into the distant future, monitoring programs that address only the near future (e.g., -10-20 years), are probably unreliable for making statements about resource conditions in the distant future. We give examples of this. Feedback loops between ecosystem response and adjustment of management actions are often broken, and therefore AM again fails. Successful ground-based monitoring must address these and other points that agencies commonly ignore. As part of the solution, publics distrustful of agency activities should be included in any monitoring program.

Moore, C.T., W.T. Plummer, and M.J. Conroy. 2005. Forest management under uncertainty for multiple bird population objectives. USDA, Forest Service, Pacific Southwest Research Station. PSW-GTR-191.

We advocate adaptive programs of decision making and monitoring for the management of forest birds when responses by populations to management, and particularly management trade-offs among populations, are uncertain. Models are necessary components of adaptive management. Under this approach, uncertainty about the behavior of a managed system is explicitly captured in a set of alternative models. The models generate testable predictions about the response of populations to management, and monitoring data provide the basis for assessing these predictions and informing future management decisions. To illustrate these principles, we examine forest management at the Piedmont National Wildlife Refuge, where management attention is focused on the recovery of the Red-cockaded Woodpecker (*Picoides borealis*) population. However, managers are also sensitive to the habitat needs of many non-target organisms, including Wood Thrushes (*Hylocichla mustelina*) and other forest interior Neotropical migratory birds. By simulating several management policies on a set of alternative forest and bird models, we found a decision policy that maximized a composite response by woodpeckers and Wood Thrushes despite our complete uncertainty regarding system behavior. Furthermore, we used monitoring data to update our measure of belief in each alternative model following one cycle of forest management. This reduction of uncertainty translates into a reallocation of model influence on the choice of optimal decision action at the next decision opportunity.

Summary

This synopsis of recent forest management literature is a starting point for public land managers in the Midwestern and Northeastern U.S. The companion database captures a wide range of recent literature and resources that can be consulted for more details. However, nothing can replace consultation with a skilled forestry professional with expertise in a specific forest habitat type.