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Natural Capital Science Note

A Forest Biodiversity Scorecard for Northeastern Managed Forest Landscapes

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Introduction

Conserving biodiversity is a fundamental goal of all major sustainable forestry certification programs (e.g., SFI, FSC, and ATFS). However, the biodiversity element of sustainable forestry has been especially challenging to landowners because biodiversity is complex, typically defined as "life in all its forms, from the level of the gene, to species, to whole ecosystems, including all the processes that maintain these various levels." Simply maintaining all plant and animal species is daunting enough for conservation biologists, but forest managers must manage primarily for timber and other components of sustainability, as well. Moreover, one can not manage for biodiversity unless one can measure and monitor it. Long-term monitoring is an essential part of responsible management but only when monitoring is cost effective and can provide critical information to land managers (Lindenmeyer and Franklin 2002).

The most practical approach to measuring and monitoring "life in all its forms" is to measure a few components of the forest ecosystem that can inform forest managers about the whole system - in essence, indicators (Hagan and Whitman 2006; Lindenmeyer and Franklin 2002). Sustainable forestry certification programs have largely relied on ***policy response*** indicators to assess whether landowners are achieving maintaining biodiversity. Policy response indicators reflect the capacities, policies, practices, and their

Fig. 1. A managed landscape in northwestern Maine.

implementation by a forest manager to protect an element of sustainability, in this case biodiversity. For example, certification may require that a landowner have a policy for managing snags. Policy response indicators describe the capacity of a management system to maintain elements of sustainability such as biodiversity; however, they provide no information about the actual *status* of biodiversity.

In contrast, ***condition*** indicators provide quantitative information about the status of the value of interest. For example, a landowner may assess snag density. Condition indicators are essential for knowing the current state of the system. They can describe the trajectory of a management system and corresponding forest management unit if tracked over time and/or used in models to assess the impacts of different scenarios. Condition indicators can move sustainable forestry into the realm of defensible quantitative science, and provide forest managers with

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Biodiversity Scorecard

Table 1. Biodiversity scorecard components, sub-components, indicators, justification for each indicator, and necessary data sources.

Components Sub-components	Indicator	Justification	Data Sources Required
1. Late-successional (LS) forest			
1a. LS structure	Mean large (≥ 16 inches DBH) tree density (tree/ acre)	A key substrate, nesting and denning structure for many species	Timber inventory plot data with large trees (≥ 16 inches DBH)
1b. LS forest	Percent area in LS forest	Key habitat for LS species vulnerable to forest management	GIS data layers: LS forest (stands that are tall, high-volume stands, ≥ 100 yrs old, or ≥ 16 large trees / acre)
2. Early successional (ES) species			
2a. ES bird habitat	Percent of landscape in ES bird habitat	A species group with widely declining populations elsewhere due to habitat loss	GIS data layers: ES (< 20 ft tall) forest
2b. Hare habitat	Percent of landscape in high-quality hare habitat (20-40 ft tall forest, > 50% canopy cover)	A keystone species as prey for many predators, dominant herbivore, and key prey species for Canada lynx	GIS data layers: High-quality hare habitat (20-40 yr old forest)
3. Aquatic/ riparian health			
3a. Stream sedimentation	Road crossings/ stream mile	Focal point for sediment delivery to water bodies	GIS data layers: Streams, roads
3b. Water temperature	Percent of stream miles with a buffer (≥ 49 (15 m) feet wide) of ≥ mid-age forest	Shade from buffers prevents streams from reaching lethal temperatures	GIS data layers: Streams, ≥ mid-age forest (≥ 20' tall, ≥ 50% canopy closure)
3c. Peak stream flow patterns	Percent of watersheds (12 HUC) with > 30% mid-age and older forest	Fast runoff from young forests increases the level of peak flows	GIS data layers: 12 HUC watersheds, ≥ mid-age forest (≥ 20' tall, ≥ 50% canopy closure)
4. Landscape elements			
4a. Fragmentation Index – Pine marten	Percent forestland with >=60% probability of pine marten occurrence	Yields habitat for an area-sensitive species and is an umbrella species for many other forest vertebrates	GIS data layers: ≥ mid-age forest.(≥ 20' tall, ≥ 50% canopy closure)
4b. Fragmentation Index – Canada lynx	Percent forestland with >=60% probability of occurrence Canada lynx	Yields habitat for an endangered species and is an umbrella species for many other forest vertebrates	GIS data layers: High-quality hare habitat (20-40 yr old forest)

concrete information about the status of biodiversity. Quantitative measures also facilitate decision making about biodiversity. To this end we have created and applied a series of biodiversity indicators (collectively called a "Biodiversity Scorecard") that integrates diverse elements for managed forest landscapes in northern New England.

How Was the Scorecard Developed?

We relied on regional science, stakeholder input, and the experience of forest managers to build the Biodiversity Scorecard to satisfy five key criteria for selecting indicators: science-based, ecological breadth, socially relevant, practical, and useful for land managers (Hagan and Whitman 2006). Previous scientific research funded by CFRU, NCASI, and others has positioned northern New England to be a leader in landscape-scale biodiversity conservation on commercial forestlands. This research has provided the scientific basis necessary for selecting robust yet practical indicators and has focused on key species, structures, and processes that characterize the diverse elements of northern New England's managed forest ecosystems: late-successional (LS) attributes, early-successional (ES) habitats, aquaticriparian system health, and landscape attributes (Table 1). This research was mostly conducted in Ecological Sections 212A-D and M212A.

Our first goal was to use this research to develop the fewest possible quantitative indicators that can provide us with the most information about the different components that make up biodiversity. Our second goal was to develop indicators that are practical and could be calculated using existing information. Therefore, we selected indicators that could be readily tracked using affordable data from existing inventory datasets and/or GIS data layers.

The Indicators

Nine indicators were selected based on previous Manomet and University of Maine research (Table 1). Two indicators of aquatic/riparian health, Indicator 3a and Indicator 3b, were developed based on an extensive review of the literature.

Indicator 1a: Large trees (mean number of large tree [≥ 16 inches DBH] trees / acre). Large trees are a key habitat feature for many LS forest species and large vertebrates (Whitman and Hagan 2007). Large tree density can be calculated from landowners' timber inventory data.

Indicator 1b: LS forest (percent of forest area in LS forest). We include an indicator to track LS forest because some LS species may require more habitat area than provided by single large trees (Indicator 1a). It can be easily calculated from landowner stand maps based on acres of high volume stands (>40 ft tall, >50% canopy closure, and most canopy stems ≥ 9 inches DBH) or from a combination of timber inventory data and stand maps.

Indicator 2a: ES bird habitat (percent of forest area in ES bird habitat). Populations of many ES bird species are declining across the region as their habitat is being lost to forest succession and sprawl (Hagan et al. 1997). ES habitat created by clearcutting may offset some habitat loss and reduce regional population declines (Hagan and Meehan 2002).

Indicator 2b: Snowshoe hare habitat (percent of forest area in high quality [≥ 1.0 hares / ha] hare habitat). Snowshoe hares are a keystone prey species for most carnivores in the Acadian Forest making up a substantial portion of most carnivore diets (Homyack 2003). They are a key prey item for Canada lynx. As the dominant herbivore, they may have a key function in mediating nutrient cycling (Homyack 2003).

Indicator 3a: Stream sedimentation (road crossings / stream mile). The most obvious impact of forest management on aquatic systems is the delivery of sediment to water bodies. Roads are responsible for more sediment pollution than other harvesting activities (Rothwell 1983). Permanent stream crossings are the source of the majority of sediment entering water bodies as they account for about 80% of the sediment delivered to streams (Swift 1985, Bilby et al 1989, Reeves et al. 2004). Hence stream crossing density is a good indicator for assessing risk levels for sedimentation due to forest management (Reeves et al. 2004, Hudy et al. 2006).

Indicator 3b: Stream water temperature (percent of streams with vegetation > 20' tall, > 50% canopy closure). Removal/thinning of the forest canopy can increase the solar radiation reaching the stream channel (Brown and Krygier 1970) often resulting in stream temperature warming (Wilkerson et al. 2006) that can be harmful to fish and other fauna (EPA 1986).

Indicator 3c: Stream peak flow patterns (percent of township acres in 12 HUC watersheds with > 30% 1-15 year old forest). Forest management can also affect water quality by changing the hydrology of watersheds. Peak flows can increase when >30% of a watershed consists of young forest (Hornbeck 1973, Hornbeck et al. 1993). Greater peak flows can increase bank erosion (Verry 2000) and sediment transport (Morisawa 1968). Twelve HUC size watershed is the smallest HUC size available as a GIS data layer. We suggest smaller HUC watersheds (14-16) be used because possible peaks flow increases have greatest impacts in small watersheds (Robinson et al. 1995).

Indicator 4a: Mature forest fragmentation index (percent forestland with >=60% probability of marten occurrence). Marten were used as an umbrella species for other area-sensitive species (e.g., large-bodied woodpeckers, birds of prey, and spruce grouse) that require large blocks of forest. Along with the Canada lynx (indicator below), the marten may be an effective umbrella species for > 85% of the vertebrate forest species occurring in northern New England. This indicator was derived from Harrsion's CFRU research (Payer and Harrison 2000a, 2000b).

Indicator 4b: ES forest fragmentation index (percent forestland with >=60% probability of lynx occurrence). The Canada lynx is rare in the U.S. and is federally listed as a threatened species with federal protection. Although the block size used here is much smaller than the home range of Canada lynx, it represents the area of 50% of observations of denning female Canada lynx and has been used in habitat suitability studies for northern Maine (Robinson 2005). This indicator is based on female home range size because females are critical for population viability.

Scorecard Toolkit and Testing

We have developed a Forest Biodiversity Scorecard Toolkit comprised of detailed information about the indicators and how to go about applying indicators. Manomet has also tested the scorecard by applying it to real landscapes using landowner data. University of Maine is using the scorecard to evaluate different future timber harvest scenarios to determine how biodiversity might fare under different harvest strategies applied at the landscape scale. These results will be available at the Manomet (**http://www.manometmaine.org**) and CFRU (**http://www.umaine.edu/cfru/**) web sites.

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References

Bilby, R.E., Sullivan, K., Duncan, S.H. 1989. The generation and fate of road surface sediment in forested watersheds in Southwestern Washington. Forest Sci. 35(2):453-468.

Brown, G.W., and J.T. Krygier. 1970. Effects of clear-cutting on stream temperature. Water Res. Research. 6(4):1133–1139.

EPA. 1986. Water quality criteria. EPA 440/5-86-001. Office of Water Regulations & Standards, Wash., DC 477 p.

Hagan, J., and A. Whitman. 2006. Biodiversity Indicators for Sustainable Forestry: Simplifying Complexity. J. Forestry (2006): 203-210.

Hagan, J.M. and A.L. Meehan. 2002. The effectiveness of stand-level and landscape-level variables for explaining bird occurrence in an industrial forest. Forest Sci. 48: 231-242.

Hagan, J.M., P.S. Mcinley, A.L. Meehan, and S.L. Grove. 1997. Diversity and abundance of landbirds in a northeastern industrial forest. J. of Wildlife Management 61: 718-735.

Homyack, J.A. 2003. Effect of precommerical thinning on snowshoe hares, small mammals, and forest structure in northern Maine. M.S. Thesis, Department of Wildlife Ecology, University of Maine, Orono, Maine. 195 pp.

Hornbeck, J.W. 1973. Storm flow from hardwood-forested and cleared watershed in New Hampshire. Water Res. Research 9:346-354.

Hornbeck, J.W., Adams, M.B., Corbett, E.S., Verry, E.S. and Lynch, J.A.: 1993, Long-Term Impacts of Forest Treatments on Water Yield: a Summary for NE USA. J. Hydrology 150: 323-344.

Hudy, M., T. Thieling, N. Gillespie, and E. Smith. 2005. Distribution, Status and Perturbations to Brook trout within the eastern United States. Final Report: Eastern Brook Trout Joint Venture. Oct. 28, 2005 Blacksburg, VA, 77pp.

Lindenmayer, D. and J. Franklin. 2003. Conserving forest biodiversity: a comprehensive multi-scaled approach. Island Press: Washington, D.C.

Morisawa, M. 1968. Streams: their dynamics and morphology, McGraw Hill, New York.

Payer, D.C. and D. J. Harrison. 2000a. Managing harvested areas to maintain habitat for marten. CFRU, University of Maine. CFRU RN 00-01.

Payer, D.C. and D. J. Harrison. 2000b. Structural differences between forests regenerating following spruce budworm defoliation and clearcut harvesting: implications for marten. Canadian J. of Forest Research 30: 1965-1972.

Reeves, G., D. Hohler,, D. Larsen, D. Busch, K. Kratz, K. Reynolds, K. Stein, T. Atzet, P. Hays, and M. Tehan. 2004. Effectiveness monitoring for the aquatic and riparian component of the Northwest Forest Plan: conceptual framework and options. Portland, OR: USDA, Forest Service. PNW-GTR-577.

Robinson, J.S., M. Sivapalan, J.D. Snell. 1995. On the relative roles of hillslope processes, channel routing, and network geomorphology in the hydrologic responses of natural catchement. Water Res. Research 31:3089-3101.

Robinson, L. 2005. Ecological relationships among partial harvesting vegetation, snowshoe hares, and Canada lynx in Maine. M.S. Thesis, Department of Wildlife Ecology, University of Maine, Orono, ME. 204 pp.

Rothwell, R.L. 1983. Erosion and sediment production at road-stream crossings. Forestry Chronicle. 23:62-66.

Swift, L.W., Jr. 1985. Forest road design to minimize erosion in the southern Appalachians. In Proceeding of Forestry and Water Quality: A Mid-South Symposium, ed. B.G. Blackmon, 141-151. Monticello, AR: Cooperative Extension Service, U. of Arkansas.

Verry, E.S. 2000. Water flow in soils and streams: sustaining hydrologic function. Pages 99-124 in Riparian management in forests of the continental eastern United States, E.S. Verry, J.W. Hornbeck, and C.A. Dolloff (editors). Lewis Publishers, Boca Raton, Florida.

Whitman, A. and J. Hagan. 2007. A late-successional index for temperate and boreal forest. Forest Ecology & Management. 246: 144–154.

Wilkerson, E., J.M. Hagan, D. Segiel, and A. Whitman. 2006. The effectiveness of different buffer widths for protecting headwater stream temperature in Maine. Forest Sci. 52: 221-231.

Natural Capital, or ecosystem services, includes all goods and services that we get from nature, such as clean water and air, food, carbon, biodiversity, and wood products. The **Natural Capital Initiative** at Manomet is helping people conserve functional ecosystems to sustain the well-being, environment, and prosperity of current and future generations.

Manomet's mission is to conserve natural resources for the benefit of wildlife and human populations.