MONITORING BIODIVERSITY ON SMALL FOREST LANDS

Prepared by Swedeen Consulting
for Northwest Natural Resource Group

Northwest Natural Resource Group

NORTHWEST CERTIFIED FORESTRY™

Contents

Published March 2014

Northwest Natural Resource Group (NNRG) specializes in working with non-industrial forest landowners, conservation organizations and public entities interested in conservation-based forest stewardship. Northwest Certified Forestry is a non-profit membership and services program developed by NNRG to assist small forest landowners in Oregon and Washington with optimizing the economic and ecological potential of their forestlands. Visit www.nnrg.org for more information.

Contact:
Northwest Natural Resource Group
1917 1st Avenue, Level A, Suite 200
Seattle, WA 98101
206-971-3709
info@nnrg.org

Acknowledgements: This white paper was funded in part by a USDA NRCS National Conservation Innovation Grant awarded to NNRG. We thank Paula Swedeen of Swedeen Consulting for putting together these materials.

This manual contains material written and produced for public distribution. You may download copies of this and other publications from NNRG at nnrg.org/ecosystem-services.

The photograph on the title page was provided by Matt Freeman-Gleason of MFG Images. His work is available at mfgimages.com.

Introduction

Forests on private lands of the Pacific Northwest have the potential to provide enhanced protection of biodiversity and water quality through either protection of existing fragments of complex mature forest or through the restoration of younger managed forests. The existence of structurally complex older forests on private lands in Washington and Oregon is rare and declining (Donnegan et al., 2008; Campbell et al., 2010). These forest types are not only important for supporting native biological diversity, but also for allowing forest ecosystems to adapt to climate change (Spies et al., 2010). Directing funds to small forest landowners to protect and restore biodiversity and water quality has been part of the pubic discussion on forest management for several years. **Even though formal Payment for Ecosystem Service programs for forests outside of carbon markets have been slow to emerge, it is still important to be prepared to take advantage of new markets and other opportunities as they arise.**

Monitoring and verification tend to be expensive aspects of ecosystem service payment programs in general. However, monitoring constitutes an essential component of feedback on the success of individual projects and the effectiveness of entire programs. It is therefore a key activity in Payment for Ecosystem Service Programs that are have been given on-going legitimacy (Wunder et al., 2008). This paper describes some basic approaches that can be taken to monitor actions on small landowner holdings for biodiversity, and how the monitoring component of payment programs can be integrated with monitoring for FSC and carbon offsets for efficiencies and cost savings.

Forest structure and biodiversity

Much research has been conducted over the past 30 years that documents the relationships between species diversity, ecological processes, and forest structure in the Pacific Northwest (e.g., Franklin et al., 1981; Ruggiero et al., 1991; Carey, 1995, Spies, 1998; Carey et al., 1999; Franklin et al., 2002; Olson et al., 2007). **Several aspects of forest structure at the stand level relate well to the presence and abundance of the full complement of plant, vertebrate, and invertebrate (to the extent that the latter is understood) diversity of forests in western Washington and Oregon forest types.** While larger animal species, and some small ones, require large landscapes and connectivity within those landscapes, to support viable populations, this paper focuses on aspects of forests that can be measured at the stand and landowner level. It should also be noted that structure by itself is not adequate to characterize all of the important ecological functions of forests. There are many important ecological processes that are crucial to the formation and maintenance of biological diversity and forest resilience (see especially Carey et al., 1999 and Franklin et al. 2002). In addition, some authors recommend monitoring biodiversity by directly measuring presence of the full range of species associated with different ecosystem types (e.g., Margurran, 1988). However, structure can be measured more readily and can serve as a proxy for whether the necessary processes are at work in the stands and landscapes that are subject to restoration and payment programs. In addition, programs that direct funds in a manner to increase the number of small forest landowners within particular landscapes and thus increase the overall amount and connectivity of mature, complex forest types are needed. Addressing the way in which such programs can be constructed is beyond the scope of this effort. However, any successful program at the landscape scale will require cost-effective monitoring at the stand and landowner level.

Forests that support the full level of biodiversity that is native to the coniferous and mixed hardwood ecosystems of western Washington and Oregon share several basic characteristics. These are: the presence of large[1] live trees, large live trees with deformities and cavities, large standing dead trees, large down trees (Johnson and O'Neil, 2001; Franklin et al., 2002), a diversity of tree sizes from seedlings to very large trees (Spies, 2006), full complements of native tree and shrub species, and small gaps or openings dispersed through stands and groups of stands, which result in a diversity of shrub and herbaceous plant species (Carey et al., 1999, Carey 2009). Over 150 species of birds, mammals, and amphibians depend on large live and dead trees (Johnson and O'Neil, 2001; Mellon-Mclean et al, 2012), while many invertebrates live in the canopies of big old trees, and in standing and lying dead wood (Schowalter et al., 1997). Dead wood is also very important for storing moisture and hosting ecologically important species of fungi that in turn provide nutrients to trees and shrubs (Rose et al., 2001). Plant diversity depends in part on variable amounts of light reaching the forest floor, a condition that is produced by the presence of small gaps and low light angles typical of the Pacific Northwest. Many species depend on layering of the forest canopy, which occurs when there are trees of various sizes and small openings that allow the growth of shrubs. Therefore, biodiversity and resilience of the whole system are intertwined with both large structures and spatial variability in forests. Photo examples of forest structure are provided in Appendix 1.

Given the abundance of research on structural attributes of forest stands associated with biological diversity, and the costs associated with directly measuring species presence and abundance, it is recommended to focus monitoring on the presence and development of vegetative characteristics of forests. Programmatic research can be conducted on the effectiveness of silvicultural treatments and the expected changes in species and functional diversity over time, but this should not be required for landowners, or sellers of services, as it would very likely make carrying costs of participating in biodiversity-related programs too high.

Formal programs

Formal payment programs which convey credits for regulatory mitigation or other binding agreements are likely to require relatively rigorous data to be collected in order to measure characteristics of forests important for biodiversity. This should especially be the case when active management is used to either maintain or restore forest biodiversity because the actual effects of interventions in stand growth and structural development will need to be verified. Whatever metric requirements are used for initial site characterization and baseline establishment usually form the basis for subsequent

[1] Large is defined here as greater than 30 inches in diameter at breast height, or dbh.

monitoring in order to accurately report changes in conditions to the characteristics of biodiversity over time.

The spreadsheet in Appendix 2 contains a matrix for variables to be collected and proposed target conditions to measure against. This matrix was built using the same structure as other metrics developed by the Willamette Partnership for its upland wildlife habitat metrics. The intent of following the same structure is to be able to integrate forest-based biodiversity metrics, including monitoring, with existing platforms for credit creation and trading. Given that there are no formal "forest biodiversity" credit programs, the targets for numbers and sizes of large trees, snags, percent cover of large down wood, canopy structure and small openings form a suggested starting point for such a program. The target conditions used in Appendix 2 are drawn from Carey, 1995; Carey et al., 1999; Johnson and O'Neil 2001; Franklin et al. 2002; McComb et al., 2002; and Mellon-McClean et al., 2012 (the DecAID model). These studies and models document forest conditions, both old growth, and second growth with significant structural legacies, that support vertebrate species native to forests of western Oregon and Washington. It is unlikely that most landowners would have forests in the optimal target condition, so initial measurement would serve to document starting conditions and form the basis for an agreement to manage for the target conditions (upon which payments would be predicated) and a management plan to reach them.

When high levels of accuracy are required, most of the data needed is collected through the installation of permanent plots. The number of plots needed is a function of both variability in the forest and the level of accuracy required by any particular program. Lower levels of accuracy (e.g., +/- 20% of the mean at a 90% confidence interval versus +/- 10%) require fewer plots and are thus less expensive. Most data about the structural attributes that indicate native biological diversity in forests can be obtained through measuring the diameter and heights of live and dead trees, the dimensions of down logs, and recording the species of trees as they are measured. Gaps or opening sizes in forests can be measured through aerial photo interpretation.

Measuring down wood with accuracy can be challenging due especially to its uneven or clumpy distribution within and across stands. There are several methods for sampling down wood, each with its own advantages and disadvantages. Evans and Ducey (2010) provide a thorough review of these methods and is a good source to consult when designing appropriate sampling methods that minimize cost but provide adequate information for payment programs. When stand conditions start with little or no down wood, adding in data gathering for this element could wait until after treatments are conducted to add down wood. This can reduce the cost of initial sampling for restoration projects.

Reasonable accuracy levels for tree-related variables can be gathered with one plot per 5-15 acres. Gathering data at this intensity is also required for all the major forest carbon offset programs that apply to the United States (see e.g., American Carbon Registry, 2011; California Air Resources Board, 2011; Verified Carbon Standard, 2010). Because growing bigger trees than are usually present on commercially managed forests is necessary for both restoring forest biodiversity, and for increasing carbon stocks, combining carbon and biodiversity credit projects can provide synergistic benefits. It is also very cost effective from a monitoring perspective given that most data needed for carbon inventories can be used directly to measure the structural attributes that serve as indicators of biodiversity. Data collection can be accomplished through a combination of plot measurements and office analysis of aerial photos and GIS data for between $5 and $12/acre depending in the accuracy levels required and/or desired. Forest carbon offset projects typically require re-measurement of plot data every ten years. A ten-year time interval would likely be reasonable for forest biodiversity payment programs as well. For a 100-acre project then, an outlay of between $500 and $1,200 dollars would be required to collect data every decade. Payments would need to be large enough to cover these and other administrative costs, in addition to covering the opportunity costs of other land management options, in order to make it worthwhile for landowners to participate.

If stand data is needed for on-going commercial management, an inventory can be designed to accomplish both timber management objectives and biodiversity monitoring objectives, with the marginal cost of additional plots and information being less than if the inventory was being installed just for a biodiversity payment program. In other words, if a commercial timber cruise is already going to be conducted, the additional expense for a biodiversity inventory would be approximately $2-$6 per acre more beyond a traditional timber cruise.

The ability of remote sensing techniques, especially LiDAR (light detection and ranging data), to measure forest structural attributes is advancing (see e.g., Falkowski et al., 2009, Martinuzzi et al., 2009; Goerndt et al., 2011). This technology has the potential to dramatically decrease the cost of monitoring for projects that require data on structural attributes of forests (and biomass and carbon as well). However, Washington and Oregon do not have wall-to-wall publically available LiDAR datasets, or consensus techniques for interpreting LiDAR for needed structural attributes that would allow for uniform application of monitoring standards with LiDAR data. Some states (e.g., North Carolina) are however, making high quality LiDAR data available for public use so the development of these tools for the Pacific Northwest is not inconceivable. When LiDAR products for structural attribute mapping become more widely available, the need for plot-based inventory data for project monitoring should decrease, if not disappear. In addition, there should be no need to have a hierarchy of monitoring quality to reduce transaction costs of PES programs because high quality monitoring data would be uniformly available.

Rapid assessments

Prior to the public availability of LiDAR-based forest mapping, there may be situations in which less rigorous data collection is preferable to collecting plot data. This could be for initial assessments of forest conditions during implementation of cost-share programs, for voluntary credit programs in which the goal is to document improvements in forest condition but for there are not binding commitments or in which the actions of forest landowners are not being used to mitigate loss of habitat elsewhere. Such an approach may also be useful for documenting the benefits of FSC certification.

In these situations, it may be preferable to use visual assessments of forest conditions and assign points to qualitative categories of forest structural attributes. For example – a walk through of a 20 acre property could reveal in a short amount of time whether there are any, some (e.g., 1-3), or a lot of (e.g. more than 3) large live trees per acre. A forester with experience in taking plot measurements could gauge tree, snag, and down wood size and distribution on an accurate enough scale to determine the relative degree to which subject properties contain the desired structural attributes. A landowner or program staff could be trained in the measuring and comparison of visual estimates of tree sizes and area estimates to conduct such assessments.

Using a rapid qualitative assessment approach can provide the basis for establishing management objectives and planning for silvicultural treatments to increase stand complexity and re-introduce important ecological processes. Appendix 3 contains the features to look for, and how to score relative abundance of each. It is derived from the more quantitative measurement approach in Appendix 2. The intent of the rapid assessment approach is to allow a low-cost assessment of current conditions, and if applied consistently, to show change over time. The absolute scores derived from applying the scheme are not as important as the relative difference between stands or properties measured at the same time (e.g., to rank the priorities of different parcels to acquire with limited funding), or the changing score of a property as it develops over time, or responds to treatments designed to increase forest biodiversity.

Crediting programs under Willamette Partnership's Counting on the Environment Program provide examples of using rapid assessment approaches for some ecosystem and credit types (willamettepartnership.org/tools-templates).

Combining biodiversity monitoring with carbon and/or FSC audits

If a landowner is already doing or intending to do a forest carbon offset project, measuring the structural components of forest biodiversity are nearly completely overlapped by the requirements for forest carbon protocols. The only exception, in some cases, will be down wood and the number of small openings. Small openings can be determined through aerial photos so no additional field time would be required. Some additional field time may be required for down wood, depending on the specific forest protocol being used (The Climate Action Reserve requires some down wood measurement, though to the same level of accuracy as other carbon pools; none of the other carbon protocol require down wood, but it can be an optional pool). Thus, if a landowner has already determined that a carbon project is financially desirable, monitoring for forest biodiversity would cost little if anything beyond data required for the carbon project. This would be an optimal situation for combining program payment types.

Another important synergistic use of forest biodiversity monitoring framework is to be able to document the impact of Forest Stewardship Council certification on maintaining and restoring biodiversity on private forestlands. There are several criteria contained in the certification standard that require attention to elements of biodiversity (e.g., Indicator 6.1a and 6.1c; and Criteria 6.3 and 9). In theory, using the measurement scheme developed here should work well with ascertaining whether the FSC standards associated with biodiversity are being met. Using the rapid assessment spreadsheet along with regular certification visits should allow for consistent quantification of improvements in structural complexity of FSC certified forests over time.

At the next level, using plot-based quantification, and having the measurements on individual landowners verified during field visits for FSC certification should allow for a reduction in verification costs when combining a biodiversity payment program with FSC certification. Having FSC assessors become dual accreditated for biodiversity payment programs (or triple accreditated, including carbon offsets) so that third-party verifiers can conduct site visits to assess multiple program requirements at the same time would reduce program transaction costs. Cost reductions could come from reducing the number of trips needed for verifiers to come to one property or set of properties. In addition, because there will be overlap in the characteristics of forests being assessed, the amount of time that a verifier needs to spend in the field ensuring that the target conditions are met for FSC, biodiversity, and carbon could reduce verification costs substantially compared to doing two or three separate visits for individual program requirements.

Because all three major forest carbon offset programs require some form of third party forest certification, and because FSC is explicitly recognized**, it should be a goal of FSC certification programs and verifiers to make sure that the verification process for obtaining and maintaining FSC certification is as integrated into the elements of forest carbon offset certification as possible.** In addition to saving travel time by coordinating audit visits, the visits themselves could be made as efficient as possible by reviewing the elements of measurement of common elements just once, and noting in program documentation where these overlaps occur. Examples include managing for native tree species diversity and maintaining appropriate snag densities to existing forest types.

Literature cited

American Carbon Registry. 2011. Improved forest management methodology for non-federal U.S. forestlands. Version 1.0. http://americancarbonregistry.org/carbon-accounting/carbon-accounting/ifm-methodology-for-non-federal-us-forestlands

California Air Resources Board, 2011. Compliance Offset Protocol U.S. Forest Projects. http://www.arb.ca.gov/regact/2010/capandtrade10/copusforest.pdf

Campbell, Sally; Waddell, Karen; Gray, Andrew, tech. eds. 2010. Washington's forest resources, 2002–2006: five-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-800. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 189 p.

Carey, A.B. 1995. Sciurids in Pacific Northwest managed and old-growth forests. *Ecological Applications*. 5(3): 648-661.

Carey, A.B., Kershner, J., Biswell, B. and L.D. de Toledo 1999. Ecological scale and forest development: Squirrels, dietary fungi, and vascular plants in managed and unmanaged forests. *Wildlife Monographs*. 142: 1-71.

Climate Action Reserve. 2012. Forest Project Protocol Version 3.3 http://www.climateactionreserve.org/how/protocols/forest/revisions

Donnegan, Joseph; Campbell, Sally; Azuma, Dave, tech. eds. 2008. Oregon's forest resources, 2001–2005: Five-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-765. Portland, OR: U.S. Forest Service, Pacific Northwest Research Station. 186 p.

Evans, A.M. and M.J. Ducey, 2010. Carbon accounting and management of lying dead wood. Forest Guild. White paper prepared for the Climate Action Reserve. Available at: http://www.climateactionreserve.org/how/protocols/forest/forest-protocol-white-papers

Falkowski, M.J., J.S. Evans, S Martinuzzi, P.E. Gessler, and A.T. Hudak. 2009. Characterizing forest succession with LiDAR data: An evaluation for the Inland Northwest, U.S.A. *Remote Sensing of Environment* 113: 946-956.

Franklin, J.F., Cromack Jr., K., Denison, W. et al., 1981. Ecological characteristics of old-growth Douglas-fir forests. Gen. Tech. Rep. PNW-GRT-118. Portland, OR: U.S. Forest Service, Pacific Northwest Research Station. 48 p.

Franklin, J.F., T.A. Spies, R. Van Pelt, A.B. Carey, D.A. Thornburgh, D. R. Berg, D.B. Lindenmayer, M.E. Harmon, W.S. Keeton, D.S. Shaw, K. Bible, and Jiquan Chen. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. *Forest Ecology and Management* 155: 399-423.

Goerndt, M.E., V.J. Monleon, and H. Temesgen. 2011. A comparison of small area estimation techniques to estimate selected stand attributes using LiDAR-derived auxiliary variables. *Canadian Journal of Forest Resources* 41: 1189-1201.

Johnson, D.H. and T.A. O'Neil, managing directors, 2001. Wildlife-habitat relationships in Oregon and

Washington. Corvallis, OR: Oregon State University Press. 736 p.

Martinuzzi, S., L.A. Vierling, W.A.Gould, M.J. Falkowski, J.S. Evans, H.T. Hudak, and K.T. Vierling. 2009. Mapping snags and understory shrubs for a LiDAR-based assessment of habitat suitability. *Remote Sensing of Environment* 113: 2433-2546.

McComb, W.C., M.T. McGrath, T.A. Spies, and D. Vesely. 2002. Models for mapping potential habitat at landscape scales: an example using Northern Spotted Owls. Forest Science 48(2): 203-216.

Mellen-McLean, Kim, Bruce G. Marcot, Janet L. Ohmann, Karen Waddell, Susan A. Livingston, Elizabeth A. Willhite, Bruce B. Hostetler, Catherine Ogden, and Tina Dreisbach. 2012. DecAID, the decayed wood advisor for managing snags, partially dead trees, and down wood for biodiversity in forests of Washington and Oregon. Version 2.20. USDA Forest Service, Pacific Northwest Region and Pacific Northwest Research Station; USDI Fish and Wildlife Service, Oregon State Office; Portland, Oregon. http://www.fs.fed.us/r6/nr/wildlife/decaid/index.shtml

Olson, D.H., P.D. Anderson, C.A. Frissel, H.H. Welsh, Jr., and D.F. Bradford. 2007. Biodiversity management approaches for stream-riparian areas: Perspectives for Pacific Northwest headwater forests, microclimates and amphibians. *Forest Ecology and Management* 246(1): 81-107.

Rose, C.L., B.G. Marot., T.K. Mellen, J.L. Ohmann, K.L. Waddell, D.L. Lindley, and B. Shreiber. 2001. Decaying wood in Pacific Northwest forests: Concepts and tools for habitat management. Chapter 24 in Johnson, D.H. and T.A. O'Neil, managing directors, 2001. Wildlife-habitat relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.736 p.

Ruggiero, L.F., Aubrey, K.B., Carey, A.B., Huff, M.H., tech eds. 1991. Wildlife and vegetation of unmanaged Douglas-fir forests. Gen. Tech. Rep. PNW-GTR-285. Portland, OR: U.S. Forest Service, Pacific Northwest Research Station. 533 p.

Scholwalter, T., E. Hansen, R. Molina, and Y. Zhang. Integrating the ecological roles of phytophageous insects, plant pathogens, and mycorrhizae in managed forests. In., *Creating a Forestry for the 21st Century: The Science of Ecosystem Management.* K. A. Kohm and J.F. Franklin, eds. Island Press, Washington, D.C. and Covelo, CA. 473 p.

Spies, T.A. 1998. Forest structure: a key to the ecosystem. *Northwest Science* 72(2): 34-39.

Spies, T.A., T.W., Giesen, F.J. Swanson, J.F. Franklin, D. Lach, and K.N. Johnson. 2010. Climate change adaptation for federal forests of the Pacific Northwest, U.S.A.: ecological, policy, and socio-economic perspectives. *Landscape Ecology* 25: 1185-1199.

Verified Carbon Standard, 2010. Methodology for Improved Forest Management Through Extension of Rotation Age. http://v-c-s.org/methodologies/VM0003

Wunder, S., Engel, S., and S. Pagiola. 2008. Taking stock: a comparative analysis of payments for environmental services programs in developed and developing countries. *Ecological Economics* 65, 834–852.

Appendix 1

Photos of structurally simple and structurally complex forests

Figure 1. This is a structurally simple second growth forest with relative uniform tree sizes (heights and diameters) with low understory plan diversity, and little vertical connectivity of the canopy. This stand also lacks snags and down wood.

Figure 2. This stands contains multiple live tree sizes and high amounts of large down woody debris.

Figure 3. This is the same stand as in Figure 2, showing large standing dead trees (snags) and multiple live tree sizes. Forests with these characteristics support higher numbers of different kinds of plant, animal, and fungal species.

Appendix 2

Example of matrix biodiversity variables to be collected in a biodiversity assessment

Sampling Methodology	Sample Measurement (s)
SCALE of APPLICATION	
Min/Max size of assessment area	
Use of Plots	
Sampling approach	
UNITS	
Output	
DATA COLLECTION	
Tools/Techniques	
Needed expertise	
Time	
Cost	
Indicator Class	**Sample Measurement (s)**
CONTEXT	
Connectivity	Proximity index; Historic and current vegetation maps
Priority	In a mapped priority (e.g. State Wildlife Action Plan, Ecoregional Plan)
Surrounding land use	Distance to each surrounding land use type
VEGETATION	
Natives	Terrestrial: % cover by strata or species, age classes, stem counts/density,
	species richness, target plant species presence
	Aquatic: % cover emergent/submergent/floating/other vegetation
Non-natives	% cover, invasive species presence
Bare ground	% cover
ABIOTIC	
Hydrology	Flow, depth/period of inundation, stream morphology, special features (e.g. springs, vernal pools, groundwater, open water/ponded)
Soil	Type, litter/duff layer depth, texture, drainage, erodability, stream
Geographic Features	Elevation, aspect, slope, microtopography
Disturbance	Fire return interval, wind regime, disease, flood regime
Climate	Precipitation

SPECIES	
Targets	Richness, presence, species counts, access to the site
Features	Sage, nests/dens, large wood, boulders
PRACTICE	
Crops	Irrigated/non-irrigation, type and rotation, soil conditioning
Inputs	Water, fertilizer, pesticide, phosphorous index/corn stalk nitrate
BMPs	List of practice implemented
Human Disturbance	Use, fragmentation, pollution
RISK	
Threats	Predators, invasive plants and animals, roads
Stewardship	Legal protection/ownership, existing use, ability to burn/flood

Habitat Metric Scores	**% of optimal**
CONTEXT	
VEGETATION	
ABIOTIC	
SPECIES	
PRACTICE	
RISK	
OVERALL HABITAT FUNCTION	

Appendix 3

Structural features to assess in forest biodiversity assessment and potential scoring

Sampling Methodology	**Sample Measurement (s)**				
SCALE of APPLICATION					
Min/Max size of assessment area	5 acres min to full extent of project area				
Use of Plots	Yes for formal mitigation projects, to establish project and every 10 years, then visual assessment in between years. Only visual assessment for informal voluntary programs, or for FSC data collection.				
Sampling approach	Sample to +/- 20% at 90% CI for eligibility; +/- 10% for extra points for stand-based structures				
UNITS					
Output	Index score: used for ranking proposed projects; raw data on stand structures for assessing progress towards goals of enrolled projects				
DATA COLLECTION					
Tools/Techniques	standard forestry plot measurement; GIS; aerial photos				
Needed expertise	plot measurement, data management, GIS, aerial photo interpretation				
Time	to be determined in field trials				

Cost	to be determined in field trials				
Indicator Class	**Sample Measurement (s)**				
CONTEXT		**Optimal Target Condition**	**Score for Optimal**	**Scores for less than optimal**	
Connectivity	Proximity index; Historic and current vegetation maps	TBD			
Priority	In a mapped priority (e.g. State Wildlife Action Plan, Ecoregional Plan, Listed Species recovery plan or critical habitat unit)	Yes	5	no = 0	
Surrounding land use	Distance to other forest; distance to forest in target condition; degree of isolation (surrounded by non-forest uses?)	Within 5 miles of other target patches; less than 10% of landscape in non-forest use within sub-watershed (small watershed scale)	5	6-10 miles; 11-15% converted watershed = 3	>10miles; greater 15% converted watershed = 0
VEGETATION	*Stand-scale attributes*				
Live trees	Canopy Cover % densiometer for plots; visual in between	60-80%	5	< 60 or >80% = 0	
	Tree species composition - based on inventory data; ave % stems per acre	Within range of natural vegetation type for site	5	> 50, <70 percent in two species or less = 3	> 70 percent in two species or less = 0

	Canopy complexity - assessed visually/ Number of large live trees - plot data	3 canopy layers or continuous canopy connectivty in vertical dimension; manage perpetually for >= 10 trees per acre > 40 in dbh	5	Two tree canopy layers = 3	One canopy layer = 0
Dead trees	number of snags per acre by size class; percent cover down wood	20 snags per acre > 10 inches dbh with at least 10 per acre >= 30 in dbh average over whole project area with 14/ac 20 in dbh on 10% of project area; manage for 10% cover of LDW of sizes between 12 and at least 20 in diameter as stand average, some clumps of up to 20% cover LDW.	5	10-19 snags 10 inches; 5-9 snags > 30 inches; 5-9% LDW cover = 3	5-9 snags >10 inches; 3-4 snags> 30 inches; 5-9% LDW cover = 1; less than these parameters = 0
Small openings	number of openings 0.25-0.5 acre in size in stand; determine using aerial photos	3-5 per stand optimal	5	1-2 or 6-7: 3	0 or >7 = 0
Understory	% cover shrubs	15-20%	5	10-14% or 21-25% = 3	<10% or > 25% = 0

Invasives	% cover	< 5%	5	>5 0	
ABIOTIC					
Hydrology	NA				
Soil	NA				
Geographic Features	NA				
Disturbance	NA				
Climate	NA				
SPECIES					
Targets	Any documented occurrence of state or federal sensitive, candidate, or listed species?	Documented presence of sensitive or listed species for the region is a bonus			
Features					
PRACTICE		Listed practices are part of agreement for payment program			
Thinning	Variable density				
Rotation Age	>= 80 years or uneven-aged management with small patch cuts				
Retention	20% of BA for even-aged; FSC limit on opening size				
Other	Snag creation and leaving LDW after harvest	Needed if starting condition lacks any of these elements			

Human Disturbance	Use, fragmentation, pollution	Active management, non-motorized recreation ok; development, dumping, motorized recreation prohibited by agreement			
RISK					
Threats	conversion pressure; generation turnover; financial duress; invasives				
Stewardship	conservation easement yes or no				
	Habitat Metric Scores	**% of optimal**			
	CONTEXT				
	VEGETATION				
	ABIOTIC				
	SPECIES				
	PRACTICE				
	RISK				
	OVERALL HABITAT FUNCTION				