# TOOLS TO MONITOR ECOSYSTEM SERVICES

## An Introduction to Forest Inventory, Carbon Biomass, Biodiversity Monitoring and Harvest Assessments

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In coordination with:
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Willamette Partnership

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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.

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## Background

Forests provide important benefits to both communities and ecosystems. The processes by which the environment, such as a forest ecosystem, provides resources are called ecosystem services. Forest ecosystem services include: purifying air and water, mitigating drought and floods, protecting stream and river channels and coastal shores from erosion, generating and preserving soils, cycling and moving nutrients, maintaining biodiversity, and contributing to climate stability. These ecosystem services are goods essential for human health, livelihood, sustainable economies, and underpin the health of resilient forests. Many of these services are traditionally viewed as free benefits to society, or "public goods".

Sustainable forest certification, carbon offset markets, and other emerging environmental service markets have the potential to provide financial incentives for small forest landowners in the Pacific Northwest who responsibly manage forests to provide ecosystem services. In turn, these incentives support improved forest practices beneficial to the entire forest ecosystem and reduce the risk of conversion of forests to non-forest uses. Barriers to accessing financial incentives for providing ecosystem services include forest owners lacking access to cost effective-yet-rigorous monitoring, and the expense of verification at the small scale.

## Purpose

The objective of this manual is to introduce you to ecosystem services assessment methods and data collection metrics that serve as a baseline for monitoring a forest's ecosystem services. Forest owners who incorporate forest inventory measurements, conduct biodiversity assessments, and evaluate forest conditions post-harvest are comprehensively monitoring their forestland. This monitoring can fulfill the monitoring requirements for participation in the Forest Stewardship Council™ (FSC®) group certificate managed by Northwest Certified Forestry, a program of Northwest Natural Resource Group.

A monitoring program is a requirement for managing a forest to the FSC standards.[1] Monitoring is one of the ten principles of the FSC certification standards, specifically, Principle 8: Monitoring and Assessment in the FSC-US Forest Management Standard (v1.0) states that:

> *"The frequency and intensity of monitoring should be determined by the scale and intensity of forest management operations as well as the relative complexity and fragility of the affected environment. Monitoring procedures should be consistent and replicable over time to allow comparison of results and assessment of change."*

[1] FSC-US Forest Management Standard (v1.0). 2010. Available at: http://us.fsc.org/download.fsc-us-forest-management-standard-v1-0.95.htm

In addition to meeting the standards of FSC certification, monitoring your forest and collecting baseline information is beneficial for documenting resources and preparing to participate in emerging ecosystem service markets. An objective of Northwest Certified Forestry is to provide forest owners with maximum flexibility to adapt to market changes; thus the assessment system described in this manual consists of metrics designed to provide initial steps toward compliance credits in a variety of carbon, water quality, and biodiversity markets.

This manual serves to introduce you to methods for:

- Conducting a forest inventory
- Running carbon biomass calculations from forest inventory data
- Assessing forest biodiversity
- Evaluating the effect of harvest activities

The monitoring tools, methods and guidebooks described in this manual have been designed for forest owners who possess few of the basic forestry skills. Implementing a comprehensive monitoring program will require time in the field, but it is a means to track baseline information beneficial for emerging ecosystem markets, to ultimately provide feedback to optimize your forest stewardship, and to meet FSC monitoring requirements.

**Find the detailed guides and datasheets described in this manual at [nnrg.org/ecosystem-services](nnrg.org/ecosystem-services)**

## Component 1: Forest Inventory

All landowners certified to FSC's management standards need to maintain an inventory of the commercially harvested forest products available from their forest. A forest inventory is the backbone of any monitoring system. It consists of stand level information that quantifies forest structure, volume, and growth over time. The extent to which information is gathered as part of the inventory system is dependent on the scale and intensity of a forest owner's management objectives.

As it is impractical to measure every tree in a stand, a statistical sample of a stand is preferred for this assessment. Inventory plots of a specific dimension are randomly located throughout a stand using a systematic sampling technique. Variables such as tree diameter, shrub cover, number of snags, etc. are then measured on each plot. Values from each plot are averaged together to generate an average value per acre for each variable measured (e.g. tree diameter).

**While completing a forest inventory can be a time-intensive task, it is the baseline for monitoring carbon and allows a manager to monitor and quantify changes in the forest over time.** As part of its Northwest Certified Forestry program, Northwest Natural Resource Group has developed step-by-step instructions in gathering baseline inventory data found in the guidebook *Forest Inventory and Monitoring Guidelines-Section 1.1 Inventory Techniques*.

A sample of a forest inventory field data sheet is provided on the following page of this manual. Once you collect data in the field, you will enter the data into the *Northwest Certified Forestry Inventory Program*, available to Northwest Certified Forestry members at nnrg.org/ecosystem-services. Instructions on how to enter data into the Program are provided in the manual *Forest Inventory and Monitoring Guidelines-Section 1.4 Office Analysis*.

## Component 1: Forest Inventory - Permanent Plot Tree Data Sheet

| | |
|---|---|
| Date: | Plot #: |
| Stand #: | Plot Size: |
| Note Taker: | Plot Radius: |
| Slope: | GPS Coordinates: |
| Aspect: | Notes: |

| Species | Dbh (0.1") | Height (ft) | Estimate? | Ht Live Cr (ft) | Wildlife Tree | Snag | Age | | Notes |
|---|---|---|---|---|---|---|---|---|---|
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## Component 2: Forest Carbon Biomass Assessment

Forest carbon is perhaps the best developed and monetized ecosystem service associated with forest ecosystems in the world. The ability of forests to accumulate and store carbon over time is recognized as an essential part of the global carbon cycle, and as crucial to mitigating the overall impacts of climate change.

Both voluntary and regulatory markets have developed which can result in payments to forest owners for avoiding emissions and increasing sequestration of $CO_2$. These markets are applicable to forest owners who change their forest management practices or agree to perpetuate practices that maintain high carbon stocks which are not otherwise required by law or considered business as usual for the landowner. The three major third-party verified forest offset programs in the U.S. are currently available for forest landowners in Washington and Oregon: the California Air Resources Board/Climate Action Reserve (CAR), the Verified Carbon Standard (VCS), and American Carbon Registry (ACR).

The unit of measure for forest carbon is a metric ton of $CO_2e$, and usually conceptualized as an "offset" credit that can be sold to another entity to counter otherwise unavoidable emissions of $CO_2$, usually from burning fossil fuels.

Forest carbon offset projects are built on high quality forest inventory data. The basic aspects of forests measured in carbon projects are the species, diameter, and height of standing live trees; diameter, height and decay class of standing dead trees; and the length, diameter, and decay class of lying dead wood.

### Component 2: Forest Inventory Program with Carbon Calculator

The Forest Inventory Program with Carbon Calculator is available for download at nnrg.org/ecosystem-services and has the ability to calculate the amount of carbon dioxide that trees in your forest contain. When tree heights and diameters are entered on the tree tab, carbon dioxide per acre values are calculated by stand and for the entire property by calculating the area-weighted average $CO_{2e}$ value per stand and summing these together.

At this point, the Carbon Calculator is set up to handle stands with Douglas-fir, western hemlock, western red cedar, red alder, big leaf maple, and Oregon White Oak (or Gary Oak).

There are two sets of equations for these species: the first is used to calculate cubic foot volume of the total stem, bark, and branches from height and diameter. The second set calculates biomass from cubic foot volume. Finally, biomass is translated into carbon and carbon dioxide. If you are curious, the equations can be seen in the Carbon Calculator spreadsheet of the Forest Inventory Program. The equation documents can be accessed here

and here. These equations are used by the Forest Service Forest Inventory and Analysis Program (FIA) to calculate carbon and many other aspects of forest inventory.

The report gives you the above ground live portion of the carbon stocks, as that is the reference amount used in the ARB and CAR protocols to help you calculate the amount of carbon you have on your property compared to the "Common Practice Indicator". The CPI is the average amount of above ground live $CO_2$ on private lands for the assessment area, or forest eco-region in which your forest is located. *If your carbon stocks are above this value, and you are not required by regulation or some other legal agreement, like a conservation easement, to keep above average stocks, you could turn your above average carbon stocks into carbon offset credits.* If you are below that average stocking number, you are not necessarily disqualified, but the economics of the project may be harder from a financial viability perspective. Using this method is just an initial estimate, however. There are many steps to developing a carbon project, including putting in a large number of plots to establish a very accurate measure of your carbon stocks. You can also use these values in other carbon protocols. The idea with this tool is just to give you an idea of how much carbon your forest stores, and where you are in relation to average stocking of your neighbors.

## Component 3: Forest Biodiversity Assessment

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 even though these forest types are important for supporting native biological diversity and for allowing forest ecosystems to adapt to climate change.

Forests that support the full level of biodiversity that is native to the coniferous and mixed hardwood ecosystems of Washington and Oregon share several basic characteristics. These are:

- Large live trees (> 30 in DBH)
- Large live trees with deformities and cavities
- Large standing dead trees
- Large down trees
- A diversity of tree sizes from seedlings to very large trees
- A diversity of native tree and shrub species
- Dead wood

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. The measurement requirements used for initial site characterization and baseline establishment usually form the basis for subsequent monitoring in order to accurately report changes in conditions to the characteristics of biodiversity over time.

Northwest Certified Forestry has developed a Forest Biodiversity Assessment tool to evaluate the structure and composition of forests that does not require a deep knowledge of plant and wildlife species or forest ecology. The intent of this rapid assessment approach is to allow a low-cost assessment of current conditions, and if applied consistently, to show change over time. Instructions on how to conduct the Forest Biodiversity Assessment are provided in the guide *Conducting a Forest Biodiversity Assessment* available at nnrg.org/ecosystem-services. A sample of a forest inventory field data sheet is provided on the following page.

## Component 3: Forest Biodiversity Assessment Data Sheet

### FOREST BIODIVERSITY ASSESSMENT

Douglas-fir/Mixed coniferous forests west of the Cascades - Pacific Northwest Version 1.0 Date:_____ Stand:_____

| TOPOGRAPHY & SITE CHARACTERISTICS | D |
|---|---|
| 1. Site on SE - SW facing slope steeper than 20 % (1:5) | ◯ |
| 2. Site on NE - NW facing slope steeper than 20 % (1:5) | |
| 3. Forested slope steeper than 60 % (3:5) | ◯ |
| 4. Conspicuous gorge or ravine | ◯ |
| 5. Conspicuous cliff, scree or talus slope | ◯ |
| 6. Large boulder(s) or rocky outcrop(s) | ◯ |
| **FOREST DYNAMICS** | |
| 7. Small (< 0.25 ac) canopy gaps | ◯ |
| 8. Medium (0.25-1 ac) canopy gap(s) | ◯ |
| 9. Larger (1-5 ac) canopy opening(s) created by wind or fire | ◯ |
| 10. Open or semi-open canopy | |
| 11. Numerous naturally regenerating tree saplings | ◯ |
| 12. Ground vegetation very patchy and heterogeneous | ◯ |
| 13. Exotic shrubs and trees absent or nearly absent | ◯ |
| 14. Trees with bark charred by recent fire | |
| 15. Living tree(s) with wounds or scars from fire | |
| 16. Living tree(s) with wounds or scars from more than one fire | ◯ |
| 17. Numerous trees or tree tops broken by ice or snow | |
| 18. Tree(s) felled by beaver or areas inundated by beaver | |
| **HABITAT IN THE FOREST** | |
| 19. Conspicuous bald(s) | ◯ |
| 20. Open or semi-open prairie, native grassland or meadow area | ◯ |
| 21. Forested wetland area | ◯ |
| 22. Open wetland area | ◯ |
| 23. Forested spring or seep area | ◯ |
| 24. Riparian forest | ◯ |
| 25. Streambed with substantial amounts of large woody debris | ◯ |
| 26. Stream with section(s) of cascades | ◯ |
| 27. Streambed with section(s) of cobble or gravel | ◯ |
| 28. Large hollow and internally decayed tree(s) | ◯ |
| 29. Tree(s) with twig nests | ◯ |
| 30. Nesting holes in trees or snags | ◯ |
| *Site total* | |
| *Highest possible site total* 24 | |

| TREES | D |
|---|---|
| 31. Some (native) nut-, berry- or fleshy fruit trees or shrubs | |
| 32. Numerous (native) nut-, berry- or fleshy fruit trees or shrubs | ◯ |
| 33. Canopy composed of 3 or more tree species | |
| 34. Canopy composed of 5 or more tree species | ◯ |
| 35. Numerous hardwood trees > 10" dbh | ◯ |
| 36. Some hardwood trees > 20" dbh | ◯ |
| 37. Numerous trees > 20" dbh | ◯ |
| 38. Some trees > 30" dbh | ◯ |
| 39. Numerous trees > 30" dbh | ◯ |
| 40. Some trees > 40" dbh | ◯ |
| **FOREST STRUCTURE** | |
| 41. Substantial amounts of understory and subcanopy trees | ◯ |
| 42. Canopy and sub-canopy trees of different diameters | ◯ |
| 43. Some large (veteran) trees from previous forest generation(s) | ◯ |
| 44. Numerous large (veteran) trees from previous forest generation(s) | ◯ |
| 45. Forest area(s) remaining or retained after fire, storm or logging | ◯ |
| 46. Some trees with thick branches or stem forks | ◯ |
| 47. Some tree trunks and branches covered by mosses and lichens | ◯ |
| **DEAD TREES, SNAGS AND DOWN LOGS** | |
| 48. Some standing dead or dying trees or snags > 10" dbh | |
| 49. Some standing sun-exposed dead or dying trees or snags > 10" dbh | |
| 50. Some standing dead or dying trees or snags > 20" dbh | |
| 51. Numerous standing dead or dying trees or snags > 20" dbh | ◯ |
| 52. Some standing dead or dying trees or snags > 30" dbh | ◯ |
| 53. Some down logs > 20" diameter at mid-log | ◯ |
| 54. Some sun-exposed down logs > 20" diameter at mid-log | ◯ |
| 55. Some down logs > 30" diameter at mid-log | |
| 56. Some down logs > 40" diameter at mid-log | ◯ |
| 57. Down logs in various different stages of decay | ◯ |
| 58. Some down logs covered by mosses | ◯ |
| 59. Some trees, snags or logs with shelf fungi | ◯ |
| 60. Signs of woodpecker foraging on trees, snags or logs | ◯ |
| *Stand total* | |
| SITE & STAND TOTAL | |
| *Highest possible stand total* 24 | |
| *Highest possible combined total* 48 | |

D = Douglas-fir/Mixed coniferous forests west of the Cascades
O = Oak/Douglas-fir - Oak/pine woodlands


E = Early seral reference condition
P = Ponderosa and Lodgepole pine forests east of the Cascades

## Component 4: FSC Harvest Audit Assessment

All certified members of Northwest Certified Forestry's FSC group certificate receive a harvest audit when they harvest more than 5 thousand board feet (mbf) of timber in one year. The purpose of the audit is to ensure that the harvest complies with the FSC standard. The audit visit is also an excellent opportunity to ask you FSC assessor or NCF forester questions about forest health, future management options, or opportunities to enhance wildlife habitat after a timber harvest.

Completing a harvest audit assessment is both a qualitative and quantitative process. It is beneficial to know the pre-harvest and post-harvest conditions of the stand. Such data include: the species and trees per acre, the shrub and understory composition, the presence or absence of invasive species, the condition of trees remaining on site (e.g. is there damage to remaining trees from the harvest?, are healthiest trees still on site?, were snags retained?), and the conditions of the soil (e.g. is there a woody debris layer covering the ground, signs of erosion such as rutting or run off, or evidenced of compaction).

The quantitative data for such an assessment can come from your Forest Inventory (Component 1). Pre-harvest activity assessment can often be done by combining it with regular inventory or general stand assessments. For example, prior to a timber harvest, an inventory, stand assessment and road assessment for the affected area is recommended. If this is not practical, an informal assessment of the site before the activity is sufficient.

Much of the qualitative data for the assessment can come from conducting a Forest Biodiversity Assessment (Component 3). In fact, you are encouraged to conduct a Forest Biodiversity Assessment pre- and post-harvest to better understand the structural and species elements that change in relation to the harvest treatment. In addition to using the specific tools provided in this guide, pre-harvest information can come from the photos and monitoring documents that are part of the forest management or stewardship plan for the forest. A sample of a FSC harvest audit data sheet is provided on the following page.

## Component 4: FSC Harvest Audit Assessment Data Sheet

Forest: _____ Assessment Date: _____

Stand(s) treated: _____ Harvest Dates: _____

| **Species 1** | | **Species 3** | |
|---|---|---|---|
| Volume | | Volume | |
| Grade | | Grade | |
| Buyer | | Buyer | |
| Sold as FSC certified? | | Sold as FSC certified? | |
| **Species 2** | | **Species 4** | |
| Volume | | Volume | |
| Grade | | Grade | |
| Buyer | | Buyer | |
| Sold as FSC certified? | | Sold as FSC certified? | |
| Describe pre- and post- harvest stocking levels: | | | |
| Describe the written harvest prescription. Was it followed on the ground? | | | |
| Did all clear cuts comply with FSC requirements (10-30% pre-harvest basal area retained in harvest openings larger than 6 acres)? | | | |
| Were all riparian or wetland buffers in the harvest area a correct size and clearly marked in the field? | | | |
| How was the site replanted? Are native species being replanted? What is the seed source? | | | |
| Did logs that were sold as FSC certified had the correct Chain of Custody number (SA-FM/COC-001394XXX) and FSC Claim (100% Pure) on invoices, load tickets, bills of lading, etc? | | | |

## Getting Started

Now that you've reviewed this manual and understand more about the tools available for monitoring ecosystem services, here's how you can get started in your forest:

1. Go to nnrg.org/ecosystem-services
2. Download the following documents and materials:
    a. Forest Inventory and Monitoring Guidelines
        i. Forest Inventory Field Forms
        ii. Forest Inventory Program
    b. Conducting a Forest Biodiversity Assessment
        i. Biodiversity Field Forms
3. Set up permanent plots in your forest
4. Collect forest inventory data
5. Enter the field data into the Forest Inventory Program
6. Calculate the carbon baseline of your forest using the Forest Inventory Program with Carbon Calculator
7. Take a 1-hour walk through your forest and conduct the Forest Biodiversity Assessment
8. Record biodiversity checklist score for future comparisons in your management files
9. If you've recently conducted a harvest in your forest, conduct the FSC Harvest Audit to know how the treatment has affected your forest
    a. Download the FSC Harvest Audit Assessment form at nnrg.org/ecosystem-services
10. Have you completed your ecosystem services monitoring? Great job! Share your results with us. Northwest Certified Forestry seeks to recognize forest owners for their careful stewardship. Contact us at info@nnrg.org.

## Summary

Monitoring is an important component of good forest management and understanding the ecosystem services your forest provides. It is through monitoring that you can better understand the dynamics and composition of your forest. It is also critical for indentifying changes, understanding impacts and evaluating management activities. Moreover, as ecosystem service markets emerge, monitoring is a means of collecting baseline information essential for participation in markets.