Handbook FOUR

Monitoring ecological effects

Collaborative Forest Restoration Program

January 2006

The multiparty monitoring handbook series

This multiparty monitoring handbook is part of a series of guides to monitoring collaborative forest restoration projects. The series was written specifically for projects funded through the USDA Forest Service's Collaborative Forest Restoration Program (CFRP). The Handbooks in the series are:

Handbook 1—What is multiparty monitoring?
Handbook 2—Developing a multiparty monitoring plan
Handbook 3—Budgeting for monitoring projects
Handbook 4—Monitoring ecological effects
Handbook 5—Monitoring social and economic effects
Handbook 6—Analyzing and interpreting monitoring data

Multiparty monitoring is required of all CFRP grantees; however, the methods and approaches presented in these workbooks are to serve as guides and references only. The specific methods are NOT required. Because there is a wide diversity of projects funded through the CFRP, many grantees will have different requirements for monitoring and/or monitoring assistance.

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These handbooks are updated periodically and the latest versions will be available on the Collaborative Forest Restoration Program Web site at www.fs.fed.us/r3/spf/cfrp/monitoring. For more information on this series, contact the Ecological Restoration Institute, Box 15017, Flagstaff AZ 86011-5017.

CFRP grantees are also eligible for multiparty monitoring training workshops and technical assistance from the CFRP monitoring team. This free service will be provided through September 2006. Call 866.614.8424 for details.

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Table of contents

Part 1

Monitoring ecological goals and indicators

What is ecological restoration?

The goal of restoration should be to create a self-sustaining ecosystem that functions well and needs little maintenance. Monitoring is essential in order to see if projects are achieving improved ecological conditions. There are at least three ecosystems that projects of the Collaborative Forest Restoration Program are working to restore:

- Ponderosa pine forests
- Pinyon-juniper woodlands
- Riparian communities

Part 1 of this handbook includes a description of common restoration goals and indicators. Methods for measuring each indicator are described in *Part 2*. Many of the goals, indicators, and methods listed throughout this handbook will apply to all three ecosystems listed above. Some methods are specific to only one or two ecosystem types, and this is indicated in the description of these methods. Most goals and indicators are appropriate for and will apply to all three ecosystems above.

Ponderosa pine forests

Ponderosa pine forests have changed dramatically in the Southwest since the late 1800s. Typical ecosystem changes include:

- Decreased cover of grasses and wildflowers
- Shifts in wildlife diversity
- Increased densities of small trees
- Decreased numbers of large old-growth trees

- Increased old-growth tree mortality rates due to competition from thickets of small trees
- Increased threats of large-scale insect attacks on trees
- Change from low-intensity ground fires to increasingly large, high-intensity “crown” fires
- Increasing threats to property and human lives

Most people agree that these changes are due to drastic changes in land use and land management, particularly fire suppression. Starting in the early 1900s, many small ponderosa pine trees germinated and survived, partly because of the lack of surface fires to thin excess seedlings and partly because of the removal of competition from grass due to overgrazing. As these trees have grown, they have created dense thickets of small trees that typically have little plant cover on the ground. These changes have in turn affected wildlife and fire regimes. Instead of surface fires, most ponderosa pine forests now burn in intense crown fires, which can kill many trees over thousands of acres. While there is no single prescription for every site needing restoration, virtually all ponderosa pine restoration projects involve some tree thinning and some prescribed burning.

Surface fires typically occur at the ground level of a forest, burning needles, fallen branches, and other fuels on the forest floor.

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They are especially important to restoration because they help reduce conditions such as dense ground fuels and excess tree seedlings that can eventually lead to crown fires.

Pinyon-juniper woodlands

Pinyon pine and juniper woodlands appear to be changing rapidly in the Southwest in recent decades. Scientists do not understand to what extent this is due to natural causes, such as natural climate change, or to human activities, such as the suppression of wildfire. The history of fire in pinyon-juniper woodlands is also not well understood. However, many people now live in areas of dense pinyon-juniper woodlands that pose a serious fire hazard to homes and villages. Restoration of pinyon-juniper ecosystems that threaten human communities involves reducing densities by thinning trees in order to reduce this risk of destructive fire.

Riparian communities

A riparian community, or bosque, refers to ecosystems located along streams and rivers, where trees such as cottonwoods and willows grow.

Southwestern riparian communities have been changed by human activities over a long period of time. Much of the Rio Grande valley has been inhabited by indigenous people for more than 1000 years, and Hispanic uses, including livestock grazing, have been important for centuries. In New Mexico, a riparian community is often called a *bosque*, a Spanish word for woodlands. Some ecosystem changes seen in riparian communities include:

- Lowered water table
- Soil erosion and unstable river banks
- Increased numbers of non-native plant species
- Decreased numbers of native plant species, especially cottonwood trees
- Increased number of jacks, levies, and other flood-control structures that straighten the river
- Reduced flooding over the banks of the river
- Increased fire hazard
- Reduced soil moisture

Non-native plants are those that come from a different region than where they are currently growing.

Traditional approaches to restoration are not useful for riparian community restoration in New Mexico. Typical restoration involves referring to sites that have been and continue to be relatively free from recent human disturbances. Because all riparian areas in New Mexico have been influenced by humans for many centuries, there are no such relatively unchanged sites. However, most lowland riparian communities were probably mosaics of the following:

- Areas of young cottonwood, willow, and native olive trees
- Forests with mature cottonwood trees
- Wet meadows, open marshes, ponds, and grasslands

Because there are no relatively natural bosques to refer to, restoration of these systems frequently involves efforts to restore natural processes. For example, a natural cycle of flooding over river banks allows cottonwood seeds to germinate. But restoring natural water flows is very difficult. A more practical restoration approach is the removal of non-native trees, such as Russian olives. This reduces the threat of fires, which can be devastating to native tree populations in the bosque.

Choosing ecological monitoring goals and indicators

What a group chooses to monitor will depend on the objectives of its restoration project. Each restoration project is unique, reflecting different localized characteristics of the forest, as well as the particular values of the multiparty monitoring team. In addition to this handbook, there are a number of publications that describe how to choose ecological monitoring approaches and variables. Some of these are listed in *Appendix 2*.

A monitoring goal is a general summary of the desired state that a project is trying to achieve. As described in *Handbook 2*, your project proposal and the legislation that created the Collaborative Forest Restoration Program are useful starting points for thinking about what goals your group may want to monitor. The following goals stem from this legislation. Groups can choose from the following goals or create their own as they develop a monitoring plan:

1 – Reduce the threat of high-intensity wildfire, create conditions that will continue to support low-intensity fires, and re-establish low-intensity fires

2 – Preserve old and large trees, both living and dead

3 – Enhance native plant populations and reduce invasive, non-native plant populations

4 – Conserve wildlife populations and habitats

5 – Conserve soil resources

6 – Conserve and protect riparian communities

Once the group has identified the goals it wants to monitor, it must select one or more indicators that can measure changes in that goal. An *indicator* is a unit of information measured over time that documents specific changes. For example, "extent of canopy cover" is an indicator of the threat of high-intensity wildfire. If a group measures “extent of canopy cover” over time, they can learn if and how the canopy changed and if the risk of high-intensity wildfire may have increased or decreased.

A good indicator is measurable, precise, consistent, and sensitive to changing conditions. When selecting indicators, multiparty monitoring groups will want to ask themselves whether a proposed indicator is:

An indicator is a feature that, when measured over time, documents specific changes.

- Relevant for the site and treatment?
- Sensitive to change so that it can detect change within the monitoring timeframe?
- Measurable with available methods that multiparty groups can use?
- Not subject to individual or organizational bias?
- Able to be measured by methods that are professionally accepted and understood?

The following section explains each of the suggested ecological monitoring goals for forest restoration projects, and lists recommended indicators for each goal. Part 2 describes methods for measuring each of these indicators.

An overview of ecological monitoring and indicators

Reduce the threat of high-intensity wildfire, create conditions that will continue to support low-intensity fires, and re-establish low-intensity fires

A primary goal of restoration is to reduce the threat of crown fire. There are several indicators that help determine the likelihood that a forest would support a crown fire. These include:

Crown fires are intensely hot fires that move quickly through tree tops and kill many trees, both large and small.

- Density and size of live trees
- Seedling density
- Extent of canopy closure
- Height from the ground to tree crowns
- Amount of surface fuel
- Landscape openings

An equally important goal of restoration is to re-establish low-intensity surface fires that burn across the forest floor. These surface fires are important because they help maintain a lower level of ground fuels and fewer excess small diameter trees. Without reintroduction of these surface fires, many of the positive ecological changes brought about by various treatments will be short-lived.

Surface fires typically occur at the ground level of a forest, burning needles, fallen branches, and other fuels on the forest floor.

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They are especially important to restoration because they help reduce conditions such as dense ground fuels and excess tree seedlings that can eventually lead to crown fires.

Low-intensity fire can be returned through prescribed burning or natural ignitions. If fire is introduced as part of a CFRP project, then the monitoring team may especially want to measure the following indicators before and after the burn:

- Seedling density
- Understory cover
- Amount of surface fuel

Preserve old and large trees, both living and dead

Old and large trees have significant ecological value for many reasons. They are no longer common in southwestern forests, so it is important to preserve those that do exist. Large trees, both living and dead, are important for wildlife. This is discussed further under the goal, "conserve wildlife populations and habitats" below. In addition, tree rings of old ponderosa pine trees are important for scientists to understand fire history, changes in climate, and other aspects of ecosystems. Two indicators help show whether or not old and large trees are preserved:

- Size of live trees
- Size of dead standing trees

Enhance native plant populations and reduce invasive, non-native plant populations

Native grasses and forbs are an important part of Southwestern ecosystems. These plants make up the *understory* and contribute to much of the biological diversity in most forests. Understory plants provide food and cover for microorganisms, insects, mammals and other wildlife. They also help protect soil from erosion and provide forage for grazing animals.

Understory refers to plants that grow close to the ground. These include grasses, other non-woody plants (called forbs), and woody shrubs.

Another crucial function for understory plants is their role in fire in ponderosa pine forests. When grasses and forbs are dry, they enable low-intensity fires to burn readily across the forest floor. Without enough understory vegetation, fires will not spread and will not perform their natural functions to kill overabundant small trees.

On the other hand, there are some plants that are not native to an area, and some become invasive, taking over large parts of the understory and displacing natives. Invasive, non-native plants can have negative effects on an ecosystem because they compete with native plants for space, light, water, and nutrients. They also can change the timing and role of fire in a system. The threat of fire from non-native species is particularly significant in riparian communities.

Native plants are those that naturally occur in an area.

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Non-native plants are those that come from a different region of the country or world than where they are currently growing.

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Invasive plants tend to be non-native and can spread aggressively.

For example, non-native cheatgrass (*Bromus tectorum*) may displace native species because it uses soil moisture early in the spring before native plants are actively growing. If cheatgrass becomes dense enough, it can change the timing of surface fires so that they burn when native grasses and forbs are actively growing and are more vulnerable. Cheatgrass is not preferred forage for grazers, and may be less able to protect soil from erosion than native plants.

Indicators for monitoring native and non-native plants in the understory include:

- Understory cover
- Understory plant species composition

Conserve wildlife habitat and populations

Species composition refers to all plant species, both native and non-native, that can be found in an area.

There are two kinds of goals for wildlife as part of ecosystem restoration, depending on the type of project implemented. If a project is specifically designed to restore habitat for wildlife, the goal is to create conditions that support native animals. For projects that do not specifically set out to restore wildlife habitat, the goal is to minimize negative impacts on wildlife.

Monitoring either of these goals is difficult because many animals hide from humans or are difficult to identify. To monitor wildlife it is often necessary to rely on more indirect indicators and measures. These can include "wildlife indicators" or habitat conditions.

Wildlife indicators are animal species that can help show changes in an ecosystem. The following are suggestions for monitoring wildlife indicators:

- Bird abundance and species composition
- Butterfly abundance and species composition

Wildlife indicators are animals that often respond quickly to restoration efforts and help show if these efforts have been successful.

Birds and butterflies are particularly useful indicators of changes in forest conditions, such as amount of light or temperature. The numbers of butterflies should also increase with greater numbers of flowering plant species that could result from a restoration project.

Habitat conditions help to show if an area is good for wildlife. For example, large trees are important to many different kinds of animals, including Goshawks, songbirds, wild turkeys, woodpeckers and bats. When large trees die, they are important to "cavity-nesting birds," such as northern flickers and mountain bluebirds, which rely on these trees for nesting. The arrangement of trees into clumps of three or four can provide important habitat for squirrels, bear, turkey, deer, and elk. Other habitat conditions important to wildlife include understory plants, food and cover, and woody plants, such as oaks and junipers, that provide large amounts of food for many animals. In addition, some dead wood on the ground provides habitat for small mammals, including those that store seeds from trees in the ground.

Habitat refers to the place where an animal is usually found. It generally includes food, cover, and nesting conditions that an animal needs to survive.

Habitat conditions that can be monitored include:

- Density and size of live trees
- Density and size of dead standing trees
- Understory plant composition
- Understory cover
- Density of woody plants that produce seeds, fruits, and nuts, such as oaks and junipers
- Landscape openings

Conserve soil resources

Soils are the foundation of any ecosystem and are an essential part of ecosystem health. Soils can easily be damaged when they are exposed to high-intensity fires or when heavy equipment moves large amounts of soil or packs it down hard. Damaged soils can take a very long time to recover. When soils are damaged, they are more likely to be invaded by non-native plants. The soil also becomes less favorable for tree seedlings to establish, and water is less likely to soak into the soil, which can lead to erosion.

The term "soil resources" actually refers to much more than "bare" soil. There are many components and functions of soil. For example, many organisms live in soil, including microbes, which help to free up nutrients so that they are in a more useable form for plants. Soil also stores seeds of many plants and provides homes for many invertebrates and small mammals. Some indicators that can measure soil resources include:

- Understory cover
- Extent of bare soil

For some restoration projects, you may be interested in monitoring the amount of soil compaction that occurs because of restoration treatments. This is especially true if one of your project goals is to test different kinds of mechanical treatments in order to compare which have the least impact on soils. Soil compaction is not included as an indicator here because of measurement challenges. A more extensive set of soil monitoring methods can be found in a manual published by Herrick and others (2001; see *Appendix 5*).

Conserve and protect riparian communities

Riparian communities are shady areas of trees, shrubs and herbaceous plants that grow along streams and rivers. They occupy less than one percent of the arid Southwest, but have the greatest diversity of plants, birds, and animals. The bosque provides habitat for many threatened or endangered species. Yet riparian communities are among the most threatened ecosystem types in the Southwest. Threats include higher risk of destructive fires; lowered water table; impacts from overgrazing; invasion by non-native plants including tamarisk, Russian olive and Siberian elm; and clearing for development.

A key goal of restoration in riparian communities is the removal of many of the non-native trees that live in riparian areas. These non-native trees increase the risk of destructive fires and displace native species. Riparian community restoration can also involve trying to re-create a more natural mosaic of plants, including forests of young cottonwood, willow, and native olive trees; forests with mature cottonwood trees; and wet meadows, open marshes, ponds, and grasslands. Two important indicators for riparian community health include:

- Understory plant species composition
- Classification of plant community structure

In addition, many other indicators also provide useful information about riparian communities. These include:

- Density and size of live trees
- Density and size of dead standing trees
- Understory cover
- Extent of canopy closure
- Height from ground to tree crowns
- Amount of surface fuel
- Landscape openings

Setting target values for your indicators

Target values are measurable outcomes, chosen by your multiparty monitoring team, which you hope to achieve with your project. For each indicator that will be monitored, your multiparty monitoring team should come to agreement on a target value or desired direction and level of change for that indicator. For example, you may have decided that you want to decrease tree density to 60 trees per acre on your project site, or that you want to increase understory cover by at least 20%. These values can then be used as benchmarks to help you decide whether or not you are achieving your goal. You may need to collect baseline data before specifying your target values.

It is difficult to prescribe target values for restoration project indicators in a general way. For one thing, all forest stands and all communities are different, and one prescription would not fit all sites. Every restoration project will define success in a different way, but many specific values for desired conditions will be similar to values in other projects. For example, most projects will want a decrease in the threat of high-intensity fires and an increase in the groundcover of grasses and forbs in the forest.

An example of a set of target values for ecological indicators is presented in Table 1 (next page). These are examples only. Your target values may vary, depending on the goals of your project. Some version of this set of values might be suitable in ponderosa pine forest restoration projects in the Southwest. (Note that Table 1 shows sample target values for ecological indicators *four years after* treatment. Target values for different time periods, such as one or five years after treatment, may be different.)

Summary of suggested goals and indicators

Table 2 (page 13) provides sample indicators that are suggested for each of the above six goals.

Table 1 — Examples of target values for ecological indicators

Indicator	Sample targets (four years post-treatment)
Bird abundance and composition	At least 10% increase in average abundance of native species
Butterly abundance and composition	At least 10% increase in average abundance of native species
Seedling density	40–50% reduction in average density
Surface fuels	At least 70% reduction in average weight
Height from ground to tree crown	Average distance of 8 feet or more
Understory plant composition	No decrease, or an increase, in the number of native species
Understory plant cover	At least 20% increase in percent cover
Extent of bare soil	No more than 30% bare soil
Permanent photo points	Increase in grasses and other understory plants
Landscape openings	More small meadows between patches of trees
Classification of riparian plant commmunity structure	More mature cottonwood trees with native understory (Type 1 and Type 2 stands)

Many of the indicators are listed under more than one goal because they provide information that can help explain different aspects of forest restoration.

Monitoring teams may want to consider measuring some of the indicators in Table 2 (facing page) that can provide information for more than one goal. As an example, tree density and size provide information about goals to change fire regimes, preserve old and large trees, conserve wildlife and habitat, and conserve riparian communities. Table 3 (page 14) shows indicators that are relatively easy to measure or provide information about multiple goals.

Table 2 — Summary of goals and indicators for ecological monitoring

Goal	Indicator
Change fire regimes	Density and size of live trees Seedling density Extent of canopy closure Height from ground to tree crowns Amount of surface fuel Understory cover Landscape openings
Preserve old and large trees	Size of live trees Size of dead standing trees
Enhance native plants/reduce non-native plants	Understory cover Understory plant species composition
Conserve wildlife populations and habitats	Density and size of live trees Density and size of dead standing trees Extent of canopy closure Understory cover Understory plant composition Bird abundance and species composition Butterfly abundance and species composition Density of woody plants that produce seeds, fruits, and nuts (such as oaks and junipers) Landscape openings
Conserve soil resources	Understory cover Extent of bare soil
Conserve and protect riparian communities	Density and size of live trees Density and size of dead standing trees Classification of plant community structure Understory plant species composition Understory cover Extent of canopy closure Height from ground to tree crown Amount of surface fuel Landscape openings

In addition, if all restoration projects in the region measure these six indicators, it may be possible to develop a more complete understanding of what is happening in ecosystems across the region. This would be an important benefit to the Collaborative Forest Restoration Program as well as to overall restoration efforts.

Table 3 — Important restoration indicators

Indicators	Goal
Density and size of live trees	Change fire regimes Preserve old and large trees Conserve wildlife habitat Conserve riparian communities
Density and size of standing dead trees	Change fire regimes Preserve old and large trees Conserve wildlife habitat Conserve riparian communities
Height from ground to tree crowns	Change fire regimes Conserve riparian communities
Understory cover	Change fire regimes Enhance native plants Conserve wildlife habitat Conserve soil resources Conserve riparian communities
Landscape openings	Change fire regimes Conserve wildlife habitat Conserve riparian communities
Amount of surface fuel	Change fire regimes Conserve riparian communities

Part 2

Ecological monitoring methods

General features of an ecological sampling design

Once a multiparty monitoring team has selected the goals and indicators it will monitor, it should create a "sampling design" that can become part of the monitoring plan. Sampling designs provide information about the number, location, and type of measurements to be taken at any given time. When creating a sampling design, a group will need to determine:

1 – What indicators will be monitored
2 – Methods to measure each indicator
3 – Spacing and numbers of measurements throughout the project area
4 – When and how often to take each measurement
5 – Who will take the measurements
6 – When and how data will be analyzed
7 – Where and how data will be stored

Explanations of each goal, and indicators that you can use to measure change toward or away from that goal, are provided on the next few pages. You will note that some of the indicators can be used to measure more than one goal. Methods used to measure each indicator are discussed on pages 19-47.

1 – What indicators will be monitored

When the multiparty team selects goals, they should also select indicators to measure each goal. When selecting indicators, it may also be useful to review the recommended methods for each indicator, presented in this section.

2 – Methods to measure each indicator

Methods are presented for each indicator in this section of this handbook. Measurements for ecological indicators are usually taken along a transect or in a set of plots.

A transect is a line across the landscape, made with a tape measure, so that measurements may be taken at regular intervals.

3 – Spacing and numbers of measurements throughout the project area

Each project should create an overall plan for sampling strategy before beginning monitoring. This plan should match the site features (for example, topography, variation across the site in vegetation communities) with the sampling design.

Use a map or aerial photo of your site to distribute places for data collection throughout the project area. If your project has different types of ecosystems within it, you should locate transects in areas that are similar to each other. For example, your project site may contain a large aspen stand within a ponderosa pine forest. If project treatments occur only within the ponderosa pine forest, then all transects should also be located within the ponderosa pine areas.

In order to make repeated measurements, it is very helpful to create permanent points within the forest. The spacing of transects and plots will depend on the size of the project area and the method being used. Specific sampling recommendations are found in each method in the next section.

4 – When and how often to take each measurement

Exact dates or seasons for sampling may vary by the indicator to be measured. For many indicators, it is important to gather data at the same time each year, such as during bird breeding season or when grasses are flowering. It is essential to gather "baseline data" **before** a project starts as well as after the project is implemented to show the direct influence of your project. For some ecological variables, it is also a good idea to sample indicators in a control site. These guidelines are explained below.

Baseline data provide information about the conditions in a project area before the project was started.

Take measurements before a project starts

It is important to document the project site's conditions before beginning the project, in order to have some basis for comparison later. Gathering baseline data means measuring indicators before starting project activities.

Take the same measurements after a project is completed

It is equally important to measure your indicators the exact same way before and after your project has been completed. Comparisons of data collected before and after a project can demonstrate changes that result from the project or that happen at the same time the project is implemented. Scientists recommend taking measurements shortly after a project is completed and at intervals for many years afterward. Some indicators take much longer to show change and may need to be monitored for 5, 10, 20 or more years after a project is completed.

A control site is an area that is similar to the project area but where no project activities take place.

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Measuring indicators in control sites helps show which changes occur from project activities and which may be from outside factors.

Take measurements in nearby "control sites"

There are many factors other than project activities that could influence changes in a project area. For example, there could be a long-term drought, or a wildfire could destroy a project site. It is always possible that observed changes have little to do with the project and a lot to do with outside forces.

Because it is impossible to control all the outside influences on a project, monitoring can be greatly strengthened by creating a "control site." A control site is an area similar to the project site but where no project activities occur. Control sites should be chosen to reflect as closely as possible the sites that will be treated. The same indicators are measured, in the same way, in the control area as in the project area. Data from control sites help to show changes that result from outside influences. Data in control areas should be collected in the exact same way as data collected within the project area, including taking measurements before and after treatment of your project site.

5 – Who will take the measurements_______________________

It is a good idea to have at least one person who is consistently involved in collecting data and training others throughout the monitoring project. People have slightly different ways of taking measurements, and keeping one person consistently involved with the project helps to minimize the differences that can come from a number of different people taking measurements. Ideally, a project would have the same person or people take measurements throughout the project.

6 – When and how data will be analyzed____________________

When a monitoring team has collected data before and after a project, they will need to analyze the data in order to see what changes the project actually produced. Some information, such as a series of photographs taken over time in the project area, can be compared fairly easily by visual comparison. Other information, such as numerical data on changes in canopy cover or density of trees, must be compared more carefully.

See Handbook 6 for more information on how to interpret data collected for ecological indicators

7 – Where and how data will be stored__________________

It is important to store monitoring data in a permanent place so that it can be used for future forest management activities. Data sheets should be carefully labeled and placed in notebooks. A second, photocopied set of the data sheets should be stored in another location. Electronic data should be backed up on computer disks or CDs. Electronic data, including electronic spreadsheets and photographs, can be stored with local resource management agencies, such as the Forest Service or a local non-profit, if desired. It is also useful to store records of plot and transect locations so that others may find and re-measure them several years after initial project activities take place.

Field methods for measuring indicators

This section of the manual is arranged by sampling method for ease of use in the field. Table 4 provides a summary of each indicator and the sampling method(s) that can be used to measure it. Some indicators may be measured with more than one method. In these cases, the indicators are listed under each method. Your monitoring team should decide which method it will use for each indicator and use these methods consistently.

Table 4 — Summary of indicators and method(s) to measure them

Sampling method	Indicator	Handbook page #
Point-based sampling	1 Permanent photo points	21
Transect-based sampling	2.1 Landscape openings	26
	2.2 Bird species abundance and composition	27
	2.3 Butterfly species abundance and composition	28
	2.4 Seedling density	29
	2.5 Amount of surface fuel	30
	2.6 Extent of canopy cover	33
	2.7 Classification of riparian plant community structure	34
Plot-based sampling	3.1 Density and size of live trees	39
	3.2 Density and size of dead standing trees	41
	3.3 Height from ground to tree crown	42
	3.4 Understory plant species composition	44
	3.5 Understory cover	45
	3.6 Extent of bare soil	47

To measure density of mast-producing tree species, use method for density and size of live trees

Some tips before heading into the field

- Make sure you know and understand the sampling design, especially how many plots or transects there will be, how to locate or establish them, and how to use each method.
- It may be helpful to do a "practice run" of your methods before collecting real data. This will give you a sense of the time commitment required as well as alerting you to any equipment or information that must be obtained before starting in earnest.
- Make lots of copies of each data sheet you will need. It is always better to have too many than not enough. There are no photocopiers in the forest!
- If the project area has been monitored before, bring copies of the earlier data sheets into the field. Sometimes it is useful to have them as a reference.
- Make sure that you have all the equipment you need and that the equipment works.
- Make sure to check if your compass is using true north or magnetic north (i.e., the compass has a declination of zero degrees). If you are using more than one compass, you should write the declination used on every data sheet.
- Bring a map of the project site.
- Before moving from a plot or transect, make sure that every data sheet is labeled with the date and transect or plot number. Without this information on the data sheet, the data may be impossible to track, and therefore useless.

...and when you return:

- Develop or download all photographs taken. Make at least two copies of each picture.
- Copy all data sheets.
- Put photos and data sheets into two sets of 3-ring binders.
- Store the two copies of data in two separate places.
- As soon as possible, enter data into a spreadsheet for later analysis.

1 — Permanent photo points

Photo points refer to permanent locations within a project area where photographs are taken over many years.

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These points help document overall changes in a forest.

Photographs taken at permanent locations within a project area over a period of years provide valuable information about how a forest has changed over time. Photographs can be repeated yearly or every few years and provide a relatively simple way to track change.

Photo points can be used for a visual representation of the extent of canopy cover, density and size of trees, understory species composition and cover, soil erosion, and sometimes amount of surface fuel. This method can be used in ponderosa pine forests, pinyon-juniper woodlands, and riparian communities.

Materials: A 35mm or digital camera, metal stakes to permanently mark each point, PVC pipe (optional), hammer, permanent marker (such as Sharpie brand) clinometer, compass, clipboard, pencil, data sheets, and cards or paper and marker for each point site name. A small dry-erase board is also useful for marking photo points.

Photo points:

Use in any ecosystem

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Sample before, after, and 3–5 years after

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Sample annually during peak growing season

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Take 10–30 photo points per site

Use Data Sheet A

When and how often to sample: Photo points can be taken once each year. Ideally, they should be taken during the peak growing season each year. Photo points can be taken at the same time that other data is collected. It is helpful to try taking the photograph at the same time of day each year so that light conditions are similar and allow easier comparison. The number of photo points taken for a treatment will depend on the size of the project and how similar it is over the landscape. For example, a small project of 50 acres may want to document the site in 10 photo points, while a larger project of 300 acres may want more, perhaps 25 or 30 photo points.

Method:

1 – Identify the location of photo points

One of the simplest ways to decide where to locate a photo point is to use the beginning of a transect line or the corners of plots that are being used to measure other indicators. This helps provide spacing between photo points and saves time.

Sometimes there is an interesting or significant feature in the landscape where there is no transect or plot. For example, there may be an old growth tree or an area with a lot of seedlings that you will want to track over time. You may want to create photo points at some of these locations as well, to help document overall conditions at a site.

If there are no transects or plots, then photo points should be created at equal intervals throughout the project area as well as at interesting landscape features.

2 – Mark permanent photo points

Like transects or plots, photo points should be permanently marked. A brightly painted metal stake or rebar is relatively stable and easy to locate. White PVC pipe can also be used to cover the metal. These pipes slide over the stake and are readily seen in the field. Because stakes can sometimes be removed, it is also be a good idea to write down significant landmarks that can help to relocate the photo point. These features should be written on the data sheet for each point. Global Positioning Systems (GPS) can also help to locate sites. If available, this information can be recorded on the data sheet for each photo point.

3 – Taking photographs for the first time

Each photograph should be taken from exactly the same position every time. The first time a photograph is taken, it is important to record the compass direction and slope (using a clinometer) of the photograph. This information becomes an important reference for future pictures. Photo points should also be labeled with the site name and number. On a piece of cardboard, paper, or a dry-erase board, write the name of the site and the number of the photo point, and position this so that it will be legible in the photograph. The photograph to the right shows an example of this.

When taking a picture, hold the camera at a standard height. Five feet is a good height for most photographs. Take three or four pictures at the same location.

When taking photographs in riparian areas, establish photo points in the middle of shallow rivers and streams, or on the banks of larger rivers, and take photographs looking upstream and downstream for each point.

Record the date, time, photo number, and compass direction on data sheets for every photograph. Compass bearings are very helpful in relocating the position of the photo. The data sheet provides space to record additional information about the photo point area. For example, you may want to note the overall condition of the overstory and understory, signs of livestock, signs of wildlife, recent weather conditions, signs of storms or fires, and other impressions of the site. This can take some practice, but these observations can be important to the overall photo point.

If using a 35mm camera, make sure to **label** each roll of film with a permanent marker so that you can keep track of them. If taking the film to a local processing center, request that they keep these numbers attached to the negatives.

4 – Archiving photographs

After each trip to the field, develop 35mm film or download digital photos as soon as possible. If there were any problems with the film, the light, or other conditions, return to the site and retake the pictures before conditions change. If this happens, make sure to record the new dates, times, and conditions at each site.

When photographs are printed, label the back of each photograph with the site name and photo point number, as well as the date of the photograph, and the compass bearing. We recommend putting each photograph in protective plastic sleeves and storing in a 3-ring binder. All photo point data sheets can also be stored in this same binder. For any data, it is also a good idea to keep two sets, in two different locations for safe-keeping. Store all negatives in plastic sleeves in the back of the three-ring binder. For digital cameras, make a back-up disk or CD that stores all photographs and put this in the back of the binder.

5 – Repeating photographs

When you return to a photo point, it is helpful to have the 3-ring binder and data sheets with you from previous site visits. Referring to earlier photos will help you to take photographs in the exact same position as before. When re-taking photographs, make sure they are in the same compass bearings as the previous photos, with the same landscape markers, and the same orientation (vertical or horizontal) of the photograph.

Analysis: For most purposes, simple visual comparison of the photos before and after treatment is most useful. Detailed descriptions of the conditions seen in the photographs should be made and stored in a notebook along with each photo. Changes observed from one date to another can include tree density, new seedling establishment, understory plant recovery, and exotic plant invasion. In some cases, it is possible to obtain quantitative information from repeat photography (see Elzinga and others 2001 for quantitative analysis methods).

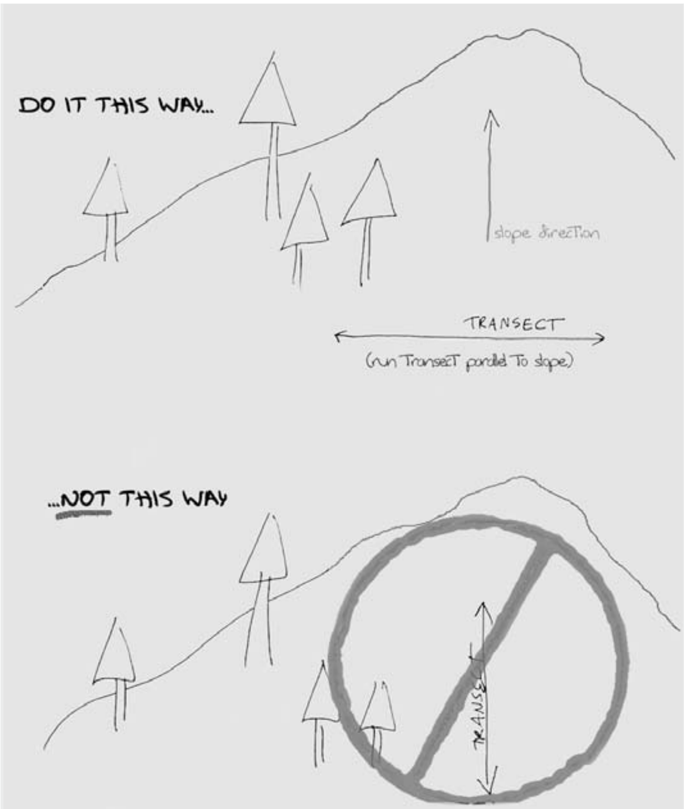
2 — Transect-based sampling

For transect-based sampling, data are collected in points at specific distances along a transect line. There are many different measures that can be taken along transects. For some indicators, plots are also located along transects to collect data. These types of measures are described in the section on plot-based sampling. Table 5 on the next page lists indicators that can be measured using transects.

A transect is a line, made with a tape measure, so that measurements may be taken at regular intervals.

Materials: 300-foot tape measure, metal stakes or rebar (two for each transect line), data sheets, clinometer, compass, clipboard, pencils

Method: Refer to your sampling design to identify the site where you want to place transects. When establishing transects at a site, the first transect should be randomly placed within the site. To do this, pick an area to sample, and throw a stick over your shoulder. Where the stick lands, mark the point by pounding a permanent metal stake into the ground. This end will be the first point of the line.



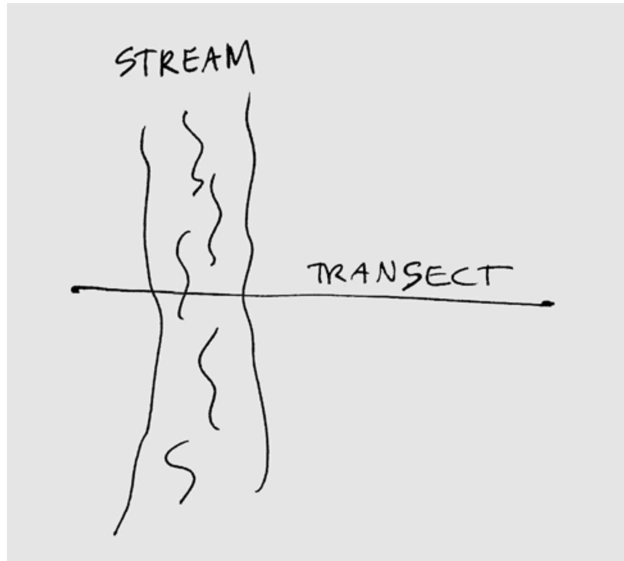
It is best if transects lie along relatively flat, consistent ground. On slopes, run transects on a level line running across the slope, rather than up or down the slope (see diagram to the left). Whenever possible, it is also best to locate all sampling points at least 300 feet from a road or project boundary.

From the first transect point, walk in a straight line. Use the compass to know the exact direction (in degrees) you are walking and record this on the data sheet for every indicator measured. Carry the tape measure and walk until you reach the length of the transect you want to establish, usually either 100 or 300 feet, depending on the method. Be sure to pull tight on the tape to remove any slack. At this second end, lie the tape measure on the ground, and place a metal stake in the ground at this site. PVC pipes are very helpful in marking the stake so that it is visible and clearly labeled. You can also use metal tags to mark the stake or the ground next to it. Later you can use a metal detector to re-locate your stakes.

Table 5 — Indicators measured with transects

Sampling method	Indicator
Transect-based sampling	2.1 Landscape openings 2.2 Bird abundance and species composition 2.3 Butterfly abundance and species composition 2.4 Seedling density 2.5 Amount of surface fuel 2.6 Extent of canopy cover 2.7 Classification of plant community structure

For riparian areas, you should run transects perpendicular to the stream, so that the transect starts at one side of the riparian community, crosses the stream, and goes to the outside edge of the riparian plants on the other side of the stream bank. If the width of the riparian plant community is very wide, then a 300 foot transect can be used. These transects can be spaced about 500 feet apart.



Once the transect is in place, you can take measurements for each indicator. The transects should be parallel to each other; choose the distance between them based on the site and your sampling needs. In general, transects should be spaced no closer than 50 feet apart and no more than 1500 feet apart. These transect lines can also be used for many of the plot-based sampling methods.

2.1 — Landscape openings

Landscape openings describe the size of openings or meadows within a forest. Openings in the forest canopy can be sampled using transects.

Landscape openings:

Use in any ecosystem

—

Sample before, after, and every 3–5 years after

—

Sample anytime

—

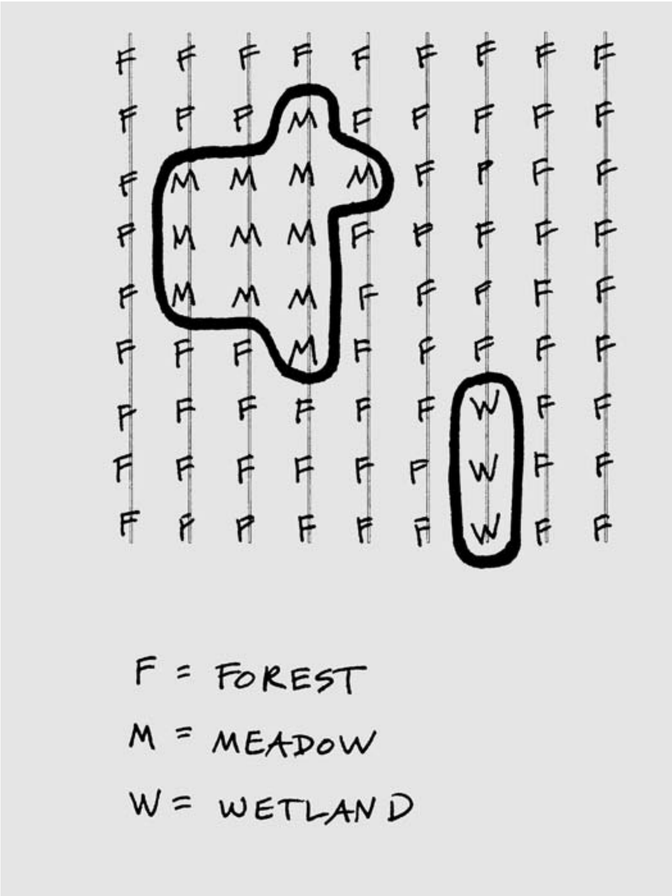
Number of transects depends on site size

Use Data Sheet B

Method: Walk through your site and identify the various landscape types found there. Make a list of these landscape types, and select a mapping symbol for each one. For example, you may identify seedling and sapling thickets (SST), mature ponderosa pine stands (PIPO), pinyon-juniper stands (PJ), and openings and meadows (OM). Write down some guidelines for identifying each landscape type in the field; for example, “openings and meadows (OM) are areas at least 15 feet in diameter with no overhead canopy.” Each project will have different mapping categories and symbols, depneding on the project’s goals and site conditions.

Walk each transect along the same compass bearing. Choose a distance to note the landscape element, for example, every five or every 10 feet. At each point, record the landscape element on the data sheet.

Using a set of parallel transects, you can make a simple but useful map with different symbols for each landscape feature. This will give you a rough estimate of the size of open meadow areas relative to the size of the whole area sampled. By repeating these measurements over time, you can measure the change of meadow size over time.



The scale for this method will depend on the size of the landscape features. For example, if meadows are large, then the sampled area will need to be larger and the transects and sampling intervals farther apart. If the openings are small, then transects and intervals must be closer together.

Landscape openings should be sampled before and after project activities, and every three to five years after the project is completed. More information on this method can be found in *Landscape Ecology*, by Forman and Godron.

Analysis: On a sheet of paper, draw parallel transects and use symbols to indicate the landscape types found at each measurement point, and draw boundaries around clusters of like symbols (see sketch). This will give you a rough map of the site, showing areas of different vegetation types, forest, meadow, and so on. The map will give you a general impression of the heterogeneity of the site and the size of meadows relative to the size of the forested area. Maps of the same site drawn before and after treatment will give you a rough indication of the change in landscape types over time.

2.2 — Bird species abundance and composition

Additional materials needed: Binoculars and North American birds field identification guide, flagging tape

Birds can be counted on points along line transects. The first point should be randomly located on the transect. Additional points can be located every 150 feet after that. Each new transect should be placed at least 500 feet from the previous transect to minimize the chance of recording the same birds at multiple points.

Bird counts are best done within ½ hour after sunrise and should be completed no later than four hours after sunrise. Upon reaching a transect, observers should wait 1–2 minutes to orient themselves, get data sheets ready, and to allow birds to return to "normal" activities after being disturbed by the person(s) walking to the site. Observers should record the species, sex (if possible), and mode of detection (song, call, visual, other) of all birds seen or heard within a 150 feet radius of the point on the transect. To help estimate distance from the counting station, place flagging tape on trees or stakes at 150 foot distances from each point on the transect where you are observing birds.

Bird abundance and composition:

Use in any ecosystem

—

Sample before, after, and 3–5 years after

—

Sample 3x in breeding season, 5x in non-breeding season, from ½ hour to 4 hours after sunrise

—

Sample 30 points per site

Use Data Sheet C

Each point should be sampled three times during the breeding and five times during the non-breeding season to account for changes in bird behavior and movements within the season. More visits are needed in the non-breeding season because birds are more patchily distributed in smaller groups.

Anyone observing birds should already have the training and skills to correctly identify them. Local chapters of the Audubon Society or government or tribal wildlife staff may be able to provide training or assistance with this method.

Analysis: Make a list of all the bird species observed in the entire sampling site. The total number of different species observed represents the observed bird species composition. Add the number of birds of each species to get species abundances observed during any one sampling period. Total abundances of birds can be estimated by adding all species abundances together.

2.3 — Butterfly abundance and species composition

Additional materials needed: binoculars, butterfly field guide

Butterflies can be sampled along transects, at least 300 feet in length. Transects should be located parallel to habitat edges, such as meadows, and at least 150 feet away from any boundaries. The species of butterflies should be recorded as well as the number of

Butterfly abundance and composition:

Use in any ecosystem

—

Sample before, after, and every 2 years after

—

Sample 4–6 times each season, in late spring and summer, from 10 AM to 4 PM

—

Sample along at least 10 transects

Use Data Sheet D

individuals of each species, or genus if the species cannot be identified. There should be at least 10 transects within the project area.

Transects should be sampled about four to six times during the late spring and summer months, on sunny, calm days between 10 AM and 4 PM. The observer should walk the transect at a steady pace, scanning the area within 15 to 30 feet, focusing on butterflies alone. A net can be used to catch and release butterflies for identification, but none should be killed or collected.

Analysis: Make a list of all the butterfly species observed in the entire sampling site. This represents the observed butterfly species composition. Total the number of individual butterflies for each species to get abundances observed during any one sampling period. Total abundance of all butterflies can be estimated by adding all species abundances together.

The publication *Butterflies as Indicators of Restoration Progress* from the Ecological Restoration Institute provides further information (see www.eri.nau.edu). Software that can help analyze data collected is available at www.urbanwildlands.org/INCA/ and an example of volunteer butterfly monitoring can be found at: www.mchenry.cc.il.us/faculty_pgs/mgarriso/butterflyproject/aBMG.html#TableofContents.

2.4 — Seedling density

Seedling density:

Use in forest ecosystems

—

Sample before, after, and 3–5 years after

—

Sample anytime

—

Sample along 5–8 transects per site

Use Data Sheet E

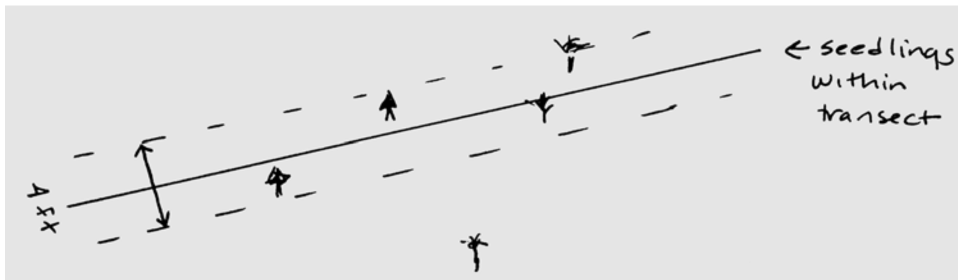
Additional materials needed: PVC pipe or other strip of wood or metal that is 4 feet in length

Seedlings are young trees that are less than 4.5 feet high. They can be counted by walking along the 300-foot transect while holding a 4-foot long PVC pipe parallel to the ground. The PVC pipe should be placed evenly over the transect line, so that two feet extend on each side of the transect (see diagram on the next page).

To count seedlings, walk along the transect line and count each seedling that is within the 4-foot length of the PVC pipe. Identify the type of tree seedling and tally the number of each species on the data sheet. Repeat this on a minimum of 5–8 transects within the project area.

Analysis: Density is expressed as number of individuals per area. A sample data sheet and sample analysis are included at the end of the manual.

1 – Count the tally marks in all transects for all seedlings of each species separately.



2 – Multiply the length times the width of each transect to get area in square feet. Multiply the area of one transect times the number of transects.

3 – Divide the number of seedlings of each species by the total transect area to get the density for that species.

4 – Convert the density of seedlings to seedlings per acre. A conversion formula is found in *Appendix 2*.

5 – Total of density of all seedlings can be found by adding the totals for each species together, and dividing by the total area sampled.

Amount of surface fuel:

Use in any ecosystem

—

Sample before, after, and every 3–5 years after

—

Sample anytime

—

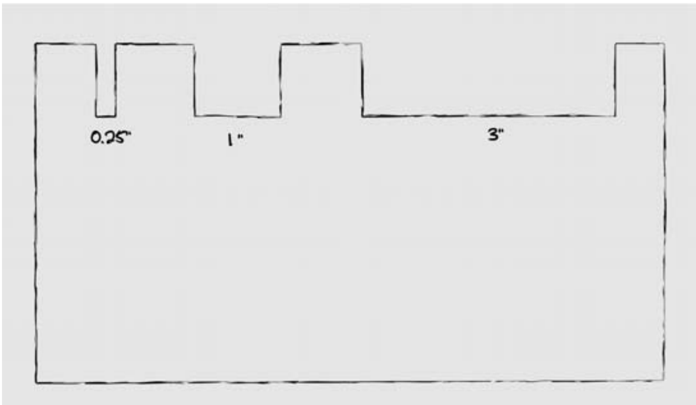
Sample along a total of 10–16 surface fuel transects per site

Use Data Sheet F

2.5 — Amount of surface fuel

Additional materials needed: watch with a second hand; piece of cardboard with a 0.25 inch slot, 1 inch slot, and a 3 inch slot cut into it; 50 foot tape measure, clinometer, compass

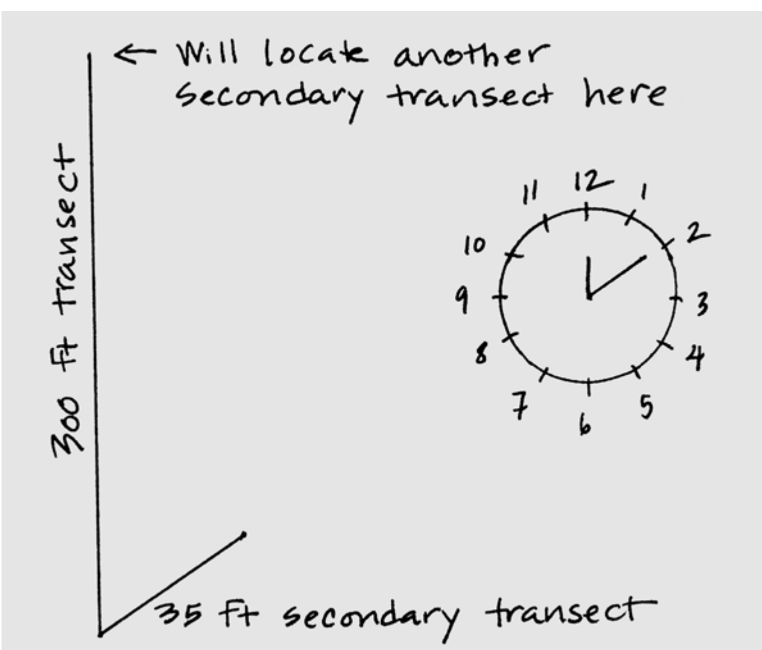
One way to measure the amount of fuels on the ground surface, is to measure the amount of dead wood that is on the ground. This woody material is called “dead and downed woody debris.” Woody debris should be monitored before and after a project is implemented, and every 3–5 years after the project is finished.



Before heading into the field, prepare a piece of cardboard (see diagram to the left) for measuring the different size classes. Cut three slots in the piece of cardboard to the following lengths: 0.25 inch, 1 inch, and 3 inches.

To inventory dead and downed woody debris, you will count and classify dead wood off the main line transect. To do this, you will create two additional short transects: one at the beginning of the main transect, and one at the end.

These transects (called "surface fuel transects") will be placed at a random angle from the main transect. To determine this random angle, start by standing at the beginning of the main transect, facing the transect line. Look at the watch with the second hand. Whatever direction the second hand is pointing is the direction you will lay the surface fuel transect. For example, if the second hand is on the 2, then you will place the surface fuel transect at this angle from the main transect. Be sure to record the direction (bearing) of your fuel transect on the data sheet and use this same bearing when you return in the future to re-measure fuels.



To create the surface fuel transect, use a second tape measure to walk 35 feet in the direction the watch was pointing. Set the tape measure down. Record the slope of the short transect with a clinometer, and record the direction of the surface fuel transect with a compass. Also make note of the dominant tree species in that part of the forest. This information will be needed when you calculate the total fuel load (see *Handbook 6*).

Classify all woody debris that crosses the transect. Only count pieces that are:

1 - Dead, not attached to a living tree,
2 - Down, not rooted in the soil (uprooted stumps can be counted), and
3 - Woody, not needle or leaf litter or herbaceous material.

Do not count pieces of wood that are rotten and have begun to fall apart. Only sound wood should be included in the census of fuels.

When you finish classifying woody debris at the beginning of the main transect, go to the other end of the main transect line and establish a second surface fuel transect. To do this, look in the direction the second hand of the watch is pointing and lay a 35 foot transect. Classify all woody debris that crosses this second transect. Make sure to record the slope and direction of this surface fuel transect on the data sheet, too.

<u>To classify woody debris, use the following method</u>:

1 – Along the first 6 feet of the short transect, count all woody material that is less than 0.25 inches in diameter. (This woody material should be smaller in diameter than the 0.25 inch slot in the cardboard.) Record the number of woody pieces you find in this size category on the data sheet.

2 – On the same first 6 feet of the short transect, count all woody material that is 0.25–0.99 inch in diameter and record this on the data sheet. (This woody material should be larger than the 0.25 inch cardboard slot and smaller than the 1 inch cardboard slot.)

3 – From 0–10 feet on the short transect, count all woody material that is 1–2.99 inches in diameter and record this on the data sheet. (This woody material should be larger than the 1 inch cardboard slot and smaller than the 3 inch cardboard slot.)

4 – From 0–35 feet on the short transect, **measure** all woody material that is greater than 3 inches and record. (This woody material should be larger than the 3 inch cardboard slot.) Unlike the other size classes, where you only count the number encountered,

Dead and down debris includes twigs, stems, branches and wood from main trunk of trees and shrubs that are lying on the ground

—

Dead woody stems and branches still attached to standing trees are not counted

—

Uproote stumps and dead roots are counted

—

Any sound dead wood that is not attached to a tree or shrub is counted

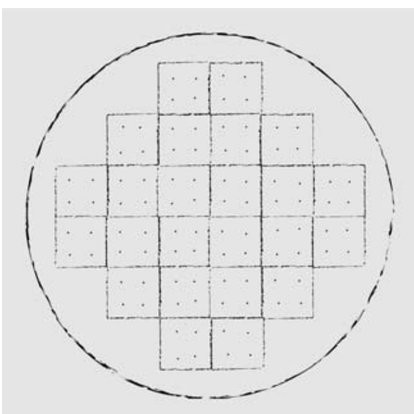
—

Pieces of wood that are rotten and have begun to fall apart should not be counted here you actually measure the diameter of each piece. To measure these pieces, take the diameter of the piece at the point where it crosses the transect. Record this diameter on your sheet.

Do not count pieces of wood that lie completely along but do not cross the tape measure. If wood crosses the tape in more than one place, count each intersection.

Analysis: You will use a formula to calculate the weight of down woody debris in tons per acre. There are two different formulas, one for debris less than 3 inches in diameter and one for debris greater than three inches in diameter. The formulas and instructions for calculating fuel load are found in *Handbook 6*.

Photo guides can also be used to estimate fuel amount on your site. These types of guides present a series of photographs of different forest conditions, and by finding the photograph that most resembles your forest, you can estimate fuel load—see *Appendix 3*.



Extent of canopy cover:

Use in any ecosystem

—

Sample before, after, and every 3–5 years after

—

Sample anytime (hard-wood dominated forests should be sampled when foliage is present)

—

Sample along a total of 5–8 transects per site

Use Data Sheet G

2.6 — Extent of canopy cover

Additional material needed: Spherical densiometer

Overhead canopy cover is the amount of shade that the canopies of trees create on the ground. Shade that the trees provide is measured visually using an instrument called a *densiometer* (left). The instrument has a round concave mirror which has a grid marked on it. The grid divides the mirror into small squares.

To take measurements with the densiometer, hold the mirror level about 12–18 inches in front of you at elbow height. If you look down at the round mirror, you can see the reflection of the tree canopy overhead. You will see areas of dark leaves or needles and areas of bright sky. In each small square, you imagine four dots arranged like the corners of a smaller square. If there is a bit of sky at the dot in one corner of the imaged box, mark a tally for sky. If you see dark leaves at the other three dots in the corners of the imaged box, mark three tallies for canopy cover. Each square of the mirror will have four tally marks, for canopy cover or no canopy cover.

This method requires two people—one to hold the mirror steady and call out the values, and another to record the values. This method is more easily and quickly done than described. Every instrument comes with clear directions as well.

Four sets of canopy cover values are taken at each sampled point: facing directly up the transect, directly down the transect, and in each direction perpendicular to the transect. For each transect, canopy cover should be sampled every four feet over a total of 40 feet. This will give 10 sampling points per transect and a total of 40 values (four sets of values at each point on the transect).

Analysis: Canopy cover is expressed as a percent, meaning the percent of the sky covered, or the percent of the ground shaded. A sample data sheet and sample analysis are included at the end of the manual.

1 – Count total number of "yes" observations of canopy cover.

2 – Divide the number of canopy cover values by the total number of observations. Multiply by 100. The final number will represent average percent canopy cover for the site.

2.7 — Classification of riparian plant community structure

The height and shape of trees and shrubs play an important role in providing wildlife habitat in riparian communities. Certain animal species are highly adapted to particular structural elements and will abandon an area if that structure is lacking. These structures should be monitored before and after a project is completed, and every 3–5 years thereafter. There are six structural types that could be present within the riparian community (Hink and Ohmart 1984). These are described in detail below but include:

- Types 1 and 2 – mature forests
- Types 3 and 4 – intermediate-age forests or woodlands
- Types 5 and 6 – shrub habitats

Plant community structure:

Use in riparian communities

—

Sample before, after, and every 3–5 years after

—

Sample during peak growing season

—

Sample along 10 or more transects per site

Use Data Sheet H

This method allows an observer to subjectively estimate the vegetation of the site by looking at configuration of trees and shrubs and deciding which of six classes it most looks like. Go to the end of each transect that is nearest the river. From this point, looking away from the river, estimate by eye the tree heights and amount of canopy cover. If you are unfamiliar with estimating tree heights, practice using a clinometer. (See method 3.3, "Height from ground to tree crowns" for details on how to estimate tree height).

Use the tree heights and canopy cover to determine which type of stand structure your site it most resembles. Record this on the data sheet. For each transect record only one structural type. The structural types are as follows:

Type 1 – Tall trees with well developed understories. This type is present if:

- there are tall or mature to mixed-age trees (taller than 40 feet) with canopy covering more than 25% of the area of the community, and
- an understory layer of about 20–40 feet tall covering more than 25% of the community, and
- substantial foliage in all height layers.

Type 2 – Tall tree canopy with little or no understory vegetation. This type is present if:

- there are tall or mature trees (taller than 40 feet), with
- canopy covering more than 25% of the community, and
- an understory layer (20–40 feet tall), with
- less than 25% of the area of the community with a majority of vegetation over 30 feet.

Type 2 areas are mature stands of trees up to 50 to 60 feet tall with most of the foliage in the canopy layer taller than 30 feet.

Type 3 – Intermediate sized trees with dense understory vegetation. This type is present if:

- there are intermediate sized trees (20–40 feet tall), with
- canopy covering more than 25% of the area of the community, and
- with understory layers (taller than 5–20 feet) covering more than 25% of the area (the majority of foliage will be shorter than 30 feet tall).

Stands of intermediate-age cottonwood trees with a thick understory of willow or Russian olive are characteristic of Type 3.

Type 4 – Intermediate-sized trees openly spaced with little understory. This type is present if:

- there are intermediate-sized trees (from 20–40 feet tall) with canopy covering less than 25% of the area, and
- a majority of foliage is between 15–30 feet tall.

Relatively open stands of intermediate-age cottonwoods are typical of Type 4.

Type 5 – Stands with dense shrubby growth. This type is present if:

- dense shrubby growth covers more than 25% of community, and
- a majority of foliage is shorter than 15 feet tall.

Type 5 has dense vegetation through about 10 or 15 feet, often including a thick layer of grass and annuals.

Type 6 – Very young, low, and/or sparse stands. This type is present if:

- vegetation covers less than 25% of community, and
- a majority of foliage is shorter than 15 feet tall.

Type 6 has low and relatively sparse herbaceous and/or shrubby vegetation, with most vegetation below 5 feet. Much of the salt cedar vegetation fits into this type.

Some stands do not have trees or shrubs. In these cases, the following classifications should be used to describe the plant community:

CAT:	Cattails
MS:	Meadow
MH:	Marsh with cattail or rush; other permanent marsh vegetation
Ag:	Agriculture
OP:	Open area (<25% aerial plant coverage)
R:	River
Rd:	Road
OW:	Open water

Analysis: List the classifications that are found in the community. There will only be one classification per transect. The method gives a qualitative impression of the type and amount of vegetation types present at the site.

3 — Plot-based sampling

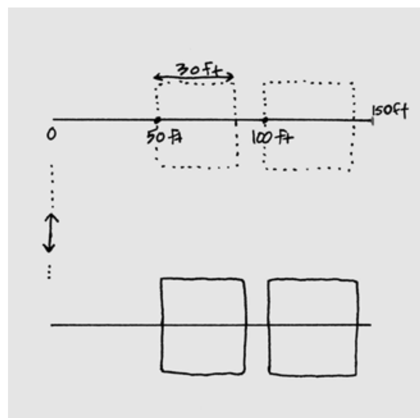
Plots are circular or square areas placed on the ground at regular distances from one another, every 60 feet, for example. The size of the plot varies depending on the indicator. For example, tree density is measured with a 30 x 30 foot plot, while understory cover is measured using a 3 x 3 foot plot. Small plots are typically square, while large plots can be either circular or square. Table 6 (page 38) shows the indicators that are measured using small and large plots.

The multiparty group will need to decide whether they will use large circular or square plots. This may depend on project partners. For example, some Forest Service personnel already collect certain kinds of data in circular plots and some along transects. Your group may want to use these same sampling methods for consistency. Regardless of the method, it is a good idea to select one in the beginning and use it throughout the monitoring project when possible. For simplicity, only square plot methods are described in this handbook.

Table 6 — Indicators sampled with plots

Sampling method	Indicator
Large circular or square plots	3.1 Density and size of live trees 3.2 Density and size of dead standing trees 3.3 Height from ground to tree crown
Small square plots	3.4 Understory plant species composition 3.5 Understory cover 3.6 Extent of bare soil

Both large and small plots are located along transect lines. These indicators can be measured at the same time, and on the same transects, as those indicators described in transect-based sampling.



Large plot sampling

Materials: 300-foot measuring tape, 50-foot measuring tape, 2 metal stakes for marking each end of a transect line, 4 pin flags, hammer, data sheets, clinometer, compass, clipboard and pencils.

Method: Square plots are set up along transects 300 feet in length. Use the line transect method to establish transects. Large square plots are 30 feet on each side. Once the transect has been laid, set up the first plot at the 50 foot mark of the transect. To do this, run a second tape measure perpendicular to the transect tape and mark 15 feet on each side of the main transect line with pin flags. Then walk another 30 feet (to the 80 foot mark) and again run a tape measure 15 feet on each side of the transect line. Mark each side with pin flags. The four pin flags form the corners of the large plot, 30 x 30 foot.

When the plot is set up, you can collect data for any of the indicators below. Collect all the data in one plot, and then relocate the plot by picking up the pin flags and moving down the transect. Transects can be located every 50 feet on the transect, with plots started at 50, 100, 150, 200, 250 and 300-foot marks on the transect line. Repeat this process, establishing plots on transects, for each transect in a site area, or for a suggested total of 10–30 plots altogether.

For every plot, you should record the direction and degree that the ground slopes. To do this, stand at the corner of the plot, facing the direction the ground is sloping. With a compass, measure and record the direction in degrees on the data sheet. With a clinometer, record the amount the ground slopes in percent on the data sheet. Repeat these two measurements for each plot.

3.1 — Density and size of live trees

Density and size of live trees:

Use in any ecosystem
—
Sample before, after, and 5 or more years after
—
Sample anytime
—
Sample in 10–30 plots per site

Use Data Sheet I

Additional materials needed: DBH (diameter at breast height) tape

To measure tree density, count every adult tree and every sapling in each plot. Adult trees have a diameter larger than 5 inches. Saplings are smaller than 5 inches in diameter but at least 4.5 feet tall. Use a DBH tape to measure the diameter of trees if you are not sure if they are adults. On the data sheet record information for each adult tree of each tree species.

To measure the tree size, use a DBH tape and measure the diameter at breast height (approximately 4.5 feet from the ground). One side of the DBH tape has numbers that show the diameter at the tree, even though the tree is sampled by putting the tape around the stem of the tree. The other side of the tape shows the tree's circumference. Use the side of the tape that measures diameter, not the side that measures distance.

To calculate the density of woody plants that produce seeds, fruits, and nuts, use the methods for seedling density and density and size of live trees, but only count those adult trees and saplings which produce seeds, fruits, and nuts important to wildlife. Examples of these species are junipers, oaks, and pinyon pine.

Take each measurement on the uphill side of the tree. Be consistent with this. Also make sure that the tape goes around the tree evenly, and that there is no slack or twists in the tape. If a tree is on the edge of a plot (if for example, only half the tree is within the plot boundary), count the tree.

For juniper, pinyon pine, and oak trees, measure the diameter at the base of the tree, not at breast height. If a tree has multiple stems below 4.5 feet, measure the largest stem and note on the data sheet how many stems the tree has.

Count tree saplings at the same time that you count adult trees. Count the number of saplings for each species in the plot but do not measure the diameter. The density of adult trees and saplings should be calculated separately.

<u>Analysis</u>: Density is expressed as number of individuals per area. Estimate the density of adult trees and saplings separately.

1 – Count the number of adult trees in all plots separately for each species. Count the tally marks in all transects for all saplings of each tree species separately.

2 – Calculate the area of all plots as follows:
If using the plot dimensions given above, multiply 900 ft^2 (the total area of one plot) by the number of plots sampled.

3 – Divide the total number of each species by the total area to get the density for that species. Repeat for each species of adult tree and each species of sapling.

4 – Total density of all adult trees can be found by adding the totals for each species together, and dividing by the total area sampled.

5 – Convert the density of adult trees in the area sampled to density per acre using the conversion formula provided in *Appendix 2*.

6 – To calculate average size of adult trees by species, add together all the diameter measures for each species. Divide this number by the number of trees of that species. This gives you average diameter of that species of tree.

To calculate average slope for the site, add together all the slope values taken with a clinometer in each plot, and divide by the total number of plots. Follow the same process to calculate average aspect.

3.2 — Density and size of dead standing trees

Additional materials needed: DBH (diameter at breast height) tape

Dead standing trees are sometimes called snags. To measure these trees, follow the same instructions as for live trees. Sample only dead standing trees that are larger than five inches at breast height. Record the species if you can still identify it. Otherwise, record the number and size of each snag.

Analysis:
1 – Density is an expression of the number of individual trees per area. To calculate density of snags, follow directions in Section 3.1 (pages 39–40). Snags are not likely to be identifiable by species, so there will usually be only a single density number for snags.

2 – Convert the density to density per acre using the conversion formula provided in *Appendix 2*.

To calculate the average size of snags, add together all the diameter measures and divide this number by the total number of snags.

What about basal area?

Basal area is not recommended as an indicator for monitoring changes in fire regime and other restoration values because:

- basal area gives no clear indication of tree size,
- basal area gives no clear indication of tree density, and,
- basal area gives no indication of the species diversity

Instead, we recommend measuring the size and density of trees for each species found on the site. The size, density, and species of trees on a site can all affect fire behavior. In addition, tree species, tree size, and tree density are useful indicators of wildlife habitat and the preservation of old and large trees.

Those wishing to calculate basal area can do so using tree size data by following these steps:

1 — Divide the diameter of every tree by two to get the radius.

2 — Multiply the radius times iteslf to get radius squared.

3 — Multiply radius squared by 3.14. This is the basal area of each tree in the plot.

4 — Add together the basal areas of all the trees in all the plots. This is the total basal area for the sampled area, measured in square inches.

5 — Divide this number by 144 to get total basal area measured in square feet.

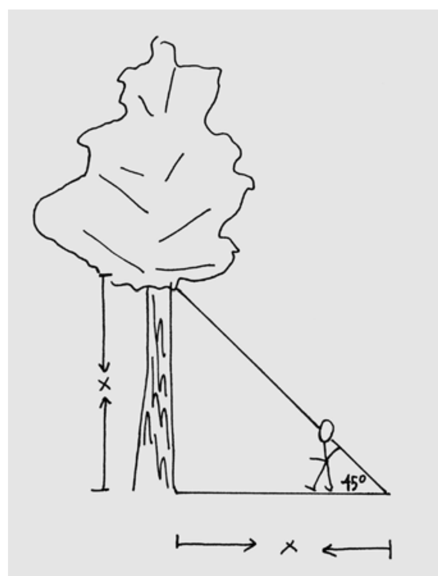
6 — Convert the basal area of the sampled area to a per-acre basis by using the conversion formula provided in *Appendix 2*.

3.3 — Height from ground to tree crowns

Additional materials needed: clinometer, 50-foot measuring tape

This indicator provides information on how low to the ground tree canopies are. It can be measured in the same plots as those developed for tree size and density.

To measure this distance, you essentially measure two sides of a triangle formed between yourself and the tree (diagram at right). To measure this, stand at the foot of the tree while holding a clinometer. Back away from the tree on level ground (not upslope or downslope from the tree) until the 45° mark on the clinometer points directly at the bottom of the canopy. This usually means the lowest large limb growing from the tree trunk. Measure your distance to the tree and record on the data sheet. This distance is the same as the distance from the ground to the first large limb.



Height from ground to tree crowns:

Use in any ecosystem

—

Sample before, after, and every 3–5 or years after

—

Sample anytime

—

Sample in 10–30 plots per site

Use Data Sheet I

For each measurement, you must also account for the extra space from your eye to the ground (usually about 5 feet). You will need to calculate how much additional length to add to each measurement to account for this.

Analysis: When the angle shown in the clinometer is 45°, the distance on the ground from the point behind the observer to the tree base is the same distance from the tree base to the bottom of the canopy. Calculate an average distance from the ground to the bottom of canopies by adding all the distances together and dividing by the number of trees measured.

Small plot sampling

Materials: 300-foot measuring tape, one 3 x 3 foot plot square, data sheets, clinometer, compass, clipboard and pencils

The 3 x 3 foot square plot can be made of 4 pieces of PVC pipe cut into 3 foot lengths. The pieces can be glued at the corners and held together with PVC elbows. This makes a permanent square that is light, solid, and easy to carry in the field.

Method: Square plots are set up along transects 100 feet in length (usually the first 100 feet of a 300 foot transect). Use the line transect method to establish transects. Set up the first plot at the 20 foot mark of the transect, using the main transect as one side of your plot and extending the plot to the left side of the transect.

Collect all data within the plot. Then move the square another 20 feet. In total, take measurements at 20, 40, 60, 80, and 100 feet. For each transect line, you will gather data in 5 plots. For any project area, you should collect data in a minimum of 30 plots.

3.4 — Understory plant species composition

Understory plant composition:

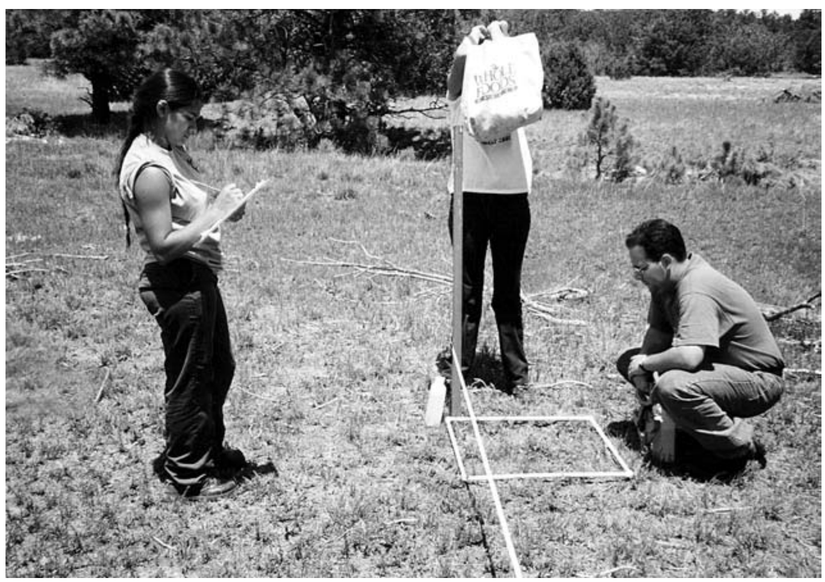
Use in any ecosystem
—
Sample before and every year after
—
Sample during peak growing season
—
Sample in 30 or more plots per site

Use Data Sheet J

Additional materials needed: Field guides to plants, plant press and paper, pin flags, 50 foot tape measure, digging tool, ziplock bags and labels (for riparian areas only), and a small plant press

Collecting data on understory plant composition is an ambitious method, because of the need to be able to identify plants by species. Not every monitoring project will want to take on identification of plant species. Assistance can be sought from local experts, colleges and agency personnel, as well as plant species identification books.

For understory plant species composition, you will use the small plots as described above, as well as an additional plot that is 3 feet by 35 feet. This second type of plot should be located on the opposite side of the transect from the smaller plots (i.e., on the right side of the transect), and should be placed between 30 and 70 feet on the measuring tape. This method can be used for plants in forests such as ponderosa pine or pinyon-juniper, as well as in riparian communities. Near pools and wetlands in riparian areas, the 3 x 35 foot plot should be located as close to the water's edge as possible.



In each small plot, look for and record every plant species found within the plot. Then count the number of individuals of each species in the plot. Then, in each larger plot, record the name of each species you find. The total number of different species found represents the site species composition.

If you cannot identify a plant species in the field, you should collect a sample. To do this, you will need to collect a whole plant that is flowering (when possible) and press the plant between two sheets of newspaper or in a plant press. Record the location of the collection, a description of where the plant was growing, the name of the person collecting the plant, and the date of the collection. These samples are especially important for grasses that are difficult to identify in the field.

Analysis: Understory species composition is represented by the number of species found. The number of individuals of each species gives you species abundance.

1 – Count the tally marks in all transects for all individuals of one species separately.

2 – Multiply the length times the width of each transect and add together all transect areas.

3 – Divide the number of individuals of each species by the total transect area to get the density for that species.

4 – Total of density of all understory plants can be found by adding the totals for each species together, and dividing by the total area sampled.

3.5 — Understory cover

Understory cover:

Use in any ecosystem
—
Sample before and every year after
—
Sample during peak growing season
—
Sample in 30 or more plots per site

Use Data Sheet K

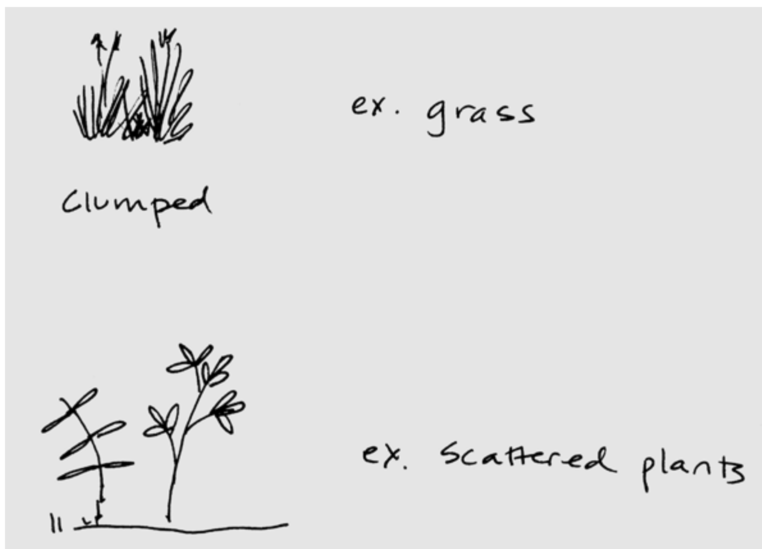
Using the small plot method, locate plots along transects. In each small plot, you will estimate the amount of ground that is shaded by plants growing near the ground surface. These should include grasses and forbs. Forbs are non-woody, broad-leafed plants, such as alfalfa.

Count grass cover and the area covered by forbs separately. Do not count understory cover provided by shrubs. If there is a shrub in your plot, ignore it. If there are grasses or forbs underneath the shrub, measure the understory cover provided by these plants.

Plant cover only measures the amount of shade from rooted plants. Plants that are not rooted but instead are laying on the ground unrooted, count as litter (see 3.6, “Extent of bare soil”).

Plant cover is estimated in percentages. You may want to cut pieces of cardboard into different shapes that represent different percentages to train your eye. The palm of your hand is a good estimate for 1% of a 3-foot square plot. The categories for plant cover are grouped into the following ranges: 0–5%, 5–25%, 25–50%, 50–75%, 75–95%, and 95–100%.

For each cover type (grasses, forbs, bare soil/rock, and litter), you should mark only one cover category. Plant cover can be estimated different according to how they grow in the ground:



Clumped and matted species. These plants tend to grow in tight groups forming clumps or mats. To estimate the amount of space these plants cover within the plot, use the palm of your hand to count 1% increments.

Scattered plants that do not form dense cover. Some plants grow individually and do not form clumps. For these plants, it is helpful to imagine pushing all the plants together into a space and estimating how much cover these plants provide.

A website at Colorado State University also provides useful tips for measuring understory plants: www.colostate.edu/projects/stohlgren/_sampling/mw_plot.html

Analysis: Understory plant cover is expressed as a percent of ground covered.

1 – Calculate one type of cover at a time. For example, start out calculating grass cover, then move on to forbs, then bare soil/rock, and finally litter.

2 – To calculate cover, first find the midpoint of each cover class. For the set used above, the midpoints are 2.5%, 15.0%, 37.5%, 62.5%, 85% and 97.5%.

3 – Convert the cover value for each plot to the midpoint. For example, if you were calculating grass cover and plot 1 had a mark for 25-50%, it is now assigned the midpoint value of 37.5%. If plot 2 had 0-5% cover, it is now assigned a midpoint value of 2.5%. So you will have one midpoint value for each of the plots sampled.

4 – Add midpoint values together for all the plots.

5 – Divide by the number of plots. This is the average percentage cover for the site. Because it is a percent, there is no need to convert it to coverage per acre.

3.6 — Extent of bare soil

Bare soil:

Use in any ecosystem

—

Sample every year

—

Sample during peak growing season

—

Sample in 30 or more plots per site

Use Data Sheet K

The extent of bare soil and rock is measured in the same way as understory cover. These measures may be taken at the same time. In fact, sometimes estimating bare soil and rock is a helpful way of helping to determine the cover provided by scattered plants. If estimating bare soil and rock, you may also want to estimate cover provided by litter. Litter can be pine needles, pine cones, or plants that are uprooted. There are spaces to record bare soil, rock, and litter on the same data sheet with the understory cover.

Analysis: Extent of bare ground and other values is expressed as a percentage. To calculate this percent, follow directions for "Understory plant cover" in Section 3.5.

Appendix 1 — Glossary

Abundance: The total number of individuals of a species in an area or community.

Basal area: The cross-sectional area of a tree trunk, measured at the base of the tree (about 10 inches up the trunk from the ground surface) or at breast height, 4.5 feet.

Baseline data: Data collected at the beginning of a project on the existing situation. These data provide a benchmark against which change that occurs during the project period can be assessed.

Canopy cover: The percentage of a fixed area covered by tree crowns, measured as the horizontal cover of the ground that the canopy covers.

Composition: A list of all the species that grow in an area.

Control site: An area similar to the project site but where no project activities occur. The same indicators are measured in the control area as in the project area.

Cover: The amount of the ground that is shaded by living plants, usually expressed as a percentage; also, the cover of the ground by dead plants and plant parts, usually called litter cover, also usually expressed as a percentage.

Data: A set of observations collected through monitoring. Information is derived from data through analysis.

DBH: Diameter at breast height.

Declination: The angle formed between the direction a freely pivoting compass needle points and true geographical north. The angle is expressed in degrees, and can be corrected on the compass.

Diameter at breast height: The diameter of a tree at breast height (approximately 4.5 feet above the ground on the uphill side of the tree); DBH.

Downed log: A fallen tree, log, or part of a log.

Ecosystem: An interacting system of living plants and animals and the nonliving parts of their environment.

Erosion: The movement of particles of soil across the surface of the ground or into watercourses; usually caused by water, but also by wind, gravity, and other factors.

Exotic plants: Plants that are non-native to a particular ecosystem or community, that often thrive on disturbed conditions and can become abundant after thinning or burning. Exotic plants can displace and reduce populations of native species.

Factors: Specific events, situations, conditions, policies, attitudes, beliefs, or behaviors that may affect the desired future condition.

Forb: A broad-leafed green plant whose stems are not woody, but not including grasses, sedges or rushes.

Goal: A general summary of the desired state that a project is working to achieve. A good goal meets the criteria of being visionary, relatively general, brief, and measurable. A goal is typically less specific than an objective.

Ground cover: The cover that grasses, forbs and other plants cast on the forest floor. Ground cover also includes other materials on the ground, such as dead needles and other litter and rocks. This measure is usually expressed as a percentage.

Indicator: A unit of information measured over time that documents changes in a specific condition. A good indicator meets the criteria of being measurable, precise, consistent, and sensitive.

Information: Knowledge that is extracted from data through the process of analysis.

Litter: The top layer of soil comprised of a variety of organic material such as dead needles, twigs, branches and dead grasses and forbs.

Monitoring: The periodic collection and evaluation of data relative to stated project goals, objectives, and activities. Implementation monitoring is important for multiparty monitoring groups because it simply asks, 'did we do what we said we would do?' Effectiveness monitoring helps determine whether or not the project goals were attained by asking the question 'did it work?' Reducing the small trees that compete with old-growth ponderosa pine, and increasing forage for deer are examples of project goals that can be measured through effectiveness monitoring. Validation monitoring involves checking the assumptions upon which our restoration efforts are based. 'Did reducing crown cover actually reduce the threat of catastrophic wildfire?' is a validation monitoring question.

Monitoring plan: An outline for the steps you will undertake to ensure that the project is on track. It lists a project's audience, their information needs, the strategies that will be used for data collection, the indicators, the methods that will be used to collect data, and when, by whom, and where data will be collected.

Objective: A specific statement detailing the desired accomplishments or outcomes of a project. If the project is well conceptualized and well designed, realization of a project's objectives should lead to the fulfillment of the project's goal. A good objective meets the criteria of being impact oriented, measurable, time limited, specific, and practical. Objectives are more specific than goals.

Resources: Items that a project needs, such as staff time, managerial time, local knowledge, money, equipment, the presence of trained people, and social and political opportunities.

Riparian community: A group of plant species that are found growing along the edges of streams, rivers and other watercourses, including dry streambeds.

Sampling: Measuring a subset of individuals, households, trees or other factors in a population like a community, forest, watershed, or transect.

Sapling: A young tree less than 5 inches in diameter but at least 4.5 feet tall.

Seedling: A young tree less than 4.5 feet tall.

Snag: A dead standing tree.

Appendix 2 — Area conversion

It is helpful to have all the values that are based on area expressed in the same units—acres. This creates a standard so that indicator values, such at the density of trees, can be compared from site to site and from one restoration project to another.

To convert a value per sampled area to a value per acre:

1 – Calculate the area sampled.

a. For the area of a plot, multiply the length times the width of each plot.

Example: 30 x 30 foot = 900 square feet.

b. Add together all plot areas (for total area sampled).

Example: 30 plots x 900 square feet = 27,000 square feet.

2 – Divide the value of the total area sampled (in square feet) by the number of square feet in an acre. The area of an acre is 43,560 square feet. This will give you the number of acres sampled.

Example: 27,000 square feet/43,560 square feet per acre = 0.62 acres sampled.

3 – Divide the number of objects (such as trees) sampled by the number of acres sampled. This will give you the number of objects per acre.

Example (continued from above): There were 50 trees in the 30 plots; 0.62 acres were sampled. 50 trees/0.62 acres = 81 trees per acre.

Appendix 3 — Useful monitoring resources

Methods:

Monitoring Plant and Animal Populations, by Elzinga and others, describes **monitoring design and implementation** for a wide range of ecological variables.

The Once and Future Forest, by Saber and McHarg, describes the entire **process of multiparty monitoring for community restorations of natural ecosystems**.

Methods for **monitoring wildlife** are presented in Morrison and Krausman, *Wildlife Restoration: Techniques for Habitat Analysis and Animal Monitoring*.

Further information on **monitoring butterflies** can be found in Butterflies as Indicators of Restoration Progress, by the Ecological Restoration Institute. An example of volunteer butterfly monitoring can be found at: www.mchenry.cc.il.us/faculty_pgs/mgarriso/butterflyproject/aBMG.html#TableofContents.
Software that can help analyze data collected is available at www.urbanwildlands.org/INCA/.

More details on the method for **monitoring landscape openings** are provided in the book *Landscape Ecology*, by Forman and Godron.

The following website has useful tips for making a **sampling design to measure understory plants**:
www.nrel.colostate.edu/projects/stohlgren/_sampling/mw_plot.html.

Full citations for the publications listed above can be found in *Appendix 5*.

Aerial photographs:

Although not covered in this handbook, aerial photographs can be useful tools for monitoring. TerraServer provides free online access to digital aerial photographs at www.terraserver-usa.com. The University of Chicago Library contains archives of thousands of aerial photographs and can be obtained through the following web address:
memory.loc.gov:8081/ammem/award97/icuhtml/aephome.html.

Photo series for fuel load estimates:

You can also use photo guides to estimate fuel on your project sites. These guides present a series of representative photographs of different forest conditions with average fuel load figures. By comparing your site to the different photographs, you can select the one that most closely resembles your site and read-off fuel load estimates. Examples of guides are:

Maxwell, Wayne and Franklin Ward. 1976. Photo series for quantifying forest residues in the: Ponderosa pine type, ponderosa pine and associated species type, lodgepole pine type. GTR-PNW-52. Portland, Oregon: USDA Forest Service, Pacific Northwest Research Station.

Fischer, William. 1981. Photo guide for appraising downed woody fuels in Montana forests: Interior ponderosa pine, ponderosa pine–larch–Douglas-fir, larch–Douglas-fir, and interior Douglas-fir cover types. GTR-INT-97. Ogden, Utah: USDA Forest Service, Rocky Mountain Research Station.

No name. Photo series for quantifying forest residues in the southwestern region: Data compiled from Black Hills ponderosa pine and spruce type, 1990; recompilation of GTR-PSW-56, 1981, GTR-PNW-105 (1980), and GTR-PNW-52 (1976). Albuquerque, New Mexico: USDA Forest Service.

Appendix 4 — Materials and equipment commonly required for monitoring

Item	Estimated cost
Aluminum tags	$35–40
Camera, 35mm	$125 and up
Camera, digital	$200–400 and up
Cassette tapes	$25
Clinometer	$100
Clipboard	$5
Compass	$15–20
Densiometer	$100
DBH (diameter at breast height) tape (also called logger's tape)	$12–25
Field notebook/paper	$5
Flagging tape	$2
Film, 35mm	$100 or more
G.P.S. (global positioning system) unit	$200–500 and up
Hammer	$10
Increment borer	$150–200
Measuring tape, 100ft	$50
Measuring tape, 300ft	$100
Metal stakes or rebar	$25–50
Penetrometer	$50 and up
Permanent writing markers	$5–15
Pin flags	$5
Soil compaction meter	$250
Various PVC pipe sections for plot squares	$25–50

The Ben Meadows Company is a good source of equipment for ecological field sampling. They can be contacted at Box 5277, Janesville WI 53547, 1.800.241.6401 or www.benmeadows.com.

Another good equipment source is Forestry Suppliers, Inc., 205 West Rankin St., Box 8397, Jackson MS 39284, 610.354.3565, or www.forestry-suppliers.com.

Other items, such as field notebooks, permanent markers, or camera equipment may be found at most office supply stores. Some on-line retailers offer good deals on camera equipment and other items.

Appendix 5 — References

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Appendix 6 — Ecological monitoring data sheets

The data sheets on the following pages can be used to record monitoring data and can be copied and used in the field. Data worksheets include:

A — Permanent photo points
B — Landscape openings
C — Bird abundance and species composition
D — Butterfly abundance and species composition
E — Seedling density
F — Amount of surface fuel
G — Extent of canopy cover
H — Classification of riparian plant community
I — Density and size of living and dead trees (plus height to tree crowns)
J — Understory plant species composition
K — Understory cover (and extent bare soil)

Permanent photo points

Site name: ____ Elevation: ___________________________

Location: ____ Date: _____________ Time: ___________

Observer(s): ____

Transect #: _____________________________ Slope: ________________ Aspect: ________________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

Film roll #: ___________

Photo of site marker	=	exposure/frame #: _______________
Photo to the North	=	exposure/frame #: _______________
Photo to the East	=	exposure/frame #: _______________
Photo to the South	=	exposure/frame #: _______________
Photo to the West	=	exposure/frame #: _______________

(for digital photos note the file name in place of the exposure/frame #)

Site description: known human history (grazing or logging), nearby structures or roads, animal signs (mounds, grazing, scat, tracks, insect infestation), signs of natural disturbance (fire, windthrow, etc.):

— Make copies of this sheet for additional transects and/or plots —

Landscape openings (see Handbook 4 page 26)

Site name: ________________________________ Elevation: ______________________

Location: ________________________________ Date: ______________________

Observer(s): ____

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ______

Length of transects: __________

Spacing between transects: __________

Sketch-map of site

Note abbreviations used : ____

— Make copies of this sheet for additional transects and/or plots —

Bird abundance and species composition

Site name: ______________________ Elevation: ______________

Location: ______________________ Date: ________ Time: ________

Observer(s): ______________________________________

Transect #: ______________ Slope: __________ Aspect: __________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

Sampling frequency: Breeding season ○ x1 ○ x2 ○ x3

Non-breeding season ○ x1 ○ x2 ○ x3 ○ x4 ○ x5

Point #	Species name	Mode of detection (song, call, visual, other)	Sex	Comments

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Butterfly abundance and species composition

Site name: ________________________________ Elevation: ______________________

Location: ________________________________ Date: __________ Time: __________

Observer(s): ____

Transcect #: ________________________ Slope: ____________ Aspect: ____________

- ◯ Control site
- ◯ Treatment site
- ◯ Before treatment
- ◯ After treatment

Number of years since treatment: ________

Point #	Species name	Number of individuals (tally marks)	Distinguishing characteristics (color, size, flight pattern, etc.)	Comments

— Make copies of this sheet for additional transects and/or plots —

Seedling density (trees less than 4.5 feet tall)

Site name: ____________________ Elevation: ____________________

Location: ____________________ Date: ____________________

Observer(s): ____

Transect #: ____________________ Slope: ____________ Aspect: ____________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

Seedlings		
Species	Number of individuals (tally marks)	Total

Use the following abbreviations to record tree species:

PP = Ponderosa Pine
GO = Gambel Oak
PY = Pinyon Pine
AJ = Alligator Juniper
OJ = One-seed Juniper
JN = Juniper
WF = White Fir
RJ = Rocky Mountain Juniper
DF = Douglas Fir

For other species make a note here of species and abbreviation(s) used: ____ = ____________________
____ = ____________________

— Make copies of this sheet for additional transects and/or plots —

Amount of surface fuel

Site name: ________________________ Elevation: ________________

Location: ________________________ Date: ________________

Observer(s): ____

Transect #: ______________	Transect #: ______________
Transect length: ______________	Transect length: ______________
Transect bearing: ______________	Transect bearing: ______________
Slope: ________ Aspect: __________	Slope: ________ Aspect: __________
◯ Control site ◯ Treatment site	◯ Control site ◯ Treatment site
◯ Before treatment ◯ After treatment	◯ Before treatment ◯ After treatment
Number of years since treatment: ________	Number of years since treatment: ________
Dominant tree species: ______________	Dominant tree species: ______________

Number of woody materials					Number of woody materials				
Less than 0.25 inches in diameter along first 6 feet	0.25 to 0.99 inches in diameter along first 6 feet	1.0 to 2.99 inches in diameter along first 10 feet	Greater than 3 inches in diameter along entire 35ft transect		Less than 0.25 inches in diameter along first 6 feet	0.25 to 0.99 inches in diameter along first 6 feet	1.0 to 2.99 inches in diameter along first 10 feet	Greater than 3 inches in diameter along entire 35ft transect	
			#	diameter				#	diameter
Totals									

— Make copies of this sheet for additional transects and/or plots —

Extent of canopy cover

Site name: ______________________ Elevation: ______________________

Location: ______________________ Date: ______________________

Observer(s): ____

Transcect #: ______________ Slope: __________ Aspect: __________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

	Densiometer measurement							
Plot #	Forward		Behind		Left		Right	
	Yes	No	Yes	No	Yes	No	Yes	No

— Make copies of this sheet for additional transects and/or plots —

Classification of riparian plant community structure

Site name: ______________________________ Elevation: ____________________

Location: ______________________________ Date: ____________________

Observer(s): ____

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

Transect #	Structure type #*

Transect #	Structure type #*

Use the following structure types to describe the site (see Handbook 4 for more details):

Type 1 = Tall trees with well developed understory
Type 2 = Tall tree canopy with little or no understory vegetation
Type 3 = Intermediate sized trees with dense understory vegetation
Type 4 = Intermediate-sized trees openly spaced with little understory
Type 5 = Stands with dense shrubby growth more than 25% of the community
Type 6 = Very young, low, and/or sparse stands less than 25% of the community

— Make copies of this sheet for additional transects and/or plots —

Density and size of live and dead trees
– and –
Height from ground to tree crown

Site name: ________________________ Elevation: ________________

Location: ________________________ Date: ________________

Observer(s): ____

Transect #: ________________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

			Adult living trees larger than 5 inches in diameter			Dead standing trees (snags)		Saplings tally	
Plot #	Slope	Aspect	Species	Diameter (inches)	Height to tree crown (feet)	Species	Diameter (inches)	Species	#

Use the following abbreviations to record tree species:

PP = Ponderosa Pine
GO = Gambel Oak
PY = Pinyon Pine
AJ = Alligator Juniper
OJ = One-seed Juniper
JN = Juniper
WF = White Fir
RJ = Rocky Mountain Juniper
DF = Douglas Fir

For other species make a note here of species and abbreviation(s) used: ____ = ________________
____ = ________________

Note: If multpile tree stems, measure the largest one and write the number of tree stems under the species name.

— Make copies of this sheet for additional transects and/or plots —

Understory plant species composition
(natives and exotics)

Site name: ______________________ Elevation: ______________________

Location: ______________________ Date: ______________________

Observer(s): ____

Transect #: ______________ Slope: __________ Aspect: __________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

Plot #	Species name	Number of individuals* (tally marks)	Total*

* Count individual plants in small plots only

— Make copies of this sheet for additional transects and/or plots —

Understory cover

Site name: ______________________ Elevation: ______________________

Location: ______________________ Date: ______________________

Observer(s): ______________________

Transect #: ______________ Slope: ______________ Aspect: ______________

○ Control site ○ Treatment site

○ Before treatment ○ After treatment

Number of years since treatment: ________

Plot #	Type of cover	Percent plant cover estimation (check only one plant cover estimate for each type)					
		0 to 5%	5 to 25%	25 to 50%	50 to 75%	75 to 95%	95 to 100%
	Grasses						
	Forbs						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Bare soil/rock						
	Litter						

— Make copies of this sheet for additional transects and/or plots —

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