Multiparty Monitoring and Assessment of Collaborative Forest Restoration Projects

Short Guide for Grant Recipients

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The information in this guide is based on the Collaborative Forest Restoration Program's Multiparty Monitoring Handbook Series, six documents that lay out in greater detail how to develop a multiparty process, set goals, choose indicators and measures, budget, and carry out a monitoring plan. These handbooks are available on-line at www.fs.usda.gov/goto/r3/cfrp. Published by the Ecological Restoration Institute and New Mexico Forest and Watershed Restoration Institute. Funded by the Collaborative Forest Restoration Program, USDA Forest Service.

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Why Monitor CFRP Projects

The purpose of monitoring is to learn from management activities by taking repeated measurements over time. Monitoring is an essential part of adaptive management, because it provides reliable feedback on the effects of management actions.

Multiparty monitoring brings together people with different perspectives, who jointly identify monitoring questions and methods to answer those questions. Multiparty monitoring can help reduce conflict over proposed actions by providing a way for people with diverse views to discuss, and reach agreement about, appropriate management activities.

Using a multiparty process to monitor the effects of your Collaborative Forest Restoration Program (CFRP) project helps achieve the program's goals of "improving communication and joint problem solving among individuals and groups" and "[evaluating] ecologically sound forest restoration techniques."

Forest restoration is a new practice. We need more experience in how we conduct the work of forest treatments, as well as how we create businesses around that work and how communities can benefit from that work. Monitoring results capture that experience.

Positive impacts are welcome and satisfying. But we can learn from mistakes and obstacles as well as successes. The purpose of multiparty monitoring is to learn from your project and share that information with others.

Collaborative Forest Restoration Program monitoring requirements

Projects funded through the Collaborative Forest Restoration Program (CFRP) are required to "include a diverse and balanced group of stakeholders as well as appropriate Federal, Tribal, State, County, and Municipal government representatives in the design, implementation, and monitoring of the project."

CFRP projects must also "include a multiparty assessment to identify the existing ecological condition of the proposed project area and the desired future condition; and report, upon project completion, on the positive or negative impact and effectiveness of the project including improvements in local management skills and on the ground results."

What follows

This document offers a basic monitoring plan for Collaborative Forest Restoration Program projects in New Mexico. The purpose of this Short Guide is to give CFRP grantees a compact and complete guide to monitoring and completing a multiparty assessment of their projects.

The 5-Step Multiparty Monitoring Process

1. Hold multiparty meeting

Identify:

- *different stakeholders' goals for and concerns about project outcomes*
- *what should be monitored*
- *monitoring budget*
- *monitoring resources (people, organizations, equipment)*

2. Write monitoring plan

Describe:

- *monitoring goals*
- *indicators to measure change in goals*
- *reliable data collection methods*
- *where data will be gathered*
- *when data will be gathered*
- *who will gather the data*

3. Gather data

Collect:

- *baseline (pre-treatment) measurements*
- *repeat measurements - usually after project is completed*
- *enough data for a reliable result*
- *carefully store your data in a safe place*

4. Analyze data

Use:

- *simple and useful calculations*
- *a multiparty team meeting to discuss and interpret results*
- *interpretation of results to inform prescriptions*

5. Share results

Report:

- *what you've learned*
- *how you did it*
- *what you would do differently next time*

Step 1: The Multiparty Meeting

The first step in building a multiparty process is to identify and invite participation from stakeholders. A stakeholder is a person or group that could affect or be affected by your project, or simply someone who has an interest in restoration. Stakeholders include all project partners, including land managers with management authority on the restoration site. Other stakeholders could include local community members, businesspeople, ranchers, conservation advocates, tribal leaders, irrigation or watershed interests, homeowners, traditional forest product users, wildlife managers, representatives of local educational institutions, resource management agencies, etc.

Once you have identified stakeholders, invite them to a multiparty meeting to discuss the project and how to monitor it. The first multiparty meeting should be held when the project proposal is being developed or soon afterward, before any on-the-ground activities have begun.

At your multiparty meeting, start by discussing the project goals and possible effects the project could have on the environment, the economy, or the community. It may be necessary to discuss some terms, like "restoration" or "large tree," to be sure that everyone means the same thing when they use these words. It is important to have a common understanding of the goals and possible impacts of the project before you discuss what to monitor.

Next, identify the possible outcomes that the group wants to monitor. These are your monitoring goals. Remember, the CFRP legislation requires that you assess your project's impact on local management skills and on-the-ground results. Many CFRP groups identify monitoring goals like 'reduce risk of crown fire' and 'develop value- added wood products.' Make sure everyone understands that the purpose of monitoring is to track changes over time to determine if the project is meeting its goals and how it is affecting other resources.

Once your group has decided what outcomes it wants to monitor, it should discuss and choose monitoring indicators. Indicators are specific measures of change, such as 'tree density' or 'number of jobs created.' This guide lists commonly used indicators for CFRP projects. Other indicators are also described in *Handbook 4 - Monitoring Ecological Effects* and *Handbook 5 - Monitoring Social and Economic Effects of Forest Restoration.*

Lastly, you should discuss who has the time, expertise, and equipment necessary to do the monitoring. You may want to reach out to resource management agencies or community groups for monitoring assistance. Many CFRP projects involve school groups or Youth Conservation Corps in data collection**.** Others hire consultants to do the data collection and analysis. Consider your monitoring budget, and read the budget information in this guide. You may need to revise your monitoring plan to reflect your monitoring budget.

Step 2: Developing your monitoring plan

The monitoring plan describes what you will be monitoring, who will collect what information, when, and how the information will be gathered. A monitoring plan template is provided on the following page. A CFRP monitoring plan has six basic elements:

1. Goals: What you hope to accomplish with the project. You can take goals directly from your grant application and put them in your monitoring plan. An example of a goal is "Reduce tree density in overstocked stands."

2. Indicators: What you will measure to track progress on meeting your goals. For example, to track progress on the goal of reducing stand density, your indicator would be trees per acre.

3. Methods: How you will measure each of your indicators. For example, for the indicator "trees per acre," your method could include recording the number and species of all trees within 30 or more large plots.

4. Sampling design: Where you will measure your indicators. What sampling design will you use? For example, you may decide to locate 6 transects across your site, each 500 feet apart.

5. Sampling schedule: When you will measure your indicators. Indicators must be measured more than once - at the minimum they should be measured before project activities begin, and after they are complete. Monitoring tracks change over time, and two measurements, before and after project activities, are essential.

6. Responsible parties: Who will measure each indicator? To create a monitoring plan with your multiparty team, start by identifying the goals of your project. For each goal, list one or more measurable indicators, and what methods you will use to measure those indicators. Discuss how much and what kinds of monitoring are possible given your budget, resources, and the abilities of your monitoring partners. Next, narrow the list of all possible indicators down to those that are most important and can realistically be measured given your available time, money, and resources. Finally, decide who will be responsible for each task and how they will be involved, and construct a timeline for collecting both baseline and post-treatment data.

Worksheet: Sample Multiparty Monitoring Plan

Project Name:_____

Multiparty Monitoring Team Members:_____

_____

Goals, Indicators, Methods, and Timeline

Goal	Indicator	Method	Where to Collect	When to Collect	Who to Collect

Step 3: Data gathering and management

There are a few precautions you can take to help ensure that your monitoring will be useful for evaluating the effects of your project. Keep the following in mind for all forms of data collection:

- Gather baseline data before beginning your project activities (such as forest treatments). *It is important to use this baseline data when you develop your site-specific ecological prescription*. Don't wait until the end of your project to start thinking about monitoring. Please refer to the "Short Guide to Developing Ecological Prescriptions for CFRP projects at www.nmhu/nmfwri/cfrp.html.

- Use the same data collection methods for baseline as you do for post-treatment monitoring.

- Make sure that monitoring partners are familiar with data collection methods before collecting any real data. Individuals and field crews who are going to collect monitoring data should be trained in standard data collection methods so that your results are reliable. The Collaborative Forest Restoration Program office in Albuquerque can direct you to appropriate trainers.

- Keep detailed records of what was monitored, where exactly your sampling is located, and when, how, and by whom data were collected.

- Practice good data management. Your data sheets should be clearly marked with the date and location. Make copies of your data sheets and store each set in a different place.

- If you are using computer software to store and analyze your data, you should do your data entry and analysis as soon as possible after collecting data. This will help prevent data loss, and also allows you to double-check the quality of the data while the information is fresh.

- Regularly back up any electronic files that contain monitoring data. Never leave data records only on the computer; they may be lost.

Data collection methods differ depending on what indicators you are measuring. See the methods sections and indicator descriptions in this guide for detailed data collection methods.

Step 4: Data analysis

Data analysis is the way to make sense of the information you have collected, by turning raw data such as numbers on data sheets into meaningful measures of change. Data analysis methods for specific indicators are included at the end of each indicator description in this guide. Some general concepts that are useful when analyzing any kind of data are described here.

Compiling data

Often the first thing to do when analyzing data is to compile similar types of data. For example, if you collected baseline and post-treatment data on tree density, you'll first want to find out:

- What was the average tree density before treatments were implemented?
- What was the average tree density once treatments were complete?

Determining change over time

For most types of monitoring, you want to be able to describe how the situation has changed over time. Using tree density as an example again, you'll want to find out the difference between the baseline and post-treatment averages. For example, if the forest had an average of 212 trees per acre before treatment, and an average of 68 trees per acre after treatment, the stand density decreased by an average of 144 trees per acre, or 68% (144/212). The stand density is now 32% (68/212) of what it was before treatment.

If you're using descriptive (non-numeric) data, you still want to find out how things changed over time. If you're examining community perceptions of the restoration project, for example, you'll want to review your data to find out how community perceptions changed between the start and the end of the project.

Step 5: Interpreting and reporting results

Once you have analyzed your monitoring data, you will want to interpret what the results mean for your project, your community, and future restoration projects. Forest restoration is a new practice. We need more experience in how we conduct the work of forest treatments, as well as how we create businesses around that work and how we benefit communities with that work. Monitoring results capture that experience.

In addition to using a multiparty process to interpret monitoring results, you will want to share what you have learned with others, at a minimum by writing a final monitoring report to include with your final CFRP project report. The best kind of final report will reflect how your particular project changed the forest and the community in ways that the partners care about.

Interpreting results: The multiparty assessment

The most important part of monitoring is figuring out what the information you have collected and analyzed means. In the multiparty assessment process, project partners can examine their monitoring results to evaluate how well the work went, and then use that information to plan better future projects. It is best to reconvene your multiparty monitoring team, including representatives of the land management entity, to jointly discuss and interpret your monitoring results.

As a multiparty team, discuss the following questions:

- Were there economic or social benefits to the community?
- How did the forest change as a result of your work?
- What skills did project team members acquire, and how could these be applied to future work?
- Which project goals were you able to accomplish?
- Which things did not work in the project, or presented difficulties?
- Were there surprises?
- How did your expectations change over the years of the project?
- If you were to do the project again, would you do some things differently?
- How might the benefits of the project be maintained and sustained into the future?

For example, suppose you burned piles of slash after thinning small trees in part of the project, and chipped and hauled off slash in other parts of the project. Your monitoring may have shown that the sites of these burned piles had twice as many exotic plants as other places, but the chipping and hauling was expensive. In this case, you could describe the tradeoffs in cost, effort and impact of these different treatment options and recommend what might be done with slash in another project. The multiparty team may want to discuss other lessons learned as well.

Capture these findings in writing so that you and others can review and refer to them in the future. By sharing the results of your monitoring with others, you assist the entire restoration community in the Southwest.

The monitoring report

The CFRP program requires a multiparty assessment that reports on "the positive or negative impacts and effectiveness of the project" and "improvements in local management skills and on-the-ground results." This means that you should report on the social and economic impacts of the project, and, if the forest was treated, on the ecological impacts as well. Of course, positive impacts are welcome and satisfying. But restoration is a new practice, and we will learn from mistakes and obstacles that are reported as well as successes.

Your monitoring report should include not just your monitoring results, but also background information on your project, what you monitored, and how you arrived at your results. You should also include your interpretation of your results - the lessons you learned that could inform other restoration projects.

1) Background information

Briefly describe your project - what did you set out to accomplish? Who are your partners? Where is the project located, and what kind of forest is being treated? Describe what kind of multiparty process you used, and why you chose your monitoring indicators.

2) Monitoring methods

Describe how you collected monitoring data. What kinds of data were collected? How often did you collect data? Who did the monitoring? Be specific - if you used transects and plots for ecological monitoring, describe how many transects you used, how long they were, how many plots were sampled and how large the plots were. If you measured tree height, diameter, and canopy cover, what tools did you use? If you surveyed the local community, how many surveys were distributed, and how were they distributed? This section can be brief, but it should give the reader a clear idea of how data were collected.

Next, describe how you analyzed your data. For example, did you calculate percent change over time in canopy cover or in tree density? Did you calculate the total amount and value of wood products produced over the life of your project?

3) Results

This is where you present a summary of your data analysis results. For example, if you measured tree size and canopy cover, this is where you would give results such as changes in the average tree size and average canopy cover. Report both pre-treatment and post-treatment results, and changes between pre-treatment and post-treatment measurements.

You may want to use tables, charts, diagrams, or descriptive text to present results. For example, if you did interviews, you could include excerpts from people's comments.

It is important to communicate your findings in summary form. Give enough information to paint a complete picture of your project, but do not include all the data. For example, report a single value for average tree size, not the diameter of every tree measured.

4) **Interpretation and conclusion**

This is where you share the results of your multiparty assessment. What are the lessons you learned from this project? What would you do differently next time? These lessons will help you, and other people as well, to do more effective restoration work in the future.

Remember, you should not base your interpretation or on simply your own perceptions of the project, or that of your project partners. As a rule of thumb, any finding that goes in your monitoring report - whether numbers or descriptions - must be based on real data, not on casual observation or speculation.

5) **Optional appendices and additional information**

If there is important information which is too bulky or detailed to fit in the main body of the monitoring report, you can include it in an appendix, which comes at the end of the report. For example, if you created a community survey, you might want to include a copy of the survey in an appendix. Or, if you have several pages of summary data which didn't fit in the results section, these can go in an appendix as well.

Sharing your results with others

In addition to writing a final monitoring report for the CFRP program, you may want to share what you have learned with others in your community or elsewhere. This can be done at the end of each project year as well as at the end of the project. There are a number of ways to do this, such as presentations at community or regional meetings and newspaper articles or editorials. Posters or short leaflets with charts and pictures can give a colorful, easy-to-understand overview of what you did and what you learned. More detailed technical reports can be posted on the Internet. Sharing your information is a great way to celebrate and advertise your project as well as inform future projects.

Budgeting for Monitoring

You should have a monitoring budget in your CFRP proposal. Monitoring budgets will vary, but a good effort will likely need between 5% and 10% of the total project budget. Items you may want to include in your monitoring budget include salaries, equipment, and transportation.

Salaries

Monitoring requires time to develop and oversee the monitoring plan, collect, manage, and analyze data, and write the final monitoring report. It is a good idea to have at least one person who is consistently involved throughout the monitoring work. This person could be a project partner or a consultant. A number of successful projects have paid someone to coordinate their monitoring work. The salary budget for monitoring will vary with the type of monitoring you do. This sample monitoring budget at the end of this section shows some estimates for different parts of the monitoring process.

You can reduce your monitoring costs by working with project partners who donate time or equipment. Many projects work with volunteers, such as high school students, community members or non-profit organizations to collect data. Youth Conservation Corps (YCC) programs exist throughout the state. These programs are sometimes available to assist on a short-term basis with data collection. Contact the New Mexico Youth Conservation Corps, 141 East DeVargas St., Box 1948, Santa Fe, NM 87504; 505- 827-1437 or www.emnrd.state.nm.us/nmycc2/default.htm to find out if there is a funded project in your area or to apply for funding yourself. Agencies such as Forest Service Ranger Districts or the Bureau of Indian Affairs may also receive federal funding for youth crews and have on-going programs with whom you can partner.

Equipment and materials

Estimates for the cost of purchasing some of the ecological monitoring equipment are:

Clinometer	$100
Diameter (dbh) tape	$12-25
Measuring tape (300 ft)	$100
Metal stakes or rebar	$25-50

Some sources for ecological monitoring equipment are:

The Ben Meadows Company
Box 5277
Janesville, WI 53547
1-800-241-6401
www.benmeadows.com

Forestry Suppliers, Inc.
205 West Rankin St., Box 8397
Jackson, MS 39284
1-610-354-3565
www.forestry-suppliers.com

Costs for social and economic monitoring equipment are variable, depending on the type of monitoring done. Costs for some equipment are as follows:

Microcassette recorder $30
Digital voice recorder $30

Mailed questionnaires $40-80

[usually around $1 per questionnaire (for postage, return postage, paper, envelopes, etc.) Internet surveys can be distributed at no cost.]

Transportation

Ecological monitoring: You should include transportation costs incurred in getting sampling crews, project managers or consultants to the project site. Social and economic monitoring: Interviews and surveys may involve significant transportation costs for the people gathering the data. If using focus groups, you may want to budget travel reimbursement for all participants.

Example of a monitoring budget

The table below is one example of a monitoring budget that includes both ecological and social & economic monitoring. Budgets can vary depending on whether a youth crew or volunteers are available to assist in data collection, and the salary rate paid to employees. A budget for monitoring should include the cost of personnel time for planning, equipment, implementation, data analysis, and reporting.

Project activities	**Estimated amount**	**Cost**	
		Cash	**In-kind**
Year 1			
Project coordination	1 person x 160 hrs x $40/hr	$6,400	
Multiparty monitoring meeting and field trip	6 people x 10 hrs x $20/hr		$1,200
Baseline ecological data collection	4 people x 10 hrs x $20/hr	$800	
Baseline social and economic data collection	2 people x 20 hrs x $20/hr	$800	
Equipment and supplies		$700	$100
Travel	1200 miles x $0.50/mile	$600	
Year 2			
Multiparty monitoring meeting and field trip	6 people x 10 hrs x $20/hr		$1,200
Continued tracking of social and economic indicators	2 people x 20 hrs x $20/hr	$800	
Year 3			
Project coordination	1 person x 120 hrs/yr x $40/hr	$4,800	
Post-treatment ecological data collection	4 people x 10 hrs x $20/hr	$800	
Post-treatment ecological data collection (volunteers)	8 people x 10 hrs x $8/hr		$640
Multiparty monitoring meeting and field trip	6 people x 10 hrs x $20/hr		$1,200
Post-treatment social and economic monitoring	2 people x 20 hrs x $20/hr	$800	
Data analysis & monitoring report writing	1 person x 60 hrs x $40/hr		$2,400
Equipment and supplies		$300	$100
Travel	1200 miles x $0.50/mile	$600	
3-Year Total		**$17,400**	**$6,840**

Social and Economic Monitoring Methods

Forest restoration projects frequently have social, economic, and cultural goals as well as ecological goals. Most CFRP grantees want to know how their project affected the local community--for example, did the community's capacity to do restoration work increase? Are there more job opportunities as a result of the project?

In this guide, we provide six indicators of social and economic changes that have been commonly used in restoration monitoring. These are:

1) jobs created
2) skills gained
3) value of wood products generated
4) outreach and education
5) distance to work
6) community perceptions

The Collaborative Forest Restoration Program requires that you monitor the first two indicators listed: number and kind of jobs created and improvements in local management skills. We encourage all grantees to consider adding value of wood products generated by the project, outreach and education activities, and distance to work. Many CFRP grantees may also choose to monitor community perceptions of their project, though this requires more resources to reliably monitor. Other indicators and methods that your multiparty team may find useful are found in *Handbook 5: Monitoring Social and Economic Effects of Forest Restoration*.

Data collection methods

Most social and economic indicators are measured by keeping notes or other documentation during the course of the project. For example, if you wanted to monitor community perceptions of your restoration project, you would have to collect opinions from local residents. You could not base your monitoring of this indicator on simply your own perceptions of the project, or that of your project partners. Any finding that goes in your monitoring report - whether numbers or descriptions - must be based on real data, not on casual observation or speculation. Monitoring is not something that can be initiated at the end of the project.

You should always practice good data management - by making copies of data sheets (such as worksheets, questionnaires, or interview notes), entering data into computer files soon after collecting the data, and backing up your electronic files. Keep detailed notes on what monitoring was done when, how, and by whom.

There are five data collection methods that are commonly used for social and economic monitoring: direct tracking, secondary data analysis, questionnaires, interviews, and focus groups. These are described briefly below. For more information on any of these methods, see *Handbook 5: Monitoring Social and Economic Effects of Forest Restoration*.

Direct tracking simply means keeping track of important events and changes as they occur, by writing them down or storing them in a computer file or database. You will want to use a worksheet or some form for recording information. This is the simplest and most common way to monitor social and economic effects of restoration project.

Secondary data collection is similar to direct tracking, but involves collecting and analyzing information that already exists somewhere else. In other words, you are collecting existing data from reports, bookkeeping records, business documents, and other sources, such as agency records, rather than collecting the data yourself.

Questionnaires are used to gather information about the beliefs, attitudes, behaviors, and other characteristics of a relatively large group, such as all households or all high school students in a community. They also are the most technical method discussed here, because they require careful question design and often require random sampling. Questionnaires typically use questions where respondents choose from a selection of specific answers. This type of question is most appropriate when you already know what the important issues are and can devise a set of answers that capture the range of public opinion. For example, the questionnaire may ask "How would you rate the ecological health of the CFRP restoration site?" and possible answers could be "a) very healthy; b) somewhat healthy; c) neither healthy nor unhealthy; d) somewhat unhealthy; e) very unhealthy; f) don't know." You are not likely to use the questionnaire method unless you decide to monitor community perceptions.

Interviews are a good method if you want to be able to gain a deeper understanding of complex issues, or if a relatively small number of people have the information you need. Questions and answers are given in a conversational style that can capture detailed information. For example, you may want to interview all wood products business owners within 30 miles of your community to find out how wood removed from your site has affected the production of value-added wood products in your region. In this case, you might ask questions like: 1) Have you used any wood generated from our CFRP project? 2) If so, how much wood have you received from our project? 3) What products did you create using that wood? 4) What amount of these products did you produce using our wood, and what was their value?

Focus groups are guided, in-depth conversations with several knowledgeable individuals. Each group should include five to ten people with similar interests or backgrounds. For example, when monitoring uses of small-diameter wood, you might convene a focus group of local wood products business owners. For other monitoring questions you may want to consult groups like community elders, forest workers, or environmental advocates. Questions are designed to encourage discussion among group participants, so that perspectives can be explored and developed.

Data collection method for questionnaires, interviews, and focus groups

Methods for questionnaires, interviews, and focus groups are more complicated than direct tracking or secondary data collection. For these methods, follow 5 basic steps:

1. **Clarify your information needs.**

Before developing questions or identifying people to answer the questions, discuss what specific information you hope to gather.

2. **Identify appropriate participants.**

Once you know your information needs, consider who has that information. For example, if you want to know community perceptions of restoration, you may want to question a representative sample of local residents. On the other hand, to identify jobs indirectly created by your CFRP project, you may choose to interview business owners in your community. Your multiparty monitoring team should work together to discuss and identify the best sources of information about your indicator.

3. **Develop and test questions.**

The questions you ask and the way that you ask them will greatly affect the quality of the data you collect. To make sure that everyone interprets the questions in the same way, avoid technical terms and jargon. Also make sure each question addresses only one topic. For example, “Do you support the use of thinning and prescribed fire to restore forests” asks at least two questions - one about thinning and another about prescribed fire, and people probably will have different ideas about what forest restoration means.

Do not ask “leading questions” (questions which bias the respondent to a certain answer). For example, a leading question could be “How has the neighborhood association interfered with the restoration project?” This question presumes that the neighborhood association has been a negative entity without legitimate concerns. A better way of asking this question would be “How has the neighborhood association been involved with the restoration project? Have they expressed any opinions about the project? Why, do you think, did they have those opinions?”

Before conducting a questionnaire, interviews, or focus groups, you should ask the multiparty monitoring team to review the questions to evaluate whether they are clear, address important issues and concerns, and whether there are too many questions. You may also want to ask an individual or organization with experience developing surveys and interviews to review your questions.

4. **Ask the questions (gather the data).**

Questionnaires are usually printed on paper and mailed or handed out to potential respondents, but they can also be administered over the telephone, in person, or on the Internet (using a free service such as surveymonkey.com). It is important that the same questions are asked of everyone, and that questions are asked the same way each time.

Interviews are usually conducted in person, or occasionally over the telephone. Focus groups are always conducted in person, and it often helps to use a neutral facilitator who can keep the group on topic and create a comfortable atmosphere. In interviews and focus groups, you don't need to limit yourself to asking only those questions you prepared ahead of time. You can follow important trains of thought by asking other questions as the session proceeds. Let people answer the monitoring questions fully and in their own words.

With any of these methods, you will want to make sure the responses are comparable. So you should always use the same method (e.g., always mail the questionnaires, or always ask questions over the telephone). In addition, when collecting data over more than one year, make sure to duplicate what you have done exactly. For example, make sure you are gathering answers from the same group of people and from the same time period. For instance, if you hold focus groups with agency personnel and environmental organizations in Year 1, expect to repeat this in Year 3 of the project.

Before asking someone to participate in questionnaires, interviews, or focus groups, you should clearly explain why this information is important to your project, who is involved in the multiparty monitoring, what the information will be used for, the individual's right not to answer, and how you will ensure their confidentiality.

5. **Record the responses.**

For interviews, focus groups, or telephone questionnaires, you can record responses either using an audio recorder or by taking written notes. When using written notes, it is important to make sure you are recording responses accurately. Try to copy down the responses word-for-word. You may also read your notes back to the respondent to be sure that you heard them correctly and wrote down all the relevant points.

Gathering representative data

If you only want to measure the opinions of a small group of people, for instance, if you live in a small community or only want the opinions of business owners in your community, you could have everyone in that group answer your questions. If you want to draw conclusions about a larger population based on information gathered from a relatively small number of people, you need to use random sampling (e.g., surveying people with names randomly drawn from the phone book). It is very useful to gather information from a non-random sample of the community, such as people attending local fairs, Earth Day events, or public meetings, but their responses will only be representative of the people attending those events, not the larger population. You may want to seek assistance with random sampling design from an individual or organization with experience designing surveys.

Number and Kinds of Jobs Created

Most CFRP recipients want to understand the impact of their project on the local economy. One way to monitor this is to measure the number of jobs created by the project. Jobs created by the project may be direct (people paid out of the grant) or indirect (job arose because of the grant, but workers were not paid out of the grant). You may also want to record the number of hours of volunteer time donated to the project. A job "created" by a project must be clearly tied to the project.

The important pieces of information to know about jobs created are:

1. **What kind of job?**
   Examples could include tree feller, exotic plant eradicator, or monitoring supervisor.

2. **For each type of job, how many people were employed?**

3. **How long did each job last?**
   This should be measured in days, weeks, months, or years. If a new job was created and is ongoing at the time of your report, explain when it began and describe it as "ongoing."

4. **Was the job full or part-time?**
   If part-time, approximately how many hours were worked each week?

5. **How do the hours worked compare to a full time employee?**
   The federal government considers a full time employee to work 2,080 hours a year.

6. **Was the job directly or indirectly created by the project?**
   If CFRP funds were used to pay wages, the job was directly created. If CFRP funds were not used, but the job arose because of your project, it was indirectly created. For example, if the local mill hires a new person to help process the logs removed from your CFRP project, this is an indirect job. Make sure that indirect jobs were actually created by the project.

Data collection methods

For jobs directly created by the CFRP project, you can gather data through good bookkeeping and reviewing project records. See the attached worksheet for a data recording template. If you have people working different numbers of hours or different lengths of time for the same type of job, record these on separate lines. Because conditions change over time, job data should be recorded on a regular basis. For example, the project manager might update the worksheet quarterly or annually.

For indirect jobs, you will need to interview the owners or managers of businesses related to your project. To gather reliable data using interviews, you should develop questions that directly address the information you are seeking. In this case, you will want questions that determine whether your project has had an influence on their workforce – have they hired new workers, or

extended the hours of existing workers, because of *your project?* It is also important to accurately record the interviewee's responses. You may want to read back the written notes back to the interviewee to be sure that you heard them correctly and wrote down the relevant points. For instance, they may be unsure whether or not new jobs were specifically due to your project. If this is the case, make a note of it in your monitoring report.

Data analysis method

Analyzing job creation data is simply a matter of compiling the information you have gathered onto a single worksheet each project year and when your project ends, and then calculating total or average numbers of jobs created over time.

For example, if a thinning crew included four full-time people for 12 weeks and three half-time people for four weeks, record these separately so you can accurately report the total number of hours of worked over the life of the project. In this case, your final number of jobs created might look like this:

Type of Job	Number of individuals employed	Length of employment	Average number of hours per week (per person)	Total number of hours worked in Year 1	Full Time Equivalent (FTE) (total # hours worked / 2080)	Direct (paid for by CFRP funds) or indirect job?
Sawyers	1 (supervisor)	14 weeks	40	560	0.26	Direct
	4 12	weeks	40	1920	0.92	Direct
Viga Hand-peelers	3 4	weeks	20	240	0.12	Direct
	2 18	weeks	30	1080	0.52	Indirect
Total Direct Jobs	8			2720	1.3	
Total Direct and Indirect Jobs	10			3800	1.8	

When the number of people employed varies over time, you might also calculate the average number of people employed. In the example above, 3 hand peelers worked for 4 weeks, while 2 worked for 18 weeks. To calculate the average number of workers in this example, you would add the number of workers employed for different durations and divide by the total number durations listed. In other words:

$$\frac{\text{3 hand peelers (for 4 weeks) + 2 hand peelers (for 18 weeks)}}{\text{2 durations of employment}} = \text{2.5 hand peelers}$$

It is also useful to convert the hours worked by job type and whether it was a direct or indirect job into the full time equivalent (FTE is 2080 hours/year). Do this by dividing the hours worked for each job type by 2080. You can then determine how many year-round jobs the grant directly and indirectly created over the life of the grant.

Data interpretation

When interpreting your data and in your report, describe the effects of the project on employment in your community, and back up this description with data summaries from your worksheets. If you think your project significantly affected employment and unemployment statistics for your community, you may want to review these statistics (available from community economic development agencies or at www.census.gov) and discuss how your project affects them. You may also want to discuss other issues, such as whether jobs went to local community members or people outside the community, whether these jobs filled in employment gaps, or whether jobs are likely to continue after the project has been completed.

Data Sheet: Number and Kind of Jobs Created

Completed by: _____ Date: _____

Type of Job	Number of people employed	Start & end dates of employment	Length of employment in weeks (determined from start & end dates)	Average number of hours per week (per person)	Total number of hours worked	Full Time Equivalent (FTE) (total # hours worked / 2080)	Direct (paid for with CFRP funds) or indirect job?	Future employment in this field likely? (yes/no)

Skills Gained

When project employees and other community members gain new skills it increases their capacity to find and keep employment, and when youth are trained it can increase their interest in and prepare them for future natural resource work. Many projects include some aspect of training, such as chainsaw safety training, training in the use of harvesting or milling equipment, training in restoration prescriptions and implementation, or training in monitoring methods and data collection. In some cases, community members may gain new skills without undergoing formal training. For example, the project manager may learn grant-writing and reporting skills during the life of the project, or a project employee may learn a new skill during the course of his or her employment. These should be monitored as well. You could also track people's interest and ability to continue working in forest-related fields after receiving training. If trained individuals find forest-related work after their training, this information should be included in the monitoring report.

To monitor skills gained by project employees, community members, or youth, keep track of the following:

- **What kinds of trainings were received?**
  These could include training in chainsaw safety, business management, plant identification, or monitoring methods. Trainings should be directly related to the project, though they need not have been paid for with CFRP funds.

- **Who provided each training opportunity?**
  Examples could include local colleges or universities, agencies such as the Bureau of Indian Affairs or U.S. Forest Service, or local community groups.

- **Who received the training?**
  For example, were the participants youth, community leaders, project employees?

- **How many people received training?**

- **How long did each training event last?**
  Some trainings may only take a few hours while others may require several days.

- **Did trainees receive any formal recognition or certification?**
  For example, did they earn a license to operate certain equipment or receive reduced workers' compensation rates as a result of the training? Did youth trainings meet requirements for school educational standards?

- **Did training provided by this project help anyone find other forest-related work?**

Data collection methods

To monitor this indicator, you will need to keep track of all trainings and other skills gained as they occur, as shown on the following data sheet.

To measure skills gained through experience rather than through formal training you may want to interview project participants to determine what skills they acquired and how these skills could be put to use. You can also use interviews to determine whether people hope to find or have found forest-related work as a result of skills gained on this project. Carefully develop questions that directly address the information you are seeking. For example, you will want to make sure that any skill you count is directly related to the project. Follow the interviewing methods described in the socioeconomic monitoring methods section of this guide.

Data analysis method

To analyze this indicator, compare the answers to your questions before and after the completion of the project. How many people received training over the life of your project? Are people able to do things now that they couldn't before?

Data interpretation

Interpret your monitoring results by considering the impact of the skills gained by project members and others. For example:

- Is the community in a position to do new kinds of work as a result of your project?
- Did new skills improve the quality of work on the project?
- Are people who were trained better able to gain future employment as a result of their acquired skills?

Your report could include a description of changes in the community due to project associated trainings, backed up by data taken from your data sheets.

Data Sheet: Skills Gained

Completed by: _____ Date: _____

Date of training or other experience	Duration of training (number of hours)	Type of training or experience	Training provider	Who received training?	Number of people who received training	Type of certification received (if any)

Value of Wood Products

One of the goals of the CFRP program is to increase the use and value of small-diameter wood. Most projects include either the removal or processing of wood products as part of restoration activities. Monitoring the economic value of wood products generated is a way of measuring the impact of your project on the local community.

The following are some questions to keep in mind when monitoring this indicator:

- **What were the different uses of wood produced by of the project?**

  For example, wood removed may have ultimately been used as firewood, vigas, latillas, fence posts, sawlogs, biomass for energy conversion, or for other uses. Be sure to note what new uses were possible because of the grant. You may also want to keep track of the different types of wood used (species and/or size).

- **How much wood was utilized for each different use?**

  For example, how many cords of firewood? How many fence posts? How many tons of biomass?

- **What was the value of the wood products?**

  Keep track of the value of each type of wood product. For example, how much was firewood sold for, or was it given away?

- **Has the community's ability to process/sell/distribute this kind of wood product changed as a result of the CFRP project?**

  Is the community able to make a new product? Is the community able to make more of a certain kind of product?

Data collection method

You can gather information on this indicator using direct tracking, interviews, or focus groups. If you are using direct tracking (writing down all wood products produced, how much wood was used, etc.), you will need to develop a data sheet and regularly record these values. See the data sheet at the end of this section for an example.

You will also want to gather data on the types and amount of wood utilized in your community or region before your project began. You can use secondary data analysis or interviews to gather this information.

If you are using interviews or focus groups, you will want to develop specific questions that address this issue and record the answers as accurately as possible. For example, you may want to interview all wood-products producers within 30 miles of your project to find out how they are using your wood. In this case, you might ask the following questions: 1) Have you used any wood generated from our project? (If the answer is no, stop here.) 2) How much wood have you received from our project? 3) What products did you create using that wood? 4) What amount of these products did you produce using our wood, and what was their value? 5) Was this a new product for you? 6) Did the availability of wood from our project increase your capacity to make these products? If yes, by how much? 7) How were these products distributed? Similar kinds of questions could be asked in a focus group setting. Follow the five steps described in the socioeconomic monitoring methods. As with the direct tracking method, you will want to record interview data on a data sheet like the one included in this guide.

Data analysis method

To analyze this data, you want to calculate the total amount and value of each type of wood product produced over the life of your project.

1. List each type of wood product, and the amount of each product that was produced as a result of your project.
2. List the value of each type of wood product. For example:
    a. If firewood was sold, record how much each cord was sold for and how many cords were sold altogether.
    b. If firewood was given away, estimate the value of the firewood based on prevailing prices or by asking firewood recipients how much the wood is worth to them.
    c. If firewood was removed by firewood collectors, estimate the amount of time needed to buck, limb and remove a cord; travel time and mileage from the community to the site; the value of the firewood collectors time; and chainsaw use that is needed to remove the wood from the site. The in-kind contribution of fuelwood removal can be substantial to many restoration projects. For example:

Period #	Cords Removed	Roundtrip Distance to Site	Value of Travel Cost	Collection Time	Value of time	Chain-saw use	Chain-saw cost	Extended Cord Value	Total Removal Cost
		From home to site (miles)	Round-trip (miles * $0.585)	Time to travel, limb, buck, and load a cord (hours)	Travel time * $12.5/hr	Time (Hours) per cord	Chainsaw use * $6/Hr (cost of running saw)	Value of distance + value of time + chainsaw cost	Extended cord value * # cords removed
2007	300	101	$59	18	$225	3	$18	$302	$ 90,600
2008	216	101	$59	18	$225	3	$18	$302	$ 65,232
Total	516							$302 (avg.)	$ 155,832
Note: This is an example and the mileage, removal time, and chainsaw use multipliers will vary by prescription, site, year, and project. It is useful to calculate the average extended cord value when these variables change.									

    d. For value-added wood products (such as structural or decorative material), record the market value of the products (what they actually sold for when finished).
    e. For wood sold to an outside entity (such as a mill or biomass facility not affiliated with the CFRP project), record how much the buyer paid for the wood. If necessary, separate value by different size classes, qualities, or species of wood.

3. Calculate the total value produced for each product by multiplying the amount of each product by its value.

4. To determine the total value of ALL products created as a result of your project, add together the total value for each product.

5. You will also want to compare the types and amount of wood utilized in your community or region before and after your project.

Data interpretation

When interpreting your monitoring data, you want to explain how the ability to use and add value to wood products has changed as a result of your project. Is it now possible to make value-added products out of material that formerly was left on site or disposed of? Has your wood use reduced the cost of forest thinning? Also consider whether wood from your project benefited the community - for example, did you help defray the costs of wood heating? Did a restoration treatment allow you to provide firewood to people who previously had to pay out of pocket for heating or cooking wood?

In some cases, circumstances may have prevented you from meeting your production targets; it is important to discuss these as well. For example, you may find that although attempts were made to remove the wood to a local sawmill, cost was prohibitive and project acres needed to be reduced to subsidize the removal of wood.

Data Sheet: Value of Wood Products Generated

Completed by: _____ Date: _____

Type of wood product	New local product? (yes/no)	Increase in existing product? (yes/no)	Species used	Sizes of wood used	Amount used /produced	Value (per unit)	Total value produced/ sold

Education and Outreach

Outreach to the wider community and education on forest restoration issues are two important components of many projects. You may want to educate people about forest health and the goals of forest restoration, or about other aspects of your project. When measuring this indicator, keep track of the following:

- **The date of each activity**

  For distinct events such as a school field tour or a booth at a local fair, just write down the date on which it occurred. For ongoing types of activities such as distributing information through a web site, note the date(s) the information was distributed.

- **A description of the activity**

  Was it a visit to a local school, a talk given to a local community group, an informative pamphlet? What was the intent of the activity and how was this accomplished?

- **Location or mode of outreach or education activity**

  If it was an educational event, where did it take place? If it was distribution of educational materials what were the materials and how were they distributed?

- **Target audience**

  Who were you trying to reach through the activity? What lessons or information were you hoping to impart?

- **Number of people contacted or number of materials distributed**

  If the activity was a tour of the project site, how many people participated? If it was a talk to a school class, how many students were in attendance? If it was a pamphlet, how many were mailed? If it was a web site, how many hits has it received?

Data collection

Use direct tracking to record these events or material distribution as they occur. Make sure you answer each of the above questions. See the data sheet for an example of recording these data.

Data analysis

Analyzing this kind of data is relatively straightforward. Simply record the different types of outreach or educational events, and add up the total number of events and total people reached for each type.

Data interpretation and reporting

Based on your analysis, report on the possible impact of the activities. For example:

- Did local youth increase their understanding of forest management issues?
- Is the local community more aware of the restoration project?
- Are there segments of the community that still need to be contacted?
- What kind of responses did you get from local youth and community members?

Data Sheet: Educational and Outreach Opportunities Created

Completed by: _____ Date: _____

Date of event or materials distribution	Description of activity or materials distributed	Location or mode of outreach (e.g., brochure, web site)	Target audience	Number of people attending event or number of materials distributed (or web site hits)

Travel Distance

One of the goals of the CFRP is to encourage "sustainable communities and sustainable forests." The commute time to work is one of several factors affecting the sustainability of forest restoration work. When forest workers must travel one or more hours to a work site, their family and quality of life are impacted. While some forest workers are able to commute to and from a worksite each day, others will camp for one or more weeks at a worksite, which can impact families and quality of life. This indicator may also be used to track consultants or other contractors involved in a project to reflect the impact on a single community versus dollars dispersed throughout the state or region.

To monitor the distance traveled to work, keep track of the following:

- **Where do workers live?**

  Record the town and zip code of all workers for analysis purposes. The actual physical address is not necessary and can be kept separate from monitoring data for confidentiality purposes.

- **Where is the project site?**

  Record the physical location of the project site. If there is more than one project site, record each location.

- **Distance to work site**

  Calculate the round-trip distance traveled to work for each worker.

- **Time to work site**

  Because of the variability in road conditions and the value of time spent commuting, also record the time it takes to travel to the work site for each worker. If workers travel together from a centralized site, record this information instead.

- **Did workers commute daily or stay overnight?**

  What is the total number of times the trip was made? If workers commuted daily, did they use personal vehicles or a business vehicle? Were they reimbursed for mileage? If workers stayed overnight, record any per diem or other compensation received.

Data analysis method

To analyze this indicator, calculate an average distance and time to work site as follows:

1. Add the distance traveled by all workers together.
2. Divide this number by the total number of workers.

Repeat steps one and two for the time traveled to work.

For the value of travel time and the cost of travel, fill in the spreadsheet below. Your data may look like this example:

Period	Town of Forest Worker (record the town and zip code for each worker involved in the project)	Location(s) of project work site(s)	# of workers	Distance to work site (in miles) for each worker, one way	Time to work site (in hours) for each worker, one way	Was travel time paid?	Value of Time (time to work site(2)*hourly rate*# times traveled)	# times traveled (for each vehicle)?	Total Miles Traveled (distance to job site * # times traveled)	Cost of Travel (Total Miles Traveled * Federal Mileage Rate)	Total Cost to Job Site (Cost of Travel + Value of Time)
May, 2007	Mora 87722	Tres Piedras RD	6	95	2.25	N	$681	11	2090	$1,223	$1,903.28

You may want to compare the distance traveled to a work site to the average distance traveled to work, as reported in U.S. Census data for the town or county (http://quickfacts.census.gov/qfd/states/35000.html). This will help to indicate whether forest restoration work entails longer, shorter, or average commute times for members of the affected community.

Data interpretation

Interpret your monitoring results by considering the impact of travel time to the work site on community sustainability. For example,

- Compare the data to the mean travel time for members of the affected community or county. Did workers have a longer, shorter, or average commute time compared to other work opportunities in the community?
- Did the travel time to work affect any workers interest in future forest restoration work?
- Was travel time paid or unpaid?
- What was the value of the miles traveled and was this covered by the contractor or the worker?
- What was the value of the travel time?
- If interested in non-forest workers, such as consultants, you could also analyze the distance traveled to work spatially (through a GIS or hand drawn map). You might also add contract dollars to this type of analysis to understand the economic impact on a specific community.

Data Sheet: Distance to Work

Completed by: _____ Date: _____

Period	Town of Forest Worker (record the town and zip code for each worker involved in the project)	Location(s) of project work site(s)	# of workers	Distance to work site (in miles) for each worker, one way	Time to work site (in hours) for each worker, round trip	Was travel time paid?	Value of Time (time to work site*hourly rate*# times traveled)	# times traveled (for each vehicle)?	Total Miles Traveled (distance to job site * # times traveled)	Cost of Travel (Total Miles Traveled * Federal Mileage Rate)	Total Cost to Job Site (Cost of Travel + Value of Time)

Community Perceptions

You may also want to know how your project is viewed by members of your community. For example, you may want to know if community members are satisfied with the project outcomes, if they have concerns about the way the site looks, or if they learned about the benefits of forest restoration. Some commonly asked questions are:

- Do people feel the restoration project was successful?
- How do people think the site looks?
- Do people feel safer (do they feel the threat of uncontrollable fire is reduced)?
- Is the site a good place for recreational activities?
- Is the site a good place for other community uses, such as plant gathering?
- Do people believe the ecological health of the site has been improved?
- Do people feel they have benefited personally from the project?
- Have people increased their knowledge of forest health or restoration?
- What concerns do people have about project impacts?
- What differences, if any, would people like to see in future restoration projects?

Every community situation is different, and it will be up to your multiparty monitoring team to decide what questions are most important and who to ask to answer them.

Data collection methods

This is the most difficult social indicator to monitor. The most common methods for measuring community perceptions are questionnaires, interviews, and focus groups. Questionnaires are best used to gather information about a relatively large group, such as all local residents. Interviews or focus groups are good methods if you want to be able to gain a deeper understanding of complex issues, or if a relatively small number of people have the information you need. All of these methods involve asking questions to get information from people. It is very important to use good question design and data collection protocols for each of these methods. See the social and economic monitoring methods. There are more detailed instructions in *Handbook 5 - Monitoring Social and Economic Effects of Forest Restoration*. For questionnaires, you also need to consider sampling design, and you may want to seek help from a consultant or other professional.

It is sometimes possible to use secondary data analysis to measure community perceptions, for example if the project has received a great deal of attention in the “letters to the editor” section of the local newspaper

Data analysis methods

For most questionnaire responses and other types of numeric information, you will probably want to use your data to calculate percentages. For example, what percentage of community members supported restoration activities before the start of the project? What percentage supported it after seeing the results of the project? What percentage thinks the site looks very or somewhat healthy? What percentage thinks it looks very or somewhat unhealthy?

To calculate a percentage, add up each type of answer to each question, divide the sum by the total number of answers to that question, and multiply by 100%.

For example, say you asked people if they agree with the statement, "The treated site looks more healthy than the adjacent untreated forest," and 43 people answered that question. If 18 people those "agree", 17 people chose "neutral", 4 people chose "disagree", and 4 people chose "don't know," you would calculate percentages as follows:

Agree:	18/43 x 100% = 42%
Neutral:	27/43 x 100% = 40%
Disagree:	4/43 x 100% = 9%
Don't Know:	4/43 x 100% = 9%

When using interviews or focus groups, the descriptive answers people give you are the data you will use to draw conclusions. Analyze these data by looking for common concerns, perceptions, or ideas. One way to do this is to write down what each person said in response to each question, as in the example on the next page. You can then read all of the answers and look for common responses. You can also count the number of times people brought up particular subjects or topics; this will give you an idea of how important these topics are to the people you interviewed.

Data interpretation

Use the answers people gave you to draw conclusions about how the project, forest health, or restoration in general is perceived. Have people's perceptions and understandings have changed over time? If so, how did the project affect these changes? Discuss the range of perceptions held by different individuals and stakeholders. Do some groups feel differently than others?

When reporting results of interviews and focus groups, take care not to reveal individual identities; you can address this by giving people pseudonyms (false names) in the report and omitting information that might be used to identify individuals.

When reporting your results, remember that information gathered only reflects the opinions of the people who provided it, unless you used a random sampling design.

Data analysis example: Analyzing qualitative data from focus groups

QUESTION:	Environmental groups	Agency personnel	Community elders	College students (ecology majors)
What are your reactions when you compare the treated site to the untreated forest next to it?	The treated area looks like a moonscape. There are only a few trees left, the ground has been scraped bare, and there's lots of rutting. There's no wildlife habitat left.	The fire risk in the treated site is much lower than in the untreated forest. Tree canopies aren't touching, and ladder fuels have been reduced. There is some unnecessary soil damage, but we expect to see more grasses and forbs in the treated area within a few years.	There are no young trees left, so we are concerned that there will be no forest left when the old trees die. There are a few grasses and shrubs in the untreated forest, but none in the treated area.	The treated forest is a closer representation of natural conditions than the untreated forest. However, there are some soil erosion concerns in the treated area, and some wildlife species may prefer the denser forest in the untreated section.

Focus group perceptions:

- Treated area is much more open, with fewer trees and no young trees or understory (3 groups)
- Treated area has soil damage, risk of soil erosion (3 groups)
- Habitat for some wildlife species is better in the untreated forest (2 groups)
- Fire risk reduced in treated area (1 group)
- Expect to see more grasses and forbs in a few years (1 group)
- Treated area is more natural (1 group)
- Treated area looks more unnatural (1 group)

Ecological Monitoring Methods

The CFRP requires projects to report the on-the-ground changes in the forest after restoration treatments, such as the reduction of the risk of crown fires, retention of old and large trees, the enhancement of understory cover, and protection of wildlife habitat. Ecological monitoring provides a systematic, reliable way to measure these changes.

Beginning in 2009, the CFRP requires monitoring of six ecological indicators for all projects with on-the-ground treatment. These are:

1) live and dead tree density
2) live and dead tree size
3) crown base height
4) overstory canopy cover
5) understory cover
6) surface fuels

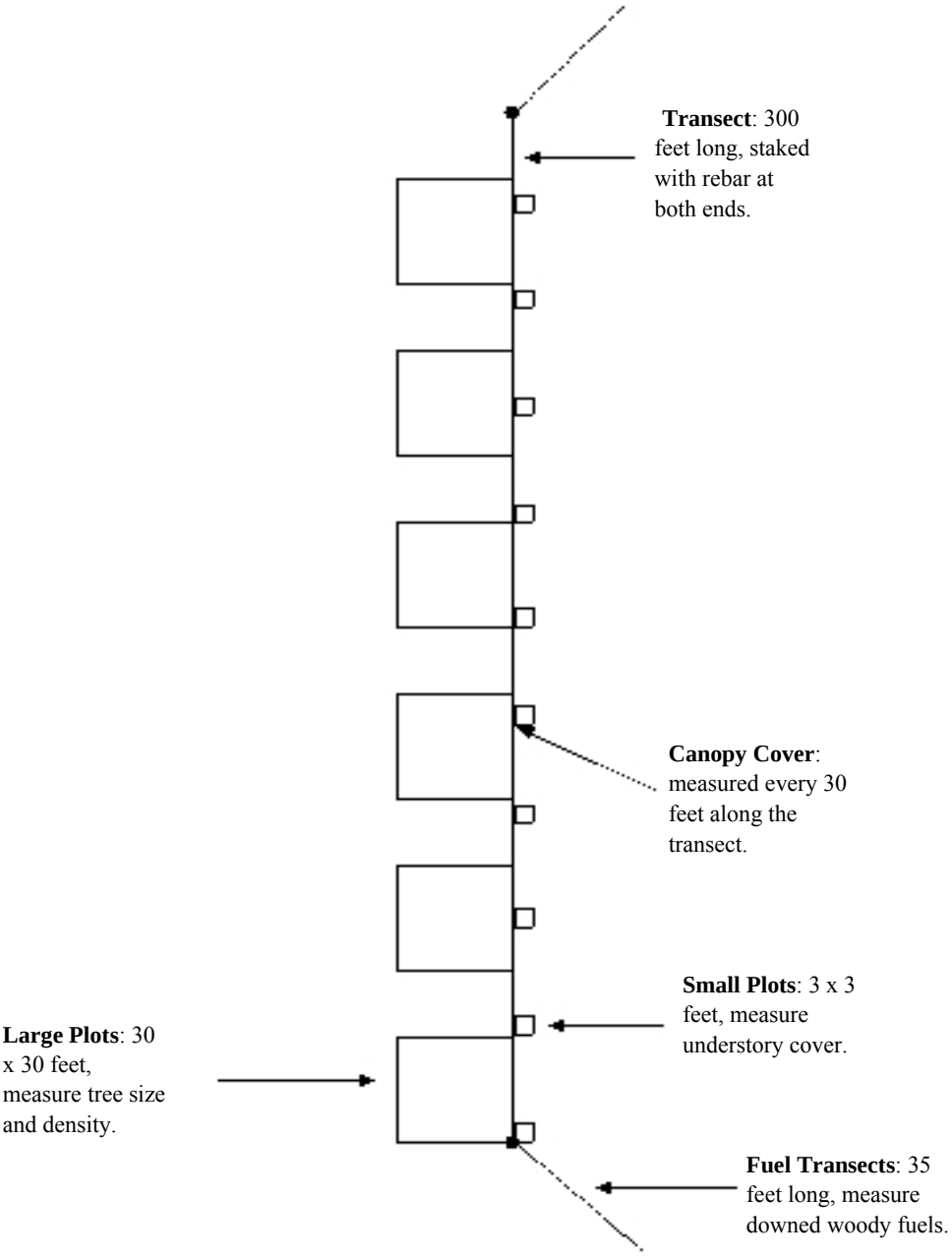
Other indicators, such as the use of before and after landscape photographs, and a more in-depth discussion of ecological monitoring can be found in the CFRP *Handbook Four: Monitoring Ecological Effects.*

Sampling design

There must be enough sampled measurements of each indicator to make monitoring reliable. For example, if only 20 trees are measured for size, this may not reflect the average size of trees on the site. It may just happen that those 20 trees are the smallest, or the biggest, in the area. For this reason, we recommend here a sampling design that will collect a minimum amount of data for reliable results. Before going into the field, make sure everyone in the monitoring team understands the sampling design and the reasons for the measurements for each indicator.

All of these five indicators can be measured at one time with one sampling design of transects and plots. A transect is a line placed in the landscape along which measurements are taken. A measuring tape is placed along the line to mark it out on the ground. We recommend 300 foot long transects. A plot is a square delineated on the ground by a measuring tape. We recommend large plots of 30 feet on a side to measure indicators such as tree density and size, and small plots of 3 feet on a side to measure understory cover. Short transects are located at the ends of the longer transects to measure surface fuels.

An adequate sampling design for these six indicators might be as follows: six or more 300-foot long transects are placed parallel to each other and 300 to 500 feet apart. Six large plots are placed at regular intervals along each of these transect lines. If the terrain is hilly, place transects along the contour of the slopes. Locate the transects in areas that seem typical for the forest stand on your site. If there is more than one type of forest on your site, such as both ponderosa forest and pinyon-juniper, a full sampling design of 6 transects should be placed in each forest type.


Transect: 300 feet long, staked with rebar at both ends.
Canopy Cover: measured every 30 feet along the transect.
Small Plots: 3 x 3 feet, measure understory cover.
Large Plots: 30 x 30 feet, measure tree size and density.
Fuel Transects: 35 feet long, measure downed woody fuels.

How often to sample

Indicators must be measured at least twice: once before and once after treatments. Measure indicators at the same time each year (e.g., late summer), so that overstory and understory cover measurements are consistent.

Data collection

When heading out into the field, make sure that the team has all the necessary equipment. For the indicators described below, the following equipment is required: a compass, lots of the sampling data sheets for each indicator, a clipboard, two 300-foot measuring tapes, 12 metal stakes (and pvc tube lengths, if using them over the stakes), a hammer, a clinometer (a tool for measuring slope), pens and pencils, a dbh (diameter at breast height) tape measure, a canopy sighting tube or densiometer, a watch with a second hand, and a cardboard slotted gauge to measure surface fuels.

Put a stake in the ground at the beginning of the first transect, then use a compass to walk in a consistent direction while you lay the 300-foot tape on the ground. Put a stake in at the end of the transect. Measure indicators on that transect. If you leave the metal stakes--rebar for example--when you leave that transect, you can return to the same place for repeat measurements. You can put pieces of pvc tubing over the rebar to make the site easier to find. You may also want to take photos to help you find the site later. Be sure that any vehicle or machine operators at the site are aware of the rebar stakes.

When you first reach a transect, record on the data sheet the slope of the transect using a clinometer; directions for its use are described below. Also record the aspect of the slope; this is the direction of the tilt of the slope: south-facing, west-facing, and so on. A flat area will not have an aspect.

Next, return to the start of the transect and walk 500 feet perpendicular to the transect to establish the second transect.

Take care to record the data on the data sheets clearly, so that someone else could understand them. Make sure that every sheet is labeled with the date, transect, and plot number. Data collection gets faster with experience. A monitoring team working together may be able to measure all five indicators on six transects in three to four days.

Storing the data

It is important to store monitoring data in a safe, permanent place so that it can be located as the project goes along, and found after the project is over. When you return from the field, make copies of the data sheets, and store them in a safe place, like a three-ring binder. Make copies of all the data sheets and put the second copy in a different place. Download digital photos and back them up onto disk or use some other storage method. Data should be carefully labeled, dated, and put in notebooks or on backup disks so they are available for other project partners, especially when the final monitoring analysis and report must be completed.

Using a compass

A field compass has a dial with a hollow red arrow and a moving needle that typically has a red half and a white half. The red part of the needle will point towards magnetic north. To determine a compass direction ("azimuth"), hold the compass with the mirrored part pointing away from you. Hold it flat in your hand so that the needle is able to move freely. Turn your whole body until you (and the compass) are directly facing the direction you want to measure (e.g., the direction of your transect). Turn the dial with your other hand until the hollow red arrow is directly beneath the moving needle. Look at the small pointer at the top end of the compass, directly below the mirror hinge - the number it points to is the correct azimuth.

A note on declination: The compass needle points towards magnetic north, which is different from true (polar) north. "Declination" describes the difference between the magnetic north and true north. It varies depending on where you are on the planet, and also changes slightly from year to year. Some of the more accurate compasses on the market include a mechanism to adjust for declination. If you're using a compass that doesn't have this feature, you should note that whenever you write down compass information on a data sheet. It is important to record whether or not your compass corrects for declination, so that people can accurately relocate important points and transect lines on future visits. For example, if your compass does not correct for declination, and you are writing down an azimuth of 38^{o}, write "38^{o} - no declination." If you're using declination, you should also note it whenever you write down an azimuth, and note what declination you're using; for example, "121^{o} - declination 11^{o} East." Whether you use declination or not, it helps to be consistent - if you start out using declination, continue to use it throughout the project. If you start out without declination, don't start using it part way through the monitoring.

Using a clinometer

Measuring surface fuels requires determining the slope of the site. An instrument called a clinometer is used to measure the incline of a slope. Every clinometer comes with a set of instructions. The clinometer is used to take a line of sight. Hold the clinometer to your eye and look through it. Since the instrument at your eye is about 5 feet from the ground, choose an object to look at that is about the same height. The easiest choice is usually the eyes of another person in the field with you. Look through the viewer of the instrument, keeping both eyes open. One eye will see the other person, and the other will see two rows of numbers inside the instrument (these numbers move as you move the instrument up and down.) Depending on the model of clinometer you're using, numbers representing percent slope will be on either the right or left side - refer to clinometer instructions or simply tilt the clinometer all the way back while continuing to look through the viewer, one side will be labeled "%." Measure percent slope once at each transect.

A clinometer is also useful for measuring crown base height of trees (lowest live branch). Be sure to purchase a clinometer with both the 66' scale and the % slope scale. The 66' scale gives you height readings when you are 66' from the base of the tree you are measuring.

Live and Dead Tree Density

Tree density is an estimate of how many trees there are per area in the forest. It is valuable information for restoration work, since many sites have a much higher density of trees than once were natural in southwestern forests. The majority of these abundant small trees are growing very slowly because of competition for light and water. Bosque forests usually have high densities of non-native trees. Many small trees serve as ladder fuel to carry fire into the crown of mature trees. Snags, or dead standing trees, make good wildlife habitat, are often scarce in the forest, and should be protected during treatments.

Data collection method

Tree density can be measured in the six 30-foot by 30-foot plots in ponderosa and piñon-juniper forests. Smaller plots, 15 feet on a side, may work better in dense bosque forests.

Plots should be laid at regular intervals along one side of each transect, for example, one beginning at the start of the tape, and others starting at the 50-foot mark, 100-foot mark, 150-foot mark, 200-foot mark, and 250-foot mark. Trees larger than 3 inches in diameter are considered adult. Trees smaller than 3 inches in diameter, but taller than breast height, are considered saplings. Since abundant numbers of saplings are also a fire hazard, counting them can be useful. Keep track of adults and saplings separately. For each adult tree in the plot, measure and record the species and whether it is living or dead. Identify the species of snags, if possible (some snags may be too decayed to identify to species).

Data analysis method

To convert the density of trees and snags per plot to a value per acre:

1. Calculate the area that was sampled in the plots.
   a. To calculate the area of a plot, multiply the length times the width of each plot;
      Example: 30 ft x 30 ft = 900 ft^2
   b. Add together all plot areas.
      Example: 36 plots x 900 ft^2 = 32,400 ft^2 sampled.

2. Divide the value of the sampled area into the total area of an acre. The area of an acre is 43,560 square feet.
   Example: 32,400 ft^2 / 43,560 ft^2 = 0.74 acres sampled.

Divide the number of trees in the sampled area by the number of acres sampled. This gives you the number of trees per acre. For example, if there were 50 trees recorded in all plots, and you sampled 0.74 acres, then 50 trees/0.74 acres = 67.6 trees per acre.

3. Calculate the density of all live adult trees together, and then calculate the density of each species separately. Notice if the density of one species changes more drastically than another after treatments. You should also calculate the density of saplings and snags, if you are monitoring these. The result will be one number, density per acre, for each of the following: adult live trees by species and all combined together, saplings by species and all combined together, and snags.

Data interpretation

The density of trees per acre is expected to go down after treatments, since many small trees are being cut down and removed. The target density for forests will vary depending on the type of forest and the site, but the objective of most restoration work is the reduction of high densities that can support crown fires. An effort to maintain densities of snags, however, especially large snags, is recommended since snags make good wildlife habitat and are usually scarce.

Live and Dead Tree Size

Tree size, like density, is an important indicator of vulnerability to crown fire. Large trees in forests where fires used to be frequent, such as ponderosa pine, are relatively safe from prescribed fires. Small trees, however, can carry fire into the canopy, where it can destroy the forest. Large dead standing trees, or snags, provide habitat for wildlife and some should be protected. Since many small trees are cut in restoration treatments, while old and large trees are protected, the average size of trees should go up after treatments.

Data collection method

It is easy to measure the size of live adult and dead trees in the same plots at the same time that you are measuring tree density. Each time a tree is counted, use a tape to measure the diameter at breast height (DBH). Put the tape around the tree at "breast height" (4.5 feet off the ground, on the uphill side of the tree). The DBH tape tells you the diameter of the tree (not its circumference). Do not measure the size of saplings.

Note for multiple-stemmed species and forked trees: Tree such as juniper and piñon frequently have multiple stems in a single tree. When measuring the diameter of a multiple-stemmed tree, apply the following rules:

- If juniper or piñon, measure the diameter at root crown (DRC) instead of the DBH, and measure all stems (within 6" above the root collar?) larger than 3" in diameter separately. Note that it is a multiple-stemmed tree on the data sheet with brackets around the trees entries in the margin of the data sheet.
- ~~If trees are forked below breast height on any tree, measure the diameter of both forks separately and combine. For an example of how to analyze this data,~~
- If trees are forked above breast height on any tree, measure the diameter at breast height.

Data analysis method

Size is reported as an average diameter of trees measured. To analyze size data, add the diameter values from all the live adult trees together, and divide by the number of trees. This gives you the average diameter of live adult trees. You can do this for all live trees that you measured on your site, but you should also find the average size of trees by species. For example, add all the size values of adult ponderosa pine trees together and divide by the number of ponderosa pine trees. The final results for tree size will be one number for average size of each species of live tree, one for all live trees combined, and one for all snags. If your site has multi-stemmed trees analyze and report both trees/acre (individuals) and stems/acre.

Data interpretation

Compare the before and after-treatment size of each species of tree and of all trees combined. The average size of all live trees combined should increase, as larger trees are protected and smaller trees are removed. The average size of individual species should increase as well, but may differ from one species to another, depending on what your treatment objectives were. The average size of snags will hopefully stay about

the same, when snags are protected. In the bosque, removal of smaller non-native species will leave larger native species. A larger average size of trees is a desirable outcome of forest restoration.

Crown Base Height

Crown base height (CBH) is the distance between the ground and the lowest live branches in the crown of a tree. This indicator is important to determine the likelihood for surface fire to move into the tree canopy. CBH for individual trees are then averaged to determine the crown base height for the area sampled. Since many small trees will be cut in restoration treatments, average CBH for a stand usually increases. An increase in CBH can represent a reduced fire risk.

Data collection method

It is easy to measure the CBH in the same plots at the same time you measure tree density and the size of live adult and dead trees. Each time a tree greater than 5" DBH is counted, measured, and its species is recorded, use a clinometer with a 66 foot scale or a stadia rod to record the height from the ground to the lowest part of the lowest live branch in the crown of a tree. If using a clinometer, walk 66 feet (') from the base of the tree and make note of the reading when you sight the lowest live branch in the device. Then not the reading when sighting the ground, and record the difference. Depending on terrain, you might get a reading of 35' at the branch and a reading of -5' at the ground. You then subtract the first reading from the second reading: 35' – (-5') = 40' CBH. If you are using a stadia rod then stand beneath the lowest live branch and extend the rod until it touches the branch and record the extension of the rod (according to the instructions). Whether you measure CBH in meters or feet, be sure to record this on the data sheets, and label your data accordingly when sharing.

Data analysis method

CBH is reported as an average height of trees measured. To analyze size data, add the height values from all the live adult trees together, and divide by the number of trees. This gives you the average CBH of live adult trees. You can do this for all live trees that you measured on your site. The final results for CBH will be one number for the average CBH of live trees.

Data interpretation

Compare the before and after treatment CBH of live and dead trees. The average CBH of all live trees combined should increase, as larger trees are protected and smaller trees are removed. In the bosque, removal of smaller non-native species will leave taller native species with a higher CBH. A higher average CBH of trees is a desirable outcome of forest restoration in the Southwest.

Density and size of live and dead trees -and-
Height from ground to tree crown **Page #: _____**

Site name: _____ Elevation: _____

Location: _____

Observer(s): _____ Date _____

Transect #: _____

◯ Control site ◯ Treatment site

◯ Before treatment ◯ After treatment Number of years since treatment: __

			Adult living trees Larger than 5 inches in diameter for all species except for pinion and juniper. For P/J measure DRC greater than 3 inches				Dead standing trees (snags)		Saplings tally		Seedlings tally	
Plot #	Slope	Aspect	Species *	Diameter (inches)	Crown Base Height (feet)	Multi-stemmed (y/n)	Species	Diameter (inches)	Species	#	Species	#

* Note: For multi-stemmed trees, bracket stems of the same tree in the margin.

Use the following abbreviations to record tree species:

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

Overstory Canopy Cover

Overstory canopy cover is a measure of the amount of leaves or needles in tree branches overhead. If the overstory canopy cover is very dense, it means that tree crowns are close together, and are likely to carry an intense fire from tree crown to tree crown. When the canopy is more open, there is more space between tree crowns, and the forest is safer from crown fires. Also, a more open canopy means that more sunlight reaches the forest floor, allowing a healthy understory of grasses and forbs to grow. However, some level of canopy cover is good for wildlife habitat, especially when large trees are left in clumps. Since restoration treatment removes trees, percent overstory canopy cover is expected to go down.

Data collection method

Overstory canopy cover is measured as a percent. It can be measured in two ways, using a PVC sighting tube or using a densiometer. Canopy cover is measured at 10 points along each 300-foot transect, or every 30 feet.

Sighting tube method

To make the sighting tube, attach two sections of wire in an X across the open top of the PVC tube. (Four tiny holes can be made in the top of the tube, and wires threaded thought them.) The PVC tube should be about 3 or 4 inches long and 2 inches wide.

Every 30 feet along the transect, look directly overhead at the canopy through the PVC pipe. Record a value from 0-4 for each quarter of the tube that contains at least 50% foliage (tree) cover. For example, record a 0 if there is no canopy cover (the tube only contains sky); record a 1 if one of the 4 quarters contains at least 50% foliage; a 2 if two of the 4 quarters contain foliage; a 3 if three of the 4 quarters contain foliage; and a 4 if all four quarters are at least 50% foliage. Repeat along each transect.

Densiometer method

A second method for measuring canopy cover uses a densiometer. This tool has a round concave or convex mirror with a grid marked on it. The grid divides the mirror into small squares. To measure canopy cover, stand at the beginning of a transect and hold the densiometer level in your hand at elbow height in front of you. You will see the dark areas of canopy and the bright areas of sky reflected in the mirror.

This method requires two people, one to hold the mirror and count out the values, and another to record them. One person looks in each grid square, and imagines four dots arranged like the corners of a small box inside the square. If there is a bit of sky at the dot in one corner, count one “no” for no foliage. If you see dark foliage at each of the other three dots, count 3 “yeses” for canopy cover. Each grid square will have four values to record, either for canopy or no canopy. A total of 96 values are counted at each sampling point. This sounds like a lot, but the count is fast. Please refer to Handbook 4 to download the densitometer data sheet at www.nmhu.edu/nmfwri/cfrp.html.

Data analysis methods

Analysis for data collected using a sighting tube:

1. Add up the total number of values for canopy cover.
2. Divide the total of all canopy cover values by the total number of observations. The number of observations will be 4 quarter-circles x 10 viewing points x the number of 300-foot transects sampled.

3. Multiply by 100%. The final number will represent an average percent canopy cover for the site.

For example, if you measured six 300-foot transects, you will have 240 observation points (6 transects x 10 points per transect x 4 quarter-circles per observation). If you recorded a total canopy cover value of 173, you will have 72% canopy cover (173/240 x 100%).

Analysis for data collected with a densiometer:

1. For each sample point, you will have a number between 0 and 96 which represents the number of "dots" taken up by canopy. To convert this into a number between 0% and 100%, multiply by 1.04. This number represents percent canopy for that sample point.

2. To find the average canopy cover for a site, add up all the percent canopy figures for all the sampled points, and divide by the number of sampled points.

For example, (33% + 14% + 72% + 55%)/4 = 43.5% average canopy cover.

Data interpretation

The percent canopy cover is expected to go down after treatments because of the removal of trees. Canopy cover before treatment is often very high in dense stands, sometimes approaching 100%. After treatment, percent canopy cover will be lower, depending on your treatment prescription and your forest type. Compare your post-treatment percent canopy cover to the pre-treatment canopy cover, and discuss post-treatment canopy cover in terms of your original goals for this project.

Data Sheet: Overstory Canopy Cover Page # _____

Site Name: _____ Elevation: _____

Location: _____ Date: _____

Observer(s): _____

○ Control Site ○ Treatment Site

○ Before Treatment ○ After Treatment Number of years since treatment: _____

	Transect 1 Value 0-4		Transect 2 Value 0-4		Transect 3 Value 0-4		Transect 4 Value 0-4		Transect 5 Value 0-4		Transect 6 Value 0-4	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Understory Cover

The understory of grass and small plants under the forest canopy is a good indicator of forest health. The understory has many ecological functions, including providing habitat for wildlife, protecting soil from erosion, and carrying low-intensity fires. Where trees have an unnaturally high density, the plant cover on the ground is usually sparse. Thinning the trees results in an increase in understory plant cover over time, but a substantial recovery may take some years. In piñon-juniper woodlands, scattering slash on the ground can facilitate understory recovery.

Data collection method

Understory cover is measured in small plots measuring 3 by 3 feet. You can use a tape measure to lay out these plots, or make a 3-foot square of pvc tubing glued together at the corners with pvc elbows. For this method it is particularly important to collect baseline data and post-treatment data during the same time of year, preferably in the spring or late summer when the understory is at its "greenest."

Place ten small plots along the transects, one every 30 feet. In each small plot, you will estimate the percentage of ground that is ***shaded*** by grasses, forbs, or shrubs growing near the ground surface as well as estimating the percentage of ground taken up by litter and bare soil/rocks. Forbs are non-woody, non-graminoid (grass, sedge, or rush) plants such as alfalfa and sunflowers. Shrubs are woody stemmed plants such as mountain mahogany and big sagebrush. You can estimate grass, forb, and shrub cover separately or together. Only estimate cover of living plants that are actually rooted in the soil. Estimate cover of plants not rooted in the plot but whose leaves shade the ground in the plot. Litter includes needles, cones, leaves, and dead and dried up plant material on the ground. Do not count small tree cover from seedlings or oak.

Understory cover is expressed as a percentage, for example, 60% cover. Stand over the small plot and estimate the percentage of the plot covered by each cover type (grass, forbs, shrubs, litter, and bare soil/rock). It is best to estimate within categories. A good set of categories to group cover values in is: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95- 100%. Practice with another person to try to get similar estimates. In fact, it is easiest to feel confident about your estimates if two people do the work together, comparing estimates as they go. Estimates from a plot can be greater or less than 100%.

Data analysis method

Understory cover is reported as a percent of ground covered. Each of the cover ranges, for example, 0-5%, 5-25% etc, is called a cover class.

1. Find the midpoint for each cover class. For the set used above, these will be 2.5%, 15.0%, 37.5%, 62.5%, 85.0% and 97.5%.

2. For each cover type (such as grass, forbs, litter, shrub, or bare soil/rock), add together the midpoint values for all plots.

Say you sampled a total of 60 understory plots, and for the grass cover type you had 20 midpoint values of 2.5%, 12 midpoints of 15.0%, 10 midpoints of 37.5%, 5 midpoints of 62.5%, 3 midpoints of 85.0%, and 10 midpoints of 97.5%. The sum total would be (20 x 2.5) + (12 x 15) + (10 x 37.5) + (5 x 62.5) + (3 x 85) + (10 x 97.5) =
2147.5.

3. Divide the total for each cover type by the number of plots sampled. Continuing the example from above, you would divide 2147.5 by 60. The answer you obtain is 35.8. This means the overall average cover of grasses on your site is 35.8%.

4. Repeat for each cover type (grasses, forbs, litter, shrub, and bare soil/rock).

Data interpretation

Understory cover of grasses, forbs, and shrubs should begin to increase as treatments allow more sunlight to reach the forest floor and lower tree density makes more resources such as water available. To interpret the data you get from this method, compare understory cover before and after treatments - did forbs and grasses become more abundant? Is there more bare soil after the treatment than there was before? Has litter been reduced? What might explain the changes you have documented?

Understory Cover

Page #: ____

Site name: ______________________________ Elevation: ______________________

Location: ______________________________ Date: ______________________

Observer(s): ____

Transect #: ______________________ Slope: ______________ Aspect: __________

◯ Control site ◯ Treatment site

◯ Before treatment ◯ After treatment

Number of years since treatment: __

Location on Transect (in 30' segments	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						
	Shrub						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Shrub						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Shrub						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Shrub						
	Bare soil/rock						
	Litter						
	Grasses						
	Forbs						
	Shrub						
	Bare soil/rock						
	Litter						

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

Amount of Surface Fuel

Surface fuels like logs and branches can burn hot and carry fires into tree crowns. So the amount of dead and down surface fuels is an important measure of how vulnerable the forest is to crown fire. In ponderosa forests that historically had frequent, cool surface fires, hot crown fires were very unusual. In the bosque, non-native trees can produce large amounts of dead and down wood that increase the risk of crown fire. The reduction of surface fuels is an important restoration goal. However, it is wise to leave some dead and down wood on the ground to foster wildlife and understory growth.

Data collection method

Surface fuels are measured on two short transects that branch off at each end of the 300-foot transects. The number of twigs, branches and logs lying on the forest floor are measured. The surface fuels transects need to be placed at a random angle to the main transect. To find this angle, start by standing at the metal stake at the beginning or end of the main transect looking along the transect. Look at a watch with a second hand. Whatever direction the second hand is pointing when you first look at it is the direction of that surface fuels transect on the ground. Place a measuring tape on the ground in the same direction indicated by the second hand. For example, if the second hand was pointing to 3 o'clock, place the surface fuel transect perpendicular to the main transect on the right hand side. The surface fuels transect should be 35 feet long. Note the main species of trees in the area and the slope of the fuels transects—both will be needed for the analysis. Also make note of the azimuth of the transect, so you can repeat measurements in the future.

The method requires counting all pieces of dead wood that cross the transect in four size categories and measuring the diameter of the largest size class. Count only dead wood not attached to a live tree. Do not count rotten wood, cones, needles, or forbs. Count the same piece twice if it crosses the transect twice. The four categories of size to be counted are:

1. less than 1/4 inch in diameter (mainly small twigs),
2. larger than 1/4 inch but smaller than 1 inch in diameter
3. larger than 1 inch but smaller than 3 inches in diameter, and
4. 3 inches and larger in diameter.

You must also measure and record the actual diameter of the wood pieces in the largest size category (3 inches and larger). Measure the diameter at the point where it crosses the fuel transect.

The fuels measurement is much easier if you use a small piece of cardboard or wood with little slots cut out for 1/4 inch and 1 inches. The piece of cardboard can be 3 inches in length. This way, the cardboard can be simply held up to a piece of dead wood to determine its size quickly. Bring several of these into the field, as they tend to get worn out.

Count all pieces of wood in the smallest two size categories on the first 6 feet of the fuels transect. The smallest category will include all pieces of wood that fit into the 1/4-inch slot. The second category will include pieces of wood that are too large for the 1/4-inch slot, but fit in the 1-inch slot. Record the number of pieces of wood for each of these size categories.

Count all pieces of wood in the third category of size, larger than 1 inch but smaller than 3 inches, in the first 10 feet of the fuels transect. You will be going over the first 6 feet of the fuels transect again. These pieces of wood will be too large to fit in the 1-inch slot but will be smaller than the width of the 3-inch cardboard. Record the number of pieces of wood of this size category.

Lastly, look for pieces of wood larger than 3 inches in diameter lying across the entire 35 feet of fuels transect. There is no upper limit to the size of wood in this category. For pieces of wood larger than 3 inches, you also need to measure and record diameter. Measure the pieces of wood with a dbh tape. There is a place on the data sheet to tally the number of pieces of wood of this size as well as the size of each piece.

Data analysis method

The data analysis method for surface fuels is provided directly after the data sheet for this method. The result of your calculation will be one value—average tons of surface fuels per acre for your site.

Data interpretation

The objective is to reduce surface fuels to safe levels. Too much surface fuel can burn hot enough to carry fire into the canopy of the trees. But some surface fuels are valuable for wildlife habitat and for providing wetter sites where tree seedlings and understory plants can germinate. Restoration should not aim to remove every scrap of surface fuels, or to create a very "clean" forest floor.

The results of the surface fuels measurement may vary considerably depending on treatments and forest type. For example, some ponderosa pine sites have little surface fuels before treatments, but more when debris remains on the ground after trees have been cut down and partially removed. This is especially true if the site has not yet been burned in a prescribed fire. In this case, the post-treatment measurement may indicate that there is a dangerous amount of fuel on the ground that requires attention. On the other hand, removing large amounts of surface fuels are often a specific target of bosque restoration, and a comparison of before and after treatment surface fuels values should show a dramatic reduction in tons of wood per acre. Note in your report when the post- treatment data was collected: Was it collected before final slash removal? Was it collected before a planned prescribed burn? The surface fuel monitoring values should be compared to prescription targets for your site and forest type.

Amount of Surface Fuel

Site name: _____ Elevation: _____

Location: _____ Date: _____

Observer(s): _____

Transect #: Transect length: Transect bearing: Slope: Aspect: ○ Control site ○ Treatment site ○ Before treatment ○ After Treatment Number of years since treatment: Dominant tree species:				Transect #: Transect length: Transect bearing: Slope: Aspect: ○ Control site ○ Treatment site ○ Before treatment ○ After Treatment Number of years since treatment: Dominant tree species:			
Number of woody materials				Number of woody materials			
1 hour	10 hour	100 hour	1000 hour	1 hour	10 hour	100 hour	1000 hour
0 – 6 feet	0 – 6 feet	0 – 10 feet	0 – 35 feet	0 – 6 feet	0 – 6 feet	0 – 10 feet	0 – 35 feet
Less than 0.25 inches in diameter	0.25 to 0.99 inches in diameter	1.0 to 2.99 inches in diameter	Greater than 3 inches in diameter	Less than 0.25 inches in diameter	0.25 to 0.99 inches in diameter	1.0 to 2.99 inches in diameter	Greater than 3 inches in diameter
			Diameter				Diameter
Total:	Total:	Total:		Total:	Total:	Total:	

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

Data Analysis: Calculating amount of downed woody fuels

Downed woody material computation summary (from Brown 1974)

Forest: _____ Compartment: _____ Stand: _____

Size class (inches)	(1) Constant	(2) N	(3) Diameter^2	(4) Specific gravity	(5) Secant	(6) Slope factor	(7) Total transect length	(8) Total tons per acre
0-0.25	11.64							I:
0.25-1	11.64							II:
1-3	11.64							III:
3+	11.64	1						IV:
						Total: I + II + III + IV =		V:

To find tons per acre for each size class, multiply (1) x (2) x (3) x (4) x (5) x (6) and divide the resulting number by (7). See text to find values for these columns.

To find total tons per acre, add I + II + III + IV to get total V.

Fill in columns (1) – (8) using the following methods:

(1) Constant: This is 11.64 for all size classes

(2) N: For sizes less than 3 inches, this is the number of pieces encountered in each size class. For sizes over 3 inches, this value is 1.

(3) Diameter^2: For sizes less than 3 inches, use the table below to determine diameter^2 based on the dominant forest type. For example, in the case of ponderosa pine nonslash in the 0.25-1" size class, simply enter 0.2366.

Size class (inches)	Forest type	(3) Diameter^2		(4) Specific gravity	
		nonslash	slash	nonslash	slash
0-0.25	Ponderosa pine	0.0378	0.0471	0.463	0.54
	Others	0.0151	0.0151	0.48	0.48
0.25-1	Ponderosa pine	0.2366	0.2467	0.464	0.543
	Others	0.289	0.289	0.48	0.48
1-3	Ponderosa pine	2.967	3.574	0.392	0.502
	Others	2.76	2.76	0.40	0.40
3+	Ponderosa pine	Square the diameter of each piece; add these together to get the value for column 3		0.40	0.40
	Others			0.40	0.40

For sizes over 3 inches, you do not need to use the table to determine diameter^2. Instead, square the diameter for each piece encountered and add these squares together. Enter this "sum of squares" into the space in column (3).

For example, if you encountered three pieces of debris, measuring 3.8", 6.1", and 12.0", you would compute the following:

(3.8 x 3.8) + (6.1 x 6.1) + (12.0 x 12.0) =

14.44 + 37.21 + 144.0 = 195.65

Enter 195.65 into the table.

(4) Specific gravity: Use the table above to determine specific gravity based on the dominant forest type.

(5) Secant: This is a number which corrects for the fact that pieces of debris do not lie at perfectly perpendicular angles to the transect line. The number you use will depend on the size and whether the pieces are slash or nonslash fuels.

Nonslash: For pieces less than 3" the secant is 1.13;
For pieces 3" and larger the secant is 1.00.

Slash:

Size class (inches)	Species	Secant	
		Fresh Slash	Slash 1 year and older
0-0.25	Ponderosa pine	1.25	1.25
	Others	1.40	1.15
0.25-1	Ponderosa pine	1.25	1.25
	Others	1.13	1.13
1-3	Ponderosa pine	1.22	1.22
	Others	1.10	1.10
3+	All species	1.00	1.00

Note: Steps 6 – 8 on following page.

(6) Slope factor: This is a number which correct for the average slope of your transects. Use the following table to determine what value to enter into column (6):

Slope (%)	Correction factor
0	1.00
10	1.00
20	1.02
30	1.04
40	1.08
50	1.12
60	1.17
70	1.22
80	1.28
90	1.35
100	1.41
110	1.49

(7) Total transect length: This is the total length of transect line, calculated for each size class. To get this value, multiply the number of transects by the length of each transect. This value will be different for different size classes, since the length of transect varies for each size class. For example, if you had six transects of six feet long for measuring the 0-0.25" size class, your total transect length would be 6 x 6 = 36. In these same six transects, if each transect was 35 feet long for the 3" + size class, your total transect length for that row would be 6 x 35 = 210.

(8) Calculating fuel load: For each size class, multiple the values in columns: (1) x (2) x (3) x (4) x (5) x (6). Divide the product of these six columns by the value in column (7). This will give you tons per acre for each size class. To calculate total fuel load, simply add the values in column (8) for each size class: I + II + III + IV. The sum of these values is the total fuel load of your sampled area, measured in tons per acre.