Fuel and Fire Effects
Monitoring Field Guide

U.S. Fish and Wildlife Service
Southeast Region

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Division of Fire Management
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EXECUTIVE SUMMARY

PURPOSE: The objective of this field guide is to provide Southeast Region field stations with helpful information for setting up a monitoring program, including:

- writing a monitoring plan;
- selecting appropriate monitoring methods;
- collecting data;
- and performing basic analyses to meet station-specific fire effects monitoring needs.

It is designed for refuge personnel with little to no experience in setting up monitoring programs. The Guide is NOT intended nor is it suitable as a substitute for a comprehensive refuge-wide habitat or species population monitoring program, nor is it a substitute for scientific research. Current appropriation language for fuels fund allocations to the Service simply prohibits using fuels funds for many monitoring and research projects station biologists and refuge managers have expressed interest in pursuing. However, fuel treatment effects monitoring can and must contribute their “fair share” toward achieving these broader ends.

NEED: Monitoring is an integral part of the adaptive management process and critical to determining the relative success of management projects. When fuels allocations (9263, 9264, and 9265 subactivities) fund treatments, fire effects monitoring is necessary to assess fuel treatment effectiveness, fire management objectives, and progress towards meeting refuge habitat objectives.

The FWS is mandated through multiple policies and guidance documents to monitor the effects of fuel treatments as well as actions that affect trust resources and habitats:

- Goal 3 of the 10-Year Comprehensive Strategy directs Federal agencies to monitor restoration and rehabilitation projects for effectiveness and to share the results in order to facilitate adaptive implementation for science-based management.

- The National Fire Plan (NFP) recommends monitoring to evaluate the effectiveness of various treatments. The NFP states that monitoring is essential in validating assumptions, reducing uncertainties, and measuring progress.

- The Refuge Improvement Act mandates monitoring on refuges, and the Fulfilling the Promise document mandates monitoring as well (WH-8; WH-9; WH-10; and WH-14):

- The Service Manual (621 FW3, Section 3.7) states that a written evaluation must be completed for all prescribed fires. The evaluation must document “...how well the fire accomplished the desired results” which would require development of specific, measurable objectives prior to treatment and subsequent monitoring to assess results. Throughout the Service Manual (621 FW1, 701 FW2, 601 FW3), monitoring is mandated with specific references for wildland and prescribed fire operations.

A DEFINITION: For the purposes of this field guide, fuel treatment monitoring is defined as:

The collection and analysis of repeated observations or measurements to evaluate change in condition and progress toward meeting a fuels treatment management objective.

THE APPROACH: Throughout this Guide, existing (public domain) fire effects monitoring references, procedures and software are emphasized in order to avoid “reinventing–the-wheel” and to permit comparisons with other land management agency monitoring results for similar fuel treatments conducted in similar ecological communities. These include:
• National Park Service Fire Monitoring Handbook (NPS FMH): Website: http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm

• FIREMON: Website: http://www.fire.org

• Bureau of Land Management Guide to Measuring and Monitoring Plant Populations:

• Photo Series/ USFS Fire Ecology Publications: Website: http://www.fs.fed.us/fire/science/index.html

• NWCG Fire Effects Guide: Website: http://www.nwcg.gov/pms/RxFire/FEG.pdf

• USGS Burn Severity References: Website: http://nrmsc.usgs.gov/research/cbi.htm

THE 6-STEP MONITORING PROCESS: This field guide takes the user step-by-step toward the development of a monitoring program. A separate section in the Guide is devoted to each of these 6-steps:

• Planning
• Methods
• Data Collection
• Analysis,
• Application
• Reporting

The appendices at the end give examples and copies of documents to help with specific needs.
The Planning Section discusses the 3 principal levels of planning that are the foundation for designing a station monitoring program, including Refuge Level (CCP’s) plans, the station Fire Management Plan, and finally the individual treatment project plan (e.g. prescribed burn plan). The different components of a station Fuel-Fire Treatment Effects Monitoring Plan are presented (mandatory and recommended). The Planning Section concludes with a discussion of the importance of clear, measurable treatment and monitoring objectives complete with examples.

The Methods Section is the largest in The Guide. The section begin with criteria users should apply in order to select the most appropriate monitoring protocol for the monitoring objective(s) identified during interdisciplinary scoping and planning. In-depth discussion of individual recommended monitoring methods, largely drawn from the inter-agency FIREMON project, are then provided for:

1. Photo Monitoring
2. Event Monitoring
   - Fire Behavior Observations
   - Weather Observations
   - Smoke Observations
3. Fuel Load Monitoring
   - Woody Fuels
   - Non-woody Fuels
4. Live Fuel Monitoring
   - Point Intercept
   - Line Intercept
   - Density
   - Cover and Frequency
5. Species Composition
6. Burn Severity Monitoring

The Section concludes with discussion of using Pilot Studies to help aid establishing sampling intensity/required sample sizes, establishing a station monitoring schedule, and establishing the order and level of sampling to achieve monitoring objectives. The Appendices provides a full set of abridged descriptions of the individual monitoring procedures that are a little more “field-friendly”.

The final Sections of The Guide are brief treatments of Data Collection Storage and Archiving, Analysis, and Reporting of Results. The emphasis throughout these sections is on establishing and adhering to standard business practices to avoid loss of hard-earned field data or failing to use those hard-learned lessons in future land management (especially fuels and fire management) decision-making. A References Section is also provided. The Appendix provides a sample Annual Monitoring/Evaluation Report.

The Appendices include samples of all field data collection forms, Monitoring Plan Signature/Approval page, equipment checklists, schematic diagram of a photo/density board, and a sample Annual Monitoring/Evaluation Report.
INTRODUCTION

What is Monitoring?

It is important to begin with a clear definition of what should be considered “monitoring.” For the purposes of this field guide, fuel treatment monitoring is defined as:

The collection and analysis of repeated observations or measurements to evaluate change in condition and progress toward meeting a fuels treatment management objective.

There are many different definitions of monitoring. The above definition will be the working definition of monitoring for this field guide. It is also important to note that there is a difference between monitoring and research. Research tests specific hypotheses to identify the correlation of effect with a potential cause, and has a specific experimental design to test hypotheses of cause and effect.

In general, monitoring can usually be performed by refuge staff as routine operations; however, specific research questions should be answered by experts who have the time and resources to adequately address research questions with a more statistically rigorous experimental design and methodology.

Why Monitor?

The U.S. Fish and Wildlife Service (FWS, the Service) has distinguished itself as the most productive and cost-efficient bureau within the U.S. Department of Interior (DOI) through its on-the-ground accomplishments in reducing hazardous fuels and Wildland Urban Interface (WUI) treatments. Fire and fuel treatments on refuges protect life and property, but are also often used as fundamental management tools to meet habitat and wildlife objectives.

Monitoring is an integral part of the adaptive management process and critical to determining the relative success of management projects. Fire effects monitoring is necessary to assess fuel treatment effectiveness, fire management objectives, and progress towards meeting refuge habitat objectives.

The FWS is mandated through multiple policies and guidance documents to monitor the effects of fuel treatments as well as actions that affect trust resources and habitats. Goal 3 of the 10-Year Comprehensive Strategy directs Federal agencies to monitor restoration and rehabilitation projects for effectiveness and to share the results in order to facilitate adaptive implementation for science-based management. The National Fire Plan (NFP) also recommends monitoring to evaluate the effectiveness of various treatments. The NFP states that monitoring is essential in validating assumptions, reducing uncertainties, and measuring progress. Monitoring elements should “include all monitoring, measurements, and frequency needed to determine if conditions for the burn are within prescription, both before it is started and while it is burning.” In addition, the Refuge Improvement Act mandates monitoring on refuges. The Service’s Fulfilling the Promise document mandates the following:

- Develop refuge inventory and monitoring plans to ensure that refuges use standard protocols to develop baseline and trends data (WH-8).
- Design or use existing database systems to store, analyze, and archive inventory and monitoring data to evaluate management practices (WH-9).
- Develop systematic habitat monitoring programs at the refuge, ecosystem, national, and international levels (WH-10).
- Use adaptive management to evaluate the effectiveness of wildlife conservation programs and periodically evaluate programs to determine if System, ecosystem, and individual refuge goals and objectives are being achieved (WH-14).

The Service Manual (621 FW3, Section 3.7) states that a written evaluation must be completed for all prescribed fires. The evaluation must document “…how well the fire accomplished the desired results” which would require development of specific, measurable objectives prior to treatment and subsequent monitoring to assess results. Throughout the Service Manual (621 FW1, 701 FW2, 601 FW3), monitoring is mandated with specific references for wildland and prescribed fire operations.
Objective of this Guide

The objective of this field guide is to provide users with information that will help set up a monitoring program, including writing a monitoring plan; selecting appropriate monitoring methods; collecting data; and performing basic analyses to meet station specific fire effects monitoring needs. It is designed for refuge personnel with little to no experience in setting up monitoring programs. The Guide is NOT intended nor is it suitable as a substitute for a comprehensive refuge-wide habitat or species population monitoring program, nor is it a substitute for scientific research. Current appropriation language for fuels fund allocations to the Service simply prohibits using fuels funds for many habitat or species inventory, monitoring and research projects station biologists and refuge managers have expressed interest in pursuing. However, fuel treatment effects monitoring can and must contribute their “fair share” toward achieving these broader ends.

For users that do not have specific ideas about monitoring objectives, it would be valuable at this point to begin with the Planning section and start working toward defining monitoring objectives (see the section on Planning – The Critical Step). An example of a Fuels Treatment Monitoring Plan can be made available from the Southeast Regional Fire Ecologist. National Guidance and information about the development of a Fuels and Fire Effects Monitoring Program can be found in the FWS Fuels and Fire Effects Monitoring Guide (FWS FFEMG) at the FWS National Fire Management Office website:


Users are encouraged to bookmark this website, not only because it is a useful reference, but also because it exists as an electronic book that is updated and replaced with new information periodically.

How to use this Guide

This field guide has been developed to take users step-by-step through the development of a monitoring program. Each step is given as a separate section (Planning, Methods, Data Collection, Data Analysis, Application, and Reporting sections). The appendices at the end give examples and copies of documents to help with specific needs. Although this field guide has been developed to serve as a field reference, much of the material presented in this guide should be read before leaving the office.

National Guidance

The National Fire Management Office of the FWS has provided general guidance and protocols for monitoring programs that can be found at the FWS website stated above.

Regional Recommendations

Guidance for developing a fire effects monitoring program, as well as a description of the monitoring protocols recommended by the FWS Southeast Regional Office (R4), are provided in this document. The monitoring guidance and recommendations follow the FWS Fuel and Fire Effects Monitoring Guide (FWS FFEMG) (obtained on the web; see above).

In addition to the National Level recommendations, the following is strongly recommended by the Southeast Regional Office (R4):

1. An approved Fire Effects Monitoring Plan must be in place before fire funds may be expended on monitoring activities.

2. Approved Fire Effects Monitoring Plans should include monitoring objectives that include:

   • Smoke, weather and behavior observations during treatments
   • Photo plots to show vertical fuel changes over time
   • Fuel load estimate changes over time
Additional Guidance and References

In addition to the National FWS FFEMG, and this regional guide, several other references may be useful for monitoring information. Some of the more commonly used references include:

   
   Website:  [http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm](http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm)
   

2. FIREMON:
   
   Website:  [http://www.fire.org](http://www.fire.org)

   
   Reference:

4. Fire Effects Information System (FEIS):
   
   Website:  [http://www.fs.fed.us/database/feis/](http://www.fs.fed.us/database/feis/)

5. Photo Series/ USFS Fire Ecology Publications:
   
   Website:  [http://www.fs.fed.us/fire/science/index.html](http://www.fs.fed.us/fire/science/index.html)

6. NWCG Fire Effects Guide:
   
   Website:  [http://www.nwcg.gov/pms/RxFire/FEG.pdf](http://www.nwcg.gov/pms/RxFire/FEG.pdf)

7. USGS Burn Severity References:
   
   Website:  [http://nrmisc.usgs.gov/research/cbi.htm](http://nrmisc.usgs.gov/research/cbi.htm)

8. Joint Fire Science Program Information:
   
   Website:  [http://jfsp.nifc.gov/](http://jfsp.nifc.gov/)
DEVELOPING A MONITORING PROGRAM

This section describes the steps needed to develop a Fuel and Fire Effects Monitoring Program.

1. **Gather Fire Ecology Information.** To begin, find information about what is known about fire regimes, fire history, fire use and fire effects for the refuge ecosystems. Good sources for this information include existing resource documents and plans (Comprehensive Conservation Plans, Habitat Management Plans, Fire Management Plans, Prescribed Fire Burn Plans, Forest Management Plans, Annual Narratives, county fire records and etc.). If these plans are not available, adjacent landowners (federal or non-federal) and local universities, as well as regional fire ecologists, biologists, foresters and other regional resource staff, may be able to provide useful information. Gather as much information as possible about the role of fire and fire effects for the ecosystems of interest.

2. **Hold scoping meetings.** The next step is to hold meetings with refuge staff (line officers, fire and resource management staff, as well as outside sources if needed) to determine: (1) the historic and current role of fire on the refuge; (2) the desired fire effects (population, species and/or landscape level effects); (3) what fuel treatment applications are used to achieve the desired effects; and (4) clearly defined monitoring objectives to be used to evaluate treatment effectiveness.

3. **Write the monitoring plan.** The next step is to write the monitoring plan. This document is used to describe: (1) the general resource management role fuels treatment applications play on the refuge; (2) the objectives of the fuels treatments; (3) what treatments will be applied; (4) what the monitoring objectives are for each treatment objective; (5) how monitoring will be set up to evaluate the treatment applications; (6) what monitoring design will be used; (7) what monitoring methods will be applied; (8) when and how data will be collected, stored and archived; (9) what analyses will be performed for treatment evaluation; (10) how results and findings will be reported; and (11) how management actions may change to reflect monitoring evaluation results. The document should be written for a life span of about 15 years or shorter if all monitoring goals and objectives have been met.

4. **Submit monitoring plan for approval and acquire funding support.** In this step, funding resources will be made available only to refuges with approved fuels treatment Monitoring Plans. Approved plans may be considered as an amendment to an already existing fire management plan or as a stand-alone document, or may be incorporated into a refuge-wide monitoring plan describing all resource monitoring activities. Once an approved plan is in place, (see Appendix A for signature approval process), appropriations for fuels treatment monitoring can be used with project funding. Funds for planning and monitoring activities will be submitted in FIREBASE annually. All monitoring activities should be reported in NFPORS (National Fire Plan Operations Reporting System) annually. Funding for monitoring activities is determined annually and is dependent on project fund availability and priorities.

5. **Implement monitoring plan.** Once an approved monitoring plan is in place at the refuge, procedures outlined in the plan will be followed. Any modifications to the plan will be noted and plans will be updated periodically to reflect these modifications, using the same review/approval procedures as for the initial plan.

6. **Analyze and interpret data.** For this phase, the guidance provided in this field guide is followed to archive data appropriately and perform general descriptive statistics to evaluate the effectiveness of the fuels treatments by refuge staff.

7. **Summarize findings and report results.** For this step, general trends, inferences, findings or conclusions that can be determined from the data analysis phase will be summarized in a report.
and archived appropriately. If the findings state that more data is needed, then that will be reported as well.

8. **Hold evaluation meetings.** In this phase, the summary of findings will be reported to resource and fire management staff (i.e., scoping meeting members) to discuss the results and needed modifications (if any) to the monitoring strategy and plan. Monitoring plans will be updated periodically to reflect any changes made to the monitoring strategy.

9. **Apply results to adaptive management process.** In this step, results of the monitoring project are interpreted, and findings are used to modify management strategies as needed in more effective fuels treatment applications. Consequences of monitoring results can fall into at least four categories: (1) need more data, (2) monitoring strategies need modification, (3) management strategies need modification, or (4) monitoring project complete.

**Figure 1. Steps to Developing a Monitoring Program.**
PLANNING – THE CRITICAL STEP

Levels of Planning

The FWS uses a series of step-down planning documents that describe sound resource management, from broad management objectives defined in the Comprehensive Conservation Plan (CCP) and stepping down to more specific objectives described in documents such as project plans or prescribed burn plans. Refuge-level management plans may include the CCP and Wildlife and Habitat Management Plans that step down to fire management plans, that in turn, step down to project-level plans such as prescribed burn plans. All of these plans can provide information useful in defining monitoring variables. In general, broader monitoring variables are identified in refuge-level plans (CCPs, Habitat and Resource Management Plans), while more specific monitoring variables are defined in project-level plans (i.e., Prescribed Burn Plans). A description of the step-down planning process in relationship to management and monitoring variables is given in Table 1.

Table 1. An example of the step-down planning process.

<table>
<thead>
<tr>
<th>Planning Level</th>
<th>Management Goals and Objectives</th>
<th>Monitoring Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive Conservation Plan</td>
<td>Restore and sustain ecological functions in wet pine savannas – GOAL</td>
<td>Ecological functions (i.e., fire, hydrology, etc.)</td>
</tr>
<tr>
<td>Habitat Management Plan</td>
<td>Restore native plant species to previously published levels for native wet pine savannas - GOAL</td>
<td>Native plant species composition</td>
</tr>
<tr>
<td>Fire Management Plan</td>
<td>Restore historic fire regimes (low to moderate intensity, late spring to early fall fires at 2 to 5 year intervals) to all wet pine savannas - OBJECTIVE</td>
<td>Fire frequency, fire seasonality, fire intensity, or fire behavior</td>
</tr>
<tr>
<td>Prescribed Fire Burn Plan</td>
<td>Reduce woody stems of gallberry by 50-80% using fire-OBJECTIVE</td>
<td>Woody stem density, or cover</td>
</tr>
<tr>
<td>Fuel Treatment and Fire Effects Monitoring Plan</td>
<td>In habitats managed for hazardous fuel reduction, a mean decrease of 50-75% in 1-hr and 10-hr fuels will be detected within 3 years following fuel treatments - OBJECTIVE</td>
<td>1-hr and 10-hr fuel reduction</td>
</tr>
</tbody>
</table>

Refuge Level Plans

These plans include the refuge CCP, Wildlife and Habitat Management Plans, Forest Management Plans, Waterfowl Management Plans, etc. These plans should broadly define the use of fuels treatments to accomplish resource management objectives. These documents may describe fire regime condition classes, fire regimes and fire use, as well as the historical and ecological roles of fire in landscapes, ecosystems, habitats, populations, or for promoting or decreasing species of concern. Specific fire effects of concern may also be described.

Fire Management Plan

This plan is stepped down from refuge-level plans and describes how fire will be used to achieve resource management objectives. It describes fuel conditions, fire frequencies, wildfire frequencies, fire management strategies, and suppression activities. Most refuge fire management plans describe fire effects very broadly. They also do not state specific fire effects monitoring objectives. As a result, fire effects monitoring plans are currently being added as amendments to existing fire management plans. In this respect, the monitoring plan can be updated and modified as needed without having to re-write the entire fire management plan.
Project Treatment Plan

The specific project plans, burn plans or fuels treatment plans (mechanical or chemical treatments, for example) may describe how the application of a treatment will accomplish specific management objectives (for example, fire will be used to top-kill 50-80% of woody stems). This last level of plans may provide the greatest detail and information useful in developing fuels treatment monitoring objectives, but higher-level documents are also very useful.

Components of a Monitoring Plan

The monitoring plan should include descriptions of fire use, desired fire effects, fire and fuel treatments, monitoring objectives, monitoring methods and implementation, scheduling and logistics, data analysis, interpretation and reporting, as well as application of results in the adaptive management process. The plan is a result of one to many scoping meetings held to flesh out information about fire and fuel treatments and the role of fire and fuels treatments in resource management at the refuge. The plan also lays out the monitoring design, sampling scheme, and methods that will be used to collect data. It gives a schedule of monitoring activities, and what methods will be used to analyze the data. It will describe who is responsible for what monitoring activities and how the work will be funded. Finally, an evaluation meeting will be held to describe evaluation of the monitoring procedures and how the monitoring results will be incorporated in the adaptive management process.

Elements of a Monitoring Plan should include the following:

- **Signature Approval Page**
- **Introduction**
  - Purpose and Need
  - Ecological Model or Ecological Habitat Descriptions
  - Fuels and Fuel Treatment Descriptions
- **Description of Management Objectives**
  - Refuge Management Objectives
  - Resource Management Objectives
- **Fuels and Fire Management Objectives**
- **Fuels and Fire Effects Monitoring Objectives**
- **Methods**
  - Description of Methods
  - Description of Sampling Design
  - Schedule of Monitoring Activities
  - Responsible Parties
  - Funding Sources
- **Data Collection, Storage and Archiving**
  - Data Collection Procedures
  - Data Storage and Archiving Procedures
- **Data Analysis**
  - Description of Analyses
- **Results Reporting**
  - Description of Reporting Procedures
- **Management Consequences**
  - Evaluating Monitoring Procedures
  - Evaluation of Management Strategies
  - Consequences of Monitoring Results
  - Adaptive Management Strategies

Defining Objectives

Objectives are defined as incremental steps taken to achieve a goal, according to the FWS Handbook “Writing Refuge Management Goals and Objectives” (USFWS 2004). Objectives provide a foundation for determining strategies, monitoring accomplishments and evaluating success. It is important
to develop clear and measurable objectives for monitoring the effectiveness of fuels treatments. A set of well-defined criteria have been developed to help write objectives called SMART criteria. These criteria are used widely in natural resource management to develop clear and measurable management objectives and should be used as guidance in developing monitoring objectives. SMART objectives contain five guiding principles:

- **Specific**
- **Measurable**
- **Achievable**
- **Results-oriented**
- **Time-fixed**

**Specific** objectives are worded clearly and are easy to understand with very little possibility of misinterpretation. **Measurable** objectives contain an element that can be readily monitored. **Achievable** objectives are realistic. **Results-oriented** objectives specify an end result. **Time-fixed** objectives should include a time frame. A description of how to apply the SMART criteria specifically to developing monitoring objectives is discussed below.

**What are Monitoring Objectives?**

As described above, defining clear and measurable monitoring objectives is one of the keys to a successful monitoring program. Applying the SMART criteria in developing objectives is essential to successful objective development. To apply SMART criteria specifically to the development of monitoring objectives, the following 4 items should be clearly identified in each objective:

1. **Definition of the management target population of interest**
2. **Definition of the range of change to be detected**
3. **Time Frame to monitor change**
4. **Define what variable will be measured**

**Target Population of Interest** -- Defines the group to be examined or monitored. A group can be a fuel type, habitat type, community indicator, population, or species. This information should be provided in refuge-level documents as well as specific burn plans. Results of scoping meetings should also help to define the management target.

**Range of Change** -- Define the range of change expected from the management activity that is acceptable and measurable. Realistic and acceptable ranges should be a product of scoping meetings, information sources, and refuge plans.

**Time Frame** – Describe the time frame needed to monitor. Use a time frame that is realistic biologically and in terms of management actions. This information should result from scoping meetings, literature searches on fire effects, and management objectives in refuge plans. It is recommended that shorter time frames should be considered due to:

- changes in fiscal support over time
- changes in personnel
- short-term changes result in more frequent evaluation of management objectives
- project ends attainable vs. long term projects with no end points

**Variables to Measure** – Indicate what variables will be counted or measured. This may be fuel loadings, mortality, density, frequency, cover, height, etc. There are many ways to detect change and there is no absolute way to measure change. Remember it may take several tries to find the most effective variable to detect change; be flexible and adaptable. It is highly recommended that a pilot project be implemented to help determine the most effective variable to detect the change desired. The level of effort for measuring variables may be restricted by limits in the amount of staff time available, limited funding, or resources (see the Method Selection section below).
**Steps to Defining Objectives**

There are many ways to define monitoring objectives. Scoping meetings should produce much of the information needed to develop monitoring objectives. To get started, take the following steps:

1. Gather fire history, frequency and regime information for the ecosystem.
2. Review refuge plans for management objectives, fuels and fuel treatment descriptions.
3. Identify target species or populations of interest.
4. Gather fire effects information on species of interest.
5. Assess available resources to conduct monitoring activities (staff, time, and funding resources).
6. Determine acceptable range of change from fuels treatments.
7. Determine time frame to achieve and measure change.
8. Determine what variables will be measured.

**Examples of Monitoring Objectives**

To monitor changes in fuel structure using photo plots:

*For selected treatment areas, visual changes in vertical fuel structure will be documented using photo monitoring plots before and periodically (1, 2, and 5 yrs) after treatments.*

To monitor reduction in 1 and 10-hr fuels:

*In habitats managed for hazardous fuel reduction, a mean decrease of 50-75% in 1-hr and 10-hr fuels will be detected within 3 years following fuel treatments.*

To monitor reduction in live woody fuels:

*For habitats managed for pine savannas, marshes, and other open grasslands and woodlands, a 25-50% reduction in the abundance of live woody fuels will be detected within 5 years following prescribed fire treatments.*

To monitor crown scorch or scorch height:

*In habitats managed for forest stand structure, a crown scorch of 0-30% and/or scorch height less than 10 ft will be detected immediately following prescribed fire treatments.*

To monitor reduction in organic duff:

*For habitats managed for marsh habitat, a 0-5% decrease in organic duff will be detected within one year following prescribed fire treatments.*

To monitor burn severity:

*For selected prescribed fire treatment sites, a mean moderate to high-level burn severity of substrate and vegetation will be detected within sites immediately following treatments.*

For further discussion on developing objectives, please see the FIREMON protocols.

**Website:** [http://www.fire.org](http://www.fire.org)

**METHODS – MAKING IT HAPPEN**

**Method Selection**

The most important considerations in selecting methods for monitoring activities are based on the level of effort available to complete this task. The level of effort that can be dedicated to monitoring activities is dependent on at least three factors: (1) amount of staff resources available, (2) amount of time available, and (3) amount of funding resources available. If adequate or knowledgeable personnel are not available, it may be better to consider using non-refuge resources (i.e., university, state or TNC staff, etc.), to complete even the most routine of monitoring activities.
Use the references below, as well as the following descriptions, to help select the protocols and methods needed to accomplish the monitoring objectives. More specific details for each method are provided within the references, and a brief summary of the methods is given below. A one-page summary of all methods is given in Appendix B. Estimates of the amount of people and time needed to complete each task are also provided.

**Suggested Protocols and Methods**

This field guide describes the methods employed in the FIREMON protocols (see References below). The list of protocols described are supported and recommended by the Southeast Regional Office. The protocols described in this guide include:

1. **Photo Monitoring**
2. **Event Monitoring**
   - Fire Behavior Observations
   - Weather Observations
   - Smoke Observations
3. **Fuel Load Monitoring**
   - Woody Fuels
   - Non-woody Fuels
4. **Live Fuel Monitoring**
   - Point Intercept
   - Line Intercept
   - Density
   - Cover and Frequency
5. **Species Composition**
6. **Burn Severity Monitoring**

Table 2. A description of the timing of data collection activities for each monitoring protocol is given in the table below.

<table>
<thead>
<tr>
<th>Monitoring Protocols</th>
<th>Pre-Fire</th>
<th>During Fire</th>
<th>Post-Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo Monitoring</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fire Behavior</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fire Weather</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Smoke</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fuel Loads, Woody</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fuel Loads, Non-Woody</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Loads, Live</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Species Composition</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Burn Severity</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

References for the protocols and methods described in this field guide include:

1. **FIREMON:**
   - Website: [http://www.fire.org](http://www.fire.org)

2. **NPS Fire Monitoring Handbook:**
   - Website: [http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm](http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm)

3. **BLM Measuring and Monitoring Plant Populations:**
   - Reference:
Photo Monitoring

Photographs are a useful means of documenting visual changes in habitats before and after fuel treatments. Photographs are good visual aids for showing the changes that occur over time, providing one can identify the time, location and scale at which the previous photographs were taken. As a result, it is important to identify the time, location and scale, where possible, of the photographs being taken. It is also important to take photographs before, as well as after, the treatments have been applied. Photo monitoring is intended to be used as a qualitative source of data, rather than as a quantitative source (meaning the measurements will not be taken directly from these photo documents).

Requirements:
The Southeast Regional Office highly recommends photographic monitoring of a representative portion of treatment units before and after treatment application as part of its minimum monitoring requirements. Photographic monitoring should be used at a minimum to document changes in fuel structure following treatments. In addition, collecting monitoring data at even a few photo plots can help calibrate the viewer’s eye to certain attributes (like cover). This data allows some attributes to be compared between all photographs.

Recommended Protocol:
1. Determine what to monitor with photographs. Photographs can be used to visually document changes in habitat structure, fuel structure, vegetation changes, plot composition, individual tree or plant treatment effects, species composition, invasive species expansions, etc.

2. A marker board for scale or density can be used to indicate the fuel density, and height in the photo. Specifications for making a scale board are provided in Appendix E.

3. Use a tripod or monopod to raise the camera to a standard height that will be used for all subsequent photos (4 ft is recommended). Exactly how to frame the photograph will depend on slope and horizon. On a hillside slope or ravine, angle the camera with the slope. Align the camera horizontally for photos. Take an additional vertical shot, if that better characterizes the features of interest. The photograph may include any stakes, other plot markers, or scale boards as needed to show exact view of photograph. The permanent marker is generally placed 30 ft from the center pole indicating the exact direction and view the photograph will capture.
4. As a general rule of thumb, a photograph is taken of the four cardinal directions from the center pole.

5. Use the Photograph Monitoring Data Form (Appendix B) to record important photograph information and to re-locate the camera position for later use. A GPS location of the center pole is recommended as well as any permanent markers used to identify the exact location of the view.

6. Assume someone else will retake the photographs; write down as much re-location information as possible for someone else to find the camera locations. Test this with another monitoring team member if possible.

7. It is important to document the photograph identification information on the roll of film, digital image file, slide frame, or back of photograph immediately after development or printing. The longer users wait to identify the photos, the less likely they are to remember the specific details of the photo. Record as much information as possible immediately after the photograph is taken. Digital photographs and images can be annotated in Microsoft Powerpoint.

8. To repeat photograph visits after treatments, every attempt should be made to relocate the exact camera position used in the previous photographs. Use of the permanent stake or marker is critical to repeating the exact view over time.


Recommended Number of Personnel Needed to Complete Task:
2 people.

Estimated Time:
Less than 30 minutes per site, not including travel to the site.

References:
This protocol is described in more detail in the NPS FMH. Additional details of commonly used photography methods are also provided in this handbook.

Website: http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm

FIREMON
Website: http://www.fire.org

On-site Fire Weather, Behavior, and Smoke Monitoring
The FWS Fire Management Handbook (Chapter 18) requires that fire weather, behavior, and where needed, smoke observation data be collected on every prescribed burn treatment. While this data should already be collected for prescribed burning operation purposes, it is also an important factor in data collection for fire and fuel treatment monitoring. No two fires are exactly alike, and on-site observations are needed to document how conditions vary during treatment. These data will help to quantify fire intensity and severity that may significantly contribute to the understanding of fire effects after treatment.

Requirements:
It is required at the FWS national level to collect on-site observations of fire weather, behavior, and where needed, smoke during prescribed fire operations for all treatment units. These data should be collected with safety in mind at all times and with SAFETY as the highest priority!
**Recommended Protocol:**

1. Always consider safety first in any on-site collection of data during fire and fuel treatment operations!

2. Collect observations at least hourly and preferably more frequently during prescribed fire operations.

3. Collect observations nearest to the monitoring plots/treatment units whenever possible.

4. Collect specific information for each observation point (weather, fire behavior or smoke observation point) including: (1) location and (2) slope, aspect and elevation of the observation point. Enter this data into the Fire Behavior Observations or Smoke Monitoring Data Forms.

5. Collect on-site weather condition observations frequently, at least once per hour, either manually or automatically from a weather station.

6. On-site weather observation data that should be collected just before the treatment application includes: (1) live fuel moistures, (2) drought index, (3) duff moisture, and (4) the fuel model(s) present in the treatment unit. Enter these data into the On-site Weather Observation Data Form.

7. Additional on-site weather observation data to be collected includes: (1) dry bulb temperature, (2) relative humidity, (3) wind speed, (4) wind direction, (5) shading and cloud cover, and (6) time-lag fuel moistures (1, 10, 100 and 1000-hr). Enter these data into the On-site Weather Observation Data Form.

8. On-site fire behavior observations should also be collected frequently and from different locations throughout the treatment unit. Data collected for fire behavior may include: (1) rate of spread, (2) perimeter or area growth over time, (3) flame length, (4) flame height, and (5) fire spread direction (having blank copies of the treatment unit may help to map fire spread). Enter these data into the On-site Fire Behavior Observation Data Form.

9. On-site smoke observations should also be collected frequently and from different locations where the smoke column is clearly visible. Data collected for smoke monitoring may include; (1) visibility, (2) particulates, (3) total smoke production, (4) mixing height, (5) transport wind speed and direction, (6) surface wind speed and direction, (7) elevation of smoke column above ground, (8) smoke column direction, (9) smoke inversion layer elevation, and (10) smoke column description. **Note:** An optional measure is to record the smoke column "lean" angle, vertical angle to top of smoke column and distance of observation to smoke column by using a clinometer or compass, and mathematically determine # 5, # 7, and # 9 above.

10. Enter data into the Smoke Monitoring Data Form. For the purposes of fire operations, any complaints downwind of treatment unit may also be noted.

**Recommended Number of Personnel Needed to Complete Task:**

1 person.

**Estimated Time:**

Observations should be collected during the length of the prescribed burn operation. Each observation may take up to 5-10 minutes to collect.

**References:**

This protocol is described in more detail in the NPS Fire Management Handbook. Additional details on data collection methods for on-site weather, fire behavior or smoke observations can be found in the NPS Handbook as well as the FIREMON protocols.
Fuel Load Monitoring

One estimate of fuel loading can be obtained by the recently published NWCG Photo Series (see website [http://www.fs.fed.us/fire/science/index.html](http://www.fs.fed.us/fire/science/index.html)) where fuel loads are estimated for various fuel types and conditions. If a crude fuel estimate is needed, this is a good source of information and is acceptable by the Southeast Regional Office.

Fuel loadings are also estimated by measuring three components of fuels: (1) dead and down woody debris, (2) duff and litter layers, and (3) understory vegetation abundance. The Southeast Regional Office recommends the use of established protocols of fuel loading estimates from FIREMON for woody fuels and is described below. A general biomass sampling protocol is recommended for non-woody fuels in grassland habitats such as savannas, marshes, prairies and other grasslands.

**For Woody Fuels (FL):**

In woody habitats, the protocols for dead and downed woody debris is estimated using Brown’s Fuel Inventory Transect Methods (Brown 1974, 1982) which is also commonly known as the Planar Intercept Method. In this method, planar transects are established within monitoring or treatment units and the number of different fuel size classes (1, 10, 100 and 1000-hr fuels) along select points of transects are tallied. Biomass of dead and down woody debris is calculated using existing equations that estimate the tons per acre of different fuel size classes. Depth of duff and litter is measured at select points along transects and loading is computed using bulk density coefficients. Cover and height measures are collected for live and dead, woody and non-woody species or life forms along transects. Vegetation density, volume and biomass estimates are calculated from the cover and height data collected of live and dead woody vegetation.

**Requirements:**

This protocol is strongly recommended by the Southeast Regional Office when estimating fuel loads present on treatment sites for woody fuels.

**Recommended Protocol for Woody Fuels:**

1. Establish a plot center with a permanent stake or marker in an area where fuel load calculations are desired. It is recommended that the plot represent the fuel load of a treatment area and additional plots are required when one plot does not capture the variation in fuel loadings. The Southeast Region recommends at least three fuel plots per fuel type to sample the variation in fuel loadings.

2. Layout the measuring tape 75 feet on an azimuth of 90 degrees (due East) from the plot center to define the first sampling plane. A minimum of 75 feet is recommended. The first 15 feet are not used to avoid trampling of vegetation sampled for other plots in the FIREMON system. The sampling plane in this example is 6 feet high by 60 feet long. Additional sampling planes may be placed along sequential transects at 60 degree intervals from the end of the first transect, moving counter-clockwise to reduce the potential bias of non-randomly oriented pieces (see Figure 3 below).
3. At least 3 sampling planes are sampled for each Fuel Load Sampling Plot, with additional sampling planes completed until 100 total pieces of dead woody debris (1, 10, 100 and 1000-hr pieces) are counted, or 7 sampling planes are completed. In heavy fuel areas fewer sampling planes (transects) may be needed; conversely, in sparse fuel areas more sampling planes may be needed.

4. Remember to note whether the distance measurements are taken in ENGLISH or METRIC.

5. Record the slope of the sampling plane in Table 1 of the Fuel Load Data Form (see Appendix B).

6. Note that no fuel particles are counted within the 0-15 foot interval. From 15 to 21 feet along the plane (see Figure 4 below), count the number of ALL dead and down fuel particles by size class that pass through the plane (count 1-, 10-, 100-, and 1000-hr fuels). Enter this data into Tables 1 and 2 of the Fuels Load Data Form (See Appendix B). Remember to record the diameter decay class (1-5; see Table xx below) and distance along the tape the point of intersection with the sampling plane for each log in the 1000-hr or larger size class appears. A caliper or go-no-go gauge may be useful to determine fuel size.

Figure 4. An illustration of sampling design of fuel load transects following FIREMON protocols.
7. At 21 feet along the plane (see Figure 4 above), discontinue counting 1-hr and 10-hr size class fuels, but continue counting the number of 100-hr and 1000-hr fuels that pass through the plane and enter it into Table 2 of the Fuel Load Data Form. A caliper or go-no-go gauge may be useful to determine fuel size.

8. At 30 feet along the plane, discontinue counting 100-hr size class fuels. Continue counting only the number of 1000-hr coarse dead fuels (see Figure 4 above) and note diameter and decay classes. Record this data into Table 2 of the Fuel Load Data Form.

<table>
<thead>
<tr>
<th>Decay Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked.</td>
</tr>
<tr>
<td>2</td>
<td>Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked.</td>
</tr>
<tr>
<td>3</td>
<td>Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked.</td>
</tr>
<tr>
<td>4</td>
<td>Looks like a class 3 log, but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances.</td>
</tr>
<tr>
<td>5</td>
<td>Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.</td>
</tr>
</tbody>
</table>

Table 3. Decay Classes used in Fuel Loading Estimates following FIREMON protocols.

9. Establish sampling points within a 3ft radius of the 45ft and 75ft marks along transect, and estimate vegetation cover within the 6ft tall by 3ft radius sampling cylinders.

10. Cover is estimated by visually compressing all vegetation within the 6ft by 3ft sampling plane, projecting it on the ground and determining how much of the ground is covered by the vegetation. This is a difficult and often subjective estimate that gets better with experience. Try to visualize the shadow cast from the vegetation onto the ground as if the sun was overhead to get a visual estimate of percent cover. Note that the sum of woody and non-woody cover will never be less than the total cover and may sum to more than 100 percent.

11. Estimate cover and cover class code for live woody species. Record data in Table 3 of the Fuel Load Data Form.

12. Estimate cover and cover class for dead woody species. Record data in Fuel Load Data Form.

13. Estimate average height (+ 0.5ft) for live and dead woody species. Record data in Fuel Load Data Form.

14. Estimate cover and cover class for live non-woody species. Record data in Fuel Load Data Form.

15. Estimate cover and cover class for dead non-woody species. Record data in Fuel Load Data Form.
16. Estimate average height (+ 0.5ft) for live and dead non-woody species. Record data in Fuel Load Data Form.

17. Using the same sampling points with a 3ft radius of the 45ft and 75ft points along the plane as in Step 9 above, take duff/litter profile measurements (two per transect). Use the blade of a trowel to work through the litter and duff layers to expose the mineral soil layer, making a profile of the duff/litter layers. Keep in mind that mineral soil is usually lighter in color than the duff layer and more coarse in particle size, often sandy or gravelly. Measure the depth of duff/litter layer and estimate what proportion of the total depth is made up of litter ± 5%. Record these data in Tables 1 and 2 of the Fuel Load Data Form.

18. Total up all downed woody debris pieces (1-, 10-, 100- and 1000-hr), if less than 100 pieces counted in number, establish another transect at 60-degree intervals from the first transect (see Figure 3 above. Continue this process until 100 pieces of woody debris or 7 planes are measured. This is termed the “100-piece rule”.

19. Keep in mind that an aggregation of fuels in large piles should be avoided as this may overestimate the fuel loads within a plot. Ask, “Do transects established adequately represent the fuel loads on the ground?” If not, move the plot to another site where transects could better represent the fuel loads.

20. Do not purposely place a plot in an area with large piles of fuel that could overestimate the fuel load for the area. To avoid this, random points can be generated for plot locations using pre-determined GPS locations.

Recommended number of personnel for task:
2 - 3 people.

Estimated Time:
Less than 30 minutes for first planar transect, with 7 planar transects completed within 1.5 hrs, not including travel time.

References:
The protocol described above is commonly referred to as “Brown’s Transects.” The methods are described in more detail in both the FIREMON and NPS FMH references.

FIREMON:
Website: [http://www.fire.org](http://www.fire.org)

NPS FMH:
Website: [http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm](http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm)

For Non-woody Fuels:

In grassland habitats, a general destructive biomass sampling protocol described by the Southeast Regional Office is recommended to estimate the amount of dead fuels or litter present in more fine fuel habitats such as grasslands, savannas, prairies and marshes where there is little dead and downed woody debris. This is a destructive sampling method and should only be used in areas where destructive sampling is permitted and will not influence other monitoring data plots, other research plots or areas where sensitive species occur.

Requirements:
This protocol is recommended by the Southeast Regional Office when estimating fuel loads in habitats that do not have dead and downed woody debris, but rather fine fuels and litter that contribute to fire spread such as marshes, savannas, prairies, and other grasslands.

**Recommended Protocol for Non-woody Fuels:**

1. Select representative fuel sampling sites within the unit. 3 representative samples is good, 5 samples are great. More than that is probably overkill, but gives a better statistical sampling power if needed. Judge the number of samples to take based on what there is time for.

2. Place frame on ground as evenly as possible. The frame may need to be disassembled and reassembled around plant clumps or around the base of plants.

3. At each site, clip all fuels of interest at the ground level that are within the frame. It is easiest to clip all dead and live fuels at this point, put them in a paper bag and bring back to the office and separate later. Separate them out in the field if preferred.

4. Bag markings should include: 1) Fuel type, 2) Site, 3) Date, 4) Live, or Dead Fuels or Both, 5) any other data of interest, like weather or time of day.

5. Close up bags tightly and bring back for weighing. Bags can be placed in a larger plastic bag for transport.

6. The samples just collected are called “wet weight samples”.

7. At the office, or lab, sort out live from dead fuels and place in separate paper bags (with empty bag weights already written on each bag).

8. Weigh and write weights on bags and Biomass Data Form (See Appendix F)

9. Write any other observations from sampling on data form.

10. Place brown bags in oven and let dry for 24 hours at 80°C. Samples are now considered “dry weight samples”.

11. Take fuel samples out of oven and let cool to room temperature (but not sit out for more than 30 minutes).

12. After 24 hours make the first dry weight reading by weighing samples and writing dry weights on bags and the data forms. Place samples back in the oven for another 24 hours to be sure the weights have dried completely and get a second reading after 48 hours. If time permits, reweigh samples after the second 24 hours and check to see that most of the moisture from the sample has dried off (if it has, it will be a very close weight to what the first reading was). Use the second weight reading as the dry weight sample where possible.

13. If the weighing can not begin right away, leave bags in refrigerator. If bags in refrigerator for more than 24 hours - go back and collect a new sample.

**Recommended number of personnel for task:**

1 person.

**Estimated Time:**

Less than 30 minutes for field sampling, less than 30 minutes for sampling processing and 48 hours for sample drying.

**References:**
The method described above is a standard description of a destructive vegetation sampling method used as a standard ecological technique to determine vegetation biomass estimates. A general description of this procedure can be found in many ecology lab manuals and textbooks.

Website: [http://bio.fiu.edu/pcb3043l/lab_manual/lab_1.pdf](http://bio.fiu.edu/pcb3043l/lab_manual/lab_1.pdf)

**Live Fuel Monitoring**

There are many ways to estimate the abundance of live vegetation in a given habitat. The methods described below follow FIREMON protocols and are recommended as useful protocols to follow for achieving various monitoring objectives. In reviewing these methods, choose the method or methods that will most appropriately meet the monitoring objectives. Table 2 below compares the methods commonly employed and recommended.

Before proceeding with selecting a method for estimating live fuels within a site, it is important to recognize the difference between three terms commonly used to describe how plant abundance is measured; 1) Frequency, 2) Cover and 3) Density.

**Frequency** can be thought of as the number of times a species occurs in the total number of plots sampled and is usually expressed as a percentage. It is a counting variable and is the usually the easiest and most repeatable ways to detect change over time.

**Density** is also a counting variable and is defined as the number of individuals (i.e., individuals, stems, grass clumps, trees, etc) per unit area. Using density counts is usually another easy and repeatable method to detect change in abundance over time.

**Cover** is more of a visual estimate than a counting variable and is defined as the foliar cover of the vertical projection of vegetation on the ground. This variable is less reliable as a repeatable measure among observers. If using cover as a measure of abundance it is important to establish rules of how the visual estimates will be determined among all observers over time.

**Requirements:**

There are no protocols that are required by the Southeast Regional Office; the descriptions below are simply recommendations. However, selecting a protocol with a counting variable is highly recommended over cover estimates.

Table 4. A comparison of commonly used methods for measuring live fuel abundance (vegetation abundance).

<table>
<thead>
<tr>
<th>FIREMON Method</th>
<th>Best Habitat for Use</th>
<th>Monitor Design</th>
<th>Objectives</th>
<th>Metrics</th>
<th>Personnel Needed</th>
<th>Time needed per plot</th>
<th>Per three plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Intercept (PO)</td>
<td>Dense grasslands and meadows</td>
<td>Transects</td>
<td>Changes in plant species cover, ground cover or height by species and size class</td>
<td>Canopy cover, height</td>
<td>1-2</td>
<td>30 min-1 hr per plot</td>
<td>1.5-3 hrs</td>
</tr>
<tr>
<td>Line Intercept (LI)</td>
<td>Open grown woody vegetation where shrubs are greater than 3 ft tall or mixed plant communities</td>
<td>Transects</td>
<td>Changes in plant species cover and height by species and size class</td>
<td>Canopy cover, height</td>
<td>1-2</td>
<td>30 min-1 hr per plot</td>
<td>1.5-3 hrs</td>
</tr>
<tr>
<td>Density (DE)</td>
<td>Grasses, forbs, and shrubs where individuals can be counted</td>
<td>Belt transects, Quadrats</td>
<td>Changes in density and height by species and size class</td>
<td>Stem density, canopy height</td>
<td>1-2</td>
<td>1-2 hours per plot</td>
<td>3-6 hrs</td>
</tr>
<tr>
<td>Cover / Frequency (CF)</td>
<td>Grasses, forbs, and shrubs less than 3 ft tall</td>
<td>Transect, Quadrats, Nested subplots</td>
<td>Changes in frequency and canopy cover by species and size class</td>
<td>Canopy cover, height, frequency</td>
<td>2-3</td>
<td>2-3 hours per plot</td>
<td>6-9 hrs</td>
</tr>
<tr>
<td>Tree Data (TD)</td>
<td>Forests</td>
<td>Plots, subplots</td>
<td>Individual tree response to fuel treatments, stand density and size structure, fire severity</td>
<td>Tree density, dbh, height, live crown length, crown class, bole char height and percent crown scorch, frequency</td>
<td>2-3</td>
<td>2-3 hours per plot</td>
<td>6-9 hrs</td>
</tr>
</tbody>
</table>

**Point Intercept Method (PO)**

The Point Intercept method is designed to sample within stand variation and quantify changes in plant species canopy cover and height over time. It uses transects located within the monitoring plot. Along each transect, the number of times a pin contacts each plant species or ground cover class is counted. Canopy cover is calculated as the number of “hits” for each plant species or ground cover class divided by the total number of points per transect. Average height is also recorded for each plant species along transect. This method is used when the fire manager wants to monitor changes in plant species cover and height or ground cover. It is best suited for sampling ground cover and grasses and forbs and shrubs less than 3 feet in height. It is also well suited for dense grasslands and wet meadow habitats where a fine textured herbaceous layer is present. For more detailed cover or frequency data, the Cover/Frequency Method (CF) should be used.

**Recommended Protocol:**

1. Locate and permanently mark monitoring plot. The number of plots will vary and must be selected to capture the information needed for monitoring objectives. A minimum of 3 monitoring plots are recommended for each treatment unit.

2. Establish a square plot of 66 X 66 ft within the treatment unit.

3. Determine the permanent baseline as a reference line from which to orient all transects. It is recommended that the baseline be located perpendicular to the slope (if present) with the 0 mark on the left and the 66ft mark on right while facing upslope. In flat topography, it is recommended that the baseline run west to east with the 0 mark on the west and 66ft mark on the east.

4. Establish three 66ft permanently marked transects perpendicular to the baseline. For flat topography areas, transects should run south to north, with the 0 mark on the south end and the 66ft mark on the north end.

5. Locations of transects should be randomly selected along the baseline. Use a random numbers table or other means to generate three random numbers from 0-66.

6. Establish 66 points at an interval of 12 inches apart along each transect. The number of points can be adjusted based on plant species or item size and spacing. Points can be more frequent (100 points spaced 8 inches apart) or fewer and spaced farther apart. At a minimum, sample enough points to adequately estimate the item of interest along transect.

7. At each interval, starting with the 0 mark, a 0.25 inch diameter pole is lowered perpendicular to the ground and each plant species or item that touches the pole as it is lowered is recorded. Record the item or bare ground and status (live or dead) as well as the average height for each item in feet (+ 10 percent of the mean plant height). Enter this data into the Transects Point Intercept Data Form (Appendix B).

8. Enter the item height if applicable in the Transects Point Intercept Data Form.
9. Tally the numbers of “hits” for each item across total points along transect and enter this data into the Transects Point Intercept Data Form.

Recommended Number of Personnel Needed to Complete the Task:
1-2 people.

Estimated Time:
From 30 minutes to one hour per plot with 3 transects completed, not including travel time to site.

References:
For more details see FIREMON.

FIREMON:
Website: http://www.fire.org

Line Intercept Method (LI)
The Line Intercept method is designed to sample within stand variation and quantify changes in plant species canopy cover and height over time. It uses transects located within the monitoring plot. Along each transect, canopy cover intercept and average height are recorded for each plant species. This method is best suited for monitoring changes in plant species cover and height. It is primarily designed to sample plant species with solid crowns or large basal areas. It works best in open grown woody vegetation, especially where shrubs are greater than 3ft tall. This is probably the best method to use in mixed plant communities with grasses, shrubs and trees.

Recommended Protocol:

1. Locate and permanently mark monitoring plot. The number of plots will vary and must be selected to capture the information needed for monitoring objectives. A minimum of 3 monitoring plots are recommended for each treatment unit.

2. Establish a square plot of 66 X 66ft within the treatment unit.

3. Determine the permanent baseline as a reference line from which to orient all transects. It is recommended that the baseline be located perpendicular to the slope (if present) with the 0 mark on the left and the 66ft mark on right facing upslope. In flat topography, it is recommended that the baseline run west to east with the 0 mark on the west and 66ft mark on the east.

4. Establish three 66ft permanently marked transects perpendicular to the baseline. For flat topography areas, transects should run south to north, with the 0 mark on the south end and the 66ft mark on the north end.

5. Locations of transects should be randomly selected along the baseline. Use a random numbers table or other means to generate three random numbers from 0-66.

6. Lay a measuring tape along transect to determine the location of canopies or items that intersect transect.

7. Record the item of interest (e.g., longleaf pine juveniles, wire grass clumps etc), the status of interest (live or dead), size class of interest and transect length. For trees, example of size class codes in FIREMON are:
Table 5. Tree Size Class Codes

<table>
<thead>
<tr>
<th>Tree Size Class Codes</th>
<th>Tree Size Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO</td>
<td>Total Cover</td>
</tr>
<tr>
<td>SE</td>
<td>Seedling (&lt;4.5 ft tall or &lt;1in dbh)</td>
</tr>
<tr>
<td>SA</td>
<td>Sapling (1in to &lt; 5in dbh)</td>
</tr>
<tr>
<td>PT</td>
<td>Pole Tree (5in to &lt;9in dbh)</td>
</tr>
<tr>
<td>MT</td>
<td>Medium Tree (9in to &lt; 2 in dbh)</td>
</tr>
<tr>
<td>LT</td>
<td>Large Tree (21in to &lt;33in dbh)</td>
</tr>
<tr>
<td>VT</td>
<td>Very Large Tree (33+in dbh)</td>
</tr>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

8. Starting at the 0 mark, along each transect and for every plant canopy or item of interest that intersects transect, record the start and stop locations along the tape and enter this data into the Line Intercept Data Form (Appendix B).

9. Record the height of each item in the Line Intercept Data Form.

10. Canopy overlap of the same species is not measured. Gaps in the canopy of less than 2 inches are not measured.

**Recommended Number of Personnel Needed to Complete the Task:**
1 - 2 people.

**Estimated Time:**
From 30 minutes to 1 hour per plot with 3 transects, not including travel time to site.

**References:**
For more details see FIREMON.

**FIREMON:**
Website: [http://www.fire.org](http://www.fire.org)

**Density Method (DE)**
Density measures are used to evaluate the change in plant species density and height within a monitoring plot. This method uses belt transects and quadrats to sample within stand variation and to produce statistically valid changes in density and height over time. Herbaceous plant species or small items are sampled with quadrats, while shrubs and trees and larger items such as large clumps of grass, etc., are sampled with belt transects. Quadrats are systematically sampled along randomly located belt transects. The number of individuals for each item in a quadrat or belt transect is calculated. Density is calculated as the number of individuals per unit area (quadrat or belt transect). This method is used for grasses, forbs, shrubs, and small trees in which individual plants or stems can be counted. Tree density of larger trees is calculated by another method (see Tree Data Method – TD description below).

**Recommended Protocol:**
1. Locate and permanently mark monitoring plot. The number of plots will vary and must be selected to capture the information needed for monitoring objectives and the variation present on a treatment unit. A minimum of 3 monitoring plots are recommended for each treatment unit.

2. Establish a square plot of 66 X 66ft within the treatment unit.

3. Determine the permanent baseline as a reference line from which to orient all transects. It is recommended that the baseline be located perpendicular to the slope (if present) with the 0 mark
on the left and the 66ft mark on right facing upslope. In flat topography, it is recommended that
the baseline run west to east with the 0 mark on the west and 66ft mark on the east.

4. Establish three 66 x 3 ft permanently marked belt transects perpendicular to the baseline. For flat
topography areas, transects should run south to north with the 0 mark on the south end and 66ft
mark on the north end. Keeping in mind that the belt transects are a minimum of 3 feet apart.

5. Locations of transects should be randomly selected along the baseline. Use a random numbers
table or other means to generate three random numbers from 0-66. Keeping in mind that the belt
transects are a minimum of 3 ft apart.

6. Establish five 3X3ft quadrats placed every 12 feet along each transect, starting at the first 12 ft
mark. Quadrats do not need to be permanently marked but the position along transect and the
location of transect are necessary for re-measurement visits. Add this data to either the quadrant
or belt transect Density Data Forms (Appendix B).

7. For each quadrat, record the species present or item of interest under item code. Record the
status of the item. Also record transect number, and size of quadrat in the Density Data Form.

8. If recording density by size class, enter the size class for each item. For tree species the size
class codes follow those given in Table 5.

9. Tally the number of individual plants for each item of interest that can be counted within each
quadrat. Record the data into the Data Density Form.

10. If average height data is desired by plant size class or item, measure the average height for each
item present. Record the average height in the Density Data Form.

Recommended Number of Personnel Needed to Complete the Task:
1-2 people.

Estimated Time:
From 1 to 2 hours per plot with 3 transects completed, not including travel time to site.

References:
For more details see FIREMON.

FIREMON:
Website: http://www.fire.org

Cover and Frequency Methods (CF)
The Cover/Frequency method (CF) of FIREMON is used to evaluate the changes that may occur in
vegetation species cover and frequency. It uses quadrats to sample the within stand variation and
quantify statistically valid changes in plant species cover, height, and frequency over time. This method
is suited for grasses, forbs, and shrub habitats less than 3 feet tall. In this method, quadrats are
systematically placed along randomly located transects. Canopy cover is measured as the percent of a
quadrat that is occupied by the vertical projection of vegetation on the ground. Plant species frequency is
recorded as the number of times a species occurs within a given number of quadrats. These methods
are used when the fire manager wants to monitor changes in plant species canopy cover, height and
frequency. Keep in mind that this method can be collapsed to sample any one of the variables (cover,
height or frequency) if resources are limited for monitoring. In addition, life form or fuel types can also be
elected instead of species data to minimize time and effort if needed.

Recommended Protocol:
1. Locate and permanently mark monitoring plot. The number of plots will vary and must be selected to capture the information needed for monitoring objectives. A minimum of 3 monitoring plots are recommended for each treatment unit.

2. Establish a square plot of 66 X 66 ft within the treatment unit.

3. Determine the permanent baseline as a reference line from which to orient all transects. It is recommended that the baseline be located perpendicular to the slope (if present) with the 0 mark on the left and the 66ft mark on right facing upslope. In flat topography, it is recommended that the baseline run west to east with the 0 mark on the west and 66ft mark on the east.

4. Establish five 66-ft (20-m) permanently marked transects perpendicular to the baseline. For flat topography areas, transects should run south to north with the 0 mark on the south end and 66ft mark on the north end.

5. Locations of transects should be randomly selected along the baseline. Be sure that transects are more than 3 feet apart. Use a random numbers table or other means to generate five random numbers from 0-66.

6. Establish five square quadrats (size depends on objectives; a 20 x 20 inch is commonly used in shrubland habitats, see Table X below for other sizes) placed every 12 feet along each transect starting at the 0 mark. Quadrats do not need to be permanently marked, but the position along transect and the location of transect are necessary for re-measurement visits. Be sure to note this information on the Cover/Frequency Data Form (see Appendix B). Further, the selected quadrat sizes should not change over time once the initial design is established.

Recommended quadrat size for habitat types in FIREMON Cover/Frequency Protocol is given in the Table 6 below.

Table 6. Quadrat size recommendations for habitat types for CF protocols.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Grasslands</th>
<th>Shrub</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 x 20 in</td>
<td>8 x 8 in</td>
<td>20 x 20 in</td>
<td>40 x 40 in</td>
</tr>
</tbody>
</table>

7. Record the transect number and transect length on the Cover/Frequency Data Form.

8. Record the quadrat number on the Cover/Frequency Data Form.

9. Walk around the quadrat and become familiar with the plant species present.

10. Record all species within the quadrat. An option here is to record the presence of only species of interest or indicator species, or group them by life form or fuel type such as herbs and forbs, low woody shrubs, tall woody shrubs, tree seedlings, tree saplings, intermediate trees, dominant and co-dominant trees, etc. List the species or life form under Item Code on the Cover/Frequency Data Form.

11. For each item, record the status as live or dead on the Cover/Frequency Data Form.

12. For each item, record the percent cover within the quadrat and enter a cover class into the Cover/Frequency Data Form. The cover class codes recommended by FIREMON are given in Table 7 below.
Table 7. Cover class codes for C/F protocol.

<table>
<thead>
<tr>
<th>Cover Class Range</th>
<th>Cover Class Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;0 - 1 %</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt;1 - 5 %</td>
<td>3</td>
</tr>
<tr>
<td>&gt;5 - 15%</td>
<td>10</td>
</tr>
<tr>
<td>&gt;15 - 25 %</td>
<td>20</td>
</tr>
<tr>
<td>&gt;25 - 35%</td>
<td>30</td>
</tr>
<tr>
<td>&gt;35 - 45%</td>
<td>40</td>
</tr>
<tr>
<td>&gt;45 - 55%</td>
<td>50</td>
</tr>
<tr>
<td>&gt;55 - 60%</td>
<td>60</td>
</tr>
<tr>
<td>&gt;65 - 75%</td>
<td>70</td>
</tr>
<tr>
<td>&gt;75 - 85%</td>
<td>80</td>
</tr>
<tr>
<td>&gt;85 - 95%</td>
<td>90</td>
</tr>
<tr>
<td>&gt;95 – 100 %</td>
<td>98</td>
</tr>
</tbody>
</table>

13. If frequency data is to be collected, a series of four nested subplots should be established within each quadrat. Subplots will vary according to habitat type and quadrat size selected. Some recommendations are included in Table 8 below.

Table 8. Subplot size recommendations.

<table>
<thead>
<tr>
<th>Subplot</th>
<th>Standard Size</th>
<th>Grasslands</th>
<th>Shrub</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 x 2 in</td>
<td>none</td>
<td>2 x 2 in</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>10 x 10 in</td>
<td>2 x 2 in</td>
<td>4 x 4 in</td>
<td>8 x 8 in</td>
</tr>
<tr>
<td>3</td>
<td>10 x 20 in</td>
<td>4 x 4 in</td>
<td>8 x 8 in</td>
<td>20 x 20 in</td>
</tr>
<tr>
<td>4</td>
<td>20 x 20 in</td>
<td>8 x 8 in</td>
<td>20 x 20 in</td>
<td>40 x 40 in</td>
</tr>
</tbody>
</table>

14. The placement of subplots within quadrats can be configured following the diagram below. In this diagram a 4 nested plot design for Frequency Methods is given. Note that the subplot ratio for this example: Subplot 1 is 1 percent of the total quadrat size; Subplot 2 is 25 percent; Subplot 3 is 50 percent and Subplot 4 is 100 percent of the total quadrat, giving a subplot ratio of 1:25:50:100. The Nested Root Frequency (NRF) subplot numbers for this example is 1:2:3:4 and both the ratio and the NRF numbers are entered in the top of the Cover/Frequency Data Form.
15. Record every species or life form of interest in the Item Code column of the Cover/Frequency Data Form (if not done already as in # 10 above).

16. Record the smallest size subplot in which each plant species or life form is rooted. Start with the smallest subplot (subplot 1). If the basal portion of the plant species or life form is rooted in that subplot, record 1 for it in the Cover/Frequency Data Form under Nested Rooted Frequency. If it occurs in Subplot 2 as the smallest plot then give it a 2 and etc. Complete this process for every species or life form listed in #15 above.

17. Measure the average height for each plant species in feet + 10% of the mean plant height. Enter into Cover/Frequency Data Form.

18. Repeat this process for every quadrat along transect.

**Recommended Number of Personnel Needed to Complete the Task:**

2 - 3 people.

**Estimated Time:**

From 2 to 3 hrs per plot of five transects with nested subplots, not including travel time to the site. The amount of time needed for this method will depend on whether every species is recorded or just life forms. Life form or fuel types will take less time than species descriptions.

**References:**

For more details on the protocols for Cover and Frequency see the FIREMON descriptions.

FIREMON:

Website: [http://www.fire.org](http://www.fire.org)

**Tree Data Method (TD)**

The Tree Data method is an accepted professional forestry method which measures individual tree characteristics that will help quantify the before and after effects of fire on trees. This method uses a fixed area circular plot sampling approach, where all trees within the boundaries of the plot and above a
specified diameter at breast height (dbh) are sampled. All trees and shrubs smaller than a specified dbh are recorded by species-height-status class or species-diameter-status class.

Recommended Protocol:
1. Locate and permanently mark the monitoring plot. The number of plots will vary and must be selected to capture the variation in tree data. A minimum of 3 tree data plots are recommended for each treatment unit.

2. The circular plot size is 0.1 acre with a radius of 37ft. The plot size for Tree Data is important and should be big enough to capture at least 20 trees above the specified minimum dbh (4 inches). Record this macroplot size in Field 1 of the Tree Data Form (Appendix B).

3. Consideration should be made about the acceptable dbh cut-off. This measure should be considered with respect to the monitoring objectives. If trees smaller than 4 inches in diameter are of interest, then the dbh cut-off point should reflect this. Record the dbh cut-off point in Field 4 of the Tree Data Form.

4. Determine rules to be used for measuring trees. Answer the following questions:
   - How will snags be measured?
   - How will trees split below dbh be measured?
   - How will trees split above dbh be measured?
   - How will broken trees be counted?
   - How will leaning trees be counted?
   - How will dying trees be counted?

5. Record this information in the Notes Section of the Tree Data Form.

6. Establish a subplot to measure trees less than 4.5 feet tall (seedlings) centered on the plot center pole. Subplots are nested within the larger monitoring plot and vary in size based on the monitoring objectives. A commonly used radius for seedlings subplots is 11.77ft, giving an area of 0.01ac. If seedling densities are less than 2 per subplot use a larger subplot (0.025 ac); conversely, if seedling densities are more than 100 use a smaller subplot size (0.0025 ac). Record this microplot size in Field 2 of the Tree Data Form.

7. Count seedlings within the established subplot. In a due north direction, run a tape from the center pole to the end of the radius (11.8ft). Hold the tape at the required height to accept or reject a seedling (54 in) and proceed to count the number of seedlings in a clockwise fashion around the subplot. A marked pole can also be useful in determining seedling height. Seedlings can be further classified into seedling height classes if desired. Recommendations for seedling height classes are given in Table 9 below.

Table 9. Seedling class size definitions.

<table>
<thead>
<tr>
<th>Seedling Class</th>
<th>Height Class (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>&gt;0-0.5</td>
</tr>
<tr>
<td>1</td>
<td>&gt;0.5-1.5</td>
</tr>
<tr>
<td>2</td>
<td>&gt;1.5-2.5</td>
</tr>
<tr>
<td>3</td>
<td>&gt;2.5-3.5</td>
</tr>
<tr>
<td>4</td>
<td>&gt;3.5-4.5</td>
</tr>
</tbody>
</table>

8. Record species, status and number for all seedlings by height class in Table 3 (the Seedling Table) of the Tree Data Form.
9. Determine the size of saplings and mature trees that will be used in the monitoring project. Sapling size and mature tree size recommendations are given in Table 10 below.

Table 10. Tree size definitions.

<table>
<thead>
<tr>
<th>Tree Size</th>
<th>Height</th>
<th>dbh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saplings</td>
<td>&gt; 54 in</td>
<td>&lt; 4 in dbh</td>
</tr>
<tr>
<td>Mature Trees</td>
<td>&gt; 54 in</td>
<td>&gt; 4 in dbh</td>
</tr>
</tbody>
</table>

10. Within the macroplot, walk around the plot in a clockwise fashion. Tag, measure and record all individual mature trees within the macroplot. Count and measure all saplings. Record the species, status and number of all saplings by diameter class groups, rather than as individual trees in Table 2 (the Sapling Table) of the Tree Data Form. Recommended sapling diameter classes are given in Table 11 below.

Table 11. Sapling diameter class definitions.

<table>
<thead>
<tr>
<th>Mid-point Diameter Class (in)</th>
<th>Diameter Range (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>&gt;0-1</td>
</tr>
<tr>
<td>1.5</td>
<td>&gt;1-2</td>
</tr>
<tr>
<td>2.5</td>
<td>&gt;2-3</td>
</tr>
<tr>
<td>3.5</td>
<td>&gt;3-4</td>
</tr>
</tbody>
</table>

11. For each sapling diameter class group record the average height of saplings and average live crown percent. Crown classes are similar to cover classes found in other methods and are used for saplings and mature trees. Recommended crown classes are given in Table 12 below.

Table 12. Crown Class code definitions.

<table>
<thead>
<tr>
<th>Live Crown Percent</th>
<th>Crown Class Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;0 - 1 %</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt;1 - 5 %</td>
<td>3</td>
</tr>
<tr>
<td>&gt;5 - 15%</td>
<td>10</td>
</tr>
<tr>
<td>&gt;15 - 25 %</td>
<td>20</td>
</tr>
<tr>
<td>&gt;25 - 35 %</td>
<td>30</td>
</tr>
<tr>
<td>&gt;35 - 45 %</td>
<td>40</td>
</tr>
<tr>
<td>&gt;45 - 55 %</td>
<td>50</td>
</tr>
<tr>
<td>&gt;55 - 60 %</td>
<td>60</td>
</tr>
<tr>
<td>&gt;65 - 75 %</td>
<td>70</td>
</tr>
<tr>
<td>&gt;75 - 85 %</td>
<td>80</td>
</tr>
<tr>
<td>&gt;85 - 95 %</td>
<td>90</td>
</tr>
<tr>
<td>&gt;95 – 100 %</td>
<td>98</td>
</tr>
</tbody>
</table>

12. For each Mature Tree, record the species, tag number, status, dbh, height, live crown percent (ratio), and crown class in the Tree Data Form. Mature Tree Status is measured by four categories as seen in Table 13 below.
Table 13. Mature Tree health code definitions.

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>little biotic or abiotic damage</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>some biotic or abiotic damage</td>
</tr>
<tr>
<td>Sick</td>
<td>extensive biotic or abiotic damage</td>
</tr>
<tr>
<td>Dead</td>
<td>no living tissue present</td>
</tr>
</tbody>
</table>

Tree height is measured to the nearest foot typically measured with a clinometer. Crown Fuel Base height is measured as the height above the ground of the lowest live or dead fuel that can spread fire into the tree. Live crown classes recommended are given in Table 14.

Table 14. Crown Class description definitions.

<table>
<thead>
<tr>
<th>Crown Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>tree not near other trees</td>
</tr>
<tr>
<td>Emergent</td>
<td>crown is totally above the canopy</td>
</tr>
<tr>
<td>Dominant</td>
<td>crown receives light from at least 3-4 directions</td>
</tr>
<tr>
<td>Co-dominant</td>
<td>crown receives light from at least 1-2 directions</td>
</tr>
<tr>
<td>Intermediate</td>
<td>crown only receives light from top</td>
</tr>
<tr>
<td>Suppressed</td>
<td>crown is entirely shaded and underneath canopy</td>
</tr>
</tbody>
</table>

13. Following fuel treatments, additional data can be collected on tree age, growth rate, decay class, mortality, damage and severity classes, char height, and percent crown scorch. Tree age and growth rate are generally taken with an increment borer to determine number of rings and distance between rings over last ten years. Enter this data into Fields 13 and 14 of the Tree Data Form.

Table 15. Tree and Snag decay class descriptions.

<table>
<thead>
<tr>
<th>Decay Class Code</th>
<th>Number of limbs</th>
<th>Top of Bole</th>
<th>Bark</th>
<th>Sapwood</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All limbs present</td>
<td>Pointed</td>
<td>100 % left</td>
<td>Intact</td>
<td>Height intact</td>
</tr>
<tr>
<td>2</td>
<td>Few, limbs</td>
<td>May be broken</td>
<td>Some loss</td>
<td>Some Decay</td>
<td>Some loss in height</td>
</tr>
<tr>
<td>3</td>
<td>Limb stubs only</td>
<td>Usually broken</td>
<td>Some sloughing</td>
<td>Some Sloughing</td>
<td>Broken top</td>
</tr>
<tr>
<td>4</td>
<td>Few or no limbs</td>
<td>Always broken</td>
<td>50% or more bark loss</td>
<td>Sloughing present</td>
<td>Loss in height always</td>
</tr>
<tr>
<td>5</td>
<td>No limbs or stubs</td>
<td>Broken and rotten</td>
<td>20% left</td>
<td>Sapwood gone</td>
<td>Decreasing height with rot</td>
</tr>
</tbody>
</table>

Tree and Snag Mortality causes can be described as in Table 16 below.
Table 16. Tree and Snag mortality code definitions.

<table>
<thead>
<tr>
<th>Mortality Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Fire Caused</td>
</tr>
<tr>
<td>I</td>
<td>Insect Caused</td>
</tr>
<tr>
<td>D</td>
<td>Disease Caused</td>
</tr>
<tr>
<td>A</td>
<td>Abiotic (Flooding, Erosion, Wind, etc)</td>
</tr>
<tr>
<td>H</td>
<td>Harvest Caused</td>
</tr>
<tr>
<td>U</td>
<td>Unable to Determine cause</td>
</tr>
<tr>
<td>X</td>
<td>Did not assess cause</td>
</tr>
</tbody>
</table>

14. Record Tree and Snag decay class and mortality class data in Fields 15 and 16 of the Tree Data Form. For damage and Severity codes see the US Forest Service Common Stand Exam Guide published as an appendix in FIREMON. Record data in Fields 17-20 of the Tree Data Form.

15. Record Bole Char height and Percent Crown Scorch in Fields 21 and 22 of the Tree Data Form.

Recommended Number of Personnel Needed to Complete the Task:
2 - 3 people.

Estimated Time:
From 2 to 3 hours per plot for seedlings, saplings, and trees, not including travel time to site.

References:
For more details and appendix of standard tree mortality cause codes see FIREMON.

FIREMON:
Website: [http://www.fire.org](http://www.fire.org)

Species composition Monitoring

The species composition methods described below are taken from FIREMON protocols. This method is used to provide visual estimates of canopy cover and height measurements for plant species of a stand or community within a selected monitoring plot. This method is suited for a variety of habitat and vegetation types and is best in habitats with tall shrubs and trees. This method uses circular plots to record plant species characteristics of canopy cover and height. The data collected from this method will provide stand structure information and vertical distribution of vegetation by species. This method can be applied to one to many species of interest within a monitoring plot to describe species diversity or community structure.

Note: This method does not quantify variability within a stand and cannot be used to detect statistically significant changes over time.

Requirements:
Due to the extensive skill level needed for identifying local plant species, and time required, this protocol is not highly recommended by the Southeast Regional Office. However, this protocol could be simplified to monitor a suite of indicator species following fuel treatment on a selected site.

Recommended Protocol:

1. Locate and permanently mark the monitoring plot. The number of plots will vary and must be selected to capture the variation in species composition.
2. The circular plot size is 0.1 acre with a radius of 37ft.

3. Walk around the plot and become familiar with the plant species present.

4. Record the minimum level of canopy cover of interest in measuring for all species in Field 1 of the Species Composition Data Form (Appendix B).

5. Record all species or items within a plot in Field 2 of the Species Composition Data Form. An option here is to record the presence of only species of interest or indicator species.

6. For each species, record the status as live or dead in the Species Composition Data Form.

7. For each species, record the size classes represented within the plot. For Tree Size Class Codes, use the following from Table 17 below.

Table 17. Tree size class code definitions.

<table>
<thead>
<tr>
<th>Tree Size Class Codes</th>
<th>Tree Size Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO</td>
<td>Total Cover</td>
</tr>
<tr>
<td>SE</td>
<td>Seedling (&lt;4.5 ft tall or &lt;1in dbh)</td>
</tr>
<tr>
<td>SA</td>
<td>Sapling (1in to &lt; 5in dbh)</td>
</tr>
<tr>
<td>PT</td>
<td>Pole Tree (5in to &lt;9in dbh)</td>
</tr>
<tr>
<td>MT</td>
<td>Medium Tree (9in to &lt; 2 in dbh)</td>
</tr>
<tr>
<td>LT</td>
<td>Large Tree (21in to &lt;33in dbh)</td>
</tr>
<tr>
<td>VT</td>
<td>Very Large Tree (33+in dbh)</td>
</tr>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

For Shrubs, Grasses and Forbs use Table 18.

Table 18. Shrub, grass and forb size class code definitions.

<table>
<thead>
<tr>
<th>Shrub/Herb Size Class Codes</th>
<th>Shrub/Grass/Forb Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO</td>
<td>Total Cover</td>
</tr>
<tr>
<td>SM</td>
<td>Small (&lt;0.5ft)</td>
</tr>
<tr>
<td>LW</td>
<td>Low (0.5 to &lt;1.5ft)</td>
</tr>
<tr>
<td>MD</td>
<td>Medium (1.5 to &lt;4.5ft)</td>
</tr>
<tr>
<td>TL</td>
<td>Tall (4.5 to &lt;8.0ft)</td>
</tr>
<tr>
<td>VT</td>
<td>Very Tall (8.0+ft)</td>
</tr>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

8. Measure the average cover and height for each plant species in feet (+ 10 % of the height) for each size class represented. Enter into the Species Composition Data Form. For cover class codes use Table 19 below.
Table 19. Cover class code definitions for species composition protocol (SC).

<table>
<thead>
<tr>
<th>Cover Class Range</th>
<th>Cover Class Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;0 - 1 %</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt;1 - 5 %</td>
<td>3</td>
</tr>
<tr>
<td>&gt;5 - 15%</td>
<td>10</td>
</tr>
<tr>
<td>&gt;15 - 25 %</td>
<td>20</td>
</tr>
<tr>
<td>&gt;25 - 35 %</td>
<td>30</td>
</tr>
<tr>
<td>&gt;35 - 45 %</td>
<td>40</td>
</tr>
<tr>
<td>&gt;45 - 55 %</td>
<td>50</td>
</tr>
<tr>
<td>&gt;55 - 60 %</td>
<td>60</td>
</tr>
<tr>
<td>&gt;65 - 75 %</td>
<td>70</td>
</tr>
<tr>
<td>&gt;75 - 85 %</td>
<td>80</td>
</tr>
<tr>
<td>&gt;85 - 95 %</td>
<td>90</td>
</tr>
<tr>
<td>&gt;95 – 100 %</td>
<td>98</td>
</tr>
</tbody>
</table>

Recommended Number of Personnel Needed to Complete the Task:
2-3 people, with at least one person knowledgeable of local plant species.

Estimated Time:
From 2 to 4 hours per plot, not including the travel time to the site.

References:
This protocol is a brief description of the methods described in more detail in FIREMON.

FIREMON:
Website: [http://www.fire.org](http://www.fire.org)

Burn Severity Monitoring

Specific measures can be taken to assess burn severity in selected treatment units called the Composite Burn Index (CBI). A detailed description of these methods is given in FIREMON and a brief description of this protocol is given below. This method gives a single index value that summarizes general fire effects found within a given area following burns. It is generally used in wildfire situations, but can be applied in fuel treatment situations as well. This measure is an attempt to quantify the range of variation in burn severity found within the treatment unit.

Burn severity is measured for each of five (5) vegetation strata (i.e., understory substrate, herbs, shrubs and small trees, overstory components such as intermediate trees, and big trees) and a composite index is then calculated for all layers combined. The composite rating can be reported separately depending on the monitoring objectives and not all layers need to be included in measurements. Only vegetation strata present need to be measured for burn severity.

The CBI represents the amount of change that occurred after fire, or how fire has altered the biophysical condition of a treatment unit. It is important to note that this measure indicates severity and not the intensity of a particular treatment which is generally indicated by flame length, and including only the upward heat flux above the soil surface. On-site Fire Behavior observations measure fire intensity.

The CBI data collected was originally intended for Landsat Data Analysis purposes and serve as part of a larger protocol to measure burn severity estimates over large landscape wildfires. In the context of fuel treatments, it is simply used as an indicator of the severity of the treatment.
**Requirements:**

The Southeast Regional Office strongly recommends that a representative proportion of prescribed burn treatment units be assessed for burn severity. The Landsat Data Analysis portion of the CBI (called the Normalized Burn Ratio or NBR) is not required to be completed.

**Recommended Protocol:**

1. Collect CBI burn severity data as soon as possible following fire, from five days to two months after fire. It is important to collect burn severity data as soon as possible within the first growing season after fire. It is also important to capture the initial severity information as soon as possible after fire, recognizing that data such as mortality or survivorship will need follow-up visits over time (within one or two years after fire).

2. Collect and record date of last fire for the unit treated, as this is an important factor in the analysis. Enter this data on the Burn Severity Data Form. **NOTE:** Use existing plot centers for burn severity (CBI) plots. Steps 3-8 are needed if CBI is the only field sampling undertaken to measure fire effects. If other monitoring plot centers exist, skip to Step 9 below.

3. Identify target areas within the treatment unit that represent all the degrees of severity and vegetation types of interest. Include unburned islands and sites adjacent to the perimeter of the treatment unit.

4. Establish sampling plots in areas that represent the variation in burn severity. This information may be provided by remote sensing products or by visually walking the site and determining what amount of variation in burn severity is present and where to locate plots.

5. Establish 3-10 plots per treatment unit sampled, depending on the variation of the burn severity within the unit. Keep in mind that not every level of severity may be represented in one burn, but that the CBI plots are trying to capture the variation in severity. The number of CBI plots can be collapsed or expanded, depending on the size of the treatment area and the resources available to complete the work.

6. Keep plot locations to accessible areas so more plots can be established (versus spending lots of effort traveling to one remote plot).

7. When setting up plots, try to find a homogeneous area of about 200X200ft with similar fire effects.

8. Establish a plot center permanently and record location using a GPS for latitude and longitude in decimal degrees. Record elevation (mean sea level) and error values for plot centers as indicated by the GPS. Record data in the Burn Severity Data Form (Appendix B).

9. From the plot center, stretch a tape to a radius of 49ft for understory vegetation and 98ft for overstory vegetation plots. Use flagging to mark the circular area that defines the perimeter of each vegetation plot. Strata descriptions are given in Table 20 below.

<table>
<thead>
<tr>
<th><strong>Strata</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate</td>
<td>Inert surface materials- rock, soil, duff, litter, and fuels</td>
</tr>
<tr>
<td>Herbs, Low Shrubs and Trees</td>
<td>Grasses, forbs, shrubs and small trees&lt; 3 ft tall</td>
</tr>
<tr>
<td>Tall shrubs, trees</td>
<td>Shrubs and trees &gt;3ft tall and &lt; 16ft tall</td>
</tr>
<tr>
<td>Intermediate Trees</td>
<td>Trees &gt;16ft tall and &lt; the canopy Trees</td>
</tr>
<tr>
<td>Big Trees</td>
<td>Dominant, Co-dominant and Canopy Trees</td>
</tr>
</tbody>
</table>
10. Score each stratum present with a severity rating from 0 (no burn effect) to 3 (highest burn effect) based on rating factors and record data into Burn Severity Data Form. If a given stratum is not present, record an “NP,” but do not record a “0.0.” Decimal scores are acceptable. The overall Burn Severity Scale is described in Table 21 below.

Table 21. Overall burn severity scale definitions.

<table>
<thead>
<tr>
<th>Overall Burn Severity Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
<tr>
<td>0.0</td>
<td>unburned, no change</td>
</tr>
<tr>
<td>&gt;0 to 1.0</td>
<td>low burn severity</td>
</tr>
<tr>
<td>&gt;1.0 to 2.0</td>
<td>moderate burn severity</td>
</tr>
<tr>
<td>&gt;2.0 to 3.0</td>
<td>high burn severity</td>
</tr>
</tbody>
</table>

11. The rating factors to consider in determining the burn severity scale for each stratum are given in Table 22 below.

Table 22. Severity Rating Factors among strata.

<table>
<thead>
<tr>
<th>Severity Rating Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate Strata</td>
</tr>
<tr>
<td>Litter and Light Fuel Consumption (fuels &lt;3in)</td>
</tr>
<tr>
<td>Duff Consumption</td>
</tr>
<tr>
<td>Medium Fuel Consumption (fuels 3-8in)</td>
</tr>
<tr>
<td>Large Fuel Consumption (fuels&gt;8in)</td>
</tr>
<tr>
<td>Soil Cover and Color</td>
</tr>
<tr>
<td>Herbs, Low Shrubs, Small Trees</td>
</tr>
<tr>
<td>Percent Foliage Altered</td>
</tr>
<tr>
<td>Percent living (or resprouting)</td>
</tr>
<tr>
<td>Colonizers</td>
</tr>
<tr>
<td>Change in Species Composition over time</td>
</tr>
<tr>
<td>Tall Shrubs and Trees</td>
</tr>
<tr>
<td>Percent Foliage Altered</td>
</tr>
<tr>
<td>Percent Living (or resprouting)</td>
</tr>
<tr>
<td>Change in Cover</td>
</tr>
<tr>
<td>Change in Species Composition over time</td>
</tr>
<tr>
<td>Intermediate and Big Trees</td>
</tr>
<tr>
<td>Percent Green</td>
</tr>
<tr>
<td>Percent Black</td>
</tr>
<tr>
<td>Percent Brown Scorch</td>
</tr>
<tr>
<td>Percent Canopy Mortality</td>
</tr>
<tr>
<td>Char Height</td>
</tr>
</tbody>
</table>

12. Consider the entire plot for each rating and score. Numeric scores may be intermediate between the integer levels of the scale. Scores are entered into the Burn Severity Data Form and used for calculations of Composite Burn Indices for understory, overstory and total plot.
13. For Intermediate and Big Trees, record any additional information on the Burn Severity Data Form such as:
   - Percent Plot Area Burned
   - Percent Girdled Trees
   - Percent Felled Trees
   - Percent Mortality

Recommended Number of Personnel Needed to Complete Task:
2 people.

Estimated Time:
Less than 30 minutes to one hour per plot, not including travel time to site.

References:
This protocol is a brief description of the methods described in more detail in FIREMON.

FIREMON:
Website: http://www.fire.org

Pilot Study
A pilot study is like a test burn. Evaluate the results of the pilot study. If it accomplishes what was desired, continue using the same methods and expand the monitoring project. If it does not seem to be producing the needed information, stop and redefine a new set of monitoring methods. Like a test burn, if it does not work, stop, re-evaluate the conditions, and start again using a different tactic or strategy. Hold another scoping meeting to discuss the changes if necessary.

Monitoring Schedule
Except for immediate post-burn monitoring activities, schedule all monitoring activities to minimize seasonal variation among visits. A good way to accomplish this is to schedule monitoring activities about the same time during the flowering season or growing season every visit. From year to year, base the monitoring schedule on the original date of plot establishment (which may need to be modified after the pilot study or after data is collected and analyzed).

For pre-treatment data collection, establish plots during the time of year when the greatest number of species can be identified, keeping in mind that two visits may be necessary to determine this date (one in the beginning of the growing season, one near the end). Ideally, plots are burned the same year or season in which the pre-fire data is collected. If more than two years have passed since plot establishment before treatment, it is best to re-visit the monitoring plots and collect new pre-treatment data.

For post-treatment data collection, assess fire severity data as soon as possible after the duff stops smoldering. Assess all post-fire variables between one week and two months after treatment. Live vegetation recovery needs follow-up sampling during the first post-treatment growing season. It is recommended that data collection of monitoring plots be accomplished 1, 2, 5, and 10 years following treatments.

For long-term monitoring, if more than 10 years occur between treatments, monitor units on a ten-year cycle. If treatments occur in less than 10-year intervals, adjust long-term monitoring to the frequency of treatment applications. For example, if plots are burned once every five years, long-term monitoring may be scheduled at five-year post-treatment intervals over the next 50 years, but include 1, 2, and 5-year visits.

For planning purposes, it may be beneficial to describe the monitoring activities for each plot and present them in a table like the one below.
Table 23. Example of a Monitoring Schedule for two burn treatment units.

<table>
<thead>
<tr>
<th>Treatment Unit</th>
<th>Monitoring Plot</th>
<th>Treatment Type</th>
<th>Treatment Cycle</th>
<th>Application Date</th>
<th>Pre-Treatment Monitoring Date</th>
<th>Post-Treatment Monitoring Date</th>
<th>Long Term Monitoring Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMU-1</td>
<td>BU-3-1</td>
<td>Burn</td>
<td>3 yrs</td>
<td>6/1/03</td>
<td>4-5/1/03</td>
<td>6-7/03</td>
<td>1,2 yrs</td>
</tr>
<tr>
<td>FMU-4</td>
<td>BU-1-2</td>
<td>Burn</td>
<td>5 yrs</td>
<td>7/15/03</td>
<td>6-7/1/03</td>
<td>8-9/03</td>
<td>1,2,5 yrs</td>
</tr>
</tbody>
</table>

**Sampling Strategies**

**Level of Sampling**

The level of sampling intensity is determined after the monitoring objectives and methods have been defined. There is a considerable amount of information available about what level of sampling intensity to choose for monitoring projects. The FIREMON protocols include a thorough explanation of the factors that should be considered in determining the level of sampling needed and users are encouraged to review those guidelines ([http://www.fire.org](http://www.fire.org)).

Ideally given unlimited funding and personnel, a monitoring design would include sampling every treatment unit across the refuge and an adequate number of plots within a unit to determine statistically significant treatment effects on the variable of interest. However, this is not always practical with dwindling budgets and increased work loads on personnel. Decisions will have to be made to determine a simple sampling level that is achievable with the resources available. Some factors that will need to be considered are:

- Safety
- Accessibility
- Travel Costs
- Equipment Costs
- Personnel Costs
- Topography/Physiography
- Vegetation Composition and Structure
- Uniformity of Fuels
- Locations of Species of Concern
- Other Treatment Applications in Unit
- Public Use Issues
- Size of Treatment Unit
- Location of Treatment Unit
- Other Refuge Concerns

Given these considerations and the amount of resources available to achieve an adequate sampling design, the Southeast Region recommends the following minimum number of plots per treatment unit for each different monitoring objective:

**At a minimum, establish three monitoring plots per selected treatment unit (i.e., burn unit).**

This minimum should be an adequate beginning sampling scheme to determine if additional plots or treatment units are needed in the sampling design. It is important to keep in mind that one treatment unit most likely will not adequately represent treatment effects across the entire refuge and more than one
treatment unit may need to be sampled. As the monitoring program develops over time and sample means and variation are generated, it will be easier to determine if the minimum sampling level above is adequate to measure the treatment effects or whether additional plots per treatment unit or additional treatment units are necessary. Decisions about sampling design should be re-visited every year during the annual monitoring meeting.

References:
The Integrated Sampling Strategy of the FIREMON protocols has an excellent discussion of the considerations needed to determine sampling level. The suggested sampling scheme above is a modified level I sampling scheme.

FIREMON:
Website: http://www.fire.org

Order of Sampling
Once the monitoring design has been determined it will be important to consider the order of sampling to minimize trampling effects on the vegetation, especially in plots where data for multiple monitoring objectives (e.g., fuel loads and plant cover) will be collected. The order in which sampling should occur to minimize trampling effects is given in Table 24 below (listed from first - # 1 to last # 9).

Table 24. Recommended order for collecting data from plots with multiple monitoring objectives. The order is ranked from 1 (first) to 9 (last).

<table>
<thead>
<tr>
<th>Order</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Species Composition (SC)</td>
</tr>
<tr>
<td>2</td>
<td>Point Intercept (PO)</td>
</tr>
<tr>
<td>3</td>
<td>Cover/ Frequency (CF)</td>
</tr>
<tr>
<td>4</td>
<td>Density (DE)</td>
</tr>
<tr>
<td>5</td>
<td>Line Intercept (LI)</td>
</tr>
<tr>
<td>6</td>
<td>Tree Data (TD)</td>
</tr>
<tr>
<td>7</td>
<td>Fuel Load (FL)</td>
</tr>
<tr>
<td>8</td>
<td>Burn Severity (CB)</td>
</tr>
<tr>
<td>9</td>
<td>Plot Description (PD)</td>
</tr>
</tbody>
</table>

DATA COLLECTION, STORAGE AND ARCHIVING
Collecting, handling and storing data can be an intimidating and daunting task, considering the effort it takes to define objectives, develop a plan, select and set up monitoring methods, as well as the hard work and sweat that goes into the field to collect the actual data. Losing the data at this point would be tragic and irresponsible. To help prevent the “oops” factor from emerging, the following sections offer some advice about data collection, storage and archiving that might be useful.

Data Collection
In today’s high tech world, many alternative mediums are used to collect data. Most popular are palm pilots and other portable hand-held computers that allow data forms to be set up electronically before entering the field and allow data entry on-site. More traditional options include water-resistant field notebooks, paper, fine-tipped permanent markers, rapid-o-graphs, pens and pencils.

Field Data Forms
For whatever medium selected, data forms should be made before entering the field. If using the FIREMON protocols, data forms are already created and just need to be printed out (see
Appendix B. The Southeast Region recommends using FIREMON Data Forms for data collection in the field.

If individualized data forms are desired they should clearly define the types of data collected. Be sure to leave plenty of room for general comments, so if the data forms were not set up adequately before hand notes can be added and forms can be modified for the next time out. Be adaptive; if the data form does not seem to be capturing the data desired, modify it and make it customized to individual need. Add columns, rows, and extra room for comments as needed. In short, whatever it takes to get the data entered in a repeatable form. Hand-held computers and palm pilots have the capability to modify data forms on-site as needed. Also, do not try to enter too much on one data form. Many data forms may be needed for the different types of data that will be collected; for example, one data form may be needed for vegetation measurements before fire and a separate one for after fire, or one data form for vegetation data and one for fire behavior, etc. Examples of data forms are presented in the Appendix B.

Reviewing the Data

Once the data are collected, it is important to review and note any outliers or problems while out in the field. Write up any comments about what was missed or needs to be address on the notes themselves while out in the field. Relying on memory is not a good way to clean up data after the fact. Try to review the data briefly in the field and revisit the plots if needed. Before leaving the field, the following questions should be asked: Did all the data get collected that was set out to be collected? Were all off the plots measured? Were there any plots missed? Were all the variables measured that were planned to be measured?

Copies, Copies and More Copies!

There can never be enough copies of the completed data forms. Having many copies of the original data forms is the best defense against the "oops" factor. Get a hard copy of the data as soon as possible after leaving the field. Several hard copies would be best (2-3). If there is no time to enter data from a field notebook, copy the pages as is. Make hard copies of electronic spreadsheet pages (no matter how big the data set!). If a computer system fails for any reason, the electronic data is gone for good.

Data Entry Options

There are, of course, many software packages available for creating spreadsheets for data entry. If using the FIREMON protocols as described above, all data should be entered into the data fields provided by the FIREMON software. This eliminates the need to repeat data entry into a statistical or analysis software package. The Southeast Region recommends using the FIREMON software for data entry.

Alternative software tools for making spreadsheets include Microsoft Excel, Access, and Word as well as many others on the market. One consideration in creating spreadsheets is to use a product that can be easily imported by statistical packages for later analysis. For this reason, it is best to choose more general and widespread software packages to create spreadsheets.

Data error checking is a critical step in the entry process. There are many ways to check the data for entry errors, by visually or verbally checking all data against originals, or looking at the distribution of data and determining if the min or max values exceeds expected values (indicating an outlier point).

Metadata

Any information describing the sampling strategy or data collection process should be entered into FIREMON as metadata. All the information used to develop a monitoring program and implement it needs to be recorded so, in the future, people will know what, why and how monitoring was done. Either a hardcopy notebook or FIREMON Metadata Data Form (MD) can be used to record the information (Appendix B).
Data Storage

File hard copies in a place where they are easily retrievable to someone other than the individual filing them. As a test, ask someone else to find specific data in the filing system. Treat the data like any other important refuge documents. If possible, keep data in a fire-proof box or safe. Ideally, copies of the data should also be kept off-site such as in the Regional Fire Management Field Office (Tallahassee, FL or Lacombe, LA) to serve as a back-up as well. This includes hard copies and electronic copies. If a digital scanner is available, a scanned electronic copy of the hard data is acceptable.

Note: The Regional Fire Management Field Office is willing to store copies of data as a back-up copy. It is strongly recommended that stations send both a hard copy and the equivalent electronic copy to the Regional Fire Ecologist at the Regional Fire Management Field Office in Tallahassee, FL or Lacombe, LA.

In addition, the Regional Fire Management Field Office will ensure that FWS data standards are met for all data received.

Archiving Data

Hard copies can serve as an archived data set as long as they are located in a fire-proof safe storage facility. It is wise to make archived copies of electronic data forms on media such as CDs, floppy disks, or electronic tapes that will not be destroyed if a computer, network server or internet access goes down. External Hard Drives are excellent for backing up data sets. Granted, these media will be subject to change over time, so periodic conversions will be necessary; but it is something to consider.

Archiving Photos, Slides and Videos

All photos, slides and videos should be treated as data sets themselves. Ideally, a data form should be made that describes the information collected on the photos, slides or videos and placed in the archived files. There is usually only one original when it comes to slides, photos and videos, so location descriptions for the archived files are critical.

Many refuges have now begun to start photo monitoring albums and Microsoft Power Point Presentations that demonstrate the visual changes over time and also serve as an electronic copy of the data.

DATA ANALYSIS – STATISTICS ANYONE?

All aspects of data analysis should be discussed up front in the planning process. A schedule of how often the data will be analyzed and what outputs will be generated should be considered in the planning process. IT IS IMPORTANT TO DECIDE WHAT DATA ANALYSIS METHODS WILL BE IMPLEMENTED BEFORE FIELD WORK BEGINS. BRING A STATISTICIAN IN EARLY IF NEEDED. This provides for a smooth transition from data collection to data analysis. It also offers a statistician (if needed) an opportunity to look over the monitoring design and make comments before any field data is collected.

Many statistical and analytical software programs are available to help analyze monitoring data. Some options are described below:

   This is one of the most accepted software packages currently being used for fire effects monitoring data. Copies can be downloaded from the internet at the NPS Fire Monitoring Handbook Website: http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm

2. FIREMON – (USFS 2003)
An up and coming statistical software package that will accept all the recommended data collection methods suggested in this guide.

3. **Do-it Yourself**
   To calculate general descriptive statistics, use the basic calculations and FIREMON data analysis software.

   FIREMON website: [http://www.fire.org](http://www.fire.org)

4. **Give it to a Statistician**
   If a user does not want anything to do with the data analysis portion of the monitoring project, a statistician may be contracted to do the analysis, however the statistician must be brought into the project from the very start. Keep in mind that statistical help can be contracted out and that it may cost additional time to meet regularly with the statistician to answer analysis questions or data inquiries.

**APPLICATION OF FINDINGS**

**Monitoring Strategy Evaluation**

Evaluate field methods, costs, sample size and relevancy of monitoring project after each data collection. Recognize that at any time in the process, a problem may develop that causes change or complete abandonment of the monitoring effort. Common problems associated with monitoring are described below.

1. **Monitoring not implemented** – A signed monitoring plan represents a commitment by the agency to implement monitoring and adhere to the level of effort needed, and gives a schedule of monitoring activities and personnel needs to accomplish the monitoring objectives defined in the plan.

2. **Differences between monitors in applying definitions** – It is important that the monitor(s) have the skill levels required to perform the monitoring activities planned. The monitoring plan can help define what skills are needed by the monitoring personnel to carry out the tasks. This field guide also briefly describes what monitoring protocols require more advanced taxonomic skills.

3. **Lead monitor transferred** – If the lead monitor or staff member tasked with monitoring leaves, the monitoring plan should continue to be used to carry on monitoring operations. Most important is to follow the procedures outlined in the plan for data collection and data storage. This point emphasizes the need for a monitoring plan that completely spells out the what, how, and why for the given monitoring program.

4. **Monitoring data not analyzed** – It may take two to ten times more effort and time in the office to process the data than to collect it from the field. Time and budget allocation for this portion of the work should be recognized by staff and administrative officers, and be reflected in the monitoring plan and budget planning processes.

5. **Monitoring data yields inconclusive results** – A pilot study is useful to determine on a small scale whether the data will be useful in assessing treatment effects. It will also help determine if the variables to be measured are adequate for monitoring the stated objectives.

6. **Statistician deemed data worthless** – A statistician should be consulted before the monitoring project is established if statistically rigorous data is desired. A station may want to invite a statistician to the initial scoping meeting or monitoring planning meetings to avoid having this problem surface after the data has already been collected.
7. **Monitoring data not summarized in reports** – Monitoring reports are extremely important! In reality, they are the end product or “deliverable” from all of the effort and funds invested in monitoring activities.

8. **Management refuses to adapt treatments that are clearly beneficial to the population/species of interest** – Other specialists may have information or concerns that need to be addressed when designing a monitoring strategy. It will be important in the planning stages to include entities with differing views to the scoping meeting of planned monitoring activities.

9. **Methods discredited by another source** – Monitoring is a kind of science, and science will never be perfect. Much of the criticism of the monitoring program can be lessened if monitoring activities are planned adequately, monitoring operations are performed accurately, and interpretations are based on the results of the monitoring program rather than on opinion. It is important to document all decisions made through annual activity reports.

During the evaluation process, ask the following questions:

- Are the monitoring variables selected the best possible representation of the variation measured?
- Will locations of monitoring plots be able to be found in years to come?
- Is the time allocated for the field or office portions of monitoring adequate?
- Is vegetation/soil trampling an issue?
- Are field personnel adequately skilled for the tasks?
- Can the monitoring design be implemented as planned?
- Are the costs of monitoring within estimates?
- Do the assumptions of the ecological model seem valid?
- Will the monitoring design, or the variables measured be able to help assess the effectiveness of the treatments with sufficient precision or certainty?

**Monitoring Design Alternatives**

If problems are detected during the evaluation phase, it may be necessary to consider the following options:

1. **Start over from the beginning of the process.** Revisit the monitoring objectives, and redesign a new monitoring strategy.

2. **Accept lower levels of sampling effort.** If it is too costly to continue with an intense sampling scheme, it may be best to scale it down to something more reasonable and less costly. The tradeoff will be the less statistically rigorous scale in which to monitor.

3. **Get more monitoring resources.** It may be necessary to try to get additional funding or personnel from other sources, such as grants or other FWS funds, perhaps cost-share with other departments within the FWS. Volunteers, interns, students and others may be willing to help in the monitoring effort, which can keep the costs down.

4. **Reconsider the sampling design.** It may be necessary to change the shape, size or number of sampling units (quadrats, transects, etc.) to provide more effective data collection. A pilot study is a good way to ensure that the sampling design is adequate.

5. **Data collection, storage or archive errors.** Occasionally, an appropriate sampling design may combine with a sufficient number of data errors to give the appearance of a flawed sampling design. All data will need to be verified and error-checked to avoid this problem. Verbal error checking following data entry is encouraged.
Adaptive Management

In the adaptive management cycle, objectives are developed to describe a desired condition; management is designed to meet those objectives; the response of the resource is monitored to determine if the objective has been met; and management is adapted (changed) if objectives have not been met.

Three possible conclusions can result from a monitoring study: (1) resource management objectives are met; (2) objectives are not met; and (3) results are inconclusive. Results that are deemed inconclusive indicate a monitoring strategy that needs to be re-evaluated and additional pilot studies are needed to determine a more efficient monitoring strategy.

If the monitoring results suggest that management objectives are met, both treatment and monitoring strategies should be continued. Based on the success of the treatment and monitoring strategies, less intense monitoring can be implemented and continued for the long term. In addition, long-term effects that were not captured in the shorter term monitoring project may become evident over time.

According to the adaptive management approach, failure to meet a management objective should result in the change in treatment identified by the monitoring plan. This may meet with a lot of resistance by land managers and rather than change a treatment strategy, the monitoring objectives are re-evaluated (see Monitoring Evaluation Section above). **It is essential to the success of any monitoring program, that the monitoring plan clearly describes the management response for a given monitoring result** during the planning process and ensure that all interested parties contribute to this discussion. Here it will be essential to describe the reason why management responses need to change as identified by the monitoring results. View this element of the monitoring plan as analogous to the Step-Up Plan included in the preparedness portion of the station’s Fire Management Plan.

RESULTS REPORTING

Annual Monitoring Report

Periodic summaries of monitoring results should be completed at least annually and reported in an Annual Monitoring Report. This report can be included in the annual narratives (either in the fire activities section or habitat monitoring section, depending on refuge format). This report is an extremely important communication tool and should be completed by the lead monitor or staff member charged with leading monitoring activities on the refuge. The reports do not have to be fancy with graphs and charts, but may have tables typed up with raw data (such as spreadsheet copies). The reports should summarize the annual monitoring activities performed (in the field and office), the data collected, and any summaries that can be drawn from the data. A management recommendation section may also be included. Any recommended monitoring activity changes or modifications to the program should also be noted. In addition, inconclusive results, problems with monitoring methods, and lack of resources to perform tasks should also be reported. A list of goals for the upcoming year or near future may also be included. An example of an annual monitoring report can be found in Appendix G.

Final Monitoring Report

At the end of the specified monitoring period, or when objectives are accomplished, summarize the results in a formal monitoring report. A formal monitoring report should be submitted every 15 years, reflecting the life of the monitoring plan or sooner if monitoring objectives have been met. Much of the information needed for the report can be taken directly from the initial monitoring plan, although deviations from the proposed approach and the reasons for them will need to be described. The final report should be a complete document so it can function as a communication tool and be incorporated into annual narratives. Completing the monitoring project with a formal report is important. The report provides a complete summary of the monitoring activity for successors, avoiding needless repetition or “re-inventing the wheel.” In addition, a professional summary lends credibility to the recommended management changes by presenting all of the evidence in a single document. The final monitoring report can include the following:

Introduction (reference initial plan)
Refuge Management Objectives (reference initial plan)

Methods
   Description of sampling design
   Description of methods implemented

Data Collection Procedures

Data Storage and Archiving Procedures

Data Analysis
   Description of data analyses performed

Summary of Results
   Summary of raw data in tables, figures, notes, etc.

Interpretation of Results
   Describe potential implications of results
   Describe any problems, errors or modifications that occurred
   Describe any sources of uncertainty in the data

Evaluation of Monitoring Project
   Describe time and resource requirements needed to conduct project
   Describe recommendations for future monitoring needs

Management Consequences
   Recommendations for management change based on findings

REFERENCES

National Park Service Fire Monitoring Handbook (NPS FMH):
   Website: http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm

FIREMON:
   Website: http://www.fire.org

Bureau of Land Management Guide to Measuring and Monitoring Plant Populations:

Fire Effects Information System (FEIS):
   Website: http://www.fs.fed.us/database/feis/

Photo Series/ USFS Fire Ecology Publications:
   Website: http://www.fs.fed.us/fire/science/index.html

NWCG Fire Effects Guide:
Website: http://www.nwcg.gov/pms/RxFire/FEG.pdf

USGS Burn Severity References:

Website: http://nrmsc.usgs.gov/research/cbi.htm

Joint Fire Science Program Information:

Website: http://jfsp.nifc.gov/
**APPENDICES**

A. Signature Approval Page Example

**Prepared By:**

________________________________________________________________________

*Biologist, or Prescribed Fire Specialist*  
*Date*

**Field Station and District Approvals:**

In signing this monitoring plan, I understand the management changes that may result from the monitoring results identified and approved under this plan.

________________________________________________________________________

*Biologist, Mountain Longleaf Refuge*  
*Date*

________________________________________________________________________

*Fire Management Officer, Fire District 7*  
*Date*

**Refuge Manager Approval:**

My approval of this plan is my assurance of this station’s commitment to implement and complete the monitoring and management actions the plan identifies.

________________________________________________________________________

*Project Leader, Mountain Longleaf NWR*  
*Date*

**Regional Approval:**

I have independently reviewed this monitoring plan and determined that the protocols identified are cost effective and statistically defensible means of addressing the monitoring objectives indicated.

________________________________________________________________________

*Fire Ecologist, Southeast Region*  
*Date*

________________________________________________________________________

*Biologist, Southeast Region*  
*Date*

________________________________________________________________________

*Fire Management Coordinator, Southeast Region*  
*Date*
## B. Data Forms

### 1. Monitoring Plot Location Data Form

**Plot Description (PD) Form**

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**Registration Information**

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- **Project ID:**  
- **Plot ID:**  
- **Date:**  
- **Frame Length (ft):**  
- **Speed Rate (ft/min):**  
- **Fire Behavior:**  
- **Fire Severity Code:**  
- **Photo:**  
- **Photo 1:**  
- **Photo 2:**  
- **Local Code 1:**  
- **Local Code 2:**  
- **Comments:**
## 2. Photo Monitoring Data Form

### FMH-23

#### PHOTOGRAPHIC RECORD SHEET

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### 3. On Site Fire Behavior, Weather and Smoke Data Form

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### FUEL / VEGETATION DATA

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### FIRE BEHAVIOR DATA

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4. Fuel Load Data Form – Fine and Coarse Woody Debris

**Fuel Load (FL) Form**

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<td>100-hr</td>
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**FL Table 1 - Fine Woody Debris (<3in / <8cm) - Duff & Litter**

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**Notes/Dry Tally Space:**

**FL Table 2 - Coarse Woody Debris (>3in / >8cm)**

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51
5. Fuel Load Data Form – Vegetation Data

**Fuel Load (FL) Form**

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<td>Dead Herb Cover 1</td>
<td>Average Herb Height 1 (ft/m)</td>
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<td>Dead Tree/Shrub Cover 2</td>
<td>Average Tree/Shrub Height 2 (ft/m)</td>
<td>Live Herb Cover 2</td>
<td>Dead Herb Cover 2</td>
<td>Average Herb Height 2 (ft/m)</td>
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Notes:
6. Point Intercept Data Form

**Point Intercept (PO) Form**

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**Registration Code:** __ __ __

**Project Code:** __ __ __ __

**Plot Number:** __ __

**Date:** __ __ __ __ __

**Notes:**

**Crew:**
## 7. Line Intercept Data Form

### Line Intercept (LI) Form

<table>
<thead>
<tr>
<th>Field 2</th>
<th>Transect Number</th>
<th>Field 2</th>
<th>Transect Number</th>
<th>Field 2</th>
<th>Transect Number</th>
<th>Field 2</th>
<th>Transect Number</th>
<th>Field 2</th>
<th>Transect Number</th>
<th>Field 2</th>
<th>Transect Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field 3</td>
<td>Item Code</td>
<td>Field 3</td>
<td>Item Code</td>
<td>Field 3</td>
<td>Item Code</td>
<td>Field 3</td>
<td>Item Code</td>
<td>Field 3</td>
<td>Item Code</td>
<td>Field 3</td>
<td>Item Code</td>
</tr>
<tr>
<td>Field 4</td>
<td>Status</td>
<td>Field 4</td>
<td>Status</td>
<td>Field 4</td>
<td>Status</td>
<td>Field 4</td>
<td>Status</td>
<td>Field 4</td>
<td>Status</td>
<td>Field 4</td>
<td>Status</td>
</tr>
<tr>
<td>Field 5</td>
<td>Size Class</td>
<td>Field 5</td>
<td>Size Class</td>
<td>Field 5</td>
<td>Size Class</td>
<td>Field 5</td>
<td>Size Class</td>
<td>Field 5</td>
<td>Size Class</td>
<td>Field 5</td>
<td>Size Class</td>
</tr>
<tr>
<td>Field 6</td>
<td>Transect Length (mm)</td>
<td>Field 6</td>
<td>Transect Length (mm)</td>
<td>Field 6</td>
<td>Transect Length (mm)</td>
<td>Field 6</td>
<td>Transect Length (mm)</td>
<td>Field 6</td>
<td>Transect Length (mm)</td>
<td>Field 6</td>
<td>Transect Length (mm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start</th>
<th>Stop</th>
<th>Height</th>
<th>Start</th>
<th>Stop</th>
<th>Height</th>
<th>Start</th>
<th>Stop</th>
<th>Height</th>
<th>Start</th>
<th>Stop</th>
<th>Height</th>
<th>Start</th>
<th>Stop</th>
<th>Height</th>
</tr>
</thead>
</table>

**Key**

- Registration Code: __________
- Project Code: __________
- Plot Number: __________
- Date: __/__/____
8. Density Data Form - Quadrats

### Density (DE) Form

**Quadrats**

<table>
<thead>
<tr>
<th>Field 1</th>
<th>Field 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Transects</td>
<td>Number of Quadrats</td>
</tr>
</tbody>
</table>

**Registration Code:** __ __

**Project Code:** __ __ __ __

**Plot Number:** __ __

**Date:** __/__/__

<table>
<thead>
<tr>
<th>Field 3</th>
<th>Field 4</th>
<th>Field 5</th>
<th>Field 6</th>
<th>Field 7</th>
<th>Field 8</th>
<th>Quadrat 1</th>
<th>Quadrat 2</th>
<th>Quadrat 3</th>
<th>Quadrat 4</th>
<th>Quadrat 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transect Number</td>
<td>Item Code</td>
<td>Status</td>
<td>Size Class</td>
<td>Quadrat Length (ft/m)</td>
<td>Quadrat Width (ft/m)</td>
<td>Count</td>
<td>Height (ft/m)</td>
<td>Count</td>
<td>Height (ft/m)</td>
<td>Count</td>
</tr>
</tbody>
</table>

---

**Notes:**

---

**Crew:**
9. Density Data Form - Belt Transects

### Density (DE) Form
Belt Transects

<table>
<thead>
<tr>
<th>Field 1</th>
<th>Number of Transects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration Code: _ _ _ _</td>
<td></td>
</tr>
<tr>
<td>Project Code: _ _ _ _ _ _ _ _</td>
<td></td>
</tr>
<tr>
<td>Plot Number: _ _</td>
<td></td>
</tr>
<tr>
<td>Date: _ _ / _ _ / _ _ _ _</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field 2</th>
<th>Field 3</th>
<th>Field 4</th>
<th>Field 5</th>
<th>Field 6</th>
<th>Transect 1</th>
<th>Transect 2</th>
<th>Transect 3</th>
<th>Transect 4</th>
<th>Transect 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item Code</td>
<td>Status</td>
<td>Size Class</td>
<td>Transect Length (ft/m)</td>
<td>Transect Width (ft/m)</td>
<td>Count</td>
<td>Height (ft/m)</td>
<td>Count</td>
<td>Height (ft/m)</td>
<td>Count</td>
</tr>
</tbody>
</table>

---

Notes:

---

Crew:
### 10. Vegetation Cover/Frequency Data Form

#### Cover/Frequency (CF) Form

<table>
<thead>
<tr>
<th>Field 1</th>
<th>Field 2</th>
<th>Field 3</th>
<th>Field 4</th>
<th>Field 5</th>
<th>Field 6</th>
<th>Field 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Transects</td>
<td>Transect Length</td>
<td>Number of Quadrats</td>
<td>Quadrat Length (m^2)</td>
<td>Quadrat Width (m)</td>
<td>NRF Subplot Ratio</td>
<td>NRF Numbers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field 8</th>
<th>Field 9</th>
<th>Field 10</th>
<th>Quadrat 1</th>
<th>Quadrat 2</th>
<th>Quadrat 3</th>
<th>Quadrat 4</th>
<th>Quadrat 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transect Number</td>
<td>Item Code</td>
<td>Status</td>
<td>Cover Class</td>
<td>Nested Rooted Frequency</td>
<td>Height (ft/m)</td>
<td>Cover Class</td>
<td>Nested Rooted Frequency</td>
</tr>
</tbody>
</table>

- RegistrationID: __ __ __
- ProjectID: __ __ __ __ __ __ __ __
- PlotID: __ __
- Date: __ / __ / __ __
11. Tree Data Form - Mature Trees

**Tree Data (TD) Form**

<table>
<thead>
<tr>
<th>Field 5</th>
<th>Field 6</th>
<th>Field 7</th>
<th>Field 8</th>
<th>Field 9</th>
<th>Field 10</th>
<th>Field 11</th>
<th>Field 12</th>
<th>Field 13</th>
<th>Field 14</th>
<th>Field 15</th>
<th>Field 16</th>
<th>Field 17</th>
<th>Field 18</th>
<th>Field 19</th>
<th>Field 20</th>
<th>Field 21</th>
<th>Field 22</th>
<th>Field 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag Number</td>
<td>Species</td>
<td>Tree Status</td>
<td>DBH (in/ft)</td>
<td>Height (ft/m)</td>
<td>Live Crown Ratio</td>
<td>Crown class</td>
<td>Age</td>
<td>Growth Rate</td>
<td>Decay Class</td>
<td>Mortality Code</td>
<td>Damage Code 1</td>
<td>Damage Severity Code 1</td>
<td>Damage Code 2</td>
<td>Damage Severity Code 2</td>
<td>Char Height (ft/m)</td>
<td>Crown Scorch %</td>
<td>Local Code</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

- Registration Code: ____
- Project Code: ____
- Plot Number: ____
- Date: ____/____/____
- Crew

**TD Table 1 - Mature Trees**

Trees > Breakpoint Diameter

- Macroplot Size: ____ ac/ha
- Microplot Size: ____ ac/ha
- Snag Plot Size: ____ ac/ha
- Breakpoint Diameter: ____ in/ft
12. Tree Data Form – Saplings and Seedlings

**Tree Data (TD) Form**

**TD Table 2 - Saplings**
Trees < Breakpoint Diameter & > 4.5 ft

<table>
<thead>
<tr>
<th>Field 24</th>
<th>Field 25</th>
<th>Field 26</th>
<th>Field 27</th>
<th>Field 28</th>
<th>Field 29</th>
<th>Field 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter Class (inches)</td>
<td>Species</td>
<td>Status</td>
<td>Count</td>
<td>Average Height (ft/m)</td>
<td>Average Live Crown %</td>
<td>Local Code</td>
</tr>
</tbody>
</table>

**TD Table 3 - Seedlings**
Trees < 4.5 ft

<table>
<thead>
<tr>
<th>Field 31</th>
<th>Field 32</th>
<th>Field 33</th>
<th>Field 34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height Class (ft/m)</td>
<td>Species</td>
<td>Status</td>
<td>Count</td>
</tr>
</tbody>
</table>

**Registration Code:**

**Project Code:**

**Plot Number:**

**Date:**

**Notes**

**Crow**
13. Plant Species Composition Data Form

Species Composition (SC) Form

Field 1
Species ID Level ______ %

Registration ID: __ __ __
Project ID: __ __ __ __ __ __
Plot ID: __ __ __
Date: __ / __ / __ __

SC Page __ of __

<table>
<thead>
<tr>
<th>Field 2</th>
<th>Field 3</th>
<th>Field 4</th>
<th>Field 5</th>
<th>Field 6</th>
<th>Field 7</th>
<th>Field 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item Code</td>
<td>Status</td>
<td>Size Class</td>
<td>Cover</td>
<td>Height (ft/m)</td>
<td>Local Field 1</td>
<td>Local Field 2</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>-----------</td>
<td>-------</td>
<td>-------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field 2</th>
<th>Field 3</th>
<th>Field 4</th>
<th>Field 5</th>
<th>Field 6</th>
<th>Field 7</th>
<th>Field 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item Code</td>
<td>Status</td>
<td>Size Class</td>
<td>Cover</td>
<td>Height (ft/m)</td>
<td>Local Field 1</td>
<td>Local Field 2</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>-----------</td>
<td>-------</td>
<td>-------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
</tbody>
</table>
14. Burn Severity Data Form

**BURN SEVERITY -- COMPOSITE BURN INDEX (BI)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No Effect</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI</td>
<td>0.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**A. SUBSTRATES**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No Effect</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Pre-Fire Cover</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% Pre-Fire Depth</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**B. HERBS, LOW SHRUBS AND TREES LESS THAN 3 FEET (1 METER):**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No Effect</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Follage Altered</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% Change in Cover</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**C. TALL SHRUBS AND TREES 3 TO 16 FEET (1 TO 5 METERS):**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No Effect</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Greens (Unimined)</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% Black (Torch)</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**D. INTERMEDIATE TREES (SUBCANOPY, POLE-SIZED TREES):**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No Effect</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Greens (Unimined)</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% Black (Torch)</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**E. BIG TREES (UPPER CANOPY, DOMINANT, CODOMINANT TREES):**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No Effect</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Greens (Unimined)</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% Black (Torch)</td>
<td>Unchanged</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Community Notes/Comments:**

<table>
<thead>
<tr>
<th>Community Notes/Comments</th>
<th>CBI</th>
<th>Sum of Scores</th>
<th>N Rated</th>
<th>CBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undersory (A+B+C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtstory (D+E)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Plot (A+B+C+D+E)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Estimation:**

<table>
<thead>
<tr>
<th>Method</th>
<th>Diameter</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 m Plot</td>
<td>3.4 m²</td>
<td>1% x 1.3 m</td>
</tr>
<tr>
<td>50 m Plot</td>
<td>7.0 m²</td>
<td>1% x 2.4 m</td>
</tr>
</tbody>
</table>

**After Key and Bonhomme 1980, USGS XBRAN, Glacier Field Station.**

**Version 4.0 27, 2004**

**Strata and Factors are defined in FIREMON Landscape Assessment, Chapter 2, and an accompanying BI "cheatsheet."**

www.fire.org/firemonk.htm
15. Metadata Form

**Metadata (MD) Form**

<table>
<thead>
<tr>
<th>Field 1</th>
<th>Field 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metadata ID</td>
<td>Subject</td>
</tr>
</tbody>
</table>

Field 3: Comments
## C. Methods Summary

<table>
<thead>
<tr>
<th>Monitoring Objective</th>
<th>Habitat</th>
<th>Method</th>
<th>Number of people needed</th>
<th>Time per plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo Plots</td>
<td>Any</td>
<td>Photo pts</td>
<td>2</td>
<td>30 mins per plot</td>
</tr>
<tr>
<td>Fuel Load, Woody</td>
<td>Forests/Woodlands/ shrublands</td>
<td>Brown’s fuel loads- planar transect</td>
<td>2-3</td>
<td>30 mins -1.5 hrs per plot</td>
</tr>
<tr>
<td>Fuel Load, Non-woody</td>
<td>Grasslands/ marshes/ prairies/ savannas</td>
<td>Biomass sampling</td>
<td>1</td>
<td>30 mins to 1hr + 48hrs sample drying</td>
</tr>
<tr>
<td>Smoke</td>
<td>All</td>
<td>On-site Observations</td>
<td>1</td>
<td>Obs taken every hour</td>
</tr>
<tr>
<td>Fire Behavior</td>
<td>All</td>
<td>On-site observations</td>
<td>1</td>
<td>Obs taken every hour</td>
</tr>
<tr>
<td>Weather observations</td>
<td>All</td>
<td>On-site observations</td>
<td>1</td>
<td>Obs taken every hour</td>
</tr>
<tr>
<td>Burn Severity</td>
<td>Any</td>
<td>Composite Burn Index (CB)</td>
<td>2</td>
<td>30 mins to 1 hr per plot</td>
</tr>
<tr>
<td>Plant Cover by points, Grasslands</td>
<td>Dense grasslands and meadows</td>
<td>Point Intercept (PO)</td>
<td>1-2</td>
<td>30 min-1 hr per plot</td>
</tr>
<tr>
<td>Plant Cover by line, Woodlands</td>
<td>Open grown woody vegetation where shrubs are greater than 3 ft tall or mixed plant communities</td>
<td>Line Intercept (LI)</td>
<td>1-2</td>
<td>30 min-1 hr per plot</td>
</tr>
<tr>
<td>Plant Density</td>
<td>Grasses, forbs, and shrubs where individuals can be counted</td>
<td>Density (DE)</td>
<td>1-2</td>
<td>1-2 hours per plot</td>
</tr>
<tr>
<td>Plant Cover and Frequency</td>
<td>Grasses, forbs, and shrubs less than 3 ft tall</td>
<td>Cover / Frequency (CF)</td>
<td>2-3</td>
<td>2-3 hours per plot</td>
</tr>
<tr>
<td>Individual Plant Responses</td>
<td>Forests, woodlands</td>
<td>Tree Data (TD)</td>
<td>2-3</td>
<td>2-3 hours per plot</td>
</tr>
<tr>
<td>Species Composition</td>
<td>Any</td>
<td>Species Diversity (SD)</td>
<td>2-3 one with local plant species knowledge</td>
<td>2-4 hrs per plot</td>
</tr>
</tbody>
</table>
### D. Equipment Checklists

X = should have
O = optional

<table>
<thead>
<tr>
<th>Equipment Item</th>
<th>Plot Setup</th>
<th>Photo Plots</th>
<th>Brown’s Fuel Trans</th>
<th>Biomass Samples</th>
<th>Duff Litter</th>
<th>Veg Data</th>
<th>Tree Data</th>
<th>Burn Severity (CB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinometer</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>X</td>
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<td>Hand Lens</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Wire Survey Flags</td>
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<td>X</td>
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<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flagging Tape</td>
<td>X</td>
<td>X</td>
<td></td>
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<td>X</td>
<td>X</td>
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<td></td>
</tr>
<tr>
<td>Handheld GPS</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Digital Camera</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photo Scale Board</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Photo Series Guides</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 meter/165’ Tape</td>
<td>X</td>
<td>X</td>
<td></td>
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<td>Quadrat/Point Frames</td>
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<tr>
<td>String/Rope</td>
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<tr>
<td>Labels/Tags for unknowns</td>
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<td>X</td>
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<tr>
<td>Quadrat frame for Biomass sampling (18&quot;X18&quot; or smaller)</td>
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<tr>
<td>Scale or balance weighing to nearest 0.1g</td>
<td>X</td>
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<tr>
<td>Clipper/shears</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>
E. Photo Board Instructions

Materials:
- One 1X8X8ft whitewood (or other lightweight wood) board - cut into two 4 ft boards. Try to buy boards that are as straight as possible.
- Two 2 ¾” x 2 ½” narrow hinges (with pin replacement)
- 8 x 3/4” flathead screws
- Small can white exterior gloss paint
- Paint brush
- One 10 ft ¾” PVC pipe-cut into one 6 ft section and two 2-inch sections
- One Tee for ¾” PVC pipe
- Two PVC pipe straps for ¾” PVC pipe
- One set 6” number stencils
- One or two very wide sharpie markers or black exterior gloss paint
- Measuring tape

Instructions:
These instructions are for building a board scale from two 4 ft boards that will fold out to 8 ft when the hinges are extended. Steps 5 through 7 are optional and are used to make a support leg for the back of the board so it can stand alone.

1. Paint both sides of each board. Allow to dry completely.

2. First attach the hinges to the end of boards, assign one board as the Top board and one board as the Bottom board. Assign Front and Back sides to each board. Try to keep any flaws in the boards to the Bottom and Back sides.

Attatch two hinges to the top of the Bottom Board and bottom of the Top Board so that it will open straight up and down when the hinges are extended.

3. Extend the board to 8 ft. Place the board on the ground with Front side up and begin measuring and marking along both sides (Top and Bottom). Starting from the Bottom, mark a line across the width of the board at:

   11, 12, 23, 24, 35, 36, 47, 48, 59, 60, 71, 72, 83, 84, and 95 inches

These markings will give a one inch band just below every one-foot mark. The top of the band is the top of the foot mark. Fill in the one inch band with black sharpie marker (or black paint if available). Position the appropriate stencil on the right hand side of the board just below the one inch band. Stencil around the appropriate number and fill in with permanent marker or paint.
4. Attach two 2” PVC pipe pieces to the straight ends of the PVC tee.

5. In the middle of the Top Board on the Back, attach the tee with the two extensions to the board using the two PVC pipe straps.

6. When the 6 ft PVC pipe is attached to the tee, it should act as a leg to hold up the Top board Back and give it some stability for it to stand on its own. Many modifications have been made to this arrangement. Add another tee to the end of the 6 ft pvc pipe and extend out the bottom of the pipe by one foot each side to give it more stability. The entire structure should look like below when standing.
F. Biomass Data Form

Calculating Fuel Loads

To calculate the tons per acre of fuel on a site or by species, convert the area measured to acres and the final sample weight to tons.

1. First, calculate the final sample weight and moisture content:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Bag</td>
<td>Bag + Wet Sample Weight</td>
<td>Wet Sample Weight</td>
<td>Bag + Dry Sample Weight</td>
<td>Dry Sample Weight (after 24 hours)</td>
<td>Bag + Dry Sample Weight (after 48 hours)</td>
<td>Final Dry Sample Weight (after 48 hours)</td>
<td>Moisture Content (wet-dry (dry*100))</td>
</tr>
<tr>
<td>Weight measured directly</td>
<td>measured directly</td>
<td>calculated: (B-A)</td>
<td>measured directly</td>
<td>calculated: (D-A)</td>
<td>measured directly</td>
<td>calculated: (F-A)</td>
<td>calculated: (C-G) (G*100)</td>
</tr>
</tbody>
</table>

2. Next, convert the final dry weight to Tons. Depending on what measurement was used for weighing, below are some conversion factors to tons. Multiply the final dry weight calculation (see G above) by the correct conversion factor below.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Tons (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 g</td>
<td>0.00000110231 tons</td>
</tr>
<tr>
<td>1 kg</td>
<td>0.00110231 tons</td>
</tr>
<tr>
<td>1 ounce</td>
<td>0.00003125 tons</td>
</tr>
<tr>
<td>1 pound</td>
<td>0.0005 tons</td>
</tr>
</tbody>
</table>

3. Convert the area measured to acres. Depending on the frame size used, below are some conversion factors for acres.

<table>
<thead>
<tr>
<th>Frame size</th>
<th>square inches</th>
<th>acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>6X6 inches</td>
<td>36 sq inches</td>
<td>0.000005739 ac</td>
</tr>
<tr>
<td>12X12 inches</td>
<td>144 sq inches</td>
<td>0.000022957 ac</td>
</tr>
<tr>
<td>18X18 inches</td>
<td>324 sq inches</td>
<td>0.000051653 ac</td>
</tr>
<tr>
<td>24X24 inches</td>
<td>576 sq inches</td>
<td>0.000091827 ac</td>
</tr>
</tbody>
</table>

4. Now divide the tons calculated in step 2 by the acre conversion factor used in step 3 above to give tons per acre.

5. Example:
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Dry Weight</td>
<td>Conversion Factor for Tons</td>
<td>grams converted to tons</td>
<td>Conversion Factor for acres</td>
<td>Tons per acre</td>
</tr>
<tr>
<td>measured in table above</td>
<td>taken from conversion table above</td>
<td>calculated, (A*B)</td>
<td>taken from table above</td>
<td>calculated (C/D)</td>
</tr>
<tr>
<td>45 g</td>
<td>0.00000110231</td>
<td>0.00000495</td>
<td>0.000022957</td>
<td>2.156 tons per acre</td>
</tr>
</tbody>
</table>
This report is the first monitoring report established in the new fire effects monitoring program for the refuge. The monitoring program essentially started in April 2004 in accordance with the development of approved prescribed fire plans and treatments.

Unit 3 – Caffey Mtn Burn Unit
2004 Summary:
- Two prescribed fire burn plans were approved in 2004; one growing season burn (Caffey Mt, Unit 3) and one dormant season burn (Marcheta Mt, Unit 5).
- Prior to the burn, 5 photo monitoring points were established and photographed along the perimeter of the burn unit (pts #8, 9, 10, 11 and 12), in early May 2004.
- One Brown’s Fuel transect was established within the unit according to the FIREMON protocols in mid May 2004.
- Fuel moistures were taken of litter, pine needles and other fine fuels in preparation of the prescribed burn.
- A majority of the burn unit was burned in late May 2004.
- On-site weather, smoke and fire behavior were monitored the day of the burn.
- 4 of the 5 photo points were re-visited immediately and within one month following the burn in 2004.
- One of the photo points was outside the portion of the unit that was burned but still within unit 3 (pt #11).

What did not get done according to prescribed fire plan:
- Only one, not two, brown fuel transects were established due to limited resources.
- No composite burn index plots established after the burn to determine severity as described in burn plan (no follow-up visit by fire ecologist after burn).

2005 Summary:
- Two additional photo pts were established in April 2005 (#13 and 16), making a total of 7 photo pts established for this unit to date.
- No one-year follow up photos were conducted in 2005.

Monitoring Plans for FY2006:
- Need two-year follow up photos for all photo pts.
- Need to take pre-burn photos before next burn cycle.
- Need to re-measure fuel loads prior to next burn.
- Need to measure longleaf abundance in unit prior to burn.
- Need to try to measure burn severity in unit following burns using Composite Burn Indices.
• Need to add more photo pts to include new acreage added to burn unit 3? (may not be necessary)
Unit 5- Marcheta Hill Burn Unit

2004 Summary
- Seven photo pts were established and visited around the perimeter of the unit in early April 2004 (#17, 117, 18, 19, 20, 21, and 22).
- No fuel load data was collected during FY 2004 for Unit 5.
- This unit was not burned in 2004.

2005 Summary
- Two additional photo pts were set up in Unit 5 (#14 and #15) and were photographed in April 2005.
- All previous photo pts were re-visited and photographed in April 2005, for a total of 9 photo pts established prior to burn.
- One Brown’s Fuel Transect was established to determine fuel loads in Unit 5 in May 2005, in preparation for burn.
- Fuel Moistures were measured and duff moistures determined. Note this information lead to the delay of an attempt to burn earlier in the season and confirmed the need to burn the unit in the dormant season.
- One set of photo pts were also established at the Brown’s Fuel Transect according to the FWS southeast field guide with a scale board in the photograph.
- No prescribed burn was conducted in 2005 for this unit.

FY 2006 Monitoring needs for Unit 5:
- Pre-burn photos?
- Re-measure fuel moistures for burn prep
- Follow-up fuel load measures post-burn
- Follow-up post burn photos
- Measure burn severity for site using Composite Burn Index protocols from FIREMON.
- Modify burn plan to include only one brown’s transect at a minimum.

Data Status:
A copy of the digital images from the photo points is archived at the Mt. Longleaf Pine NWR headquarters in the Biologist, Bill Garland’s computer files and a back-up copy exists with the Regional Fire Ecologist Computer files in Lacombe, LA

General Plans for FY 2006:
- Continue to work towards finalizing the draft monitoring plan for the refuge
- Continue to collect data according to the needs stated above.
- Hold annual work meeting to discuss future plans (completed in Dec. 2005).