# Four Forests Restoration Initiative (4FRI) Adaptive Management, Biophysical and Socio-economic Monitoring Plan December 2013

## OUTLINE OF THIS PLAN

1) Introduction
2) Adaptive management process
3) Monitoring
   a) Requirements for monitoring
   b) Types of monitoring
   c) Monitoring: Desired Conditions, Indicators, Thresholds, and Triggers
   d) Monitoring tiers – Prioritization of Monitoring
   e) Scales of monitoring
   f) Biophysical Monitoring Overview and Plan
   e) Socio-economic Monitoring Plan
4) References

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Numerous people contributed to this document from the 4FRI Stakeholder Group and the U.S. Forest Service;

## Introduction

The pace and scale of 4FRI is likely to affect many aspects of the ponderosa pine ecosystems of northern Arizona. The anticipated effects of our treatments are disclosed in the first analysis area Environmental Impact Statement (EIS). Monitoring will help determine if intended effects are achieved, recognizing that our management should improve as monitoring information is collected and applied.

In preparation for implementing 4FRI, this section was prepared to: 1) clarify the process for both monitoring and adaptive management in the 4FRI landscape; 2) clarify the requirements for monitoring; 3) and provide the collaboratively-developed monitoring and adaptive management plan that lays the groundwork for this multi-party monitoring framework. The 4FRI Collaborative Stakeholders Group and the U.S. Forest Service (USFS) coordinated on the design of this monitoring and adaptive management plan, with the intent for it to be integrated within this EIS and operationalized within the entire 4FRI project. The 4FRI Stakeholder group will also provide a Multi-Party Monitoring Board (Monitoring Board) which will work with the USFS to oversee monitoring prioritization, implementation, data storage and assessment. All monitoring results, including positive progress towards desired conditions, unexpected benefits or challenges, will be used for stakeholder learning and developed into outreach material for broader dissemination.

Recommended indicators are focused on the Desired Conditions (DCs), described in the Purpose and Need as well as within each specialist report for the 4FRI project. (And see table X – currently still in excel as DC Xwalk). 4FRI's emphasis is the restoration of a fire adapted ecosystem. Restoration is defined as "the process of assisting the recovery of resilience and adaptive capacity of ecosystems that have been degraded, damaged, or destroyed. Restoration focuses on establishing the **composition, structure, pattern** and **ecological process** necessary to make terrestrial and aquatic ecosystems sustainable, resilient and healthy under current and future conditions. FSM 2020.5." Our monitoring and adaptive management plan will assess these changes and determine the degree to which they meet desired conditions through the use of a multi-scaled suite of indicators and sampling strategies at fine and broad scales. Monitoring is intended to answer the question: that these proposed actions will positively affect the ecological processes within the project area and the greater landscape.

Stakeholders acknowledge that federal funding constraints will influence the year to year funding. In addition, stakeholders recognize that the 4FRI project as a whole encompasses a 2.4-million acre landscape, of which this analysis area comprises approximately one half. While this appendix details the framework and process for monitoring this analysis area, stakeholders and the USFS recognize that the monitoring and adaptive management plan outlined in this document should be applied to the entire initiative area.

## Adaptive Management Process:

The 4FRI Project is a long-term forest restoration effort that is unprecedented in scale in the southwest region. Implementation of the entire project is anticipated to take over 20 years. Coupled with this size and scope, the project is occurring as the southwest is experiencing increased climatic changes, such as periods of extended drought and increased temperatures—the effects of which are unknown or at a minimum, untested. The uncertainties inherent in a project of this magnitude mandate that management actions be flexible to accommodate needed modifications. This adaptive management plan is intended to provide the information necessary to respond to changing conditions and new knowledge.

Adaptive management refers to a "rigorous approach for learning through deliberately designing and applying management actions as experiments" (Murray and Marmorek 2003). Monitoring of alternative management actions provides the data for the adaptive management process. When used in an adaptive management framework, monitoring should link landscape management with learning, and ultimately allow for improved efficiency in planning and implementation.

In conceptualizing monitoring and adaptive management of the 4FRI project, the Stakeholder Group and USFS developed desired conditions, and then the indicators and indicator metrics best to measure trends towards the desired conditions. To assure adequate metrics are used to assess trends, indicator selection is based on attributes that can be easily measured, are precise, sensitive to changes overtime, and satisfy multiple objectives of the monitoring process (Eagan and Estrada-Bustillo 2011, Moote 2011, Derr et al. 2005). Identification of indicators alone is not sufficient for adaptive management. “Triggers” or “thresholds” must also be identified to alert to an undesired outcome; triggers can help indicate whether or not a change in management is necessary. In some cases, current scientific knowledge may not provide these quantitative triggers; therefore, the analysis of monitoring data will help develop these triggers and thresholds for future management purposes.

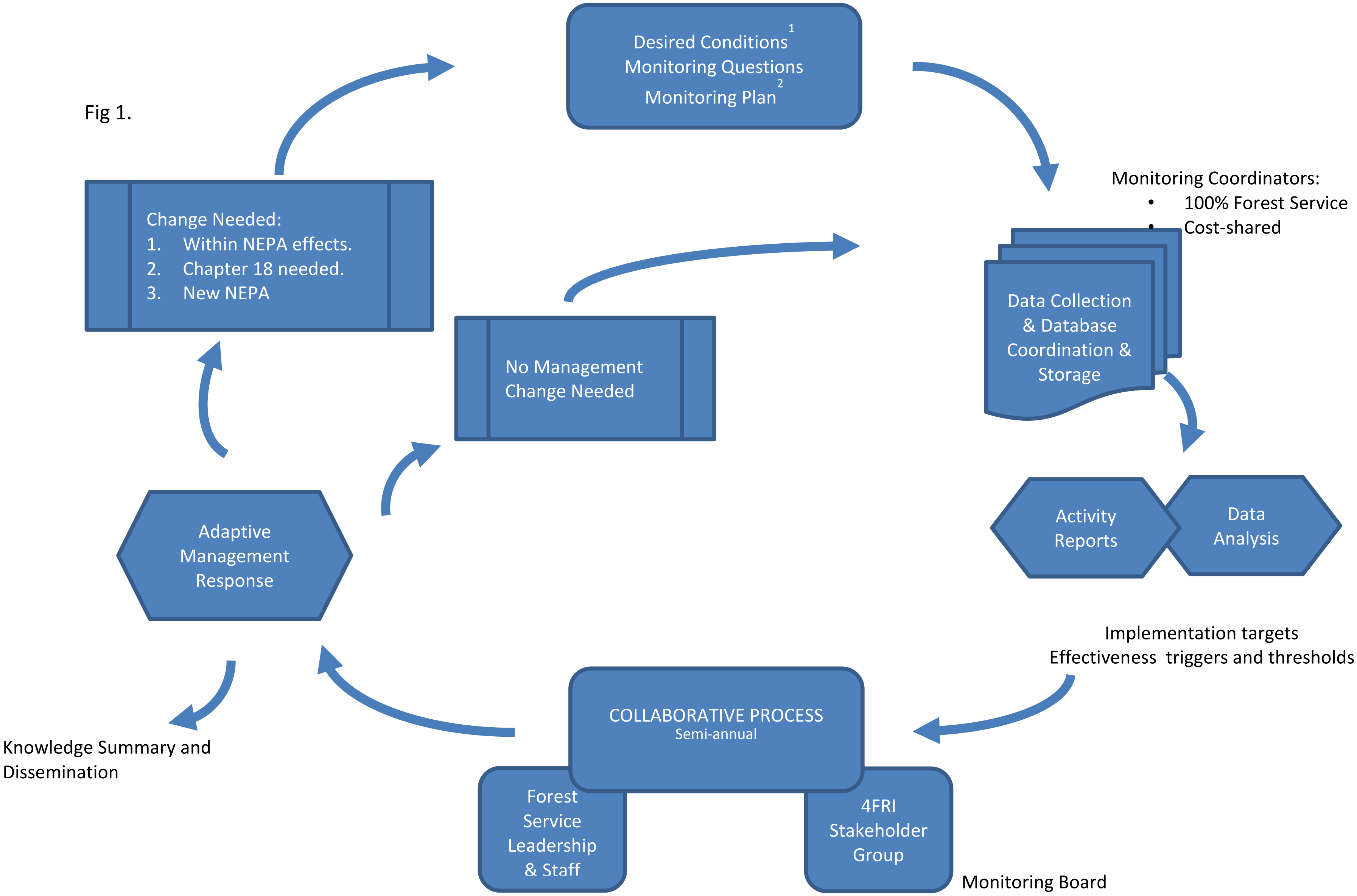
More specifically, included in the biophysical, social and economic monitoring frameworks is a column “Management Action THEN…” that will be used to describe what needs to be done if an “Undesirable Condition,” where possible described as a trigger, delineates a trend in the wrong direction. Initially, the “THEN” actions in this monitoring framework focus on the need to stop, assess and re-evaluate if and how management actions have contributed to the outcomes. As the project matures and a baseline is established, these triggers can be adjusted to more specific acceptable quantitative ranges that will indicate whether or not adaptive management is necessary for each specific objective/question that is being assessed. To assure success of the monitoring program, a clear link describing how monitoring information will be utilized in future decision-making is essential (Noon 2003, Williams et al. 2009). This has been achieved administratively (Mulder et al. 1999, Sitko and Hurteau 2010), legally via the NEPA process (Buckley et al. 2001, RECOVER 2009), or through collaborative agreements (Gori and Schussman 2005, Greater Flagstaff Forest Partnership Monitoring and Research Team 2005). Stakeholders, the public, and the USFS must commit to a strong adaptive management process. Stakeholders that are concerned about potential management outcomes are more likely to support management actions if they are confident that results from these actions are not only carefully monitored, but used to modify actions as necessary (RVCC 2011). In describing the “THEN,” stakeholders will continue to work closely with the USFS in protocol development of recommended management actions.

There is an expectation that monitoring priorities will change (adapt) throughout the course of the project as information is gained and new questions are revealed. The Stakeholder Group will work with the USFS to assess monitoring priorities throughout the course of the project.

Figure 1 depicts the Adaptive Management Process developed for the 4FRI landscape. This process consists of: 1) Key indicators developed for biophysical, economic, and social Desired Conditions and are measured; 2) Data from these measurements are stored, analyzed, and reported back to multiple audiences, including the Monitoring Board, the public, the USFS, and the Collaborative Stakeholder Group; 3) Trends and effects are assessed and compared to triggers, thresholds, and other measures of success; 4) The need for change is determined, and the best process to implement each specific change is developed collaboratively with the USFS, Stakeholder Group, and the Monitoring Board. These changes may or may not require additional NEPA analyses, a determination ultimately to be made by the USFS. The process is iterative, as new information is consistently accumulated and evaluated. The process diagram includes insertion points for Monitoring Board input and depicts roles for key partners, and closely follows the recommendations found in Moote (2013).

# 4FRI Adaptive Management Process

Fig 1.




[1] Desired Conditions found in 4FRI foundational documents.

[2] Monitoring Questions and Plan found in 4FRI Stakeholder Biophysical, Social and Economic Monitoring Plans.

# Monitoring

## *Requirements for Monitoring*

The 4FRI Project is supported by multiple federal mandates, regulations, and funding programs. As such, there are different monitoring requirements for each of these programs.

**Collaborative Forest Landscape Program**
In 2010, the 4FRI project was selected for funding under CFLRP. The purpose of CFLRP is to encourage the collaborative, science-based ecosystem restoration of priority forest landscapes through a process that: 1) encourages ecological, economic and social sustainability; 2) leverages local resources with national and private resources; 3) facilitates the reduction of wildfire management costs, including through reestablishing natural fire regimes and reducing the risk of uncharacteristic wildfire; and 4) demonstrates the degree to which various ecological restoration techniques achieve ecological and watershed health objectives and affect wildfire activity and management cost; and where the use of forest restoration byproducts can offset treatment costs while benefitting local rural economies and improving forest health (PL 111-11, sec 4001, Omnibus Public Land Management Act of 2009).

Section g-3 of the Act specifies annual reporting on the accomplishments of each selected project. Annual reporting includes: 1) a description of all acres treated and restored through projects implementing the strategy; 2)an evaluation of progress, including performance measures and how prior year evaluations have contributed to improved project performance; 3) a description of community benefits achieved, including any local economic benefits; 4) the results of multiparty monitoring, evaluation, and accountability process. Items 1-3 are compiled locally and sent to the USFS's Washington Office for annual reporting. The multi-party monitoring (item 4) focuses on effectiveness monitoring and reporting timeframes are dependent on the variables measures but will be included in the 5, 10 and 15-year CFLRP reporting. Multi-party indicator monitor is accomplished through a partnership of USFS and partner funding and staff.

The Collaborative Forest Landscape Restoration Project requires multiparty monitoring and reports at 5, 10 and 15 years post the authorizing Act (2009) that also include the national indicators to assess project goals. The 4FRI proposal requires a minimum of 10% of each year's CFLRP allocated award to go towards monitoring. As the first 15,000 – 30,000 acres of task orders are issued from the first Analysis Area Project, field-based intensive monitoring will be implemented to test the assumptions within the document, assess implementation of desired conditions and refine the adaptive management process. There is an expectation that other FS budgets will contribute to monitoring and that collaborative partners will solicit and contribute both in-kind and monetary funding from private foundations and other sources in order to leverage monitoring efforts. In addition, a national forest may still complete project level implementation and compliance monitoring with funding from stewardship retained receipts (see Stewardship Contracting below) as outlined in FSM 2409.19 section 67.2, when there is interest and support from local collaborative partners. Retained receipts may defray the direct costs of local multi-party process monitoring and support the collaborative monitoring process by paying for facilitation, meeting rooms, travel, incidental expenses, data collection, and dissemination of monitoring findings to the public.

**Stewardship Contracting**
Stewardship contracting is only one administrative tool that can be used for project implementation. While the use of stewardship contracts is beyond the scope of this NEPA analysis, there are monitoring requirements that are embedded within this tool, and have been included in this collaboratively-developed monitoring and adaptive management plan. Currently, the stewardship contract authorizing language only requires programmatic process monitoring of: 1) the status of development, execution and administration of stewardship contracts or agreements; 2) the specific accomplishments that have resulted; and 3) the role of local communities in development of agreements or contract plans.

## *Types of Monitoring*

**Ecological (also referred to as environmental) monitoring** is generally undertaken to determine whether the current state of the biophysical system matches or is trending toward some desired condition (Noon 2003). When conducted systematically, monitoring can provide valuable feedback regarding the effects of land management on resource conditions (Palmer and Mulder 1999, Lindenmayer and Likens 2010).

**Social monitoring** is done to assess society's perceptions on an issue or group of issues. Changes in these perceptions are assessed through time as issues change in scope or context.

**Economic monitoring** is done to assess the economic impact of the 4FRI project.

Monitoring activities related to land management can be further classified into three categories: implementation, effectiveness, and validation (Busch and Trexler 2003).

- **Implementation monitoring** is designed to determine the extent to which a management action was carried out as designed (did we do what we said we were going to do). Implementation monitoring is closely associated with Process monitoring as described above.
- **Effectiveness monitoring** tracks the extent to which the management action achieved its ultimate objective. Effectiveness monitoring refers to an assessment of treatment effects, rather than to measuring whether they were applied as intended or whether they validate a pre-existing concept.
- **Validation monitoring** assesses the degree to which underlying assumptions about ecosystem relationships are supported (Block et al. 2001, Busch and Trexler 2003). Validation monitoring is often closely associated with research and is not integrated in this monitoring plan.

## *Monitoring: Desired Conditions, Indicators, Thresholds, and Triggers*

A vital component of a successful adaptive management and monitoring program is an explicit statement of desired conditions that will be a result of the proposed actions. Monitoring efforts use indicators to determine how progress is made towards desired conditions. Thresholds and triggers can be considered as benchmarks that inform management directions (i.e. maintain or modify). (Ringold et al. 1999, Lindenmayer and Likens 2010). These desired conditions should provide information that results in timely adjustment of management activities to better meet objectives and support informed decision making (Noon et al. 1999, Noon 2003).

In the 4FRI monitoring program, the monitoring indicators are organized by <u>desired conditions</u> (DCs) that guide the project strategy. The DCs are taken from Chapter 1, the Purpose and Need, as well as in Chapter 3, the Effects Analysis. (maybe make this crosswalk a report that can be accessed online, like the Specialist's reports? see also Table X - DC x-walk). <u>Monitoring indicators</u> are recommended to evaluate progress towards DCs. Recognizing that both the DCs and the monitoring indicators are dynamic, they have been organized in tabular form for flexibility in making revisions as the project´s desired conditions are finalized. Quantitative standards have been used wherever possible, but many of the DCs are qualitative and generalized. Indicator ranges have been described where possible for both desirable as well as undesirable conditions. Triggers and thresholds were developed through literature reviews, expert inputs, and social values.

## *Prioritization – Monitoring Tiers*

As mentioned above, financial resources (both USFS and Stakeholder contributions) will be dedicated to monitoring. However, budgetary limitations will dictate how much and what type of monitoring can be accomplished. In order to help prioritize what monitoring will be accomplished, this plan provides a tiered system for prioritizing monitoring. The intent of a tiered system is that Tier 1 monitoring takes priority over Tier 2 and so on. Note, Tier 1 includes both implementation (compliance) monitoring and effectiveness monitoring. While these are designated as 1a. and 1b. for clarification, priorities between the a. and b. designations remain equal. Implementation/Compliance monitoring is understood as necessary to meet legal regulations and is usually completed by the land manager; in addition, subsequent effectiveness monitoring cannot be adequately analyzed without understanding what was implemented. Effectiveness Tier 1 indicators are top priority to meet the adaptive management goals and implementation checklist included in these project documents. Prioritization of monitoring within each Tier is expected. Research is independent of monitoring and will rely on separate finances. However, the results of research should be considered during implementation and adaptive management of the project.

Table 1 displays the monitoring tiers and their prioritization.

| Monitoring Tier | Priority for Completion | Who Will Complete | Type of Monitoring | Type of Funding |
|---|---|---|---|---|
| **Tier 1a** | 1 | USFS – Contractor | Implementation/ Compliance | Appropriated, Implementation |
| **Tier 1b** | 1 | Multiparty<br>- USFS<br>- Stakeholders<br>- Agency Partners | Effectiveness | Appropriated, Implementation, Partner |
| **Tier 2** | 2 | Multiparty<br>- USFS<br>- Stakeholders<br>- Agency Partners | Effectiveness | Implementation, Partner |
| **Research** | Occurs as approved by Forest Supervisor; Opportunistic | Research Advocate | Implementation, Process, Effectiveness, Validation | Research Advocate, Partner |

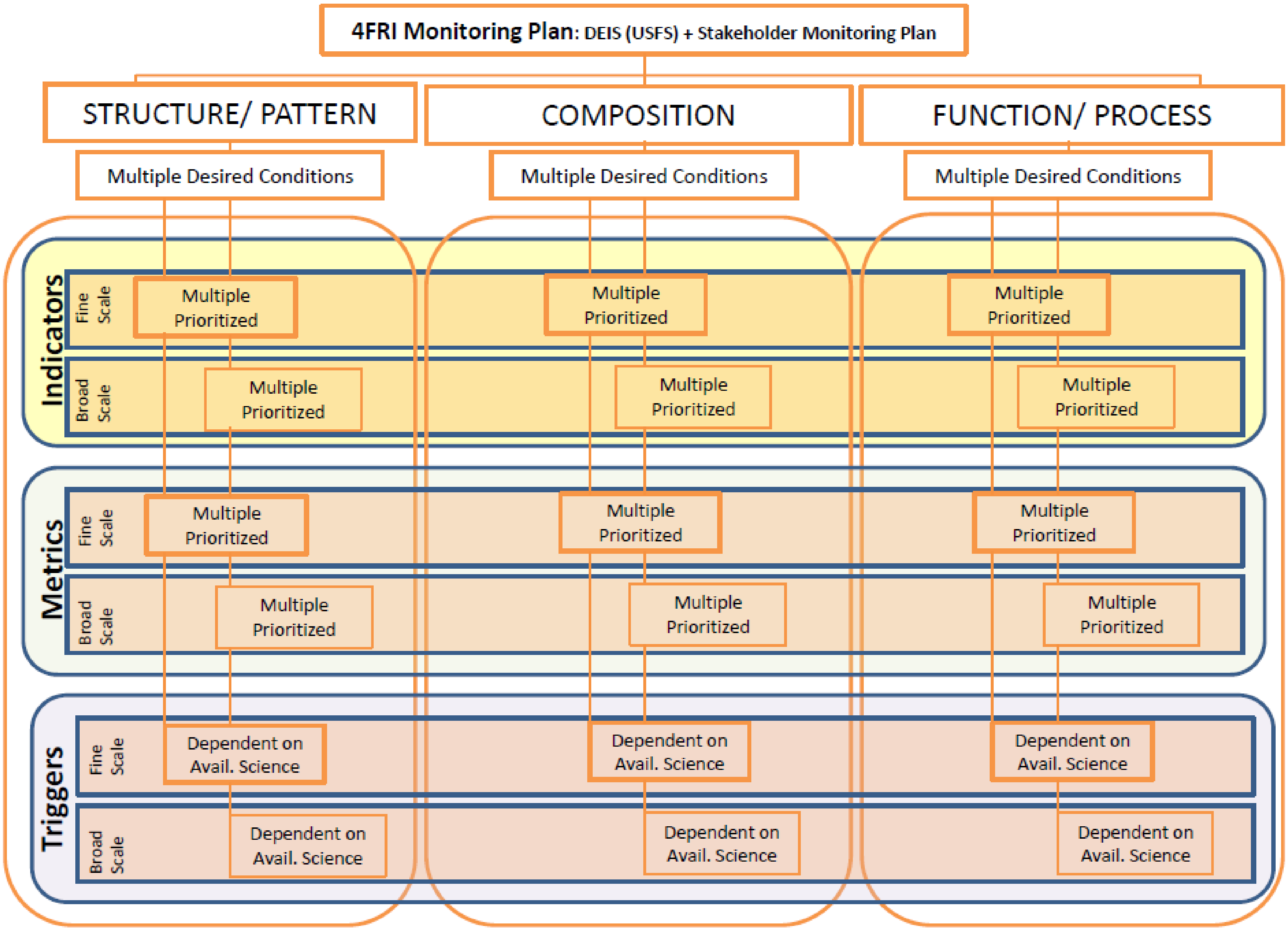
## Scale

The 4FRI will implement management at scales beyond those typically used in management of the National Forests. As such, we feel it is necessary to provide clarification of the scales described in this document. Table 1 provides a crosswalk of the various spatial scales used in forest management documents. For ease of understanding, all terms have been categorized as either "fine" or "broad" scales. This does not preclude monitoring efforts that focus on any one of the specific scales; for example, some monitoring can occur at both, or either, the "group" and "site" scale, depending on the questions and information needed to make informed decisions. Or, alternatively, some monitoring may occur at both a fine and a broad scale.

**Table 2: Scale conventions for cross walking USFS and SH 4FRI documents and indicators.**

| *Scale* | *Convention – How scale is described and where monitoring indicators fit* | | |
|---|---|---|---|
| **Size in Acres** | **Stakeholders - 4FRI Landscape Strategy** | **USFS – 4FRI EIS Coconino Kaibab** | **SH & FS – DC's & Monitoring Indicators from Mon. Plan** |
| **<1** | Group | | Fine; Group and Site |
| **1-1000** | Site | Stand | Fine; Group and Site |
| **1000-10k** | Treatment Area | Sub-unit | Broad; Treatment Area-, Restoration Unit-, Analysis Area-, and Landscape Scales |
| **10K-100k** | TA/Firescape | Restoration Unit | Broad; (as above) |
| **100k-1,000k+** | Firescape, Analysis Area, Landscape | Analysis Area | Broad; (as above) |

Figure 2. provides the reader with a graphical organization of the Biophysical component of the Four Forests Restoration Initiative (4FRI) Monitoring Plan, simplifying the complexity of this 4FRI First Analysis Area project's Desired Conditions and Scale. Emphasized are the hierarchical structures and linkages between the ecosystem components (structure/pattern, composition and function/process), desired conditions, indicators, metrics and triggers (thresholds).



| PLAN COMPONENTS | EXPLANATIONS | OBJECTIVES |
|---|---|---|
| **Four Forests Restoration Initiative (4FRI) Adaptive Management, Biophysical Monitoring Plan** → | **Integrates monitoring information from two documents:** (1) the Forest Service' FEIS and (2) the Stakeholder Group's Adaptive Management, Biophysical Monitoring Plan. This co-authored Plan will serve as the guiding document for the Multi-party Monitoring Board, who is responsible for overseeing 4FRI monitoring under the CFLRA. → | Specific **objectives** of this document are to provide: **(1)** the a detailed description of the adaptive management process, including background information, collaborative adaptive management recommendation development and delivery to Forest Service Line Officers for applying monitoring information to adaptive management within the decision space of the 4FRI EIS and the authority of the Forest Service; **(2)** the monitoring frameworks for physical, biophysical, social, and economic aspects of restoration in alignment with the desired conditions for the 4FRI landscape, with estimated costs and timeframes for a range of monitoring options and **(3)** identification of triggers and thresholds for key monitoring indicators. |
| **COMPOSITION** – **STRUCTURE/ PATTERN** – **FUNCTION/ PROCESS** → | **Different ecological terms** for similar concepts were cross-walked between the USFS and Stakeholder Plans. Throughout this document, unless noted otherwise, "Structure" is synonymous to "Pattern" and "Function" is synonymous to "Process" (see definitions on left). → | Monitor the effects of forest treatments on ecosystem **composition, structure** and **ecological process** in order to evaluate progress towards restoring terrestrial and aquatic ecosystems to sustainable, **resilient** and healthy states. 4FRI's ultimate emphasis is the restoration of a fire adapted ecosystem. |
| **DESIRED CONDITIONS (DC's)** → | Desired conditions are the **questions that guide the monitoring plan.** The Plan tracks progress towards (#) desired conditions, drawn from the DEIS (primarily CH 1) and the Stakeholder Plan (Table 2, pg 37 of this Plan). → | Defines progress towards DC's using implementation monitoring (primarily drawn from the DEIS), effectiveness monitoring (primarily drawn from the Stakeholder Group's Plan, and prior documents: the Landscape Restoration Strategy and the Path Forward) and validation monitoring (research-driven inquiry on issues lacking best available science). |
| **INDICATORS** → | Quantitatively and qualitatively determine if DC's are being achieved, using best available science. Prioritized into tiers (Table 2, pg 37); at least 1 per DC. → | Ensure that 4FRI monitoring is consistent with previous efforts and with widely accepted measurements of forest variables. |
| **METRICS** → | The units of measurement for quantifying Indicators; at least one per indicator (Table 2, pg 37); → | Track indicators in an ecologically precise and economically cost-effective manner. |
| **TRIGGERS** → | The threshold value for a metric at which point adaptive management action is required. Dependent on available science—not all metrics will initially have a trigger. → | Learn when and how to adjust treatment actions to achieve DC's. |
| **Fine Scale vs Broad Scale** → | Metrics are gathered at either fine or broad scales of analysis (see Table 1) according to method feasibility and best available science. → | Achieve monitoring effectiveness across all scales of the entire project area (988,674 acres). |

**Composition:** *is the number of species/patch types/features represented on a landscape and their relative abundance*

**Structure/Pattern:** *(determined by composition) is the configuration and proportion of different species/patch types/features across the landscape*

**Function/Process:** *refers to how each element in the landscape interacts based on its life cycle events*

## *Biophysical Monitoring Plan*

***The Biophysical Monitoring represents the complexity of this 4FRI First Analysis Area project's desired Conditions and Scale. Figure 2 above maps out the hierarchical structure and linkages between the ecosystem components (structure/pattern, composition and function/process), desired conditions, indicators, metrics and triggers (thresholds).***

## *Biophysical Monitoring for Structure & Pattern*:*

* Note: USFS documents Pattern as a separate desired condition; and define Structure as more specific to overstory stand characteristics. The Stakeholder Group Desired Conditions define Structure in a ecological context, which incorporates ecosystem Pattern as a component of Structure. Individual indicators within the Structure/Pattern section can be tiered directly to FS Structure and Pattern Desired Conditions.

***Relevant Desired Conditions***

I. **Conservation of Biological Diversity:**

a. Ponderosa pine ecosystems provide the necessary … structure, abundance, distribution… that contributes to the diversity of native plant and animal species…
b. Where fire use is not possible, mechanical treatments are designed to restore and/or maintain forest structure over time. [Implementation Monitoring – not addressed in this document]
c. Ponderosa pine ecosystems are composed of all age and size classes within the analysis area and are distributed in patterns more consistent with reference conditions.
d. Ponderosa pine ecosystems are heterogeneous in structure and distribution at the analysis area scale. Openings and densities vary within the analysis area to maintain a mosaic appropriate to support resilience of individual trees and groups of trees.

II. **Ecosystem Resilience:** Ponderosa pine ecosystems are restored to more natural tree densities in order to maintain availability of moisture and nutrients to support adaptation to climate change without rapid, large-scale type shifts.

III. **Conservation and maintenance of soil, water, and air resources:**

a. Forest structure supports a variety of natural resource values and processes, including hydrologic function, which meets ecological and human needs.
b. Forest openings are designed to improve snow accumulation and subsequent soil moisture and surface water yield.

***Description and Justification***

Many of the Desired Conditions related to structural components of ponderosa pine forests specify a need for heterogeneous forests that more closely approximate reference conditions. Investigations of historical ponderosa pine conditions indicate that forests were generally open in structure wherein trees occurred in multi-aged clumps of differing size among abundant understory plant communities (Mast et al. 1999, Waltz et al. 2003, Sánchez Meador et al. 2011). It has been suggested that restoration treatments that focus on creating this structure of uneven-aged tree groups interspersed with openings of various sizes will provide the greatest benefit in terms of biological diversity and ecosystem function (Sabo et al. 2009, Kalies et al. 2010).

Determining the extent to which restoration treatments benefit and affect native plant and animal diversity will require a multi-scaled approach to characterizing several aspects of structural diversity. Wildlife and plants respond to their environment across multiple spatial and temporal scales (Wiens 1989). Indeed, management that creates or maintains structural complexity at the stand or patch scale while preserving a diverse assemblage of stands (or patches) that differ in size and spatial arrangement at broader scales has been identified as a necessary component of managing forested systems for diversity (Lindenmayer et al. 2006). Understanding the contribution of forest structure and composition to biodiversity is further complicated by the potential existence of "domains of scale" (i.e., areas where a process may behave predictably, but beyond which the process may change in an unpredictable and non-linear way) and that any single scale of measurement is likely to be arbitrary with respect to the process of interest (Wiens 1989).

Forest structure is a multi-dimensional attribute that is not assessed adequately by any single measure. Similarly, heterogeneity in forest structure occurs at multiple scales requiring multiple indicators (Cushman et al. 2008, Cushman et al. 2010). Thus, we recommend two distinct sets of indicators for assessing changes in forest structure that result from 4FRI-implemented treatments.

### *Site- and Group-scale Assessment*

**Tier 1b (Effectiveness) Suggested Indicators:** Age Structure, Spatial Aggregation, Canopy Openness

- **Age Structure (Diameter Distribution):** We recommend measuring the diameter distribution (both pre- and post-treatment) within stands initially treated under the first Analysis signed EIS. While this will likely require a fairly intensive field effort, it will allow quantification of structural complexity in terms of age (size) structure and will also provide information for calculating changes in density and basal area that result from treatment. If priority is given to the first task orders, benefits can include an increase in stakeholder trust and understanding of the LTRS implementation. Cost savings can be realized through the use of well-trained volunteers as these data are relatively simple to collect. Finally, because structures in southwestern ponderosa pine forests change relatively slowly (e.g. Fule et al. 1997, Laughlin et al. 2008), the frequency of sampling is greatly reduced.
  - ***Assessment:*** *Field sampling of tree diameter (both pre- and post-treatment) of treated sites*
  - ***Frequency:*** *Immediately post-treatment (either mechanical or prescribed fire); every 10 years thereafter.*
- **Spatial Aggregation (Ripley's K and/or Getis Ord):** Measures of spatial aggregation can be used to determine "patchiness". Many of the investigations of spatial aggregation in ponderosa pine forests have used Ripley's *K* to test for the existence of "clumps" (e.g., Sitko and Hurteau 2010, Sánchez Meador et al. 2011). Continued use of this metric can allow assessment of whether "restored" areas exhibit a degree of spatial aggregation similar to that seen on "reference sites". Ripley's *K* is based on the clustering and distribution of a series of points (e.g., trees); however, it does not account for the magnitude of the observation at that point (e.g., canopy cover) (Mueller-Warrant et al. 2008). While less frequently used to describe "reference conditions", the Getis Ord statistic incorporates observations at the point allowing a more complete description of the clustering process and the identification of "hot" and "cold" spots for a more complete description of spatial aggregation that can be helpful in understanding ecosystem processes. Furthermore, it allows a more robust estimate of local aggregation (i.e., autocorrelation) that accounts for aggregation at larger scales (Ord and Getis 2001).
  - *Assessment: Freely available pre- and post-treatment aerial photography of stands identified for treatment*
  - *Frequency: Immediately post-treatment (either mechanical or prescribed fire); every 10 years thereafter.*
- **Canopy Openness (Percent and Characteristics of Openings):** Because many of the treatment types being applied within 4FRI are designed explicitly to achieve a particular post-treatment percentage of canopy openness, we recommend measuring the pre- and post-treatment percentage of canopy cover (where openings = 1-canopy cover). This indicator in conjunction with the spatial aggregation statistics can help describe the degree to which 4FRI treatments are achieving "patchiness" and the degree to

which those patches vary. Also, tracking the size and orientation of forest openings is important to determine their impacts on snowpack accumulation and retention that affect soil moisture, plant-available soil water and system resilience to climate variability.

- *Assessment: Utilize USFS tools developed by the Remote Sensing and Application Center (RSAC) to process input images (NAIP, LiDAR, etc) into canopy/ non canopy patches and assess for spatial pattern (Landscape Indices, FRAGSTATS).*
- *Frequency: Immediately post-treatment (either mechanical or prescribed fire); every 3-10 years thereafter.*

### *Treatment Area-, Restoration Unit-, Analysis Area-, and Landscape-Scale Assessment*

**Tier 1b (Effectiveness) Suggested Indicators:** Patch size, patch configuration, patch diversity, and patch evenness (Table 2: Monitoring required for adaptive management).

**Threshold/ Trigger:** Because a level of uncertainty around desired patch conditions exists, the collaborative recommends no set thresholds/ triggers be set at this time. Recommend that other key indicators include linkages to develop hypotheses for patch characteristics that meet desired conditions. Indicators to link include: a. Reduce landscape fire behavior characteristics; b. Maintain sustainable wildlife habitat for the diversity of endemic species.

**Adaptive Management:** Recommend that adaptive management be tiered to linked indicators (including wildlife diversity, understory diversity and wildfire behavior) with opportunity to refine as monitoring and research data are available.

- **Patch Size (Patch area, Patch density, Patch Size Distribution):** Patch area is a fundamental quantity for understanding landscape composition that can be used both to calculate a variety of other indicators as well as model species richness, occupancy, and distribution in conjunction with field data. Patch density can be used as an index for spatial heterogeneity across a landscape, but has the added utility of being comparable across areas of differing size (e.g., comparisons between treatment areas or restoration units) (McGarigal and Marks 1995). Distribution of patch size provides information on the variability of patch sizes within a particular class (e.g., groups, openings, etc.). These data, in conjunction with mean patch size, can provide information on key aspects of landscape heterogeneity and composition, particularly as patch size changes as a result of restoration treatments. These indicators can provide an indication of the ability of restoration treatments to achieve heterogeneity (and diversity) at spatial extents beyond the stand-level and can be calculated within the freely available FRAGSTATS program (McGarigal et al. 2002).
    - *Assessment: Categorical maps (e.g., groups, openings, etc.) based on satellite imagery and/or aerial photography*
    - *Frequency: Annually to track broad-scale change*
- **Patch Configuration (Nearest neighbor distance distribution and Contagion):** These two indicators provide information on landscape configuration (i.e., the spatial arrangement of patches, treatment areas, etc.). Nearest neighbor distances that are narrowly distributed (i.e., little variation) tend to indicate a fairly even distribution of patches across the landscape. Contagion measures both the intermixing of different patch types as well as their spatial distribution. These two indicators provide a characterization of heterogeneity in terms of landscape configuration (i.e., spatial relationships among differing patch types) and has been used to characterize a variety of different landscapes (McGarigal and Marks 1995, Cushman et al. 2008). These indicators are also available within FRAGSTATS (McGarigal and Marks 1995, McGarigal et al. 2002).
    - *Assessment: Categorical maps (e.g., groups, openings, etc.) based on satellite imagery and/or aerial photography*

- *Frequency: Annually to track broad-scale change*

- **Diversity and Evenness (Simpson's Diversity and Evenness Indices):** These measures have been historically associated with estimates of species diversity; however, in this case they are being used to assess the diversity of patch types across the landscape. Simpson's diversity index represents the probability that any two randomly drawn patches will be of a different type. A higher value indicates greater diversity of patch types. Similarly, larger values of evenness indicate greater landscape diversity (i.e., less dominance by any particular patch type). FRAGSTATS implements a variety of diversity and evenness indices; however, these were selected because they are considered easier to interpret (McGarigal and Marks 1995, Magurran 2004).
  - *Assessment: Categorical maps (e.g., groups, openings, etc.) based on satellite imagery and/or aerial photography*
  - *Frequency: Annually to track broad-scale change*

**Tier 1 Suggested indicators:** Soil moisture relative to forest opening size and orientation. Forest openings, depending on their size and orientation, promote greater snowpack accumulation and retention and hence greater soil water storage (Baker and Ffolliott 2003). Deeply rooted plants, such as mature ponderosa pines, that depend on moisture from winter precipitation are expected to be the most affected by changes in snowpack.
Per-tree plant-available soil moisture is expected to be higher in thinned ponderosa pine stands than unthinned stands (Zou et al. 2008), which should promote plant vigor, resilience to climate variability and perhaps even resistance to wildfire. If, however, restoration treatments push soil moisture in the opposite direction, recognizing such a trend is critical information that can direct adjustments in treatment approaches. Monitoring of lower elevations, south facing slopes and shallow soils that are susceptible to drying are a priority.

**Threshold/trigger:** Trends of decreasing soil moisture (after adjusting for climatic variability) in stands with similar treatment types and/or physiographic characteristics.

**Adaptive management:** Evaluate treatments and make adjustments in treatment methods and forest pattern as appropriate, especially at lower elevations, on south facing slopes and on shallow soils that are susceptible to drying.

- ***Assessment:*** *Soil moisture measurements made using soil moisture probes, portable Time Domain Reflectometer (TDR) and/or gravimetric analysis at shallow and deep rooting depths according to a statistical design. Soil moisture may be analyzed within the context of a paired watershed study (see below), but additional monitoring is recommended at sensitive sites such as lower elevations, south facing slopes and shallow soils*
- ***Frequency:*** *Pretreatment, post-treatment, annually during pre- and post-monsoon water stress periods*

## *Monitoring for Composition*

Relevant Desired Conditions

I. ***Conservation of Biological Diversity:***
   - ***a.*** *Ponderosa pine ecosystems provide the necessary … composition… that contributes to the diversity of native plant and animal species…*
   - b. *Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance.*

c. *All pre-settlement trees are retained.*
d. *Understory vegetation composition and abundance are consistent with the natural range of variability.*
e. *Protect old-growth forest structure during planned and unplanned fires. [Implementation Monitoring]*
f. *Natural and prescribed fires maintain and enhance but do not degrade habitat for listed, rare, and sensitive species.*
g. *Habitat management is contributing to the recovery of listed species.*
h. *Planned an unplanned fires support diverse native understory communities and their associated biodiversity.*
i. *Populations of native species occur in natural patterns of distribution and abundance.*

II. ***Ecosystem Resilience:***
a. *There is reduced potential for introduction, establishment, and spread of invasive species. Additionally, efforts are made to reduce existing infestations.*
b. *Exotic species are rare or absent and do not create novel ecological communities following disturbance.*

*XIX.* ***Conservation and Maintenance of Soil, Water, and Air Resources:*** *Emissions factors, smoldering and smoke residence times are reduced as fires burn more grass and less green or woody biomass over time.*

### *Description and Justification*

Many Desired Conditions are specified to reflect a number of aspects of forest composition. Both the USFS Desired Conditions for ponderosa pine and 4FRI Stakeholder Desired Conditions identify certain patch components (e.g., Gambel oak (*Quercus gambelii*), snags, coarse woody debris, and old-growth) that contribute disproportionately to habitat values and the diversity of a patch or landscape (Bennetts et al. 1996, Kotliar et al. 2002, Fule et al. 2007, Bunnell and Houde 2010). In contrast, Desired Conditions for the understory and wildlife are specified both for their contributions to diversity and their ability to indicate ecosystem functionality.

Monitoring of understory composition is recommended as an indication of both ecosystem resilience and soil productivity. Reductions in overstory pine volumes can be correlated with increased understory production (Laughlin and Grace 2006, Laughlin et al. 2005, Weiher et al. 2004), and this increased understory productivity is a key assumption being used in the 4FRI NEPA analysis. However, stand replacing wildfire in ponderosa pine forests may lead to shifts toward exotic, invasive species dominance in understory plant communities (Crawford et al. 2001). Minimal or temporary increases over time in invasive species populations indicate high ecological resilience. Establishment and rapid spread of invasive species populations may lead to native species replacement and indicate low ecological resilience. Additional consideration for soil properties will be given below; however, for the purposes of this document soil productivity is interpreted as the ability of the soil to sustain native vegetation.

Many of the Desired Conditions for wildlife species are specified with respect to both viability and natural patterns of distribution and abundance. Historically, viability has been difficult or impossible to assess particularly when resources are limited due to the difficulty of gathering reliable estimates of all of the relevant population rates. Literature searches can provide a valuable starting point; however, case studies of viability rarely reveal generalizations useful for conservation management (Traill et al. 2007). As a potential solution to this issue, Flather et al. 2011 recommend focusing on those factors most likely to cause declines in a species such that it may become unviable particularly when the demographic data necessary for calculating fitness or viability are unknown. Monitoring of population response (particularly productivity and abundance) of threatened, endangered, and rare species should be focused on those areas directly impacted by treatment (e.g., Mexican Spotted Owl Protected Activity Centers within xxx distance of restoration treatments or wildfire) as these are likely to be directly impacted by the presence of personnel, equipment, and infrastructure associated with treatments and disturbance.

The majority of species affected by 4FRI are likely to be affected through changes in habitat particularly at larger scales. Site occupancy can be used in a monitoring context to reflect the current state of the population, and, through multi-season extensions, provide information on population trends. Estimating occupancy often require fewer detections than other density estimation techniques allowing for more precise estimates of rare or infrequently detected species (MacKenzie et al. 2003, MacKenzie et al. 2005). Furthermore, efforts to relate occupancy to habitat-relevant covariates allow estimation and prediction of changes in population state due to coarser-scale changes in land-use and climate (e.g., Dickson et al. 2009, Mattsson and Marshall 2009). Deriving these habitat-occupancy relationships using high-resolution satellite imagery provides the opportunity to identify the impacts of more localized changes (e.g., forest restoration treatments) across larger spatial scales.

Monitoring for forest composition will require both field measurements and sophisticated modeling techniques to determine the degree to which restoration treatments are achieving desired conditions at all scales. Given uncertainties in the response of both wildlife and invasive species, this monitoring is especially important. Many of the indicators identified below will require significant resources to assess and we recommend pursuing partnerships within the 4FRI Collaborative Group as a means to offset costs and identify opportunities for seek additional funding.

### *Site- and Group-scale Assessment*

**Tier 1b (Effectiveness) Suggested Indicators: Rare Ecosystem Elements (Springs Protection):** Forest restoration thinning has the potential to improve the hydrogeology of springs by increasing soil water storage and groundwater recharge (McCarthy and Dobrowolski 1999). Because springs create rare habitat for multiple threatened species as well as more common wildlife species, understanding the relationship between treatments and spring responses is critical for making adaptive management decisions to optimize springs restoration projects. A collaborative group with skills in spring assessment is available to assist Coconino and Kaibab National Forests in selecting springs for monitoring and restoration. Current partners in the collaboration include NAU, Grand Canyon Trust, Grand Canyon Wildlands Council and the Spring Stewards, but more partners may join in the collaboration at any time. Because important springs in the region do not always coincide with the 4FRI analysis area, we strongly encourage the USFS to monitor some springs that lie within "shelf stock" areas, such as Hoxworth Spring. Hoxworth has been monitored for several years and has hosted multiple restoration efforts. Forest thinning and burning in the Hoxworth Spring's recharge area under the 4FRI contract (but outside of the analysis area) will likely affect the hydrogeology and ecology of the spring. Establishing a fixed discharge monitoring station in the channel downstream of Hoxworth Spring is highly recommended.

**Thresholds/triggers:** 1. No net increase in facultative and obligative wetland species at springs or wet meadows targeted for both forest and spring restoration. 2. Decrease in spring discharge (adjusted for climate variation) following treatments.

**Adaptive management:** 1. & 2. Review spring restoration techniques. Review treatment methods in the recharge area. Make appropriate adjustments.

- *Assessment*
    - *Groundwater Dependent Ecosystems Protocol (USFS 2011)*
    - *Spring discharge measurements*

- *Frequency  Pre- and post-treatment,  every two years following treatment for the first 6 years after treatment, then every 5 years.*

**Tier 1b (Effectiveness) Suggested Indicators: Understory Species Composition (Percent Foliar Cover, Percent Bare Ground):** Native species composition and the percentage of bare mineral soil provide an indication of soil productivity.  In addition, restoration treatments have potential to increase abundance of native plant communities (Laughlin et al. 2006, Moore et al. 2006, McGlone et al. 2009); however, invasive plant species may also increase in cover on sites where restoration thinning, prescribed fire, and livestock grazing occur (McGlone et al. 2009). Native plant communities that are minimally disturbed during thinning or burning activities may better resist compositional shifts toward invasive species (Korb et al. 2004, McGlone et al. 2011).  While assessment at the "Group" scale is not necessary, stand-scale assessment will require field sampling that will require university and volunteer partners.

**Triggers and Thresholds**: 1. Within 5 years of mechanical treatment, change in cover should be 20+/-5% (15-25%) above controls (Laughlin et al 2011). 2. Within 5 years of treatment (mechanical and/or fire), bare soil should comprise less than 20% of area affected by treatment. 3. Within ten years of treatment, seedling and sapling density should be within 0.4 to 3.6 plants/hectare/decade on basalt soils (Mast et al 1999).

**Adaptive Management:** 1. If this threshold is not reached, then re-evaluate treatment for management change, taking into account soils and burn treatment, e.g., reduce overstory basal area. 2. If bare soil exceeds 20% of area within plots, re-evaluate restoration treatment for modification. 3. If seedlings and saplings fall below this range across sub-units where regeneration is a desired condition, then evaluate implementation of BMPs to increase probability of successful regeneration. If regeneration falls above this range, then more aggressive prescription burning may be necessary to reduce plant density.

**Tier 1b (Effectiveness) Suggested Indicators: Understory Species Composition (Invasive species)** For invasive species, prevention of invasion of 4FRI treatment areas by new species, and prevention of spread by existing species are always the first and most important management strategies. Increasing the health and resilience of native plant communities are the best ways to reduce the probability that noxious and invasive plants can spread or get established. The 4FRI Stakeholders support adherence by the USFS to Appendix B – Design Features, Best Management Practices, Required Protection Measures, and Mitigation Measures of the three National Forests' (Prescott, Kaibab, and Coconino) plan for "Integrated Treatment of Noxious or Invasive Weeds," here referred to as the Weed Plan. Because the Weed Plan applies to all lands within the three National Forests, and the 4FRI

first project area falls within a subset of elevations covered by the Weed Plan, stakeholders have shortened the

list of species most likely to be affected by management, and have changed the categories under which plant species are organized (see Table 2, Weed Plan).

- ***Watch List** -- These species are currently not known to fall within 4FRI treatment areas, and if they do show up and are detected, aggressive eradication efforts should be a top priority and applied quickly.*
  - *These species include Malta starthistle ( ), Russian olive (Eleagnus angustifolia), Himalayan blackberry (*Rubus armeniacus *and* Rubus discolor*), giant reed (Arundo donax), sulfur cinquefoil (Potentilla recta), tree of heaven (Ailanthus altissima), Siberian elm (Ulmus pumila), halogeton (Halogeton glomeratus), dyer's woad (Isatis tinctoria), Eurasian water-*

*milfoil (Myriophyllum spicatum), oxeye daisy (Leucanthemum vulgare), and Canada thistle (Cirsium arvense).*

- ***High Risk** -- These species currently have limited geographic distribution within 4FRI treatment areas, and if current inventories indicate their presence within treatment areas, these species should be eradicated immediately.*
  - *These species include leafy spurge (Euphorbia esula), camelthorn (Alhagi maurorum), yellow starthistle (Centaurea solstitalis), spotted knapweed (Centaurea biebersteinii), diffuse knapweed (Centaurea diffusa), Russian knapweed (Acroptilon repens), white top (Cardaria draba), Mediterranean sage (Salvia aethiopis), Scotch thistle (Onopordum acanthium), tamarisk (Tamarix spp.), common teasel (*Dipsacus sylvestris*), and musk thistle (Carduus nutans).*

- ***Medium Risk** -- These species have widespread distribution within 4FRI treatment areas in large populations, with either no effective treatment, or cost-prohibitive effective treatment, or for which effectiveness of current treatment strategies is unknown or not monitored. We recommend that areas should be prioritized for treatment based on risk to conservation value (presence or proximity of TES species) and areas of high wildlife habitat value (e.g., pine- sagebrush ecotones). Stakeholders also recommend that weed treatment strategies be monitored for effectiveness to gauge return on investment.*
  - *These species include Dalmatian toadflax (Linaria dalmatica), bull thistle (Cirsium vulgare), and wild oats (Avena fatua).*
- ***Cheatgrass** (Bromus tectorum) – Cheatgrass invasion of ponderosa pine systems after restoration-based treatments is a burgeoning issue of significant concern (Keeley and McGinnis*
  - *2007, McGlone et al. 2009a and b). Widespread invasion of cheatgrass often shifts invaded ecosystems into irreversible alternate stable states where cheatgrass-mediated fire intervals exclude native understory plants (Brandt and Rickard 1994, D'Antonio and Vitousek 1992, Brooks et al. 2004). Means of prevention and treatment have not been adequately tested or found successful in ponderosa pine systems, however the risk of ecological transformation caused by cheatgrass warrants aggressive monitoring and adaptive management in the 4FRI project. Preventative actions pre-treatment will be just as critical as adaptive management responses post-treatment, and **will require identification of areas at risk for cheatgrass invasion prior to project implementation, such as areas where cheatgrass is already present or ecotonal areas adjacent to existing cheatgrass populations**.*
- *Assessment: Percent cover of native and non-native species based on field sampling.*
- *Frequency: Pre- and immediately post-disturbance (i.e., mechanical thinning, prescribed fire, and wildfire); every 5 years thereafter.*

**Thresholds/ Triggers:** 1. If inventories, surveys and map checks indicate presence of 'high risk' or 'watch list' species (see narrative), follow design features, BMPs, protection measures, and mitigation measures in appendix B of the three-forest Noxious and Invasive Weed EIS prior to mechanical harvest and burning activities. Evaluate effectiveness of weed control treatments. Evaluate all BMPs, especially for cleaning equipment moving from infested sites to clean sites. 2. If inventories, surveys and map checks indicate presence of 'medium risk' species (see narrative), control these species on individual basis as control opportunities are limited, no effective weed control treatment has been identified, or weed control treatment effectiveness is unknown. See narrative. 3. As in above narrative, this indicator focuses on high risk areas where cheatgrass already exists or ecotonal areas adjacent to cheatgrass populations.

**Adaptive Management:** 1. If treatments do not reduce cover of target 'high risk' spp by 50% within 2 years, discontinue current treatment and evaluate for alternative management approach. If treatment does not eradicate or reduce cover of 'watch list' spp by 90% within 1 year, evaluate area for change in management (eg, prohibit mechanized harvest or other activities that may contribute to spread). 2. If weed control treatments do not reduce cover of target invasive spp by 20% within 5 years, discontinue current weed control treatment and evaluate for alternative management approach. 3. With regard to cheatgrass, p*otential preventative actions in **areas of high risk** could include (but should not be limited to):*

- Chemically treating and native re-seeding of small infestations of cheatgrass prior to thinning and burning
- Avoiding whole-tree skidding and other actions that cause significant soil disturbance
- Removing slash and avoiding creation of large slash piles resulting from thinning operations
- Properly manage grazing so that perennial grasses are maintained
- Deferring burns in heavily infested areas
- Delaying burns and lengthening fire return intervals post-thinning to allow native perennials time to establish
- Applying native, perennial seed (e.g., bottlebrush squirrel tail, which has shown promise in successfully competing with cheatgrass) after fire.
- Cleaning equipment and clothing after working in infested areas

If cheatgrass begins to dominate restoration sub-units after thinning and burning treatments within the 4FRI project area, we recommend delaying further treatments in areas of high risk until USFS, stakeholders and experts can be convened to evaluate alternative management options.

**Tier 1b (Effectiveness) Suggested Indicators: Habitat Suitability (Occupancy Probability):** Occupancy, in cases where sample sizes are large, can be defined as the proportion of total area occupied and can provide a useful alternative to density or abundance, especially for uncommon species (MacKenzie et al. 2006). More generally, occupancy also can be interpreted as the probability of locating an individual of species *x* in location *y*. This interpretation (probability of occupancy) reflects an a priori expectation that a site will be occupied based on a hypothesis about the underlying process determining occupancy. The former interpretation (proportion of area occupied) is the realization of that process, given large sample sizes (MacKenzie et al. 2006). Higher probabilities of occupancy may be interpreted to indicate more "use" of a habitat by a particular species. Information on songbird occupancy (based on existing Rocky Mountain Bird Observatory Data) will be necessary for evaluating changes in songbird species richness and its associated adaptive management strategy. As this information becomes available, triggers/ thresholds and adaptive management recommendations will be developed through a collaborative, iterative process.

- *Assessment: Field surveys of presence & absence at both treated and untreated sites*
- *Frequency: Immediately post-treatment and every 2 years thereafter*

**Tier 1b (Effectiveness) Suggested indicator: Songbird Species Richness (Jackknife2, Chao 2, or ICE Species Richness Estimator,):** While estimating the changes in the aforementioned forest structural components provides some indication of how 4FRI treatments may be contributing to diversity goals, documenting the ways in which restoration treatments facilitate ponderosa pine forests contribution to native diversity ultimately requires knowledge of how diversity is changing over time. We anticipate that the abundance of species will change due to treatment and recommend the use of incidence, or occurrence-based estimators as a way of documenting the actual change in the number of species. These incidence based species richness estimators have been shown to be more accurate and potentially less biased than historical estimators of species richness (e.g., Shannon's Index, Simpson's Diversity Index) (Walther and Moore 2005). These estimators can be computed within EstimateS, (*http://viceroy.eeb.uconn.edu/estimates)*, a freely available diversity-estimation software program, using existing, ongoing surveys conducted by Rocky Mountain Bird Observatory in conjunction with the Forests. As this information becomes available, triggers/ thresholds and adaptive management recommendations will be developed through a collaborative, iterative process.

- *Assessment: Field sampling of communities of interest (e.g., songbirds)*
- *Frequency: Immediately post-treatment (either mechanical or prescribed fire); every 3-5 years thereafter.*

**Tier 2 Suggested Indicators: Rare Ecosystem Elements (Percent Cover of Gambel Oak, Aspen, and other Riparian Communities):** Oak, aspen, and riparian areas contribute heavily to the diversity of ponderosa pine forests in the Southwest. For example, pine-oak forests tend to have a greater diversity of songbirds and small mammals than ponderosa forests that lack an oak component (Block et al. 2005, Jentsch et al. 2008). Removal of overstory competition from ponderosa pine and more regular low-severity fire are likely to alter the cover and composition of the oak component within treated stands. Removal of ponderosa pine competition may also encourage aspen regeneration and increase the size of riparian communities due to increases in available water. We recommend assessing the percent cover of these rare ecosystem elements prior to treatment and tracking its subsequent response to restoration treatments.

- *Assessment: Rapid assessment conducted while collecting diameter distribution data (or use of aerial imagery once techniques become available)*
- *Frequency: Immediately post-treatment (either mechanical or prescribed fire); every 5 years thereafter*

**Tier 2 Suggested Indicators:** Snags, old trees, rare ecosystem elements, understory species composition; responses of rare, sensitive, threatened, and endangered species; habitat "suitability", species richness, evenness

- **Snags (Number, Size Distribution, Condition):** We recommend measuring the number and size of snags present within treated sites due to their role in providing valuable habitat for a variety of wildlife species (e.g., Kotliar et al. 2002, Miller and Chambers 2007, Hurteau et al. 2010) and the potential for restoration treatments to alter snag composition within treated sites (Bagne et al. 2008, Hessburg et al. 2010). In addition, assessing the condition of the snags (sound vs. soft) can provide an indication of the expected longevity for those snags.
  - *Assessment: Rapid assessment conducted while collecting diameter distribution data*
  - *Frequency: Immediately post-treatment (either mechanical or prescribed fire); every 5 years thereafter.*
- **Old Trees (Number of Old Trees):** The 4FRI Landscape Strategy places a large emphasis on pre-settlement trees. Furthermore, higher levels of biodiversity have been attributed to those areas

that still contain old-growth components (Binkley et al. 2007) and these components may be susceptible to mortality immediately post-treatment (Fule et al. 2007, Roccaforte et al. 2010). Evidence suggests,

however, that this mortality can be avoided through a variety of "protection" measures and that over time restoration treatments can increase the vigor of old trees (Kolb et al. 2007).Thus, we recommend counting the number of old-growth trees present on sites prior to treatment and tracking responses to treatment.

- *Assessment: Rapid assessment conducted while collecting diameter distribution data*
- *Frequency: Immediately post-treatment (either mechanical or prescribed fire); every 5 years thereafter*

### *Treatment Area-, Restoration Unit-, Analysis Area-, and Landscape-Scale Assessment*

**Tier 1b (Effectiveness) Suggested Indicators: Response of Rare, Threatened, and Endangered Species (Population trends):** Treatments conducted under 4FRI may affect rare, threatened, or endangered species through a variety of mechanisms and at a variety of scales. This is particularly true for wildlife species such as the Northern Goshawk and Mexican Spotted Owl. Understanding the effects of treatment on productivity (and thus viability) of these species likely requires a research effort beyond the scope of the monitoring proposed here. We recommend that the USFS adopt the population monitoring proposed under the new Mexican Spotted Owl Recovery Plan and expand the Northern Goshawk monitoring program being developed by NAU's Lab of Landscape Ecology and Conservation Biology (LLECB) and the KNF across the 4FRI region. The stakeholders anticipate working with the experts developing these programs to identify appropriate thresholds and adaptive management options.

- *Assessment: USFS protocols with protocols developed by MSO Recovery Team and LLECB/KNF*
- *Frequency: In accordance with the aforementioned protocols.*

**Tier 1b (Effectiveness) Suggested Indicators: Wildlife Response (Landscape Predictions of Songbird Species, Richness,):** Field assessment of these indicators (with the exception of connectivity) can be used in conjunction with remotely sensed habitat covariates to track changes at larger scales and provide information on landscape distribution patterns. Additionally, hierarchical modeling could provide a multi-scalar inference by using other information collected from other field assessments identified here. These models can be used to create "map-based" depictions of occupancy and richness that can then be summarized at multiple scales. Development and subsequent validation of these models will be especially critical for threatened, endangered, sensitive, and rare species and will likely require partnership with research institutions. Ongoing field assessment of songbird populations and the subsequent ability to estimate occupancy as a function of forest structural covariates will be critical for this indicator.

**Thresholds/ Triggers:** 1. Any non-zero decline over a 5-year period.

**Adaptive Management:**

a. Songbird Species Richness: If a 5 year decline is evident, the data will be evaluated to identify the species "responsible" for the decline and group them according to the categories below. Grouping will be empirically determined by modeling species probability of occupancy as a function of forest structural attributes. If the species does indeed respond to changes in forest structure (as determined through the modeling process) then the following actions are recommended:

b. Closed canopy species: Increase group density for all treatments by xx/ac**; Increase group size for all treatments [based on AGFD experiment]; Reduce intensity of all UEA 40-55 treatments; Identify 25% of planned UEA 40-55 treatments and reduce intensity to 25-40; ** TBD from empirical relationship between species incidence and forest structure.
c. Open canopy species: Increase the size of openings in all treatment types; Identify 25% of planned UEA 25-40 treatments and increase intensity to 40-55%
d. Pine-sage species: Alter timing of treatment to reduce impacts on sage; Delay post-treatment burning to allow sage recover.

- *Assessment: Field sampling in conjunction with remote sensing*
- *Frequency: Annual interpretations of new satellite imagery*

**Tier 1b (Effectiveness) Suggested Indicator:** Changes in landscape connectivity and permeability for several species representing closed canopy (black bear OR grey fox) and open canopy (pronghorn) conditions. Building connectivity models for species that are predicated on various aspects of patch structure, density, and orientation provides an opportunity to evaluate the effects of landscape heterogeneity on a key ecosystem process. Furthermore, these models can be validated through the use of telemetry studies a property not shared by fire models (our other landscape metric). While a variety of factors can and do influence connectivity, the models will be formulated to reflect specific hypotheses related to landscape structure.

**Thresholds/ Triggers:**
1. Restriction of bear/fox movements (reduced connectivity between patches of untreated, higher density, or pine-oak) when comparing pre- to post-treatment.
2. For pronghorn, no increase in pronghorn movement when comparing pre- to post-treatment.

**Adaptive Management:**
1. Bear/fox: increase group size, decrease treatment intensity within known pathways
2. Pronghorn: increase opening percentage, increase treatment intensity within known pathways

**Tier 2 Suggested Indicators: Invasive Species Response (Number, Size, and Percent of Landscape with Invasive Species):** Understory responses are typically monitored using field-based methods, although high-resolution imagery may be effective. Spatially explicit monitoring will track locations and dynamics of invasive populations.

- *Assessment: Field sampling in conjunction with remote sensing*
- *Frequency: Immediately post-treatment; five years post-treatment, ten years post-treatment*

## Biophysical Monitoring for Function (or Process)

***Relevant Desired Conditions***

*I.* ***Conservation of Biological Diversity:***

a. *Ponderosa pine ecosystems provide the necessary … processes…that contributes to the diversity of native plant and animal species…*
b. *Natural disturbance processes (e.g., fire, drought-mortality, endemic levels of forest pests and pathogens) are the primary agents shaping forest ecosystem structure, dynamics, habitats, and diversity over time.*
c. *There is low potential for unnaturally severe fire to spread across the Restoration Unit.*
d. *Wherever practicable, natural fire regimes regulate forest structure and composition.*
e. *Planned and unplanned fires support diverse native understory communities and their associated biodiversity.*

II. ***Ecological Resilience:***

a. *Ponderosa pine ecosystems in the 4FRI are capable of adapting to or persisting with climate change without rapid, large scale type shifts.*
b. *Low intensity frequent fire operates as the primary natural process maintaining forest structure and function.*
c. *Mixed severity fire is sometimes used as a restoration tool in appropriate ecological and social settings (e.g., non-WUI areas) to restore and maintain natural forest types[Implementation Monitoring – not addressed in this document]*
d. *Forest insects and pathogens occur and operate at endemic levels.*
e. *Ponderosa pine ecosystems in the 4FRI are capable of regeneration and recovery following natural disturbance (e.g., fire, outbreaks of insects and pathogens).*
f. *A majority of the ponderosa pine ecosystems supports frequent, low-intensity fire.*
g. *Mixed severity fire is used as a restoration tool where it is consistent with reference conditions and safe to do so. [Implementation Monitoring – not addressed in this document .*
h. *Natural disturbance processes (e.g., fire, endemic pests, and pathogens) are within the natural range of variability.*
i. *Strategically placed treatments allow fire managers to safely manage planned and unplanned natural ignitions fires in a way that benefits and enhances the resilience of forest ecosystems.*
j. *Restoration results in forests that are trending toward natural variability, self- regulating, and positioned to adapt to climate change without large, rapid type shifts.*

III. ***Conservation of Soil, Water, and Air Resources****:*

a. *Soil productivity, watershed function, and air quality are not at risk of being degraded by uncharacteristically severe disturbances (e.g., landscape level high- severity fire).*
b. *Sensitive soils are protected through use of appropriate timber harvesting equipment and techniques to reduce erosion and sedimentation that could otherwise damage aquatic life, increase flooding, reduce reservoir capacity, and increase costs of maintaining infrastructure in the vicinity of waterways. [Implementation Monitoring]*
c. *Fire is used as a management tool to support hydrologic function while minimizing impacts to soils and other natural resource values. [Implementation Monitoring]*
d. *Rare and ecologically valuable springs and wet meadows are protected and enhanced*

*through appropriate restoration treatments where needed.*

e. *Ponderosa pine vegetation treatments are implemented so as to minimize negative impacts to water quality, soil productivity, and air quality. Short- term impacts are minimized through the implementation of best management practices and strategies.*

f. *Restored ponderosa pine ecosystems accommodate natural and other fires without uncharacteristic impacts to soil productivity and or watershed resources.*

g. *Ponderosa pine vegetation within the analysis area is managed strategically and at a level appropriate to prevent degradation of air quality beyond regulatory standards (through wildland fire or managed fire).*

h. *Hydrologic processes are re-established to restore springs and wet meadow ecosystems.*

i. *Strategically placed treatments allow fire managers to manage planned and unplanned fires in locations, seasons and conditions that maximize smoke dispersion and minimize smoke impacts.*

j. *Stable, restored ecosystems foster watersheds that yield enhanced water quantity and quality and are resilient to climatic variability.*

## *Description and Justification*

The majority of 4FRI Desired Conditions focus on the need to maintain ecosystem processes within the natural range of variability. While the Desired Conditions are numerous, indicators for assessing them fall into several major categories: ecosystem type shifts, fire size and severity, forest pests and pathogens, soil stability and sedimentation, and the generation of smoke.

An ecosystem that is resilient shows persistence in relationships and low probability of extinction (Holling 1973). A resilient system absorbs fluctuations in state variables (e.g., population numbers) and processes. Persistence and return of characteristic ecosystem structure and function following disturbance indicate high ecological resilience. Rapid, large-scale type shifts indicate low ecological resilience.

Future climate models for the southwestern United States predict warmer and drier conditions (Seager et al. 2007). Potential impacts of climate changes include increased tree morality as a function of drought, fire, and pathogens. In addition, tree regeneration may be affected by loss of seed trees and drought-induced seedling mortality. Potential impacts of climate change are likely to be exacerbated under current forest conditions. Restoration treatments in ponderosa pine forests have the potential to increase growth and vigor of residual trees, lower potential for crown fire, provide growing space and microsites for tree regeneration, and increase available resources for native plant communities (Laughlin et al. 2006, Kolb et al. 2007, Roccaforte et al. 2008). Such effects are likely to buffer the ecosystem against climate change and enhance resilience at fine to coarse scales (Fulé 2008).

Ponderosa pine forests were historically resilient and persisted under a frequent, low-intensity fire regime. Current forest conditions are outside the historical range of variability in terms of tree density and structure. Fire under current structural conditions has greater potential to be stand-replacing, indicating conditions of low ecological resiliency. Restoration treatments that reduce forest density and fuel loading can in turn reduce potential for stand-replacing crown fire (Fulé et al. 2001, Roccaforte et al. 2009).

Ponderosa pine trees are coevolved with native insect herbivores and pathogens. Forests with endemic levels of insects and pathogens do not experience large-scale and long-term type shifts. Epidemic levels of insects and pathogens may lead to rapid ecological shifts, which represents conditions of low ecological resilience.

Bark beetles, dwarf mistletoe, and to some extent root diseases are the major damaging insects and pathogens of ponderosa pine forests (Wilson and Tkacz 1996). Overly dense forest conditions may lead to increased susceptibility to these agents and result in extensive tree mortality (Wilson and Tkacz 1996, Negrón et al. 2000). Restoration thinning can enhance tree resistance to various insects and pathogens (Kolb et al. 2007). Severe fire effects, whether from prescribed burning or wildfire, can increase susceptibility to damaging insects and pathogens (McHugh et al. 2003).

Hydrologically, there are five fundamental watershed functions, and two secondary functions: (1) collection of the water from rainfall, snowmelt, and storage that becomes runoff, (2) storage of various amounts and durations, (3) discharge of water as runoff (4) sediment transport, and (5) groundwater recharge. In fact, the first and third of these functions have long been incorporated in the commonly-used terms, "catchment" and "watershed"; storage is the inevitable consequence of water being detained within an area between "catching" and "shedding." Ecologically, the watershed functions in two additional ways: (1) it provides diverse sites and pathways along which vital chemical reactions take place, and (2) it provides habitat for the flora and fauna that constitute the biological elements of ecosystems. Large, uncharacteristically severe wildfires such as the Rodeo- Chediski, Schultz and Wallow have had deleterious effects on watershed function through downcutting of channels, soil erosion, and excessive sediment transport (Gottfried et al. 2003, Moody and Martin 2009). Mechanical thinning and prescribed burning can help maintain hydrologic function of ponderosa pine forests. Yet, side effects of restoration treatments, such as soil compaction from heavy equipment and fire-related damage to the soil biotic community and soil nutrient balance, must be monitored to inform adaptive management.

Smoke is a natural consequence of ponderosa pine forest material combustion, and can be managed through a variety of prescribed conditions that managers use in controlling fire, including fuel moisture content, fuel loading and arrangement, air temperature, relative humidity, wind direction and speed, and seasonality of burn (lower atmosphere ventilation). Smoke from forest combustion is also a contributor to visual haze, and the timing, amount, and quality of its generation from controllable sources such as prescribed burns is regulated by the Arizona Department of Environmental Quality (ADEQ) because of smoke's impacts on human health. While restoration activities accomplished by 4FRI will generate a substantial amount of smoke, coordinated efforts to manage underlying and prescribed conditions will help to mitigate the amount and quality of smoke released, and reduces total impacts on air quality.

With the exception of tree mortality and regeneration dynamics, the ecosystem processes described above operate at broad scales. Thus, assessing progress towards Desired Conditions will require a variety of remotely sensed and modeled data to interpret the effects of restoration treatments within the context of the larger landscape. Developing more robust and accurate models of these processes will benefit greatly from information gathered as part of a field sampling effort.

### *Site- and Group-level Assessment*

**Tier 1b (Effectiveness) Suggested Indicators: (None at this scale, see Treatment Area-, Restoration Unit-, Analysis Area-, and**
**Landscape-Scales Assessment).**

**Tier 2 Suggested Indicators:** Tree mortality, regeneration, insect pathogen dynamics, fuel hazard

- **Tree Mortality (Stand Density, Basal Area, and Species Composition):** Monitoring for desired conditions with respect to ecosystem type shifts should focus on tree mortality and tree regeneration. Values for stand density, basal area, and percentage species composition can be used to track tree mortality as well as contribute to determining effects of restoration treatments on fire behavior.

- *Assessment: Field sampling within treated sites*
- *Frequency: Immediately post-treatment, every five years thereafter*

- **Regeneration (Density of Seedlings, Poles and Saplings):** Regeneration is the second critical component of determining whether type shifts are occurring. While these measurements require field sampling, it is not possible to assess regeneration accurately using remote sensing technology.
  - *Assessment: Field sampling within treated sites*
  - *Frequency: Immediately post-treatment, every five years thereafter*
- **Insect and Pathogen Dynamics (Bark Beetle Rating, Dwarf Mistletoe Rating, and Number of Trees Affected by Pests/Pathogens):** Monitoring of insects and pathogens should focus on levels of tree mortality as described above. In addition, bark beetle and mistletoe rating systems (Hawksworth 1977, Sánchez-Martínez and Wagner 2002) should be used in field plot measurements in order to track changes in levels of occurrence.
  - *Assessment: Field sampling within treated sites*
  - *Frequency: Immediately post-treatment, every five years thereafter*
- **Fuel Hazard (Crown Bulk Density, Crown Base Height, and Surface Fuel Loading):** Monitoring of forests' potential to support frequent, low-intensity fire should be focused on structural conditions and fuel loading. Data to assess these conditions can be obtained from satellite imagery, although ground truth and calibration plots are likely to be necessary. Thus, we recommend collecting crown bulk density, crown base height, and surface fuel loadings as part of a field sampling program.
  - *Assessment: Field sampling within treated sites*
  - *Frequency: Immediately post-treatment, every five years thereafter*

### *Treatment Area-, Restoration Unit-, Analysis Area-, and Landscape Scales*

**Tier 1b (Effectiveness) Suggested Indicators:** Fuel/fire hazard, fire occurrence, soil and watershed function

- **Fuel/Fire Hazard (Crown Bulk Density, Crown Base Height, Surface Fuel Loading, and Predicted Fire Behavior):** These indicators allow assessment of the ability of restoration treatments to meet strategic goals with respect to large-scale, uncharacteristically severe fire. These indicators can be calculated using Landsat imagery. Alternatively, coarse estimates can be obtained freely from the LANDFIRE Program.

**Thresholds/ Triggers;** (based on predicted fire behavior only): Percent land area of Fire Regime I vegetation types in first EIS showing predicted passive or active crown fire potential is still > 25% after first 5 yrs and > 10% after 10 yrs.

**Adaptive Management:** Re-evaluate potential causes: acres treated, treatment prescriptions; develop adaptive management based on lessons learned.

- *Assessment: Remote Sensing information*
- *Frequency: Immediately post-treatment; every 5 years thereafter*

- **Fire Occurrence (Severity and Size of Fires, Acres of High Severity Fire, Total Acres Burned,):** As restoration progresses, the size and severity of wildfire should decrease. Use of freely-available information from the Monitoring Trends in Burn Severity program and Forest-level databases on managed fire can be used to assess how treatments affect size and severity of fires. It should be noted that this assessment is limited to those portions of the landscape where restoration treatments are complete.

**Thresholds/ Triggers;** (based on predicted fire behavior only): Patch size of adjacent pixels expressing stand replacement fire sizes: max size 50 acres for first 5 years and max size 10 acres after 10 years; patches greater than suggested sizes serve as trigger for adaptive management.

**Adaptive Management:** Re-evaluate potential causes: acres treated, treatment prescriptions; develop adaptive management based on lessons learned.

- *Assessment: Monitoring Trends in Burn Severity data*
- *Frequency: Available annually for all fires larger than 1000 acres*

**Tier 1b (Effectiveness) Suggested Indicator: Soil & Watershed Function** (**Water Balance):** An important component of forest restoration is to understand the link between forest health or functionality and provision of ecosystem services such as water discharge to human communities. Whereas paired watershed studies in Arizona's ponderosa pine forests have previously established that thinning can increase surface water yield for a period of 6-10 years (Baker 2003), none of the previous treatment types were consistent with restoration treatments, no studies examined the effects of follow-up treatments (eg. re-establishment of the natural fire return interval), and none of the previous studies quantified effects on recharge to shallow or regional groundwater aquifers. Also, none of the previous treatments were on a scale of 4FRI, had the potential to significantly impact regional water availability or provided the opportunity to adapt to climate change. A new paired watershed study is an appropriate means to monitor water resources effects due to the scope and scale of 4FRI and to inform essential adaptive management.4FRI treatments provide the opportunity for us to understand the effects of large-scale treatments on water quality and quantity through a series of paired watersheds that are treated and untreated, and the resulting watershed function quantified through a water balance determination – including quantification of precipitation, snow water equivalence (SWE), soil moisture, evapotranspiration (ET), water runoff, and groundwater recharge. Sediment discharge should also be measured to understand soil loss through erosional processes, as would surface water quality be monitored, including turbidity and total organic carbon which may be directly affected by treatments and impact downstream water users. The proposed paired watershed study would be a collaborative effort of NAU, ERI, Salt River Project and potentially other partners. The researchers request that two experimental watersheds in the Lake Mary watershed and 2 experimental watersheds in the middle Sycamore watershed have their prescriptions converted to “Evidenced-based Full Restoration” (Moore et al. 1999) for the purposes as assessing the full range of treatment alternatives that may benefit forest health in Northern Arizona.

**Threshold/triggers:**

- Static or decreasing soil moisture
- Static or decreasing surface water discharge
- Diminished water quality (esp. increased turbidity or total organic carbon)
- Increased water stress (after accounting for climate variability)

**Adaptive management:** Implement mitigation measures, reevaluate treatment methods and/or BMPs, and make adjustments.

- *Assessment:*
  - *Field data collection - some SWE and soil moisture data*
    - *Automated data collection - weather stations, precipitation sampling, soil moisture probes,ET, stream gages, water quality probes, water quality autosampler*
    - *Laboratory analysis - precipitation and runoff water quality (Chloride balance of*

*precipitation and runoff can be used to estimate ET and groundwater recharge. Turbidity and total organic carbon (TOC) measure soil erosion due to thinning and fire treatments)*

- *Remotely sensed data(potentially) - SWE, soil moisture, ET and groundwater*
- *Frequency: Immediately pre- and post-treatment; annual summary each year following treatment with biennial recommendations after 3 years monitoring*

**Tier 1b (Effectiveness) Suggested Indicator: Soil & Watershed Function** (**Sensitive Soils Protection):** Highly and moderately erodible soils and slopes are classified within the Terrestrial Ecosystem Survey Units (TESU). Forest management activities are planned to avoid impacting these areas to reduce compaction, erosion, and sediment transport downstream. TESU maps can be overlain with management activity maps to ensure that protection has occurred, and field plots could sample areas where mitigation measures were implemented to assess the percentage of area that has been affected.

While the USFS Soil Disturbance Protocol (Page-Dumroese et al. 2009a and 2009b) is very useful for evaluating soil impacts from operator actions and for guiding BMPs and mitigation, it is a qualitative classification system and as such does not provide quantitative data that can be used in statistical analyses of trends , necessary for an understanding of broader treatment impacts (DeLuca and Archer 2009) . The addition of simple, inexpensive quantitative methods will strengthen long -term monitoring and adaptive management.

**Thresholds/ Triggers:**

- Soil disturbance is > 15% of treated area.
- Trends of increasing bulk density
- Trends of decreasing infiltration rates.

**Adaptive Management:** Implement mitigation measures . Re-evaluate treatment methods and /or BMPs. Make adjustments based on lessons learned.

- *Assessment:*
  - *Remotely sensed data, TESU maps, field plots*
  - *Forest Disturbance Protocol 2009 (WO 82A and WO 82B) that is utilized as part of contract oversight*
  - *Additional quanti tative tests such as bulk density and infiltration capacity collected according t o a statistical design.*
- *Frequency: Immediately post -treatment and every 5 years thereafter , with more frequent follow -up in heavily impacted places to assess recovery.*

**Tier 1b (Effectiveness) Suggested Indicator: Soil & Watershed Function (Soil Productivity):** Multiple effects of forest management actions can cause reduction in the ability of plants to uptake nitrogen from soil, as indicated by a shift in the C:N ratio (Steve Overby personal communication 2012). Testing C:N ratios is a simple and inexpensive way of tracking soil productivity. Soil productivity can be impacted by restoration activities, especially where soils and soil organisms are disturbed by mechanical treatments and prescribed fire (Owen et al. 2009). Also, changes in forest pattern that affect insolation and soil moisture can change biochemical processes that influence the balance of soil nutrients (Paul and Clark 1996). Because soil nutrition is fundamentally important for plant metabolism, tracking soil nutrition is an effective approach for assessing the suitability of restoration treatments for improving forest health.

**Threshold/trigger:** C:N ratios increasing from 12-14 toward 30, indicating a reduction in nitrogen availability that would impact plant productivity

**Adaptive management:** Evaluate treatments in light of soil processes and make adjustments in treatment methods and forest pattern.

- ***Assessment:*** *Test carbon- to-nitrogen ratios from soil samples collected according to a statistical design*
- ***Frequency:*** *Pre-treatment, post-treatment, annually in the first 3 years if a shift in C:N is found following treatment until ratio recovers or stabilizes, otherwise every 5 years.*

**Tier 2 Suggested Indicators:** Tree mortality, Airshed function

- **Tree Mortality (Canopy Cover, Number of Pathogen-affected Patches, Size of Mortality Patches, and Percent of Landscape in Mortality Patches)**: These indicators are necessary to assess changes in mortality dynamics across the larger 4FRI landscape particularly those that result from endemic pests and pathogens. Freely available data from the National Agricultural Image Program (NAIP) and the National Forest Health Monitoring (NFHM) Program can be used to generate these estimates.
  - *Assessment: NFHM assessment and NAIP imagery*
  - *Frequency: NFHM data is available annually, NAIP imagery is available every 3 years*

- **Airshed Function (Air Quality):** There are air quality attainment goals for each geographical "airshed" dictated by ADEQ. Several measures could be used to qualitatively assess 4FRI prescribed burning activities' contributions toward attainment of those goals: %prescribed burns within prescriptions that reduce smoke generation, % (by area) of prescribed fires conducted during high ventilation periods (May -September), modeled outputs of smoke from piles burned (grams/hectare treated), modeled outputs of smoke from broadcast burns (grams/hectare); modeled output of smoke avoided from uncharacteristic wildfire (grams/hectare)
  - *Assessment: Model runs, ADEQ attainment or exceedance ranking*
  - *Frequency: During prescribed and other burns*

# *Monitoring Tiers*

Following the selection of indicators that best address the Desired Conditions described in the 4FRI EIS for the First Analysis Area, we incorporated Stakeholder perspectives to clarify indicator ranges for both desirable as well as undesirable conditions.   The mandatory multiparty effectiveness monitoring for the 4FRI project is identified in Table 2 (Tier 1b).  These items and their associated thresholds and subsequent management actions make up the core of the 4FRI Adaptive Management Strategy. These items must be monitored to mitigate the risks of unintended consequences and ensure that treatments are placing the landscape on a trajectory towards Desired Conditions.  Resources (both those contributed from CFLRP funding and those contributed by the Stakeholder Group) will be dedicated to these items first.  Future management actions will be modified in accordance with the “subsequent management actions column” when monitoring information indicates that a threshold has been crossed.

The pace and scale of 4FRI is likely to affect many aspects of the ponderosa pine ecosystems in northern Arizona.  It is understood that the USFS cannot commit to monitoring all of these effects without collaborative partners.  We recognize that management can be greatly improved with additional information on some ecosystem aspects.  Table 3 lists these critical multiparty effectiveness monitoring items (Tier 1b, 2 and 3).  Here, the “subsequent management actions” column identifies potential changes to management actions should the data be available.   Collaborative effort will continue to update the trigger/ thresholds and adaptive management in this monitoring subset as data becomes available.

Table 2: Tier 1a Suggested Indicators: Mandatory multiparty monitoring needed for adaptive management.

| Indicator # | Monitoring Tier | Ecological Framework | **Desired Condition or Resource and monitoring Questions** | **Indicator** | **Indicator Metric** | **Method & Sampling Techniques** | **Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape** | **Trigger (Threshold indicating possible need for change)** | **Adaptive Management** | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | ***Responsible Partner*** | ***Annual Cost Estimate*** | ***Cost per Task Order? or Work Plan annual cost - 15,000 acres*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 1a & 1b | Composition | Effects to Threatened or Endangered Species are within those disclosed in the Biological Assessment for the 4FRI project | USFWS Biological Opinion | Various | Approved protocols as described in the Biological Opinion | Fine and Broad Scale | As described in the Biological Opinion for this project | As described in the Biological Opinion for this project and subsequent consultation | Y | Y | N | Y | Y | | *USFS* | *MSO survey $10/acre; PAC survey $175* | |
| **2** | 1a & 1b | Composition | Effects to Regional Forester designated Sensitive species within those disclosed in the Sensitive Species Biological Analysis/Evaluation for the project | Forest trends | Various habitat and species monitoring | Approved Region 3 protocols | Fine and Broad Scale | When forest trends indicate a need for listing under the Endangered Species Act. | As appropriate in consultation with USFWS | Y | Y | N | Y | Y | | *USFS* | *NOGO PFA $150, Habitat survey $15/acre; Leopard Frog $75/location* | |
| **8** | 1a & 1b | Process | Ephemeral Channels – restore the functionality of 32 miles of ephemeral streams (USDA 1987). | Miles of stream channels restored | Acres of vegetation maintained and improved. | Resource specialist determinations | Broad Scale | 0 miles/acres of ephemeral channels restored | Implement ephemeral channel restoration when possible | Y | Y | | Y | | | *USFS* | *Covered by FS Administrati ve PCF $150/year* | |
| **3** | 1a | Composition | Management strives to achieve a "no Effect" or "no adverse effect" determination for cultural resources | Post treatment site monitoring | Unanticipated site damage | Survey a sample of known sites within a treatment area to determine effectiveness of mitigation measures | Fine Scale | When mitigation measures are determined to be ineffective at protecting cultural resources | Shift mitigation techniques as appropriate | Y | | N | Y | *Y* | | *USFS* | *$125/site* | |
| **4** | 1a | Composition | Restore decommissioned road prisms to a natural condition | Miles of road decommission ed | Miles of road decommissioned | Quantify miles of road effectively decommissioned through treatment of all or portions of existing roadbeds | Broad Scale | No miles of road decommissioning annually | Implement road decommissioning | Y | Y | N | Y | | | *USFS* | *Covered by FS Administrati ve* | |
| **5** | 1a | Composition | Temporary roads are decommissioned after use | Miles of temporary road decommission ed | Miles of temporary road decommissioned | Quantify miles of temporary road decommissioned | Broad Scale | 0 miles of temporary road decommissioning annually | Implement temporary road decommissioning | Y | Y | N | Y | | | *USFS* | *Covered by FS Administrati ve* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6** | 1a | Composition | Existing roads are not contributing to adverse watershed effects | Miles of road reconstructed or relocated | Road reconstruction or relocation is consistent with the EIS for this project | Miles of road reconstructed or relocated | Broad Scale | 0 miles of road relocated or reconstructed | Implement road relocation or reconstructions | Y | Y | N | Y | | | *USFS* | *Covered by FS Administrati ve* | |
| **7** | 1a | Process | Springs-maintain necessary soil, water and vegetation attributes to be healthy and functioning at or nearly potential. Waterflow patterns, recharge rates and geochemistry would be similar to historic levels and persist over time. Water quality and quantity would maintain native aquatic and riparian habitat and water for wildlife and designated beneficial uses, consistent with water rights and site capability. | Acres of spring habitat improved | Acres of prescribed fire in spring habitat | | Fine and Broad Scale | | | | | | | | | | *$150 to $1000 per site dependent on partner costs* | |
| **7** | 1a | Process | Springs-maintain necessary soil, water and vegetation attributes to be healthy and functioning at or nearly potential. Waterflow patterns, recharge rates and geochemistry would be similar to historic levels and persist over time. Water quality and quantity would maintain native aquatic and riparian habitat and water for wildlife and designated beneficial uses, consistent with water rights and site capability. | Acres of spring habitat improved | Miles of spring habitat protective measures installed | | Fine and Broad Scale | | | | | | | | | | | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7** | 1a | Process | Springs-maintain necessary soil, water and vegetation attributes to be healthy and functioning at or nearly potential. Waterflow patterns, recharge rates and geochemistry would be similar to historic levels and persist over time. Water quality and quantity would maintain native aquatic and riparian habitat and water for wildlife and designated beneficial uses, consistent with water rights and site capability. | Acres of spring habitat improved | Acres of trees removed to presettlement conditions from spring habitat | Resource specialist review and determination | Broad Scale | 0 acres of spring habitat improved | Implement spring habitat improvement when possible | Y | Y | | Y | | | *USFS* | *Covered by FS Administrative PFC $150/year* | |
| **8** | 1a | Process | Ephemeral Channels – restore the functionality of 32 miles of ephemeral streams (USDA 1987). | Miles of stream channels restored | Acres of tree encroachment reduced | | Fine and Broad Scale | | | | | | | | | | *Covered by FS Administrative PCF $150/year* | |
| **9** | 1a | Composition | Springs and Aspen – Protective fencing | Miles of protective fencing | Miles of protective fencing | Resource specialists measurements | Fine and Broad Scale | 0 miles of protective fencing constructed | Evaluation of need for fencing | | | | Y | | | *USFS* | *Covered by FS Administrative: $150/year* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11** | 1b | Structure | There is reduced potential for introduction, establishment, and spread of invasive species. Additionally, efforts are made to reduce existing infestations. | Invasive Plants | Species cover | Field & Remote Sensing (RS) | Fine Scale | If inventories, surveys and map checks indicate presence of 'high risk' or 'watch list' species (see narrative), follow design features, BMPs, protection measures, and mitigation measures in appendix B of the three-forest Noxious and Invasive Weed EIS prior to mechanical harvest and burning activities. Evaluate effectiveness of weed control treatments. Evaluate all BMPs, especially for cleaning equipment moving from infested sites to clean sites. | If weed control treatments do not reduce cover of target 'high risk' spp by 50% over pre-treatment data within 2 years, evaluate for alternative management approach. If treatment does not eradicate or reduce cover of 'watch list' spp by 90% within 1 year, evaluate area for change in management (eg, prohibit mechanized harvest or other activities that may contribute to spread). | Y | Y | N | Y | Y | Y | *USFS & Partners* | *$80/acre* | |

| **Indicator #** | **Monitoring Tier** | **Ecological Framework** | **Desired Condition or Resource and monitoring Questions** | **Indicator** | **Indicator Metric** | **Method & Sampling Techniques** | **Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape** | **Trigger (Threshold indicating possible need for change)** | **Adaptive Management** | **FS Plan Req.?** | **CFLRP requirement?** | **Stew. Contract req.?** | **Implementation Mon.** | **Short term effects Mon.** | ***Long term effects Mon.*** | ***Responsible Partner*** | ***Annual Cost Estimate*** | ***Cost per Task Order? or Work Plan annual cost - 15,000 acres*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11** | 1b | Structure | There is reduced potential for introduction, establishment, and spread of invasive species. Additionally, efforts are made to reduce existing infestations. | Invasive Plants | Species cover | | Fine Scale | If inventories, surveys and map checks indicate presence of 'medium risk' species (see narrative), control these species on individual basis as control opportunities are limited, no effective weed control treatment has been identified, or weed control treatment effectiveness is unknown. See narrative. | If weed control treatments do not reduce cover of target invasive spp by 20% within 5 years, discontinue current weed control treatment and evaluate for alternative management approach. | Y | Y | tbd | Y | Y | Y | *USFS & Partners* | *$80/acre* | |
| **11** | 1b | Structure | There is reduced potential for introduction, establishment, and spread of invasive species. Additionally, efforts are made to reduce existing infestations. | Invasive Plants | Cheatgrass | | Fine Scale | If inventories, surveys, and map checks indicate a high risk of cheatgrass, this triggers use of preventative measures. | Preventative measures are described in the narrative above. | Y | Y | tbd | Y | Y | Y | *USFS & Partners* | *$80/acre* | |
| **11** | 1b | Structure | There is reduced potential for introduction, establishment, and spread of invasive species. Additionally, efforts are made to reduce existing infestations. | Invasive Plants | Cheatgrass | | Fine Scale | If inventories, surveys, and map checks indicate dominance of cheatgrass across restoration sub-units. | If restoration sub-units become dominated by cheatgrass, discontinue thinning and burning treatments in adjacent high-risk areas and evaluate for alternative management approach. | | | | | | | *USFS & Partners* | *$80/ acre* | |

| **Indicator #** | **Monitoring Tier** | **Ecological Framework** | **Desired Condition or Resource and monitoring Questions** | **Indicator** | **Indicator Metric** | **Method & Sampling Techniques** | **Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape** | **Trigger (Threshold indicating possible need for change)** | **Adaptive Management** | **FS Plan Req.?** | **CFLRP requirement?** | **Stew. Contract req.?** | **Implementation Mon.** | **Short term effects Mon.** | ***Long term effects Mon.*** | ***Responsible Partner*** | ***Annual Cost Estimate*** | ***Cost per Task Order? or Work Plan annual cost - 15,000 acres*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **12** | 1b | Structure | Restore forest structure and pattern, forest health, and vegetation composition and diversity. Ponderosa pine ecosystems are heterogeneous in structure and distribution at the analysis area scale. Openings and densities vary within the analysis area to maintain a mosaic appropriate to support resilience of individual trees and groups of trees. (Many additional) | Landscape Structure | Landscape metrics (patch characteristics; configuration; diversity) | RS | Broad Scale | There is a high level of uncertainty around desired patch conditions. Triggers associated with other indicators (fire behavior, wildlife habitat) correspond to patch dynamics. Patch dynamic methods are currently under development by USFS Region 3, Remote Sensing Applications Center (RSAC, USFS) and academic partners. Triggers will be reassessed as data becomes available. | See narrative. | ? | ?N | N | Y | Y | Y | *USFS + Analyst Time? Master's Student?* | *20,000* | 20000 |
| **14** | 1b | Composition | Understory vegetation composition and abundance are consistent with the natural range of variability. | Diversity (understory communities) | % cover native species | Field collected - quadrats | Fine Scale | Within 5 years of mechanical treatment, change in cover should be 20+/-5% (15-25%) above controls (Laughlin et al 2011). | If this threshold is not reached, then re-evaluate treatment for management change, taking into account soils and burn treatment, e.g., reduce overstory basal area. | Y | N | tbd | N | Y | Y | *Contract or SH Partner* | **Included in Plot Costs Below* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **14** | 1b | Composition | Understory vegetation composition and abundance are consistent with the natural range of variability. | Diversity (understory communities) | % Bare Soil within treatment blocks | Field collected - quadrats | Fine Scale | Within 5 years of treatment (mechanical and/or fire), bare soil should comprise less than 30% of area affected by treatment. | If bare soil exceeds 30% of area within plots, re-evaluate restoration treatment for modification. | N | ? | tbd | N | Y | Y | *Contract or SH Partner* | **Included in Plot Costs Below* | |
| **14** | 1b | Composition | Understory vegetation composition and abundance are consistent with the natural range of variability. | Diversity (understory communities) | seedlings and saplings | Field collected - quadrats | Fine Scale | Within ten years of treatment, seedling and sapling density should be within 0.4 to 3.6 plants/hectare/decade on basalt soils (Mast et al 1999). | If seedlings and saplings fall below this range across sub-units where regeneration is a desired condition, then evaluate implementation of BMPs to increase probability of successful regeneration. If regeneration falls above this range, then more aggressive rx burning may be necessary to reduce plant density. | Y | ? | tbd | N | Y | Y | *Contract or SH Partner* | **Included in Plot Costs Below* | |
| **15** | 1b | Process | There is low potential for unnaturally severe fire to spread across the Restoration Unit. | Potential Fire Behavior | Crowning index; torching index; rate of spread | RS & Modeling | Broad Scale | TRIGGER 1: % of FR I vegtypes in first EIS with passive or active crown potential <25% after first 5 yrs and < 10% after 10 yrs. | Reevaluate potential causes: acres treated, treatment prescriptions. | N | Y | N | Y | Y | Y | *USFS* | | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **15** | 1b | Process | There is low potential for unnaturally severe fire to spread across the Restoration Unit. | Potential Fire Behavior | | | Broad Scale | TRIGGER 2: Patch size of adjacent pixels expressing stand replacement fire sizes: max size 50 acres for first 5 yrs and max size 10 acres after 10 yrs. | Reevaluate potential causes: acres treated, treatment prescriptions. | N | Y | N | Y | Y | Y | *Contract or SH Partner* | *10,000* | *10,000* |
| **16** | 1b | Process | Sensitive soils are protected through use of appropriate timber harvesting equipment and techniques to reduce erosion and sedimentation that could otherwise damage aquatic life, increase flooding, reduce reservoir capacity, and increase costs of maintaining infrastructure in the vicinity of waterways. | Soils | Soil Disturbance - including compaction and hydrobicity | Forest Disturbance Protocol 2009 (WO 82A and WO 82B) that is utilized as part of contract oversight, **plus** additional quantitative tests such as bulk density and infiltration capacity that are collected according to a statistical design. | Fine Scale | 1. >15% soil disturbance (area of bare ground or invasive plants); 2. Trends of increasing bulk density 3. Trends of decreasing infiltration capacity. | Implement mitigation measures, reevaluate treatment methods and/or BMPs, and make adjustments. | Y | ? | Y | Y | Y | ? | *Springer – NAU Hydrology: Paired Watershed Study?* | *?* | |
| **16** | 1b | Process | Sensitive soils are protected through use of appropriate timber harvesting equipment and techniques to reduce erosion and sedimentation that could otherwise damage aquatic life, increase flooding, reduce reservoir capacity, and increase costs of maintaining infrastructure in the vicinity of waterways. | Soils | Soil productivity | Test carbon to nitrogen ratios from soil samples collected according to a statistical design | Fine Scale | C:N ratios increasing from 12-14 toward 30, indicating a reduction in nitrogen availability that would impact plant productivity | Evaluate treatments in light of soil processes and make adjustments in treatment methods and forest pattern. | ? | ? | ? | ? | ? | ? | *Springer – NAU Hydrology: Paired Watershed Study?* | *?* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **16** | 1b | Process | Sensitive soils are protected through use of appropriate timber harvesting equipment and techniques to reduce erosion and sedimentation that could otherwise damage aquatic life, increase flooding, reduce reservoir capacity, and increase costs of maintaining infrastructure in the vicinity of waterways. | Soils | Soil moisture | Soil moisture sensors placed at paired watersheds and soil moisture data collected systematically using a portable Time Domain Reflectometer | Fine and Broad Scale | Trends of decreasing soil moisture (after adjusting for climatic variability) in stands with similar treatment types and/or physiographic characteristics. | Evaluate treatments and make adjustments in treatment methods and forest pattern. Monitoring of lower elevations, south facing slopes and shallow soils that are susceptible to drying would be a priority. | ? | ? | ? | ? | ? | ? | Springer – NAU Hydrology | ? | |
| **17** | 1b | Process | Restored ponderosa pine ecosystems accommodate natural and other fires without uncharacteristic impacts to soil productivity and watershed resources. | Watershed Function | springs protection | Groundwater Dependant Ecosystems Protocol, discharge measurements | Fine and Broad Scale | Triggers: 1. No net increase in facultative and obligative wetland species at springs or wet meadows targeted for both forest and spring restoration, 2. Decrease in spring discharge (adjusted for climate variation) following treatments | Review spring restoration techniques. Review treatment methods In recharge area. Make appropriate adjustments, such as improving structure of patches and openings to promote snow accumulation and retention to enhance recharge. | ? | ? | ? | ? | Y | Y | *Springer - NAU Hydrology Paired Watershed Study* | *?* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **20** | 1b | Structure | Ponderosa pine ecosystems are heterogeneous in structure and distribution at the analysis area scale. Openings and densities vary within the analysis area to maintain a mosaic appropriate to support resilience of individual trees and groups of trees. Ponderosa pine ecosystems provide the necessary composition, structure, abundance, distribution and process that contribute to the diversity of native plant and animal species across the 2.4 million acre 4FRI landscape. | Canopy Openness | Canopy cover | Remote Sensing | Broad Scale | *Trigger is unexpected deviation from Table 64/ Silvi Report (update with Final EIS) desired conditions. (Learning objective: this is a starting point to learn how treatments impact trends in opennes (see text changes).* | *Increase or focus monitoring efforts on areas with unexpected deviation. Re-assess with SHG* | Y | | | Y | | | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: closed canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Closed canopy species: Increase group density for all treatments by xx/ac** | Y | Y | N | N | Y | Y | *RMBO – but funded by?* | *$1000 per grid (1 grids per 1,000 acres?)* | 15000 |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: closed canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Increase group size for all treatments [based on AGFD experiment] | | | | | | | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: closed canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Reduce intensity of all UEA 40-55 treatments | | | | | | | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: closed canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Identify 25% of planned UEA 40-55 treatments and reduce intensity to 25-40 | | | | | | | | | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: closed canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | ** TBD from empirical relationship between species incidence and forest structure | | | | | | | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: open canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Open canopy species: Increase the size of openings in all treatment types | Y | Y | N | N | Y | Y | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: open canopy species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Identify 25% of planned UEA 25-40 treatments and increase intensity to 40-55% | | | | | | | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: pine-sage species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Pine-sage species: Alter timing of treatment to reduce impacts on sage | Y | Y | N | N | Y | Y | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: pine-sage species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Delay post-treatment burning to allow sage recovery | | | | | | | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: pine-oak species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Pine-oak species: Increase the size of openings designed for oak regeneration | Y | Y | N | N | Y | Y | | | |
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: pine-oak species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Restrict ungulate access to stands to allow oak regeneration | | | | | | | | | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **13a** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Songbird species richness: pine-oak species | Field (RMBO songbird surveys), RS, Modeling | Fine and Broad Scale | 5 year decrease at the Treatment Area or larger scales. See narrative (attached). | Increase emphasis on management of oak component in non-"Restricted Habitat" Stands | | | | | | | | | |
| **13b** | 1b | Composition | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Northern goshawk | Northern goshawk occupancy (population trends) | Utilize existing framework from USFS National Guidelines, as a minimum, with proposed modifications developed by Kaibab NF staff and LLECB (B. Dickson). | Broad Scale | If population trends down over a 5 and 10 year average at treatment area to landscape scale. | INCREASE or FOCUS monitoring on declining area; Note, may look at this even with declining trend observed at 1 or 2 datapoints - NOT significantly different in a statistical way, but as a high profile species addresses the need to follow this qualitatively more closely. | Y | tbd | N | N | N | Y | *USFS* | | |
| **13b** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Changes in landscape connectivity and permeability: bear/fox | Movement data from transmitted black bear OR grey fox (to represent denser forest conditions) and pronghorn (to represent more open forest conditions) | Broad Scale | Restriction of bear/fox movements (reduced connectivity between patches of untreated, higher density, or pine-oak) when comparing pre- to post-treatment. | Bear/fox: increase group size, decrease treatment intensity within known pathways | N | tbd | N | N | N | Y | *? TBD ?* | *?* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **13b** | 1b | Structure | Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance. | Diversity (wildlife communities) | Changes in landscape connectivity and permeability: pronghorn | Movement data from transmittered black bear OR grey fox (to represent denser forest conditions) and pronghorn (to represent more open forest conditions) | Broad Scale | For pronghorn, no increase in pronghorn movement when comparing pre- to post-treatment. | Pronghorn: increase opening percentage, increase treatment intensity within known pathways | N | tbd | N | N | N | Y | *? TBD ?* | *?* | |
| **18a** | 1b | Structure, Composition & Process | Ponderosa pine ecosystems are composed of all age and size classes within the analysis area and are distributed in patterns more consistent with reference conditions. | Tree Size Distribution | Tree diameters, density, species composition, conditions | Field Methods | Fine Scale | *Use of LTRS captured and notated in implementation checklist* | *Review by Monitoring Board* | Y | | | Y | | Y | *Contract or SH Partner* | *$2000/plot to install, $1000 to remeasure includes analysis time. (500m grid; 1 plot per 25ha, 61.2 acres)* | 500,000 |
| **18c** | 1b | Structure, Composition & Process | Protect old-growth forest structure during planned and unplanned fires. | Old Trees | Old tree density, conditions | Field Methods | Fine Scale | *Cutting 1 old tree, and then captured in implementation checklist.* | *Review by Monitoring Board* | Y | | | Y | | | | *(*Included in Plot costs)* | |

Table 3: Tier 2 Suggested Indicators: Funding-conditional critical multiparty monitoring. *Trigger and Adaptive Management are not completed for these Tier 2 monitoring indicators: an iterative process will be used to complete this table as funded and informed by monitoring.

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | *Long term effects Mon.* | *Responsible Partner* | *Annual Cost Estimate* | *Cost per Task Order? or Work Plan annual cost - 15,000 acres* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***25a*** | *2* | *Process* | *A majority of the ponderosa pine ecosystems supports frequent, low-intensity fire.* | *Fuel Hazard* | *Crown bulk density (diameters); crown base height; surface fuels* | *Fuel loadings; hazard rating* | *Fine Scale* | | | | | | *Y* | | | | *(*Included in Plot costs)* | |
| ***19*** | *2* | *Structure* | *Forest insects and pathogens occur and operate at endemic levels.* | *Insect Pathogens* | *Bark beetle rating; Mistletoe rating; evidence of attack* | *Field Methods* | *Fine Scale* | | | | | | | | *Y* | | *(*Included in Plot costs)* | |
| ***18b*** | *2* | *Structure, Composition & Process* | *Ponderosa pine ecosystems are composed of all age and size classes within the analysis area and are distributed in patterns more consistent with reference conditions.* | *Snags* | *Snag sizes, density, conditions* | *Field Methods* | *Fine Scale* | | | *Y* | | | *Y* | | | | *(*Included in Plot costs)* | |
| ***18d*** | *2* | *Structure, Composition & Process* | *Protect old-growth forest structure during planned and unplanned fires.* | *Tree Mortality* | *Tree diameters, density, species composition, conditions Landscape level patterns from remote sensing.* | *Field Methods* | *Fine Scale* | | | | | | *Y* | | *Y* | | *(*Included in Plot costs)* | |
| ***18e*** | *2* | *Structure, Composition & Process* | *Protect old-growth forest structure during planned and unplanned fires.* | *Regeneration* | *Seedling/sapling density, species composition* | *Field Methods* | *Fine Scale* | | | | | | | | *Y* | | *(*Included in Plot costs)* | |
| ***26*** | *2* | *Process* | *Restored ponderosa pine ecosystems accommodate natural and other fires without uncharacteristic impacts to soil productivity and or watershed resources.* | *Watershed Function* | *Precipitation; soil moisture; stream flow; water quality;* | | *Fine and Broad Scale* | | | | | | | *Y* | *Y* | *Springer – NAU Hydrology* | *?* | |
| ***23*** | *2* | *structure* | *Viable, ecologically functional populations of native species that include common, listed, rare, and sensitive species persist in natural patterns of distribution and abundance.* | *Response of Wildlife T&E* | *Fecundity; reproduction; survival* | *Field Methods* | *Fine and Broad Scale* | | | *yes but tbd* | | | | | *Y* | *USFWS proposed paired PAC study* | *USFS - 1st Analysis EIS* | |

| Indicator # | Monitoring Tier | Ecological Framework | Desired Condition or Resource and monitoring Questions | Indicator | Indicator Metric | Method & Sampling Techniques | Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape | Trigger (Threshold indicating possible need for change) | Adaptive Management | FS Plan Req.? | CFLRP requirement? | Stew. Contract req.? | Implementation Mon. | Short term effects Mon. | Long term effects Mon. | Responsible Partner | Annual Cost Estimate | Cost per Task Order? or Work Plan annual cost - 15,000 acres |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **21** | 2 | Composition | *Rare and ecologically valuable springs and wet meadows are protected and enhanced through appropriate restoration treatments where needed.* | *Rare/ Unique Habitats* | *Type cover* | *Remote Sensing* | *Broad Scale* | | | *Y* | | | *Y* | | | | | |
| **27** | 2 | *Process* | *Restored ponderosa pine ecosystems accommodate natural and other fires without uncharacteristic impacts to soil productivity and watershed resources.* | *Watershed Function* | *paired watershed study* | *precipitation, snow water equivalence (SWE), soil moisture, evapotranspiration (ET), surface water discharge, water quality; RS might be possible for some SWE, soil moisture and ET data* | *Broad Scale* | *Triggers: 1. Static or decreasing soil moisture, 2. Static or decreasing surface water discharge, 3. diminished water quality (esp. increased turbidity or total organic carbon), 4. Increased water stress (after accounying for climate variability)* | *Implement mitigations measures. Reevaluate treatment methods and/or BMPs. Make adjustments as appropriate, including changes to structure of patches and openings to promote snow accumulation and retention to enhance soil water storage, groundwater recharge, and surface water discharge.* | | | | | *Y* | *Y* | *Springer – NAU Hydrology* | *Get from Abe S. – SRP funding initially* | |
| **28** | 2 | *Process* | *Ponderosa pine vegetation within the analysis area is managed strategically and at a level appropriate to prevent degradation of air quality beyond regulatory standards (through wildland fire or managed fire).* | *Air Quality* | *Smoke output* | *TBD* | *Broad Scale* | | | | | | *Y* | | | *USFS* | *USFS - 1st Analysis EIS* | |
| **25b** | 2 | *Process* | *A majority of the ponderosa pine ecosystems supports frequent, low-intensity fire.* | *Fire Characteristics* | *Fire severity; fire size* | *Modeling* | *Broad Scale* | | | | | | | | *Y* | *USFS* | *USFS - 1st Analysis EIS* | |
| **20** | 2 | *Structure* | *Ponderosa pine ecosystems are composed of all age and size classes within the analysis area and are distributed in patterns more consistent with reference conditions.* | *Spatial Aggregation* | *Ripley's K; Getis G* | *Remote Sensing* | *Broad Scale* | | | *Y* | | | *Y* | | | *USFS & additional analyst? Master's studend?* | *(*Included in Landscape Metrics Cost)* | |

| **Indicator #** | **Monitoring Tier** | **Ecological Framework** | **Desired Condition or Resource and monitoring Questions** | **Indicator** | **Indicator Metric** | **Method & Sampling Techniques** | **Fine Scale = Group, Site and Stand Scale; Broad Scale = Sub-Unit, Restoration unit, Forest, Analysis Area, Landscape** | **Trigger (Threshold indicating possible need for change)** | **Adaptive Management** | **FS Plan Req.?** | **CFLRP requirement?** | **Stew. Contract req.?** | **Implementation Mon.** | **Short term effects Mon.** | ***Long term effects Mon.*** | ***Responsible Partner*** | ***Annual Cost Estimate*** | ***Cost per Task Order? or Work Plan annual cost - 15,000 acres*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***20*** | *2* | *Structure* | *Ponderosa pine ecosystems are composed of all age and size classes within the analysis area and are distributed in patterns more consistent with reference conditions.* | *Canopy Openness* | *Canopy cover* | *Remote Sensing* | *Broad Scale* | | | *Y* | | | *Y* | | | | | |
| ***22*** | *2* | *Structure* | *Populations of native species occur in natural patterns of distribution and abundance.* | *Wildlife Response (Habitat)* | *Landscape metrics (patch characteristics; configuration; diversity) w/ wildlife usage data* | *Remote Sensing* | *Broad Scale* | | | | | | *Y* | *Y* | | *AZ G&F proposed study* | *AZ G&F check – funded pre-trt* | |
| ***24*** | *2* | *structure* | *Populations of native species occur in natural patterns of distribution and abundance.* | *Habitat Suitability* | *Occupancy* | *Modeling* | *Broad Scale* | | | | | | | | *Y* | *? TBD ?* | *?* | |

# Socioeconomic Monitoring

## Introduction

Preparation and tracking of both the social and economic impacts of the Four Forest Restoration Initiative (4FRI) project is paramount to the success of the project. Social awareness, knowledge and support coupled with economic viability, such as a prepared workforce, adequate infrastructure, and reliable wood supplies, are critical factors that will be primary drivers of the project's progression. Typically, social and economic monitoring has not been a priority and was identified as one of the five major challenges by the Rural Voice for Conservation Coalition's (RVCC) Issue Paper (2011) in stating, "There is insufficient monitoring of the social and economic impacts of land management" and they further stressed this as a key recommendation for the U.S. Forest Service (USFS). Robbins and Daniels (2011) affirm this by reiterating, "…that the socioeconomic aspects of restoration are 'underemphasized, or often ignored all together'" (Aronson et al. 2010). Thus, ensuring integration of ecological, social and economic impacts will augment effective management actions that will address multiple criteria necessary for community health and sustainability.

As the monitoring frameworks were conceptualized, beginning with a broad vision for both social and economic factors affected by restoration can be drawn from the 4FRI's foundational documents, such as the Path Forward (2010). Within the Path Forward, the importance of integrating monitoring that includes ecological, social and economic impacts was raised in stating, "Landscape-scale restoration efforts should adopt and make full use of rigorous science, including research, monitoring, and adaptive management that enhances our understanding about their ecological, social, and economic implications" (2010).

## Purpose and Application

The purpose of this report is to provide a framework to guide socioeconomic monitoring of the 4FRI project for the First Analysis Area Environmental Impact Statement (EIS). Both the 4FRI Science and Monitoring Working Group (S&MWG) and the USFS will contribute to monitoring the socioeconomic aspects of the project. The 4FRI project is funded through the Omnibus Land Management Act of 2009, Title IV-Forest Landscape Restoration. The 4FRI socioeconomic monitoring process is geared towards the purpose of the Act:

> The purpose of this title is to encourage the collaborative, science-based ecosystem restoration of priority forest landscapes through a process that--
> 1) encourages ecological, economic, and social sustainability;
> 2) leverages local resources with national and private resources;
> 3) facilitates the reduction of wildfire management costs, including through reestablishing natural fire regimes and reducing the risk of uncharacteristic wildfire; and
> 4) demonstrates the degree to which--
> (A) various ecological restoration techniques--
> (i) achieve ecological and watershed health objectives; and
> (ii) affect wildfire activity and management costs; and
> (B) the use of forest restoration byproducts can offset treatment costs while benefitting local rural economies and improving forest health.

The monitoring objectives identified in this report overlap with many of the key social and economic issues analyzed by the USFS in the "Environmental Consequences" section of the EIS. In the EIS, the USFS will assess the social and economic elements of 4FRI implementation. This analysis will include the Coconino and Kaibab National Forests and Coconino, Yavapai and Maricopa counties. Although Maricopa County is not within the Kaibab and Coconino National Forests, it is included in the analysis due to the social and economic linkages between Maricopa County and the assessment area.

There are two main components to the USFS social and economic analysis that include: 1) the affected environment description and, 2) the assessment of environmental consequences. The USFS analysis of the social and economic affected environment description in the EIS considers population and demographic characteristics and trends (e.g. population change and educational attainment), employment and income data (e.g. economic specialization and median income), and environmental justice concerns (e.g. the distribution of minority and low income populations in the study area and their relationship to the Forest lands). This will include estimates of employment and income consequences during the 4FRI implementation lifecycle. Input- output-analyses using IMPLAN (*www.implan.com*) will estimate the employment and income effects of the 4FRI project. Ultimately, the estimates from IMPLAN can be compared to actual economic outcomes that will be collected as primary data from contractors, subcontractors, etc.

The USFS environmental consequences analysis estimates will be primarily a qualitative assessment and will describe how 4FRI implementation activities will affect quality of life, non-market economic values and employment and income in the study area. For quality of life, some of the key indicators are: 1) Particulate matter (PM) pollution from wildfire and prescribed fire (air quality modeling) and how PM pollution may lead to reduced quality of life through activity days, respiratory events, hospital admissions, etc.; 2) recreation opportunities (e.g. 4FRI implementation may temporary displace some activities; uncharacteristic wildfire can have long-term displacement consequences, etc.) and; 3) local economic sustainability; this will extend the quantitative economic discussion of employment and income to the social sphere to discuss how changing economic conditions affect community well-being. Non-market values will be measured chiefly through ecological indicators provided by other USFS specialists in their analysis (e.g. effects on habitat, water quality, soil quality, etc.). The economic efficiency of 4FRI implementation will also be analyzed by the USFS by using data on federal and private expenditures and the projected benefits of ecological restoration.

To supplement the USFS socioeconomic monitoring data and analyses, through multiparty monitoring, the 4FRI Collaborative will utilize the information contained in this report to complete both social and economic monitoring of the 4FRI project. Although this report contains an extensive list of possible objectives that could be monitored, based on the 4FRI Collaborative's priorities and the information gaps contained in the USFS required socioeconomic monitoring, specific objectives/questions will be targeted. To assure the project's success and longevity, it is recommended that socioeconomic monitoring is conducted before project implementation and there is immediate and ongoing execution within approximately the first five years of project implementation (Personal Communication, Nielsen 2011). Once socioeconomic monitoring data verifies the 4FRI project is socially and economically on track, the pressing need to conduct this type of monitoring will dissipate and the priority socioeconomic factors can be monitored less frequently to assess longitudinal changes.

The purpose of the joint effort of the S&MWG and the USFS monitoring process is to assess the accuracy of USFS estimates and provide data for adaptive management. In this way, the information provided by the USFS in the EIS, coupled with this monitoring framework, are linked to support a thorough and on-going assessment of social and economic conditions in the study area.

# Methodology

The 4FRI S&MWG developed both social and economic monitoring frameworks to assess relevant socioeconomic factors that will determine these effects in planning, implementation and adaptive management of the 4FRI project. Relative to other land management activities, monitoring issues that need to be addressed within ecological restoration projects are broader and should encompass objectives that affect the widest variety of stakeholders (Egan and Estrada-Bustillo 2011; Fulé 2003). As a starting point, social and economic desired conditions from the Landscape Restoration Strategy for the First Analysis Area (LRS) (4FRI Stakeholder Group, Oct 2010) were compiled from the report (Appendix A). Additional economic desired conditions were extrapolated from Appendix A of the LRS report. Within the LRS report, both economic and social desired conditions were defined within three spatial scales that include landscape, analysis area and firescape. These spatial scales are more applicable to biophysical conditions; therefore, for the purpose of developing this monitoring framework, the socioeconomic desired conditions were not delineated by these spatial scales. At times, the original sets of desired conditions were either repeated within each scale or they were not applicable as a socioeconomic desired condition for monitoring.

Omission or modifications of these desired conditions are listed and explained in tabular format in Appendix B.

Once the final set of desired conditions, or broad goals, were determined, firm, measurable monitoring objectives (UO 2011) were developed through broad stakeholder input. As objectives were developed, considerations were based on those that the stakeholder group and/or the USFS have the ability to influence and adapt (Ibid). Monitoring questions were matched to the objectives to ensure the questions asked provide essential information that is needed to measure the stated objectives. Indicator selection was based on attributes that can be easily measured, are precise, and concisely describe current conditions (Moote 2011) as well as those that are sensitive to changes overtime (Moote 2011; Eagan and Estrada-Bustillo 2011). In addition, indicators that can satisfy multiple objectives should be recognized to assist in the efficacy of the monitoring process (Derr et al. 2005). The methods used to evaluate the selected indicators are described in the Toolbox section of this report (page 6). Once the appropriate assessment(s) were delineated, the recommended frequencies of the assessments, how often the monitoring data and analyses are completed, were matched to the assessment. Lastly, data sources, whether primary or secondary, were delineated to retrieve the necessary data to answer the questions.
It is important to note that these frameworks should be viewed as a "continuing, inclusive and evolutionary process" (Personal Communication, A. Egan 2011) that is malleable and adaptive over time.

Consideration of temporal and spatial scales is critical to the monitoring process and effects should be addressed at micro and macro levels as well as in the short and long-term. For example, results from project-level monitoring will provide necessary information to assess a variety of programmatic (cumulative) monitoring objectives/questions that can be tracked over time (UO 2011).

The social and economic framework matrices included in this report are not exhaustive; however, provide a basis for framing a 4FRI social and/or economic monitoring project (Appendix C and D). For example, there may be several monitoring questions for a specific objective; however, the associated monitoring questions may not be relevant and/or appropriated funding will only support answering one of the monitoring questions. Similarly, there is a fairly comprehensive list of indicators; however, not all will be measured for a respective monitoring project. In the end, the purpose of the study, the constituency requesting the information, how the information will be used and, respective funding will ultimately dictate a specific methodology of the monitoring project.

Due to the groundbreaking nature of the landscape scale 4FRI project and the unpredictability of the results, the "If Statements" or triggers for adaptive management, are described as "Undesirable Conditions" (Personal Communication, T. Cheng 2011). The "Undesirable Conditions" have been initially expressed as broad qualitative statements that will delineate trends. As the project matures, and a baseline is established, these triggers can be adjusted to more specific acceptable quantitative ranges that will indicate whether or not adaptive management is necessary for each specific objective/question that is being assessed. In addition, once a contract(s) is awarded and contractors' business plans are identified, economic triggers can be more clearly delineated and assessments can be designed to determine whether implementation is in line with contractors' business plans.

In most cases, when socioeconomic studies are conducted, several monitoring questions can be addressed simultaneously, thus increasing the efficacy of the monitoring project. For example, a telephone survey to residents in the first analysis area can provide necessary data for multiple monitoring questions. As economic studies are planned and conducted, when contractor surveys are designed and distributed before project implementation, several indicators can be tracked and these data can be used for multiple monitoring requirements.

## *Program Evaluation*

As monitoring protocols are established and implemented for the 4FRI project, program evaluation can be used as an appropriate social science methodology. Program evaluation is a set of "systematic procedures used in seeking facts or principles" so that theoretical positions can be tested (cited in Royse et al. 2001:2). Program evaluation follows a simple research design procedure that includes four main steps: 1. formulate a problem or question, 2. develop a research design for data collection efforts, 3. collect data, and 4. analyze the data (Ibid). Although this design is similar to a traditional research design, the underlying distinction is based on the results. In most instances, in a research design, results can be generalized to a broader population, while results from a program evaluation may only be applicable to the specific project or multiple projects that have distinct similarities. Moreover, program evaluation is designed to facilitate a "structured comparison" so that conclusions have a type of relative valuation (cited in Royce 2001:11).

Ideally monitoring should be conducted before and after implementation so that pre- and post- measurements can be compared. Due to the ongoing and malleable nature of monitoring, a process evaluation can be conducted throughout the life of the project that provides a program's description, a program's monitoring protocol and quality assurance measures (Ibid). Due to the nature of process evaluation, operations are documented and will provide the necessary information to replicate or convey the technology of a specific project. Process evaluations are typically used for research and demonstration projects as they provide information that will inform what was learned during project implementation (Ibid).

To take this one step further, a program logic model developed by the W. K. Kellogg Foundation (W.K. Kellogg Foundation Evaluation Handbook 2004) supports this application whereas evaluations are seen as adaptive, applying mid-course adjustments as needed, while at the same time, documenting its successes (WKKF 2004). This evaluative approach also encourages a broad participatory base of all involved stakeholders, from developing the question to analyzing the data. The logic model does not just focus on the outcome but explains what you are doing, the expected results and a series of outcomes from immediate to long-term (Ibid). Moreover, this model helps to identify whether the project is on-track and emphasizes learning as an ongoing process - an integral part of the evaluation.

## *Institutional Review Board (IRB)*

When collecting information on human subjects, an Institutional Review Board (IRB) should complete a review of the proposed project. As subjects participate in research projects, he/she should be informed their participation is voluntary and all of their answers are confidential and reported as an aggregate, or as a group response. If research is conducted remotely, through the telephone or the Internet, informed consent is completed verbally or in a screen that is read by the respondent. If participants are interviewed face-to-face, participants should sign consent forms before the interview/focus groups begin. The consent and reviews protect the rights of human subjects when used in research and prevent unethical treatment during the process (IRB NAU 2011).

## *Tool Box for Assessment*

### Scale – Sampling Frame

As the purpose of socioeconomic studies is conceptualized, and objectives/questions are designed to study a specific population (e.g. "local"), a concise, self-determined definition is necessary to pinpoint the sampling frame, or scale, of the population under study (UA 2011). Since this definition is *dependent* on the purpose of the study and, ultimately how the information will be used, it could vary considerably from study to study. The definition of the study's population, or the sampling frame, should reflect one or more factors that include geographic (natural, physical), administrative, social, and/or economic boundaries/conditions that are adequately representative of the location, political and/or public service jurisdictions, group of people or economic factors (EPA 2002).

## Study Design

Both social and economic monitoring should begin with an assessment of current conditions by establishing baseline data before project implementation and/or education and outreach programs or events. Once a baseline is established, proceeding data collection should occur after major interventions to assess the change from the baseline to post-intervention and continue to assess changes longitudinally to track them over time. Depending on the selected social or economic analysis, accounting for specific issues and concerns within the population or the designated area of the study (e.g. community, city, county, EIS Analysis Area, etc.) should be considered and integrated in the study design (Egan and Estrada-Bustillo 2011). In addition, the study's design will be dependent on the goals of the study, the constituency, or who is requesting the monitoring results, and ultimately, how the monitoring information will be used. Ideally, socioeconomic monitoring should be a priority and should be implemented immediately and tracked for the first five years to assure the project's success (Personal Communication, Nielsen 2011).

The type of study that is initiated will dictate whether the purpose of the study is exploratory, descriptive or explanatory. Exploratory studies are typically conducted when researchers are breaking new ground, want to better understand the issue at hand, test the feasibility of developing a more extensive study and/or develop methods to employ in a subsequent study (Babbie 2010). Descriptive research is precise reporting or measurements and answers the what, when, how and where questions and explanatory research reports relationships among the area of study and answers the question, why (Ibid). In general, as socioeconomic research designs are conceptualized, more than one study type will be integrated in its design.

To illustrate utilizing multiple study types in assessing social systems affected by the 4FRI project, understanding the general publics' perceptions will most likely take two types of research to adequately answer the monitoring questions. First, an exploratory study that consists of focus groups of the general public and personal interviews with land managers will provide information that is specific to the defined area of study (e.g. 1st Analysis Area, city, county, Forest etc.). Once this qualitative data is analyzed, this information will give researchers a basis for a more structured (quantitative/qualitative) descriptive and/or explanatory study that is geared towards the population in question. For example, if exploratory studies were conducted in the first and second analysis areas, commonalities and differences can be identified between the subpopulations and subsequently, questions relevant to both populations can be formulated as well as modules that are specific to each subpopulation.

Another key driver in the study's design is how the information will be used. If the constituency requesting monitoring data requires findings to be representative of the population in question, probability sampling must be employed. This occurs if all of the individuals in the population have an equal chance of being selected and the selection method is randomized. If this is the case, the results of the study can be generalized to the population as a whole (Babbie 2010). Probability sampling verifies the sample is not biased and enables estimates of the precision that the results reflect the study's population (Fowler 2002). These results can be statistically verified with a sampling error, the degree of inaccuracy in the sampling design, as well as a confidence level, that the results are representative of the population. Non-probability sampling can be appropriate when a complete list of the study's population is unavailable, resources are limited, study requirements do not dictate stringent probability sampling results or the purpose of the study is exploratory. For example, "purposive sampling" is appropriate when a select number of key informants provide information needed to understand the key issues and is either used to understand specific circumstances and/or develop a more stringent study that can be generalized to a broader population.

To all extent possible, in conducting the socioeconomic studies, assuring the results are reliable, they would consistently yield similar results and valid, they adequately represent the concept under consideration, should be an underpinning of the research design (Royse 2001). However, at times, there is a tradeoff between the two and the purpose of the study, the constituency and how the results will be used will assist in determining whether there is an emphasis on reliability or validity and/or whether this distinction is necessary.

### Data Sources

Data sources listed in both the social and economic frameworks include both primary and secondary data. The social analyses primary data collection includes focus groups, interviews, surveys and content analysis. Secondary data sources for social analyses included reports by forests, government reports (city, county state and federal) and federal and private databases, such as Headwaters Institute and Firewise Communities USA.

The economic analyses primary data sources include contractor, visitor and business surveys. Secondary data for the economic analyses include various government reports (forest, municipal, state and federal), previous studies and government databases used in similar studies. As monitoring projects are developed and conducted, data sources in the frameworks will be reassessed and refined and new data sources will be added.

### Literature Review

Generally, upon initiation of a socioeconomic study, background research through a literature review is conducted to assess previous research on the topic. More specifically, previous studies can assist with determining a study's design, questionnaire/protocol development, relevant data sources, and various analyses that were used and, whether previous studies reveal consistent findings. In addition, this information can reveal whether there are consistent flaws in previous research that may be remedied (Babbie 2010).

### Census Research

Census data provide information that is inclusive of all individuals in a population (Fowler 2002). Census data covers 200 specific topics that describe a population or a "community" that includes demographic information such as employment, education, income, a population's size, and "urban" versus "rural" communities (EPA 2002). Census data can also be used to verify the demographic data in the study group is reflective of the demographics of the area under study.

### Survey Research

The choice of data collection mode, whether it's through the mail, telephone, personal interviews or group administration will be based on the sampling frame, the research question, characteristics of the sample, required response rates, question format, availability of trained staff and facilities and funding available for the project (Fowler 2002).

Surveys are one of the best methods used to describe a population's attitudes and orientations that are too large to observe directly and provide a standardized measurement across individuals in a given population (Ibid). There are self-administered questionnaires and survey administered by interviewers.  Self-administered surveys through the mail or on the Internet are generally less representative of a population due to typically low response rates. In administering Internet surveys, many times the population is not representative as the sampling frame is not inclusive of the entire population, nor is the Internet regularly accessible to a broader population. However, Internet surveys can be appropriate to populations that have known computer access, such as USFS employees. In general, telephone surveys delivered by a live interviewer tend to be the most reliable method to collect data as the response rate is much higher, thus reveling results that are more indicative of the group that is being studied. Also, telephone survey methodology, although not perfect, provides a sampling frame that is most inclusive of a population. A note of caution - automated telephone surveys will not yield reliable results for many reasons such as, the respondent's identity is not verified (e.g. a child on the phone), there may be screener questions that verifies specific information about a respondent in the household and there is no assurance that the question was understood and did not need to be repeated. In general surveys, coupled with valid operationalization of concepts through appropriately worded questions, provide uncanny accuracy of a population's beliefs and attitudes (Babbie 2010). In addition, data collection through surveys can also provide a population's characteristics (demographics) that can be linked to the responses thus, increasing understanding of specific group's perceptions or beliefs (EPA

2002).

Data collection of telephone surveys is streamlined through the use of computer programs, such as Computer Assisted Telephone Interviewing (CATI). These programs allow for survey question programming and results are recorded as the interview is conducted. Not only does this improve data collection entry error but also, the phone numbers in the sample are randomized (Random Digit Dialing -RDD) and shown on the screen for the interviewer to call. In addition, programs such as these allow for responses, whether they are closed- or open-ended, to be directly exported into programs such as Statistical Package for the Social Sciences (SPSS) for analysis. Nicholls et al. reports use of programs such as CATI, are more efficient than conventional techniques (paper and pencil surveys) and do not affect data quality (cited in Babbie 2001:265).

For the 4FRI project, generally if researchers are seeking broad public opinion and attitudes about a number of issues, telephone surveys will yield results that can be generalized to the population. For more specific economic data, if secondary data is available from reliable sources, these will be used.  In addition, primary data collected through self-administered surveys from contractors or others involved in the restoration process, are the best method, as contractors need to track the information and refer to their records. In collecting primary data from contractors, the sooner they are aware of these efforts and receive the survey forms/files, the easier it will be for them to track the necessary information.

### Personal Interviews and Focus Groups

Personal interviews that occur face-to-face can be appropriate when the questions require: qualitative in-depth answers, high response rates, interviewer observation, longer interviews, rapport building and allow for multi data collection modes that could include diagrams (Fowler 2002). Personal interviews can include key informants that will provide valuable in-depth information such as, USFS personnel and community leaders such as, the County Board of Supervisors. Focus groups are a useful tool and usually engage 12-15 people in a guided discussion of a topic. The participants would not statistically represent segments of the population; therefore, this mode of observation is used to more deeply explore a topic and become more familiar with the issues under consideration (Babbie 2010). These results can be used to design a descriptive or explanatory study and/or used for strategic planning efforts (EPA 2002).

### Content Analysis

Content analysis is used when various mediums of communication provide information in either a written form, such as newspaper articles, or in a multimedia format such as movies, speeches, photos etc. (C. Marshall and G. Rossman 2006; EPA 2002). These analyses reveal recorded historic human communication or the artifacts of a social group (Babbie 2010; Marshall and G. Rossman 2006). Content analysis will reveal what has been communicated and the analysis will answer the question “why” it was communicated and “what was the effect” of the communication (Babbie 2010).  To complete the qualitative analyses of the various formats, a software program, NVivo (2012), can be used for evaluation of the data.

## *Collaborative Performance*

The first collaborative performance evaluation has been conducted through a Survey Monkey instrument developed in conjunction with the 4FRI Stakeholders and the US Institute for Conflict Resolution (October 2011, Appendix E). In addition, a separate evaluation conducted by Northern Arizona University (W. Greer, E. Nielsen) and Colorado State University (T. Cheng) that includes a 4FRI Case History and a Collaborative Governance Case History will supplement the 4FRI Collaborative’s effectiveness and performance measures (May 2012). The intent is to track performance over time and to adaptively manage the Collaborative so that improvements are made to key areas identified by stakeholders.

# *Economic Analyses*

Economic analyses are essential tools for planning, prioritizing and evaluating restoration projects (Robbins and Daniels 2011). Economics will provide a suite of tools to inform decision-making and improve transparency in selecting projects (Ibid). Based on a recent review of literature in describing economic concepts in the context of ecological restoration, Robbins and Daniels (2011) outline decision-analysis frameworks that incorporate an inclusive array of restoration benefits and costs. A "travel costs method" is employed to determine values associated with recreational sites by assessing visitor time and expenditures. "Stated preference method" or assessing willingness to pay for environmental improvements is used when indirect values, such as watershed protection, are being assessed. The stated preference method can be measured by a "contingent valuation," or how much individuals are willing to pay for a policy or project. As an alternative, an "experimental choice method" can be employed as a non-monetary valuation that asks individuals to choose from a set of alternatives and rank their preferences. "Benefit costs analysis" includes total benefits or revenues and costs (using a weighted distribution of each) of a project over time with a defendable discount rate. Alternatively, "cost effective analysis" can provide a framework to compare relative costs of alternative methods geared towards achieving the same outcome. Lastly, "multi-criteria decision analysis" uses nonmonetary values through relative quantitative or qualitative performance scores. This review also revealed that although direct costs and revenues should be easy to capture, they are rarely reported. To address this lack of accounting, as suggested early in this report, streamlining expenditure, revenue and employment data reporting with prepared protocols and contractor reporting forms as well as creating a centralized data base prior to project implementation, should assist in closing this gap.

Additionally, to capture local economic conditions, economic base theory, a causal model, can be employed that divides the local economy into two sectors: 1) a basic, or non-local and 2) non-basic, or local. This theory is grounded on the premise that the basic sector, or those businesses that are dependent on non-local firms to buy their products, is the driver of the local economy. Thus, the local economy is strongest when it is not dependent on local factors and can better insulate itself from local economic downturns. This distinction is important because the means of strengthening a local economy is to develop and enhance the basic sector (McClure 2009; Chapin 2004).

# *Prioritization*

Although there are a multitude of monitoring objectives/questions in both the social and economic frameworks, due to identified preferences of the stakeholders and limitations in resources, objectives/questions need to be prioritized by the 4FRI Stakeholders. A basis for prioritizing the questions/objectives are issues and concerns that are relevant to the communities that are directly affected by the ensuing forest restoration efforts as well as those across the four Forests and the State.

In a study conducted by Egan and Estrada-Bustillo (2011), a model to prioritize socioeconomic indicators was developed through a Delphi process. Based on project objectives and availability of resources, results indicate there are three levels of indicators that include: 1) a core set that utilizes minimum effort at the forest or stand level; 2) includes the set of core indicators and balances ecological with socioeconomic dimensions and is used for long-term projects requiring more time and expertise and; 3) includes the first two sets of indicators; however, the primary focus is socioeconomic outcomes and is used across jurisdictions on landscape-scale projects and requires the highest level of expertise and resources. In addition to the recommended intensity of the socioeconomic monitoring, specific indicators can be weighted in using an average/median rating. Based on these results, overall socioeconomic objectives/questions can be identified, will provide guidance in selecting the best indicators for the assessment, and can guide resource allocation for a given project. Although prioritization is necessary, it is Important to keep in mind, as socioeconomic studies are conducted, multiple monitoring questions can be addressed simultaneously, thus increasing the efficacy of the monitoring project and stakeholders can select groups of objectives/questions as priorities.

## *Table X. Four Forest Restoration Initiative Social Systems Framework*

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| **SOCIAL SYSTEMS** | | | | | | | | |
| GOAL: There is broad public awareness, understanding, knowledge and support for collaboratively based forest restoration decisions, processes, and outcomes, including the use of fire as a management tool. | | | | | | | | |
| There is broad public awareness for collaboratively based forest restoration. | Is the public aware of the collaboratively-based 4FRI forest restoration project (e.g. current decisions, processes and outcomes)? | Awareness of the collaboratively-based 4FRI forest restoration project (e.g. current decisions, processes and outcomes). | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is unaware of the collaboratively-based 4FRI forest restoration project (e.g. current decisions, processes and outcomes). | | |
| There is broad public understanding/ knowledge for collaboratively based forest restoration. | Is the public knowledgeable of the collaboratively-based 4FRI forest restoration efforts (e.g. current decisions, processes and outcomes)? | Public's understanding/ knowledge for collaboratively-based forest restoration. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers..<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not knowledgeable of collaboratively-based forest restoration. | | |
| There is broad public support/acceptance for collaboratively based forest restoration. | Is there broad public support/acceptance for the collaboratively-based 4FRI forest restoration project (e.g. current decisions, processes and outcomes)? | Support /acceptance for collaboratively-based 4FRI forest restoration project (e.g. current decisions, processes and outcomes). | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public does not support/accept collaboratively-based forest restoration. | | |
| Number of appeals and lawsuits for 4FRI projects are minimized. | Are the number of appeals and lawsuits for 4FRI projects at a minimum and/or decreasing? | Number & length of time of lawsuits. | Appeals database available at: www.fs.fed.us/forum/nepa (Cortner et. al 2003). | Track annually for first 5 years post/analysis area. | Appeals database available at: www.fs.fed.us/forum/nepa (Cortner et. al 2003). | Appeals and lawsuits for 4FRI projects are delaying project implementation. | | |
| There is broad public awareness for the use of fire as a management tool. | Is the public aware of the use of fire as a management tool? | Public awareness for the use of fire as a management tool. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is unaware of the use of fire as a management tool. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| There is broad public understanding/ knowledge for the use of fire as a management tool. | Does the public understand/have knowledge of the use of fire as a management tool? | Public understanding/ knowledge for the use of fire as a management tool. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public does not have the understanding/ knowledge for the use of fire as a management tool. | | |
| There is broad public support/acceptance for the use of fire as a management tool. | Does the public support/accept the use of fire as a management tool? | Public support/acceptance for the use of fire as a management tool. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public does not support/accept the use of fire as a management tool. | | |
| GOAL: The public is knowledgeable/understands, accepts/supports the byproduct of smoke from prescribed and managed fires. | | | | | | | | |
| The public is knowledgeable/ understands the byproduct of smoke from prescribed/managed/pile fires (presence & duration.) | Is the public knowledgeable/ understands why prescribed/managed/pile fires are necessary and will have the byproduct of smoke? | Public knowledgeable/ understanding of why prescribed fire is necessary and will have the byproduct of smoke. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. USFS complaint logs. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Public does not understand why prescribed fire is necessary and will have the byproduct of smoke. | | |
| The public accepts/supports the byproduct of smoke from prescribed/managed/pile fires (presence & duration.). | Does the public accepts/support the byproduct of smoke from prescribed/managed/pile fires? | Public acceptance/support of the byproduct of smoke from prescribed fire. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. USFS complaint logs. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Public does not accept/support the byproduct of smoke from prescribed fire. | | |
| GOAL: The public understands, accepts, and supports fire's natural role in forest ecosystems. | | | | | | | | |
| The public understands fire's natural role in forest ecosystems. | Does the public understand fire's natural role in forest ecosystems? | Public understanding fire's natural role in forest ecosystems. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Public does not understand fire's natural role in forest ecosystems. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| The public accepts/ supports fire's natural role in forest ecosystems. | Does the public accept/support fire's natural role in forest ecosystems? | Public acceptance/ support for fire's natural role in forest ecosystems. | 1. Focus groups with community members. 2. Interviews with land managers/key decision-makers. 3. Telephone survey with residents in study area. | Pre- post- implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Public does not accept/ support fire's natural role in forest ecosystems. | | |
| GOAL: Rural communities are protected from high-severity fire and their quality of life is enhanced through forest restoration. | | | | | | | | |
| Rural communities' risks from high-severity fire are reduced. | Is the frequency and size of high severity fires decreasing? | 1. Frequency of wildfires. 2. Size (acres) of wildfires. | Frequency and & size of wildfires 5 yrs. post-4FRI implementation vs. frequency and duration of wildfires 5 yrs. pre-4FRI implementation. | 5 years | USFS by Forests (GFFP 2010). | Rural communities' risk from high-severity fire is not decreasing. | | |
| Rural community residents' perceived risk of high-severity fire is reduced. | [If frequency and size of high severity fires are decreasing] Do rural community residents' perceive rural communities are being protected from high-severity fire? | Rural community residents' perception of risk of high severity fires. | 1. Focus groups with community members. 2. Interviews with land managers/key decision-makers. 3. Telephone survey with residents in study area. | Pre- post- implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Rural community residents' perceived risk of high-severity fire is not decreasing. | | |
| Landowners adjacent to or in the proximity of the four forests (e.g. state, private, tribal, municipal, etc.) are encouraged to participate in restoring all forested lands in Northern Arizona. | **Q1:** Are landowners adjacent to or in the proximity of the four forests participating in restoring their forested lands? **Q2:** What programs are in place to encourage land owners to treat their lands? | **Q1/Q2: 1.** Land ownership, location, number and total $ value of: State Fire Assistance grants, Tribal Forest Protection Act, AZ Forest Health Program, Forest Stewardship Program, etc. 2. Fire behavior including adjacent non-USFS lands. | **Q1:** Tracking land ownership/location and respective treatments (fire behavior). **Q2:** 1. Tracking outreach efforts to state, private, tribal, municipal landowners. 2. Tracking land ownership, location number and total $ value of grants awarded. | 5 years | 1. Headwaters Institute. 2. State, private, tribal, municipal grant/project reports. 3. USFS by Forests. 4. 4FRI Stakeholder Group. | Landowners adjacent to or in the proximity of the four forests (e.g. state, private, tribal, municipal, etc.) are not encouraged to participate/are not restoring forested lands in Northern Arizona. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: Social values and recreational opportunities are protected and/or enhanced through forest restoration activities. | | | | | | | | |
| Recreational opportunities are protected through forest restoration activities. | **Q1:** Are recreational opportunities protected as restoration projects are implemented? **Q2:** Does the public perceive recreational opportunities are protected through forest restoration activities? | **Q1:** Number & type of recreational activities. **Q2:** Public perception of protection of recreational opportunities through forest restoration activities. | **Q1:** Analysis of USFS, AZG&F, USFWS reports. **Q2:** 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | **Q1:** 1. National Visitor Use Monitoring Program (USFS 2005).<br>2. Headwaters Institute<br>3. AZG&F The Economic Importance of Fishing and Hunting (utilizes IMPLAN input/output model) (AZG&F 2001). 4. USFWS National Survey of Fishing, Wildlife, Hunting, & Wildlife Assoc. Recreation (USFWS 2006).<br>5. Visitor surveys. **Q2:** Focus group, interview and survey results. | Recreational opportunities are not protected as forest restoration activities occur. | | |
| Recreational opportunities are enhanced through forest restoration activities. | **Q1:** Are recreational opportunities improving as restoration projects are implemented?<br>**Q2:** Does the public perceive recreational opportunities are improving as forest restoration activities are occurring? | **Q1:** Number & type of recreational activities. **Q2:** Public perception of improving recreational opportunities as forest restoration activities are occurring. | **Q1:** 1. Analysis of USFS, AZG&F, USFWS reports. 2. Visitor surveys **Q2:** 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. | Pre- post-implementation/ outreach. Track annually for first 5 years post. | As above. | **Q1:** Recreational opportunities are not improving as restoration projects are implemented. **Q2:** Public perceives recreational opportunities are not improving as forest restoration activities are occurring. | | |
| Aesthetic values are protected through forest restoration activities. | Does the public perceive aesthetic values are protected through forest restoration activities? | Public perception that aesthetic values are protected through forest restoration activities. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. Comparative analysis of field trips to treated vs. untreated sites (*timing relevant to post-implementation is critical-minimum one-year post). | 1. Pre- post-implementation/ outreach. Track annually for first 5 years post. | 1. Focus group, interview and survey results.<br>2. Headwaters Institute. | The public perceives that aesthetic values are not being protected as forest restoration activities are occurring. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| Aesthetic values are enhanced through forest restoration activities. | Does the public perceive aesthetic values are enhanced through forest restoration activities? | Public perception that aesthetic values are enhanced through forest restoration activities. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. 4. Comparative analysis of field trips to treated vs. untreated sites (*timing relevant to post-implementation is critical-minimum one-year post). | 1. Pre- post-implementation/ outreach. Track annually for first 5 years post. | 1. Focus group, interview and survey results. 2. Headwaters Institute. | The public perceives that aesthetic values are not enhanced as forest restoration activities are occurring. | | |
| GOAL: Rural communities play an active part in reducing fire risk by implementing FireWise actions and creating defensible space around their property. | | | | | | | | |
| Rural community residents are aware/ knowledgeable of FireWise principles/ FireWise communities. | Are rural community residents aware/ knowledgeable of FireWise principles/FireWise communities? | Public awareness/ knowledge for FireWise principles. | 1. Focus groups with community members. 2. Interviews with fire prevention managers. 3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Rural community residents are unaware/not knowledgeable of FireWise principles/ FireWise communities. | | |
| Rural community residents are aware/ knowledgeable of implementing defensible space. | Are rural community residents aware/ knowledgeable of implementing defensible space? | Public awareness/ knowledge of implementing defensible space. | 1. Focus groups with community members. 2. Interviews with fire prevention managers. 3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Rural community residents are unaware/not knowledgeable of implementing defensible space. | | |
| Number of communities that are recognized as FireWise increases. | Are the numbers of communities that are recognized as FireWise increasing? | Number of communities recognized as FireWise. | Track # of communities recognized as Firewise. | Pre- post-implementation /outreach. 5 years. | Firewise Communities USA (http://www.firewise.org/Communities/USA-Recognition-Program.aspx). | Number of communities that are recognized as FireWise is not increasing. | | |
| GOAL: There is broad public support for the 4FRI Collaborative as forest restoration activities are implemented. | | | | | | | | |
| The public is aware of the 4FRI Collaborative. | Is the public aware of the 4FRI Collaborative? | Public awareness of the 4FRI Collaborative. | 1. Focus groups with community members. 2. Interviews with land managers/key decision-makers. 3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not aware of the 4FRI Collaborative. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| The public is knowledgeable/understands the 4FRI Collaborative's role in the 4FRI Initiative. | Is the public knowledgeable/understands the 4FRI Collaborative's role in the 4FRI Initiative? | Public's knowledge of the 4FRI Collaborative's role in the 4FRI Initiative. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public does not understand the 4FRI Collaborative's role in the 4FRI Initiative. | | |
| The public is supportive of the 4FRI Collaborative. | Is the public supportive of the 4FRI Collaborative? | Public support for the 4FRI Collaborative. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not supportive of the 4FRI Collaborative. | | |
| GOAL: There is public support for the USFS as forest restoration activities are implemented. | | | | | | | | |
| The public is aware of the USFS's involvement/role with the 4FRI Collaborative. | Is the public aware of the USFS's involvement/role with the 4FRI Collaborative? | Public awareness for the USFS's involvement/role with the 4FRI Collaborative. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not aware of the USFS's involvement/role with the 4FRI Collaborative. | | |
| The public is aware of the USFS's involvement with the 4FRI Project. | Is the public aware of the USFS's involvement with the 4FRI Project? | Public awareness for the USFS's involvement/role with the 4FRI Project. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not aware of the USFS's involvement with the 4FRI Project. | | |
| The public is supportive of the USFS's involvement with the 4FRI Collaborative. | Is there public support/acceptance for the USFS's involvement with the 4FRI Collaborative? | Public support for the USFS's involvement with the 4FRI Collaborative. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not supportive of the USFS's involvement with the 4FRI Collaborative. | | |
| The public is supportive of the USFS's involvement with the 4FRI Project. | Is there public support/acceptance for the USFS's involvement with the 4FRI Project? | Public support for the USFS's involvement with the 4FRI Project. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The public is not supportive of the USFS's involvement with the 4FRI Project. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: The general public is aware, knowledgeable and supportive of 4FRI implemented treatments within the analysis area. | | | | | | | | |
| The general public is aware of 4FRI implemented treatments within the analysis area. | Is the general public aware of 4FRI implemented treatments within the analysis area? | Public awareness of 4FRI implemented treatments within the analysis area. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The general public is unaware of 4FRI implemented treatments within the analysis area. | | |
| The general public is knowledgeable/ understands 4FRI implemented treatments (mechanical thinning, road alteration, etc. as necessary tools) for ecological restoration within the analysis area. | Is the general public knowledgeable/ understands 4FRI implemented treatments for ecological restoration within the analysis area? | Public knowledge/ understanding 4FRI implemented treatments (mechanical thinning, road alteration, etc.) as necessary tools for ecological restoration within the analysis area. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The general public is not knowledgeable/does not understand 4FRI implemented treatments (mechanical thinning, road alteration, etc.) as necessary tools for ecological restoration within the analysis area. | | |
| The general public is supportive of 4FRI implemented treatments within the analysis area. | Is the general public supportive of 4FRI implemented treatments within the analysis area? | Public support for 4FRI implemented treatments within the analysis area. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers...<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The general public is not supportive of 4FRI implemented treatments within the analysis area. | | |
| There is ample notification to the public of 4FRI implemented projects that may include road construction, mechanical thinning, prescribed and managed fires, etc. | **Q1:** Does the public believe there is ample notification of restoration projects?<br>**Q2:** What campaigns and public notifications are in place to inform the public of restoration treatments and/or prep for those treatments? | **Q1:** Public perception of notification of restoration projects/activities.<br>**Q2:** Website postings, newspaper, radio, direct signage in the forest, 4FRI 800#, etc. | **Q1:** 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area.<br>**Q2:** Number, type, content analysis of public campaigns/ notifications. | **Q1:** Pre- post-implementation/outreach. Track annually for first 5 years post. **Q2:** Annual | **Q1:** Focus group, interview and survey results.<br>**Q2:** Results from content analysis. | **Q1:** Public perception of notifications of 4FRI implemented projects is not sufficient (road construction, mechanical thinning, prescribed and managed fires, etc.).<br>Q2: An insufficient amount of campaigns and public notifications are in place to adequately inform the public of restoration treatments and/or prep for those treatments. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: The general public is aware of 4FRI educational and outreach programs and has the opportunity to participate in the 4FRI effort. | | | | | | | | |
| The general public is aware of 4FRI educational and outreach programs. | Is the general public aware of 4FRI educational and outreach programs? | Public awareness of 4FRI educational and outreach programs. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The general public is unaware of 4FRI educational and outreach programs. | | |
| The general public has the opportunity to participate in the 4FRI educational and outreach programs. | Does the general public have the opportunity to participate in the 4FRI educational and outreach programs? | Public's opportunity to participate in the 4FRI educational and outreach programs. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area.<br>4. Number, frequency, type of educational and outreach programs. | Annual | 1. Focus group, interview and survey results.<br>2. USFS by forest. 3. 4FRI Collaborative Stakeholder group. | The general public has not had ample opportunity to participate in the 4FRI educational and outreach programs. | | |
| Youth are aware of 4FRI educational and outreach programs. | Are youth aware of 4FRI educational and outreach programs? | Youth awareness for 4FRI educational and outreach programs. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Youth are not aware of 4FRI educational and outreach programs. | | |
| Youth has the opportunity to participate in the 4FRI educational and outreach programs. | Do youth have the opportunity to participate in the 4FRI educational and outreach programs? | Opportunities for youth to participate in the 4FRI educational and outreach programs. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area.<br>4. Survey local youth group coordinators. 5. Number, frequency, type of youth programs related to the 4FRI effort. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Youth have not had ample opportunity to participate in the 4FRI educational and outreach programs. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| Low income/minority populations are aware of 4FRI educational and outreach programs. | Are low income/minority populations aware of 4FRI educational and outreach programs? | Awareness of low income/minority populations of 4FRI educational and outreach programs. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. Oversample low income/minority populations.<br>5. Number, frequency, type of outreach programs geared towards low income/minority populations related to the 4FRI effort. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Low income/minority populations are unaware of 4FRI educational and outreach programs. | | |
| Low income/minority populations have the opportunity to participate in the 4FRI educational and outreach programs. | Do low income/minority populations have the opportunity to participate in the 4FRI educational and outreach programs? | Low income/minority populations opportunity to participate in the 4FRI educational and outreach programs. | 1. Focus groups with community members.2. Interviews with land managers/key decision-makers.3. Telephone survey with residents in study area.<br>4. Oversample low income/minority populations.<br>5. Number, frequency, type of outreach programs geared towards low income/minority populations related to the 4FRI effort. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | Low income/minority populations have not had ample opportunity to participate in the 4FRI educational and outreach programs. | | |
| The general public has the opportunity to participate in the 4FRI effort. | Does the general public have the opportunity to participate in the 4FRI effort? | Public's opportunity to participate in the 4FRI effort. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. Number, frequency, type of outreach programs for public participation in the 4FRI effort. | Pre- post-implementation/outreach. Track annually for first 5 years post. | Focus group, interview and survey results. | The general public has not had ample opportunity to participate in the 4FRI effort. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN…* | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: Treatments within the analysis area minimize short-term impacts and enhance vegetation characteristics valued by Forest users over the long-term. | | | | | | | | |
| Treatments within the analysis area minimize short-term impacts such as skid trails, decks, excessive slash, roads etc. | **Q1:** What are the short-term impacts of concern to Forest users? **Q2:** Are treatments within the analysis area minimizing short-term impacts such as: skid trails, decks, excessive slash, roads etc.? | **Q1:** Treatments' short-term impacts of concern to forest users. Q2: Public's perception of short-term impacts of treatments. | **Q1:** Review BMP monitoring reports. **Q2:** 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. Field trips/focus groups to restoration sites. | Pre- post-implementation/outreach. Track annually for first 5 years post. | **Q1:** BMP Reports **Q2:** Focus group, interview, field trip and survey results. | Treatments within the analysis area are not minimizing short-term impacts of concern to forest users (e.g. skid trails, decks, excessive slash, etc.). | | |
| Treatments within the analysis area enhance vegetation characteristics valued by Forest users over the long-term. | **Q1:** What are the vegetative characteristics valued by Forest users over the long-term?<br>**Q2:** Do these treatments enhance vegetation characteristics valued by Forest users over the long-term? | **Q1:** Vegetative characteristics valued by Forest users over the long-term.<br>Q2: Public's perception of vegetative characteristics that are valued by Forest users over the long-term. | 1. Focus groups with community members.<br>2. Interviews with land managers/key decision-makers.<br>3. Telephone survey with residents in study area.<br>4. Field trips/focus groups to restoration sites. | Pre- post-implementation/outreach. Track in 10-year increments over life of project. | Focus group, interview and survey results. | Treatments within the analysis area do not enhance vegetation characteristics that are valued by Forest users over the long-term. | | |

***Rev. 4/11/12***

**Columns "Management Action Then" and "Monitoring Costs" will be completed at a later date.*

References included in this table are listed in the Socioeconomic Monitoring report.

*Table X: Four Forest Restoration Initiative Economic Framework*

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| | | | | ECONOMIC | | | | |
| GOAL: The byproducts of mechanical forest restoration offset the costs of treatment implementation. | | | | | | | | |
| Wood byproduct sales exceed the costs of implementation (Contractors are operating at a profit and the USFS does not have to pay contractors' treatment costs). | **Q1:** Do byproduct sales exceed operational costs? **Q2:** Are treatments adequately sequenced to enable contractors to offset their overall operational costs? **Q3:** Are USFS contracting costs decreasing? | **Q1:** 1. Operational costs of treatments: a. Mobilization: to move equipment from site to site, to move operators (daily) from home base to site. b. Loading: cutting, skidding, delimbing, piling slash, loading stems. c. Haul: transport costs from landing to processing site (time & distance). 2. Amount of wood and its value (4FRI 11/2010). 3. Degree of deviation from business plan(s). **Q2:** 1. # of task orders and location. 2. Wood yields/task order (4FRI 11/2010). | **Q1:** Operational costs of treatments vs. amount of wood & its value (4FRI 11/2010). _____ **Q2:** Average wood yields vs. # of task orders balanced on a semi-annual or quarterly basis (4FRI 11/2010). | Dependent on business plan(s). | 1. Contractor surveys 2. USFS business plans (PC: D. Jaeorski 2011). 3. Contracts: federal databases a. USAspending.gov b. USFS Natural Resource Manager Database (UO 2011). 4. Headwaters Institute | **Q1:** Operational costs of treatments exceed byproduct sales. **Q2:** Average wood yields per #s of task orders do not support contractors operating at a profit. | | |
| GOAL: The economic value of ecosystem services provided by restored forests (such as the value of recreation or water) are captured and reinvested to support forest restoration and ecosystem management. | | | | | | | | |
| The economic value of ecosystem services provided by restored forests, such as ***the value of recreation/tourism,*** are captured and re-invested to support forest restoration and ecosystem management. | **Q1:** What is the increase (%) in direct service revenues related to recreation/tourism? **Q2:** What is the increase (%) in revenues associated w/fee imposed recreation activities (e.g. hunting, fishing, pass/entry fees etc.)? _ **Q3:** 1. Has a portion of the determined value of increased recreational revenues been reinvested in forest restoration? 2. How many collaborators are involved in contributing to this program? | **Q1:** 1. Lodging, 2. Restaurant, 3. Groceries, 4. Gas/Oil, 5. Other transportation, 6. Activities, 7. Admissions/Fees, 8. Souvenirs/Other, expenditures (USFS 2005). ____________**Q2:** 1. AZG&F license sales by County. 2. Visitor fees. **Q3:** Dollar value of fees invested in forest restoration activates | **Q1-Q3:** Travel cost method using: USFS, AZG&F, USFWS reports tracked with investments made in forest restoration from fees/licenses/private revenues. | 5 years (USFS 2005; USFWS 2006) | **Q1:** 1. National Visitor Use Monitoring Program (USFS 2005). 2. Headwaters Institute **Q2:** 1. AZG&F The Economic Importance of Fishing and Hunting (utilizes IMPLAN input/output model) (AZG&F 2001). 2. USFWS National Survey of Fishing, Wildlife, Hunting, & Wildlife Assoc. Recreation (USFWS 2006). 3. Visitor surveys. **Q3:** S&MWG database | **Q1/Q2:** Direct service revenues and license fees related to recreation/tourism are decreasing as forest restoration activates are occurring. **Q3:** A portion of revenues generated from recreation and tourism are not being reinvested in forest restoration activities. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| The economic value of ecosystem services provided by restored forests, such as ***the value of water,*** are captured and reinvested to support forest restoration and ecosystem management. | **Q1:** What is the effect in water yield, pre- post-restoration? **Q2:** What is the effect in sedimentation, pre- post-restoration? **Q3:** What is the economic value of increase/loss of water yield? **Q4:** [If increased] Has a portion of the determined value of increased water yield been reinvested in forest restoration? _ **Q5:** Are restoration projects reducing the costs of producing a potable water supply? **Q6:** How many collaborators are involved in contributing to this program and what is the $ value of each? | **Q1/Q2:** SRP Paired Watershed Study Costs associated w/: a. Transport, b. Treating, c. Developing new/existing water supplies, d. Capture, e. Delivery **Q3-Q5:** Watershed fund revenues (e.g. assess a fee to each water consumer based on use, projected at $x.xx per 5,000 gallons per month (SFWA 2009; CoF 2010). a. Operation & maintenance expenses b. Taxes/transfers c. Capital additions/replacement d. Debt services (principle/interest) e. Allocated indirect costs f. Administration (CoF 2010). | **Q1/Q2:** SRP Paired Watershed Study compare results to Beaver Creek and Castle Creek Watershed Studies (AFRTG 2010). **Q3-Q5:** Determined value of increased water yield vs. proportion of this value invested in forest restoration activities. | Dependent on SRP Study and Promotion of Ecosystem Services Investment. | **Q1/Q2:** 1.SRP/NAU 2. Beaver Creek Watershed Study 3. Castle Creek Watershed Study (AFRTG 2010). 4. Watershed Conditions Framework (USFS). **Q4/Q5/Q6:** 1. City of Flagstaff Utilities (Water) Dept. 2. Long-term Financial Plan & Rate & Fee Study (CoF 2010). 3. S&MWG database. | **Q1:** Water yield is decreasing as restoration activities are occurring. **Q2:** Sedimentation is increasing as restoration activities are occurring. **Q3:** A portion of revenues generated from watershed restoration and protection are not being reinvested in forest restoration activities. **Q5:** Restoration projects are not assisting in reducing the costs of producing a potable water supply. | | |
| The economic value of ecosystem services provided by restored forests, such as ***wildlife habitat creation and preservation,*** are captured and reinvested to support forest restoration and ecosystem management. | Are forest restoration activities maintaining and enhancing habitat for wildlife to an extent that biodiversity offsets and compensation programs can be implemented and resulting funds are reinvested into forest restoration activities? | 1. Wetland & Stream Ecosystems Compensation. 2. Endangered Species Compensation. 3. Conservation Banking (Madsen 2010). | Value of compensation for preservation of wetland and stream ecosystems and endangered species vs. the proportion reinvested into forest restoration activities (Madsen 2010). | 10 years | USFWS NMFS (Madsen 2010). | Forest restoration activities are not maintaining and enhancing habitat for wildlife to an extent that biodiversity offsets and compensation programs can be implemented and resulting funds are reinvested into forest restoration activities. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| The economic value of ecosystem services provided by restored forests, such as ***wildfire cost savings,*** are captured and reinvested to support forest restoration and ecosystem management. | **Q1:** What are the fire suppression costs incurred 5 years post 4FRI implementation and how does this compare to 5 years pre 4FRI implementation? **Q2:** What is the amount of cost savings (avoided costs vs. treatment costs) of wildfire suppression that has been reinvested in forest restoration activities? | **Q1:** Federal, state and local suppression costs, Private property losses (insured & uninsured), Damage to utility lines, Damage to recreation facilities, Loss of timber resources, Aid to evacuees (WFLC 2010), resurveying land boundaries (PC: M. Lata 2011). **Q2:** 1. Acres treated & $ amount/acre of risk reduction. 2. Dollar value reinvested in restoration activities. | Wildfire suppression costs 5 yrs. post-4FRI implementation (control for increases in population and housing) vs. the amount of cost savings that is reinvested in forest restoration activities. | 5 years post-implementation | **Q1:** 1. Direct suppression costs obtained from: USFS, BLM, NRCD, NIFC, State, County, FEMA, DHS, Insurance companies, American Red Cross (WFLC 2010). **Q1/Q2:** 1. Direct treatment costs obtained from: USFS, contractors. 2. Headwaters Economics (population/housing). 3. USFS budget staff (PC: D. Jaworski 2011) 4. S&MWG database. | **Q1:** Fire suppression costs are not decreasing (5 years post 4FRI when compared to 5 years pre 4FRI). **Q2:** A proportion of cost savings of wildfire suppression has not been reinvested in forest restoration activities. | | |
| GOAL: Rural communities receive direct and indirect economic benefits and ecosystem services as a result of forest restoration and resilient forests. | | | | | | | | |
| Forest restoration activities will create direct quality jobs in rural communities in Arizona. | **Q1:** How many direct jobs have been created by forest restoration activities? **Q2:** What is the quality of the jobs? **Q3:** Are the jobs filled by local residents? **Q4:** How many direct jobs have been filled by low-income/minority populations? | **Q1-Q3:** Number, Types (FT vs. PT vs. seasonal), Positions, % of jobs over total employment (A. Egan, V. Estrada-Bustillo 2011) Avg. length of employment, % receiving benefits or payments in lieu of, Wages (avg./worker, family-supported), Locations, % of contracts w/ on the job training, Safety (% & # of contracts w/o job related injuries/illnesses resulting in lost wk. time), % and # of local workforce (resident zip codes), Distance traveled to work (UO 2011). | Economic Impact Analysis: Direct reporting of primary and secondary data. | Annual | 1. Contractor reporting form/survey. 2. Headwaters Institute (EPS-HDT Socioeconomic profiles). 3. Bureau of Labor Statistics (Stynes 1992). | **Q1:** Forest restoration activities have not created a sufficient number of direct jobs. **Q2:** Forest restoration activities have not created a sufficient number of quality jobs (e.g. FT, positions, benefits, trainings, safety, etc.). **Q3:** Forest restoration activities have not created a sufficient number of jobs that are filled by local residents. | | |
| Forest restoration activities will create indirect jobs in rural communities in Arizona. | How many indirect jobs have been created by forest restoration activities? | Direct Jobs: Number, Types (FT vs. PT), Avg. length of employment (UO 2011). | Region specific dollar-tracking and multiplier effects of direct employment *(for every x $s spent by a business, x $s are created)* (A. Egan, V. Estrada-Bustillo 2011, WMSP 2010, Stynes 1992). | Annual | 1. Contractor reporting form/survey. 2. Headwaters Institute (EPS-HDT Socioeconomic profiles). 3. Bureau of Labor Statistics (Stynes 1992). | Forest restoration activities have not created a sufficient number of indirect jobs. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
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| Forest restoration activities will create increased retail sales/services in rural communities in Arizona. | **Q1:** Has city/county sales tax on goods and services increased as forest restoration activities have occurred? **Q2:** Have retail sales/service revenues increased as forest restoration activities have occurred? | **Q1:** City/county sales tax on goods and services. **Q2:** Retail sales & services revenue. | Dollar-tracking and multiplier effects (region-specific) (WMSP 2010) of business activity (Stynes 1992). | Annual | 1. AZ Dept. of Revenue. 2. City reports. 3. County reports. 4. US Census Bureau. 5. U.S. Department of Labor, Bureau of Labor Statistics. 6. Arizona Indicators (MIPP 2011). | **Q1:** City/county sales tax on goods and services has not increased as forest restoration projects have been implemented. **Q2:** Retail sales & services revenue has not increased as forest restoration projects have been implemented. | | |
| Forest restoration activities will create increased tax revenues (e.g. property tax, business expenditures) in rural communities in Arizona. | **Q1:** Have taxes generated from forest industry business expenditures increased as forest restoration activities have occurred? **Q2:** Have property/sales tax/school revenues generated from forest industry employees (direct/indirect jobs) increased as forest restoration activities have occurred? | **Q1:** 1. Sales of wood products. 2. Capital expenditures of project materials. 3. Subcontract thinning services (WMSP 2010). **Q2:** 1. Sales/property taxes generated by employees (direct & indirect) (by county). 2. School revenues generated by avg. family. 3. Sales tax generated by avg. per capita expenditures on consumable goods/supplies (by county) (WMSP 2010). | **Q1/Q2:** Total net employee revenue based on jobs estimates and economic contributions from forest industry employees (direct/indirect). Indirect jobs: use regional multiplier effect, inout/output modeling) (WMSP 2010). | Annual | 1. Contractor reporting form/survey. 2. U.S. Bureau of Economic Analysis (WMSP 2010). 2. Headwaters Institute (EPS-HDT Socioeconomic profiles). | **Q1:** Taxes generated from forest industry business expenditures have not increased as forest restoration activities are implemented. **Q2:** Property/sales tax/school revenues generated from forest industry employees (direct/indirect jobs) have not increased as forest restoration activities are implemented. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| Forest restoration activities will increase recreation/tourism in rural communities in Arizona. | **Q1:** Has recreation increased as forest restoration activities have occurred? **Q2**: Has tourism increased as forest restoration activities have occurred? ___ **Q3:** Has tourism related jobs/housing increased as forest restoration activities have occurred? | **Q1:** 1. AZG&F license sales by County. 2. Visitor days **Q2:** 1. Lodging 2. Restaurant 3. Groceries 4. Gas/Oil 5. Other transportation 6. Activities 7. Admissions/Fees 8. Souvenirs/Other expenditures (USFS 2005). 9. Tourism tax (e.g. Flagstaff Bed, Board & Booze (BBB) tax). _____ **Q3:** 1. Travel and tourism jobs (seasonal employment). 2. Housing related to tourism jobs. | Economic Impact Analysis: Track flow of economic activity associated with tourism. | 5 years (USFS 2005; USFWS 2006). | 1. National Visitor Use Monitoring Program (USFS 2005). 2. AZG&F The Economic Importance of Fishing and Hunting (utilizes IMPLAN input/output model) (AZG&F 2001). 3. USFWS National Survey of Fishing, Wildlife, Hunting, & Wildlife Assoc. Recreation (USFWS 2006). 4. Sales Tax by City (if applicable, Tourism tax). 5. AZG&F 6. Headwaters Institute (EPS-HDT Socioeconomic profiles). 7. Visitor surveys. | **Q1:** Recreation has decreased as forest restoration activities have occurred. **Q2:** Tourism has decreased as forest restoration activities have occurred. **Q3:** Tourism related jobs/housing has decreased as forest restoration activities have occurred. | | |
| Opportunity for local contractors to conduct restoration work increases. | **Q1:** Have opportunities for local contractors to conduct restoration work increased? **Q2:** What is the proportion of local to non-local awards? **Q3:** Where are the contractors located? | **Q1/Q3:** Location of businesses (zip code by county) **Q2:** Percentage of local contracted businesses (contractor and subcontractors) and total contractual amount for each (UO 2011). | Comparative analysis of local contract awards vs. non-local (# of contracts and respective value). | Every ten years or length of the contract. | 1. Contracts: federal databases 1. USAspending.gov 2. USFS Natural Resource Manager Database (UO 2011). | **Q1:** Opportunities for local contractors to conduct restoration work has not increased. **Q2/Q3:** Local awards are proportionally lower than non-local awards (# of contracts and respective value). | | |
| Construction and/or improvement of infrastructure required for forest restoration activities increase revenues to local businesses. | Have revenues to local businesses providing supplies for infrastructure increased? | Revenues of local businesses providing supplies for infrastructure. | Economic Impact Analysis: Track flow of economic activity associated with construction and/or improvement of infrastructure. | Dependent on timing of infrastructure development/improvement. | 1. Contractor reporting form/survey. 2. Local business reporting form/survey. 3. U.S. Bureau of Economic Analysis (WMSP 2010). | Revenues to local businesses supporting construction and/or improvement of infrastructure do not increase. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: The average net cost per acre of treatment and/or prep, administrative costs in the 4FRI project/analysis area are reduced significantly. | | | | | | | | |
| The average net cost (operational costs of the contract) of treatment per acre in the 4FRI project area over a thirty-year period (the life of the project) is decreasing over time. | Are the average net cost of treatment per acre that are attached to the contract in the 4FRI project area decreasing as new contracts are released and awarded? | Operational cost (per acre) attached to the contract (PC: D Fleishman 2011). | Tracking and comparison of operational costs of contracts. | Every ten years or length of the contract. | 1. Contracts: federal databases: a. USAspending.gov b. USFS Natural Resource Manager Database (UO 2011). | The average net costs of treatment per acre that are attached to the contract in the 4FRI project area are increasing as new contracts are released and awarded. | | |
| The average net cost of treatment per acre in the analysis area for preparation and administration costs are reduced over time. | **Q1:** What is the difference in average net cost of treatment per acre in the analysis area for preparation and administrative costs associated with different restoration designations (e.g. description vs. prescription)? **Q2:** Is average net cost of treatment per acre in the analysis area for preparation and administration costs reduced over time? | Costs include: 1. Project prep 2.Task order/contract administration 3. Planning under NEPA/NFMA 4. Project management 5. Project-level monitoring 6. Contract monitoring (4FRI 11/2010; WMSC 2010). | **Q1:** Cost effective analysis (Robbins and Daniels 2011). **Q2:** Tracking and comparison of prep and admin costs of contracts. | Every ten years or length of the contract. | Southwestern Region Restoration Task Group (cited in 4FRI LRS 10/2011). | **Q1:** Various restoration designation costs are not analyzed and compared. **Q2:** The average net cost of treatment per acre in the analysis area for preparation and administration costs is increasing over time. | | |
| Mechanical treatment costs are reduced. * See Rx fire costs GOAL: Wildfire management costs are reduced; aggressive fire suppression is unneeded or rare (pg. xx). | Are mechanical treatment costs decreasing over time? | 1. Move equipment and operators 2. Cutting 3. Skidding 4. Delimbing 5. Loading 6. Slash piling 7. Road Maintenance, 8. Overhead (4FRI 11/2010). | Tracking of mechanical costs over time. | 5 years | Contractor surveys. | Mechanical treatment costs increasing over time. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: Sufficient harvest and manufacturing capacity exists to achieve restoration of at least 300,000 acres in the next ten years. | | | | | | | | |
| Sufficient contractor capability exists to harvest approx. 30,000 acres per year. | Is there sufficient contractor capability to harvest approx. 30,000 acres per year? | 1. Total number of contracts by work type, size and distribution (# of task orders & corresponding acres) (Mosley & Davis, 2010; UO 2011; 4FRI 11/2010). 2. Financial incentive programs (e.g. grants, loan guarantees, tax incentives) available to contractors (4FRI 11/2010). | 1. Track contracts by work type, size and distribution. 2. Track financial incentive programs. | Every ten years or length of the contract. | 1. Contracts, federal databases a. USAspending.gov b. USFS Natural Resource Manager Database (UO 2011). 2. Contractor surveys 3. Headwaters Institute-Payments from federal lands (financial incentive programs). | There is insufficient contractor capability to harvest approx. 30,000 acres per year. | | |
| Sufficient private infrastructure exists to utilize woody biomass extracted from approx. 30,000 acres per year. | Is there sufficient private infrastructure to utilize woody biomass extracted from approx. 30,000 acres per year? | 1. Volume of material produced per biomass plant vs. volume utilized. 2. Location of private infrastructure relative to harvesting activities. | Track type of infrastructure, location and corresponding processing capability. | Tracked annually across ten years (or length of the contract). | Contractor surveys. | There is insufficient private infrastructure to process woody biomass extracted from approx. 30,000 acres per year. | | |
| A sufficient workforce (public & private) exists to harvest and utilize wood byproducts extracted from approx. 30,000 acres per year. | Is there a sufficient workforce (public & private) to harvest and utilize wood byproducts extracted from approx. 30,000 acres per year? | 1. # of FTE USFS employees designated for project planning, administration, and implementation. 2. # of FTE private sector employees designated for harvesting & processing. 3. USFS workload (dependent on current conditions-e.g. shift from overgrown forest to savannah system, shift from planning to implementation). 4. USFS workforce by position. | 1. # of FTE USFS employees designated vs. # of USFS employees needed to plan/administer/ implement 30k acres/year. _ 2. # of private employees trained and hired vs. # of employees needed to harvest/process 30k acres/year. 3. USFS workload vs. USFS positions (PC: M. Lata 2011). | Tracked annually across ten years or length of the contract. | 1. USFS by forest. 2. Headwaters Institute (EPS-HDT Socioeconomic profiles) 3. Bureau of Labor Statistics (Stynes 1992). 4. Contractor reporting form/survey. | There is an insufficient workforce (public & private) to harvest and process woody biomass extracted from approx. 30,000 acres per year. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: Wildfire management costs are reduced; aggressive fire suppression is unneeded or rare. | | | | | | | | |
| Direct wildfire suppression costs in 4FRI treated areas are reduced. | **Q1:** Are direct costs associated with wildfire suppression in 4FRI treated areas decreasing as forest restoration projects are implemented over time? __ **Q2:** What is the difference between direct wildfire suppression costs in 4FRI treated areas and treatment (planning, prep, admin & operational) costs? | **Q1:** Wildfire Supp Costs: (as above). **Q2:** 1. Planning, prep, admin costs: (as above). 2. Operational Costs: (as above). | **Q1:** Wildfire suppression costs 5 yrs. post-4FRI implementation (control for increases in population and housing) vs. wildfire suppression costs 5 yrs. pre-4FRI implementation. **Q2:** Wildfire suppression costs 5 yrs. post-4FRI implementation vs. treatment costs (planning, prep, admin & operational costs). | 5 years | **Q1:** 1. Direct suppression costs obtained from: USFS, BLM, NRCD, NIFC, State, County, FEMA, DHS, Insurance companies, American Red Cross (WFLC 2010). 2. Headwaters Institute (EPS-HDT Socioeconomic profiles). 3. USFS budget staff (PC: D. Jaworski 2011). **Q2:** 1. Southwestern Region Restoration Task Group (cited in LRS 2011). 2. Contractor surveys. | **Q1:** Direct costs associated with wildfire suppression are increasing as forest restoration projects are implemented over time. **Q2:** Direct wildfire suppression costs are higher than and treatment (planning, prep, admin & operational) costs. | | |
| Short-term (direct) rehabilitation costs are reduced. | Are short-term (direct) rehabilitation costs associated with wildfire rehabilitation decreasing as forest restoration projects are implemented over time (e.g. Burned Area Emergency Rehabilitation (BAER))? | BAER funds appropriated (tracked annually) (WFLC 2010). | BAER expenditures 5 yrs. post-4FRI implementation vs. BAER expenditures 5 yrs. pre-4FRI implementation. | 5 years (annual expenditures) | USFS BAER expenditure database (WFLC 2010). | Short-term (direct) rehabilitation costs associated with wildfire rehabilitation are increasing as forest restoration projects are implemented over time. | | |
| Wildfire suppression frequency and duration in 4FRI treated areas are reduced. | Are wildfire suppression efforts in 4FRI treated areas frequency and duration decreasing as forest restoration projects are implemented over time? | 1. Frequency of wildfires. 2. Duration of wildfires. | Frequency and duration of wildfires 5 yrs. post-4FRI implementation vs. frequency and duration of wildfires 5 yrs. pre-4FRI implementation. | 5 years | USFS by Forests (GFFP 2010). | Wildfire suppression efforts frequency and duration are increasing as forest restoration projects are implemented. | | |
| Managed fire frequency and duration are increasing. | Are managed fire frequency and duration increasing as forest restoration projects are implemented over time? | 1. Frequency of managed fires. 2. Duration of managed fires. | Frequency and duration of managed fires 5 yrs. post-4FRI implementation vs. frequency and duration of managed fires 5 yrs. pre-4FRI implementation. | 5 years | USFS by Forests (GFFP 2010). | Managed fire frequency and duration are decreasing as forest restoration projects are implemented. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| Prescribed fire frequency and duration are reduced. | Are prescribed fire frequency and duration decreasing as forest restoration projects are implemented over time? | 1. Frequency of prescribed fires.<br>2. Duration of prescribed fires. | Frequency and duration of prescribed fires 10 yrs. post-4FRI implementation vs. frequency and duration of prescribed fires 10 yrs. pre-4FRI implementation. | 10 years | USFS by Forests (GFFP 2010). | Prescribed fire frequency and duration are increasing as forest restoration projects are implemented. | | |
| Prescribed fire costs are reduced. | Are prescribed fire costs decreasing as forest restoration projects are implemented over time? | 1. Burn plans 2. Prep work 3. Cutting hand lines 4. Implement burn 5. Monitor burn (Irwin 2010: cited in 4FRI 11/2010). | Costs of prescribed fires 10 yrs. post-4FRI implementation vs. costs of prescribed fires 10 yrs. pre-4FRI implementation. | 10 years | USFS budget staff (PC: D. Jaworski 2011). | Prescribed fire costs are increasing as forest restoration projects are implemented. | | |
| Reduce size, and frequency of pile burns. | **Q1:** Is the frequency and size of pile burns decreasing as forest restoration projects are implemented over time? **Q2**: Is the volume of slash that is chipped (not burned) increasing? | **Q1:** 1. Frequency of pile burns. 2. Size of pile burns. **Q2:** Volume of slash that is chipped. | **Q1:** Frequency and size of pile burns 10 yrs. post-4FRI implementation vs. frequency and size of pile burns 10 yrs. pre-4FRI implementation. **Q2:** Volume of slash chipped 10 yrs. post-4FRI implementation vs. volume 10 yrs. pre-4FRI implementation. | 10 years | USFS by Forests (GFFP 2010). | Size and frequency of pile burns is increasing and volume of slash that is chipped is decreasing as forest restoration projects are implemented. | | |
| GOAL: There is a sufficient market place for small diameter wood products. | | | | | | | | |
| A sufficient market exists to consume wood biomass products. | Is there a sufficient market to sell wood biomass products? | 1. # of businesses and type of wood biomass material purchased (e.g. clean chips, dirty chips, round wood and saw timber) (WMSP 2010). 2. Dollar amount and/or % of available inventory/sales businesses purchased. | Economic Impact Analysis: include # of businesses, type of small diameter wood material purchased and dollar amount and/or % of available inventory/sales businesses purchased. | 5 years | Business surveys | There is an insufficient market to sell small diameter wood products. | | |
| Economic value of wood biomass products is sufficient to profitably process small diameter wood products. | Does the market value of wood products exceed production costs? | 1. Sales ($ value) of wood products.<br>2. Production costs: raw materials (wood products), hauling, petroleum products, mill equipment/parts, heavy equipment/parts, electricity, vehicle parts/tires, and transport equipment (WMSP 2010). | Financial analysis: Compare sales of wood products to production costs. | 5 years | Business surveys | The market value of wood products does not exceed production costs. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| Increase the amount of wood products (wood biomass and value-added) that are processed locally. | What is the proportion of biomass processed locally vs. non-local? | 1. Number of local businesses processing small diameter wood products. 2. Number of non-local businesses processing small diameter wood products.<br>3. Amount of wood (volume) products processed locally. 4. Amount of wood (volume) products processed non-locally (GFFP 2005). | 1. Compare # of local vs. non-local businesses (% each). 2. Compare local vs. non-local business volume of wood product production (% each). | 5 years | 1. Contractor surveys. 2. Contracts, federal databases<br>a. USAspending.gov<br>b. USFS Natural Resource Manager Database (UO 2011). | The proportion of biomass processed locally is lower than biomass processed outside of the defined local area. | | |
| Increase the amount of wood products (wood biomass and value-added) that are distributed locally. | **Q1:** Where are the wood products distributed?<br>**Q2:** What is the proportion of end-products distributed locally vs. non-local? | **Q1:** Location of wood product distribution. **Q2:** Volume/quantity of wood products distributed locally and non-local. | Compare location of wood product distribution and proportion of volume of wood products distributed locally vs. non-local. | 5 years | 1. Contractor surveys. 2. Contracts, federal databases<br>a. USAspending.gov<br>b. USFS Natural Resource Manager Database (UO 2011). | **Q1/Q2:** The amount of wood products (small diameter and value-added) that are distributed locally are not increasing. | | |
| Investment, research and development in utilization of wood biomass are increasing. | Are investment, research and development in utilization of wood biomass increasing? | 1. Number of forest product industries involved in market research for small diameter wood uses.<br>2. Amount invested by businesses for development and research.<br>3. Type and amount of market analysis.<br>4. Number of companies applying for grants that support small diameter market research (GFFP 2005). | Track # involved in market research for small-diameter wood uses, amount invested, type and intensity of market research, # of companies applying for grants supporting small diameter product development. | 5 years | 1. Contractor/business surveys.<br>2. Headwaters Institute | Investment, research and development in utilization of small diameter trees are not increasing. | | |
| Uses for wood biomass and/or value-added products are expanded and diversified. | **Q1:** What is the type and proportion of the production of wood biomass end-products? **Q2:** Are uses for wood biomass and/or value-added products expanding and diversifying? | **Q1/Q2:** Percentage production of: Pellets, Pallets, Molding, Small lumber, Biomass-energy, Livestock bedding, Soil fertilizers, (Sitko and Hurteau 2010) OSB, Plywood, Particle board, Fiberboard, Roundwood products (Larson 2001: cited in 4FRI 11/2010). | Compare % of production of type of wood products and track over time. | 5 years | Contractor/business surveys. | **Q1/Q2:** Uses for small diameter material and/or value-added products are not expanding and diversifying. | | |

| Objective | Monitoring Question | Monitoring Indicator(s) (Metric) | Assessment | Frequency of Assessment | Data Source | Threshold IF… (Undesirable Conditions) | Management Action THEN… * | Cost * |
|---|---|---|---|---|---|---|---|---|
| GOAL: There is a predictable wood supply throughout the life of the 4FRI project. | | | | | | | | |
| Ensure the availability of forest material at a sustainable, consistent level to support appropriate forest product industries throughout the life of the 4FRI project. | **Q1:** Are the length of contracts sufficient to recover costs and realize return on investment? **Q2:** Do contracts provide the flexibility to respond to fluctuating markets (e.g. pile and burn slash vs. removal) & redetermination of wood product's value? **Q3:** Do contracts provide guaranteed treatable acres that will provide a return on investment? **Q4:** Are appeals and lawsuits for 4FRI projects hampering the project's progression? | **Q1:** 1. Length of contracts. 2. Operational cost incurred to complete contracts (as above). 3. Wood yields and respective value/contract. 4. Number of acres/year USFS admin planning are complete. **Q2: 1. P**ile/burn costs 2. Slash removal costs 3. Wood product value **Q3:** 1. Avg. wood yield/ treatable acres/contract. 2. Operational cost incurred to complete contracts (as above). **Q4:** Number and length of time (each) of appeals and lawsuits that are delaying the 4FRI project's progression. | **Q1:** Economic Impact Analysis: 1. Operational costs vs. wood yields and respective value. 2. # of acres USFS admin/planning are complete vs. # of acres/contract. **Q2:** Contract analysis of: 1. Pile/burn slash costs vs. removal costs. 2. Valuation of wood products. **Q3:** Avg. wood yield per treatable acres/contract and its respective value vs. operational costs. **Q4:** # & length of time of lawsuits; # of delayed treatable acres, volume and its value. | Ten years or length of the contract. | **Q1-Q3:** 1. Contractor surveys 2. USFS business plans (PC: D. Jaworski 2011). 3. Contracts: federal databases a. USAspending.gov b. USFS Natural Resource Manager Database (UO 2011). 4. Headwaters Institute **Q4:** Appeals database available at: www.fs.fed.us/forum/nepa (Cortner et. al 2003). | **Q1:** The length of contracts is not long enough to recover costs and realize a return on investment. **Q2:** Contracts do not provide the flexibility to respond to fluctuating markets & redetermination of wood product's value. **Q3:** Contracts do not provide guaranteed treatable acres that will yield a return on investment. **Q4:** Appeals and lawsuits for 4FRI projects are significantly delaying the project's progression (acres treated & respective value). | | |

***Rev. 4/11/12***

**Columns "Management Action Then" and "Monitoring Costs" will be completed at a later date.*

**Acronyms defined** (alphabetical order):

| | |
|---|---|
| AZG&F | Arizona Game & Fish Department |
| BAER | Burned Area Emergency Rehabilitation |
| BLM | Bureau of Land Management |
| DHS | Department of Homeland Security |
| FEMA | Federal Emergency Management Agency |
| NEPA | National Environmental Protection Act |
| NIFC | National Interagency Fire Center |
| NFMA | National Forest Management Act |
| NMFS | National Marine Fisheries Service |
| NRCD | Natural Resource Conservation Districts |
| SRP | Salt River Project Power & Water |
| SWRRTG | Southwestern Region Restoration Task Group |
| WMSC | White Mountain Stewardship Contract |
| USFS | United States Forests Service |
| USFWS | United States Fish & Wildlife Service |

References included in this table are listed in the Socioeconomic Monitoring report.

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## *Appendix 6. Multi-Party Monitoring Efforts in the 4FRI Region*

| **Past Multiparty Monitoring Efforts Across the Four Forest Restoration Initiative Project Area (2004-2010)** | | |
|---|---|---|
| **Project Name** | **Year** | **Description or url (if available)** |
| Grand Canyon Forests Partnership *Multiparty Monitoring Plan* (Stewardship Project) | 2004 | http://www.gffp.org/gfv/gfv.htm |
| *Report on a Needs Assessment for Collaborative Landscape Planning in the White Mountains of Arizona Ecological Restoration Institute (ERI)* | 2005 | http://www.eri.nau.edu/files/Research/WMNeedsAssessmentFinal.pdf |
| Greater Flagstaff Forests Partnership (GFFP) *Adaptive Management Framework* | 2005 | http://www.gffp.org/monitor/AdaptiveManagement.pdf |
| *Monitoring the Effectiveness of Fuel Reduction Treatments within the Wildland/Urban Interface Zone of Flagstaff Area Community Wildfire Protection Plan* (National Forest Foundation Grant -GFFP) | 2005 | http://www.gffp.org/Reports/Post_Trtmt_Effectiveness_ForPonderosa.pptm |
| *A Baseline Social Assessment for Communities of Navajo and Apache Counties* (White Mountain Stewardship Project (WMSP)) | 2005 | http://www.fs.fed.us/r3/asnf/stewardship/s-docs/Dr%20Collins%20Social%20Assessment%20Summary%20Flyer%202006.pdf |
| White Mountain Stewardship Monitoring Framework | 2005 | Adapted from GFFP's |
| *WMSP Economic Assessment* | 2005-2007 | http://www.fs.fed.us/r3/asnf/stewardship/multi-party-monitoring.shtml |
| Strategic Planning Team Focus Group – GFFP and USFS | 2005 | Institutional Health |
| *Fort Valley Pilot Study* | 2006 | |
| Greater-Flagstaff Omnibus Survey Spring 2006 – Greater Flagstaff Forests Partnership (Social monitoring) | 2006 | (AZ Daily Sun article, USFS Success Story) http://www.gffp.org/about_gffp/GFFP_OmnibusReport.pdf http://www.azdailysun.com/articles/2006/06/26/news/20060626_news_15.txt http://www.gffp.org/about_gffp/nfp_success.htm |
| Greater-Flagstaff Omnibus Survey Spring 2007 (Social monitoring – longitudinal) | 2007 | http://www.gffp.org/monitor/Survey-Results_07_09.pdf |
| Devil's Head Communication Site (Photo points – pre and post-treatment) (GFFP) | 2008 | http://www.gffp.org/monitor/devils_head.pdf |
| City Well Field Monitoring Project (GFFP) | 2008 | http://www.gffp.org/monitor/city_wells.pdf |
| Southwest Ecological Restoration Institutes (SWERI) - Moving Toward Tomorrow: Developing a Framework for Monitoring the Forested Ecosystems of the Southwest | 2008 | http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASHcfb7.dir/doc.pdf |
| AZ Governor's Forest Health Council Statewide Strategy Scorecard | In progress | |
| GFFP Monitoring Protocol (Modified from: USFS Region 3 Common Stand Exam Field Guide; Version 1.7 USFS 2005) (GFFP) | 2009 | http://www.gffp.org/monitor/docs/GFFP_Monitoring_Protocall.pdf |
| WMSP Five Year Report | 2010 | http://www.sierraforestlegacy.org/Resources/Community/Biomass/BM_White_Mtn_5years_ES.pdf |
| Forest Restoration and Community Wildfire Protection: Ten Years of Lesson Learned from the Greater Flagstaff Forest Partnership | 2010 | http://www.gffp.org/Reports/Lessons_Learned_Report.pdf |

| | | |
|---|---|---|
| Mountainaire Partner Mark Qualitative Assessment (GFFP) | 2010 | http://www.gffp.org/Reports/MountainaireII.pdf |
| GFFP, ERI, NAU's School of Forestry and Arizona Game and Fish Airport Monitoring Project | In progress | AZ Daily Sun Article http://azdailysun.com/articles/2009/11/24/news/20091124_front_208021.txt |
| GFFP Mountainaire Partner Marks – three sites | In progress | Designated USFS land used as demonstration projects for marking from GFFP's perspective. |