Summary of Results from the Kaibab National Forest Monitoring and Adaptive Management Workshop

June 28, 2012

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Summary of Results from the Kaibab National Forest Monitoring and Adaptive Management Workshop

June 28, 2012

Introduction

This document summarizes participant results from the Kaibab National Forest Monitoring and Adaptive Management Workshop held on June 28th, 2012. You are receiving this document because you either participated in the workshop or were invited to the workshop but were unable to attend. The Kaibab National Forest would like to give you another opportunity to provide feedback on the monitoring indicators discussed at the workshop. The goal of this effort is to ensure that the Monitoring and Adaptive Management Plan included as a part of the Kaibab National Forest Plan Revision (Chapter 5) meets the expectations of stakeholders (Appendix B). You are invited to provide feedback on this document and send it back via email to Anastasia.Begley@nau.edu by July 20th. Thank you in advance for your time and interest.

Understanding this document

In preparation for the June 28th workshop all invitees were asked to complete a survey designed to identify the top three concerns stakeholders have about conducting landscape-level forest restoration. (See Appendix A for results). The three main concerns identified through the survey became the focus of the afternoon session of the workshop. Using a collaborative process participants were asked for feedback on the three main concerns through a series of related questions.

Each discussion begins with the original concern. It is followed by the indicators and metrics that were included in Chapter 5 of the Kaibab National Forest Revised Forest Land Management Plan. The information from the monitoring plan matrix is followed by the series of questions that participants were asked during the collaborative writing session and their responses. Some comments also evolved through follow up group discussion and were noted as well. We invite you to add your responses in the last box highlighted in yellow.

Note: Terminology is defined in Appendix B - Chapter 5 of the Kaibab National Forest Revised Forest Land Management Plan.

Concern 1: Treatments will not be intense enough to effectively reduce the potential for active crown fire.

There are four existing monitoring questions extracted from Chapter 5 of the draft Revised Forest Plan that may help to inform this concern for the following six questions posed to workshop participants:

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)
02 **(RAPID)**	**Ponderosa Pine and Frequent Fire Mixed Conifer**	Is the fuel loading within the desired range?	Tons per acre	**Midscale DC Ponderosa Pine:** Coarse woody debris greater than 3 inches in diameter (including downed logs) ranges from 3 to 10 tons per acre. **Midscale DC Frequent Fire Mixed Conifer:** Coarse woody debris, including downed logs, ranges from 5 to 15 tons per acre.	1-5	2 -5
08 **(REMOTE)**	**Ponderosa Pine and Frequent Fire Mixed Conifer**	How many acres are predicted to support active crown fire as modeled under typical peak fire danger conditions at the midscale.	Acres	**Midscale DC:** Fires burn primarily on the forest floor and typically do not spread between tree groups as crown fire. **Obj (PIPO):** To reduce the potential for active crown fire in ponderosa pine communities: • Mechanically thin 11,000 to 19,000 acres annually. • Burn an average of 13,000 to 55,000 acres annually using a combination of prescribed fire and naturally ignited wildfires. **Obj (ffMC):** burn an average of 1,000 to 13,000 acres annually using prescribed fire and/or naturally ignited wildfires. Mechanically thin 1,200 to 2,100 acres per year.	3-5	3-5
11 **(REMOTE)**	**Ponderosa Pine and Frequent Fire Mixed Conifer**	What is the total area within the desired range for basal area? Openings?	BA, Open: Canopy	**Midscale DC:** Basal area within forested areas generally ranges from 20 to 80 sqft/acre. Openings with grass/forb/shrub vegetation are variably shaped and typically range from 10 to 70 percent.	3-5	3-5
15 **(EXISTING SOURCES – RAVG)**	**Fire Adapted Ecosystems**	How many acres were burned with desired fire behavior and effects?	Acres	**Finescale DC:** Fires generally burn as surface fires, but single tree torching and isolated group torching is not uncommon. **Midscale DC:** Fires primarily burn on the forest floor and typically do not spread between tree groups as crown fire. **Landscape DC:** Fire and other disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris loads, and nutrient cycling. Frequent, low severity fires (Fire Regime I) occur across the entire landscape with a return interval of 0 to 35 years.	Annually	5

Question 1-1: Of these questions, is there one that best lends itself to the adaptive management cycle? Why?	
1	Need both rapid and remote
2	Item 2 and item 8
3	Yes, acres supporting active crown fire
4	Item 8 (second bullet) but we're not fire ecologists
5	Relationship between basal area and crown fire is unclear - would not recommend item 11 for use in Adaptive Management
6	Item 8 best measures the rate of reduction of active crown fire risk
7	Rapid provides empirical measurement that is key to train and validate remote
8	Item 8 is best for the question because it directly models fire behavior
9	Basal area best lends itself to quantitative specifics
10	Item 15 would be best but change acres to percent and compare to areas that were not treated and/or compare to historic range of variability.
11	Item 8 REMOTE. I think this will be the best measure of progress and effectiveness in the next several years; others may take longer to evaluate.
12	Item 8 can be assessed quickly after treatment
13	Fuel loading (item 2) may also play a part
14	Amount of acres burned
15	Predicted fire was used to design treatments
16	Item 15 is very good, but data gathered would be variable over the years due to variability in fire occurrence.
17	Spatial patterns and density of trees to carry crown fire
18	Leadership can relate to fire behavior
19	Knowledge of the relationship between treatments and acres actually burned is important for future treatments - not clear how one might respond to a threshold for acres actually burned

Question 1-2: What is the appropriate evaluation interval for these metrics / variables? Why? Keep in mind this may be defined spatially or temporally.	
1	<= 5 years; perhaps tied to rate of change (managed or "natural")
2	3-5 year. Frequent enough to be relevant to guide continuing management, long enough to allow sufficient landscape change and cost
3	As soon after treatment as possible given remote sensing data availability
4	Annual, forest-wide; need to be able to track progress annually and the scale for the forest
5	Annually.
6	Depends on amount of activity. If certain % of area burns per year then may want to do yearly. if no treatment, new analysis unnecessary
7	Spatial scale should be multiple levels -- plan area - and midscale, and evaluate ranges expected and desired
8	Pre- and post- management activity
9	1, 3, & 5 years afterward
10	Annual monitoring would seem sufficient. We may want to further subdivide the parameter. Perhaps the number of acres of active crown fire reduced in the Wildland Urban Interface and in proximity to Mexican Spotted Owl habitat.
11	Evaluate at project level annually and landscape 3-5 years
12	This would depend of vegetation type dependent of the higher end of the historical fire interval
13	Should be assessed beyond just treated area - as fire is a landscape process
14	Treatment goal is to modify fire across landscape and not within treatment per se

Question 1-3: What would constitute a meaningful benchmark? Why?	
1	Need detailed and specific objectives in terms of area and patch size and configuration of fire risk categories across the landscape
2	Keep predicted fire spread rate and distance to specific value
3	Referring to 8 REMOTE, 90% of treatment area is predicted to remain below ACF threshold for >= 30years
4	A reduction in mean annual # of crown fires/5 yrs.
5	Benchmark should be based on the ability of treatments to alter fire at the plan area scale not within treated areas
6	Use simulation modeling to evaluate expected range of fire size and area burned under different management and climate change scenarios -- this will guide desired conditions and benchmark
7	Benchmark should be based on amount of forest that has potential before treatment and how much treatment reduced risk. need to determine amount of risk that is acceptable to set benchmark
8	Range could be based on simulations under a variety of "extreme" conditions
9	10% to 15% decrease in risk of crown fire to vegetation type (e.g. Ponderosa pine type or Dry Mixed Conifer type) annually.
10	Keep area of active crown fire to predetermined acreage as treatments progress, i.e. 100K first few years, 50K 3-5 years, 1K after 10 years
11	I like the idea of changing benchmarks from current conditions to future conditions depending on changing landscape structure and composition. That is as time passes and multiple treatments are applied and conditions are closer to desired

Question 1-4: When a re-evaluation is triggered, what follow up questions need to be asked?	
1	Change relative to detailed specific and quantitative desired conditions
2	If outside range of desired conditions, then did you move toward or away? What direction and how far from desired condition?
3	Evaluate need for changing benchmark based on new information
4	Are we at the desired condition?
5	Depends on if benchmark was achieved or not
6	Are basal area and percent of area on openings in desired conditions sufficient to modify fire behavior to surface fire at the midscale?
7	Are there new methods that we could employ to reach desired conditions
8	The main thing is to *DO* the evaluation and re-ask the question in light of current knowledge and perceived threats.
9	Does new data or research suggest that we're on the right track?
10	If treatments are not achieving landscape reduction of crown fire risk evaluate: a) Was treatment deployment strategy sound or b) Should treatments be more intense?
11	Additional questions would be: were there any unintended consequences has enough time past to properly evaluate the actions and thus make a conclusion
12	Has enough time passed to see meaningful results?
13	Are we measuring the right variables?
14	By reducing fire intensity, have other resources been compromised?
15	Follow-up question is: Do we need to thin to a lower basal area (assumes that crown fires are still too frequent)?
16	If treatments are meeting desired modeled outputs, but demonstrated fire behavior is "undesirable" revisit assumptions?

Question 1-5: In response to the new information that would come from a re-evaluation, what are the potential ways that management can respond?	
1	If not meeting desired conditions, change management to move toward it -- e.g. increase area or intensity of treatment or evaluate need to change desired condition based on improved knowledge form validation monitoring increasing link between treatment and conditions
2	Redefine desired conditions.
3	Change amount and intensity of treatments
4	Management should direct changes in treatments/prescriptions
5	Increate or back off treatment intensity
6	First verify whether original desired condition was meaningful then potentially reevaluate deployment and treatment strategy
7	Collaborate for new research to verify assumptions
8	Refine parameters within desired conditions
9	For this to work need detailed, specific and quantitative DC and monitoring directly in terms of these
10	Try multiple strategies and experiment to be able to compare options
11	Modify management practices that may have contributed to undesirable effects. (e.g. activity slash treatment or arrangement.)
12	Requires that you have articulated a deployment strategy and identified how you think treatments will help you meet desired conditions

Question 1-6: Are there any other questions, methods, and/or variables that have not been identified that would help to inform this concern?	
1	Are we approaching a natural fire regime?
2	Spacing and configuration of treatments to most effectively and cost-efficiently move toward landscape scale desired condition.
3	Impacts to other resources.
4	Forest structure; number of small trees, crown base height
5	How to implement treatment for this desired condition that also maximally contributes to moving conditions toward other desired conditions for other resources.
6	Evaluating fire behavior above the mid-scale.
7	How to guide stand-level management to most optimally contribute to mid- and broad-scale plan-level desired conditions
8	What is the whole cost of getting to the desired conditions (low ACF)? This aims at evaluating how much can be done in a given amount of time for the available funding, especially for projects that have a net cost per acre treated.)
9	By focusing on fire, are we ignoring climate change and increasing drought?

Concern 2: Treatment may result in unacceptable increases noxious weeds that could alter ecosystem function

There are two existing monitoring questions from Chapter 5 of the draft Revised Forest Plan that may address this concern. Those monitoring questions are below.

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)
03 **(RAPID)**	**Soils and Watersheds**	What is the percent of effective ground cover? What is the proportion of live and dead vegetation, rock, and bare ground?	Percent cover	**Soils DC:** Vegetative ground cover is well distributed across the soil surface to promote nutrient cycling and water infiltration. **Vegetation Landscape DC:** Organic ground cover and robust herbaceous vegetation provide protection for soil and moisture infiltration, and contribute to plant and animal diversity and to ecosystem function.	1-5	2 -5
06 **(RAPID)**	**Nonnative Species**	What is the percent cover of noxious weeds1 by species?	Percent cover	**Nonnative Invasive DC:** species are contained and/or controlled so that they do not disrupt the structure or function of ecosystems. **Nonnative Invasive Guideline:** New populations are detected early, monitored, and treated as soon as possible.	1-5	2-5

Question 2-1: What species is your greatest concern in fire adaptive ecosystems? Why?	
1	Cheat grass
2	Cheatgrass, knapweed
3	Cheatgrass, knapweed
4	Cheatgrass, due to its ability to nearly completely alter fire regimes. Also it seems to be downplayed as "Well, it's here we can't do anything about it."
5	CHEAT GRASS would alter fire regime.
6	B. tectorum
7	Annual grasses change fire regimes
8	Any/all new invaders - early detection rapid response will be critical
9	Cheatgrass due its potential for rapid expansion with application of fire.
10	Have not seen much cheatgrass problem in PP/DMC, except at the lower fringes. Not sure there is a big threat to these systems.
11	Humans
12	Toadflax in listed plant species areas

Question 2-2: What is the optimal method that would efficiently provide repeatable information for change in % cover?	
1	Before and after control design to measure % cover before and after treatment in gridded sample network within treatments and control areas
2	Focus less on existing “seas” of invasion but focus more on expansion and new invasions.
3	More research on effective control methods
4	Fixed plots as part of an experimental or Before After Control Impact (BACI) design
5	Any species brought in from borrow pits for road maintenance
6	Before and after each treatment
7	Avoid or treat before considering treatment of vegetation
8	Rapid plots using Before After Control Impact design: 1 month and 1 year post treatment and annually after
9	Don't just assume it’s a pinion-juniper problem
10	Permanent plot with quadrats
11	Specific training protocols for year to year crews
12	We have talked about frequency or occupancy based on presence absence estimates as they are less likely to fluctuate than % cover (there can be a lot of difference between observers on % cover estimates)
13	For early detection species presence is likely more important than cover
14	Visual observation followed by transects as needed.

Question 2-3: What is the appropriate evaluation interval? Why? Keep in mind this may be defined spatially or temporally, and differences in short and long-term responses.	
1	Pre and post treatment. At least annually
2	Immediately post treatment
3	Depends on the ecology of the species
4	Both short and long term as it relates to cheatgrass
5	Long term -3-5 year interval; post disturbance yearly for first five years
6	1, 3 & 5 years
7	First evaluation should be quick to allow adaptive management before you do too many more treatments. Second evaluation could be 3-5 yrs.
8	Annually for the first 5-10 years (dependent on drought cycles) post disturbance and again after any subsequent disturbance
9	Project area
10	Pretreatment and post-treatment. 5 years after treatment.
11	If intend to control the species, want to evaluate early. 1 year after treatment
12	Will have to deal with differences in phenology
13	Assure BMPs adhered to
14	Annually for borrow pits

Question 2-4: What would constitute a meaningful benchmark? e.g. % cover, % change, or both ? Why?	
1	Percent cover
2	Number of treatments with an infestation larger than x or a frequency higher than x
3	For new pops, density/number of plants
4	Presence where it was not before, plus change in cover %
5	%change
6	Initially , presence of new plants
7	If no species present before treatment, should be low <1%
8	Not sure what the value is, but it should relate to a change in the fire regime for the system.
9	Proportion of treated areas in which the target invasive was 1) present and 2) exceeded x% cover
10	If species present before treatment, may not care about growth
11	Increase in occupancy rate of more than 10% across treatments
12	Increase in % cover of more than 20% in areas with invasive previously present
13	No increase infrequency should not increase by more than 10% across the treated site relative to pre-treatment
14	Depends on species, cheatgrass is % change; knapweed, leafy spurge, thistles is presence absence
15	Model distribution and predict future spread. Locate areas of likely future spread. monitor these intensively and count rate of spread
16	Triage -- map established populations, predict spread, monitor areas where new infestations are occurring. Focus management to eradicate the new pops before they become firmly established
17	Concurrent experimentation should help identify site conditions that help predict susceptibility to future invasion helping to plan future treatments

Question 2-5: What are the potential ways that management can respond?	
1	Focus management on incipient infestations to eradicate before they become established work with researchers to predict areas of likely spread and monitor these intensively
2	Must link herbicide application with active restoration - establishing competition is key
3	Treat and restore using appropriate methods such as herbicide and replacing with early succession grasses native to the area
4	Triage to determine feasibility of control; determine where eradication vs. control is desired
5	Plan future treatments to avoid highly susceptible sites
6	Early detection, washing equipment
7	Take it seriously, i.e. you may have to forego treatments if infestation is intense enough across multiple vegetation types
8	Determine where/when bio-controls are appropriate
9	Experimental studies of interaction between grazing, treatment, and cheatgrass spread and dominance
10	Require & enforce best management practices
11	Assure that treatments that may increase the problem; only go forward with intensive treatment and restoration programs
12	Grazing management
13	Manage grazing

Question 2-6: Are there other questions, methods, and/or variables that have not been identified that would help to inform this concern? (info only no follow up)	
1	Consider a cheat grass model like Grand Canyon Trust did to assist in where future cheatgrass establishment may occur. Focus or avoid treatments based on that data
2	Triage for potential to address infestation
3	Any evaluation that compares no action vs. action should also include the effects of ACF and MSF.
4	"Susceptibility" to invasion may be as important as actual invasion for planning future treatments
5	Refine 3 forests weed plan to integrate across jurisdictions
6	The proportion of annually treated sites that are occupied by set cover classes of invasives (0-2%, 2-10%, etc.)
7	More research to determine most effective methods for treatment
8	Refine detailed and specific quantitative desired condition
9	Develop monitoring directly in terms of variables in desired conditions statements
10	More effort/funding of pre-treatment inventories.
11	Better communication across resource areas with the Forest Service to communicate where and when it's occurring
12	Linking invasive species to the ecological process they are purported to interrupt will be key to identifying appropriate desired conditions (why is cover important)
13	Better integration of Forest Service and other groups like San Francisco Weed Management Area to divide and conquer
14	Refine DFCs as exotic species populations change over time

Concern 3: Post treatment conditions will be more homogenous than desired at the fine scale.

There are two existing monitoring questions from Chapter 5 of the draft Revised Forest Plan that may address this concern.

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)
07 **(REMOTE)**	**Ponderosa Pine and Frequent Fire Mixed Conifer**	How many acres of the forest is in an uneven aged open state, at the midscale (above 100 acres)?	Acres	**Landscape DC:** The ponderosa pine forest vegetation community is a mosaic of forest conditions composed of structural stages ranging from young to old trees. The forest is generally uneven aged and open. **Midscale DC:** The ponderosa pine forest vegetation community is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The mosaic of tree groups generally comprises an uneven-aged forest with all age classes and structural stages present. **Midscale DC:** Forest conditions in some areas contain 10 to 20 percent higher basal area in mid-aged to old tree groups than in the general forest (e.g. goshawk post-fledging family areas, Mexican spotted owl protected areas, drainages, and steep north-facing slopes). **Other:** Mexican Spotted Owl (MSO) Recovery Plan	3-5	3 -5
11 **(REMOTE)**	**Ponderosa Pine and Frequent Fire Mixed Conifer**	What is the total area within the desired range for basal area? Openings?	BA, Open: Canopy	**Midscale DC:** Basal area within forested areas generally ranges from 20 to 80 sqft/acre. Openings with grass/forb/shrub vegetation are variably shaped and typically range from 10 to 70 percent.	3-5	3-5

Question 3-1: Of these questions (or others not yet identified), is there one that best lends itself to the adaptive management cycle? Why?	
1	Item 11 -- really important to evaluate range of conditions, and develop a "distribution" of frequency of different levels of basal area/canopy closer etc. --- and then develop multi-scaled desired condition that are targeted to create c (no further content provided)
2	How is "desired uneven aged state" defined? Relative to a harvest rotation? A wildlife species?
3	Important=ant to quantitatively define "range" and distribution of range as a function of scale -- 10-70 appropriate for mid-scale -- and how do we define expected distribution of frequency of conditions between 10 and 70?
4	Item 11
5	Item 11 and 8 both; need to incorporate juxtaposition/distribution and actual range/variance
6	Item 11 with the proposed modification could be very useful, but would require thought regarding the shape of the distribution within the range
7	It may be important to evaluate this from the standpoint of several metrics, so a single question does not necessarily lend itself better than others.
8	If using plot data where plots have a fine-scale relationship to each other, monitoring uneven-aged condition trends seems best.
9	Need to assure that basal area isn't "averaged" to the low or high end of the range
10	Could use alpha and beta diversity of patch sizes to track homogeneity at multiple scales
11	Desired condition could be defined in terms of interspersion and juxtaposition of different basal area and canopy cover classes among adjacent mosaic of patches -- use fragstats metrics to develop quantitative and specific desired conditions and use to (no further content provided)
12	How is desired uneven aged define
13	Would be helpful to show not only average, but range and amount of area in each basal area
14	Some idea of the kurtosis of the plot density (basal area) curves by scale would also help
15	Need a metric for heterogeneity for the mid & landscape scale also
16	Rapid plots could be used to sample diameter distributions as a complement to RS versions of basal area and trees per acre to asses heterogeneity at multiple scales
17	Are there other ecological processes that achieving uneven aged conditions should benefit? These could be used to identify ideal distributions? Alternatively, one could measure those specific processes/attributes

Due to time constraints question 3-2 was not considered by participants and is not included here.

Question 3-3: What would constitute a meaningful benchmark? Why?	
1	Desired condition based on range of variation expected at that scale across soil types or site classes - quantitative and specific ranges and distributions
2	To develop these ranges and distributions would need to use models to simulate and/or evaluation of multi-scale assessments of historic conditions
3	Truncation of the expected distribution - action would depend on which "tail" is underrepresented
4	Refer to measures defined in the monitoring implementation guide (perhaps distribution curves) and some level of agreement with those.
5	Would define the desired condition in terms of ranges of size, juxtaposition and interspersion of different basal area/canopy cover classes in mosaic of patches -- use fragstats to quantify and monitor

Question 3-4: When a re-evaluation is triggered, what follow up questions need to be asked?	
1	Reassess desired conditions -- benchmark and ranges of variability and distribution of frequencies at different basal area/canopy cover classes -- based on improved understanding of system dynamics from simulation and reconstructions'
2	Was the desired forest condition distribution of basal area's appropriate?
3	What direction are we departed, how far, and what kind of management, where, how large, what spacing, would best move toward the desired range of conditions?
4	What condition are the ecological processes/attributes of interest in? If fine reevaluate the uneven aged desired condition; if there is cause for concern, evaluate the relationship between the uneven age condition and the concern
5	Relook at the desired condition to evaluate if it has the right range
6	What guidance can be provided to contractor in designing treatments?
7	Is the problem with the implementation or the outcome?
8	Is the observed degree of heterogeneity in any correlated with greater or fewer catastrophic fires, changes in wildlife pops, or other responses?

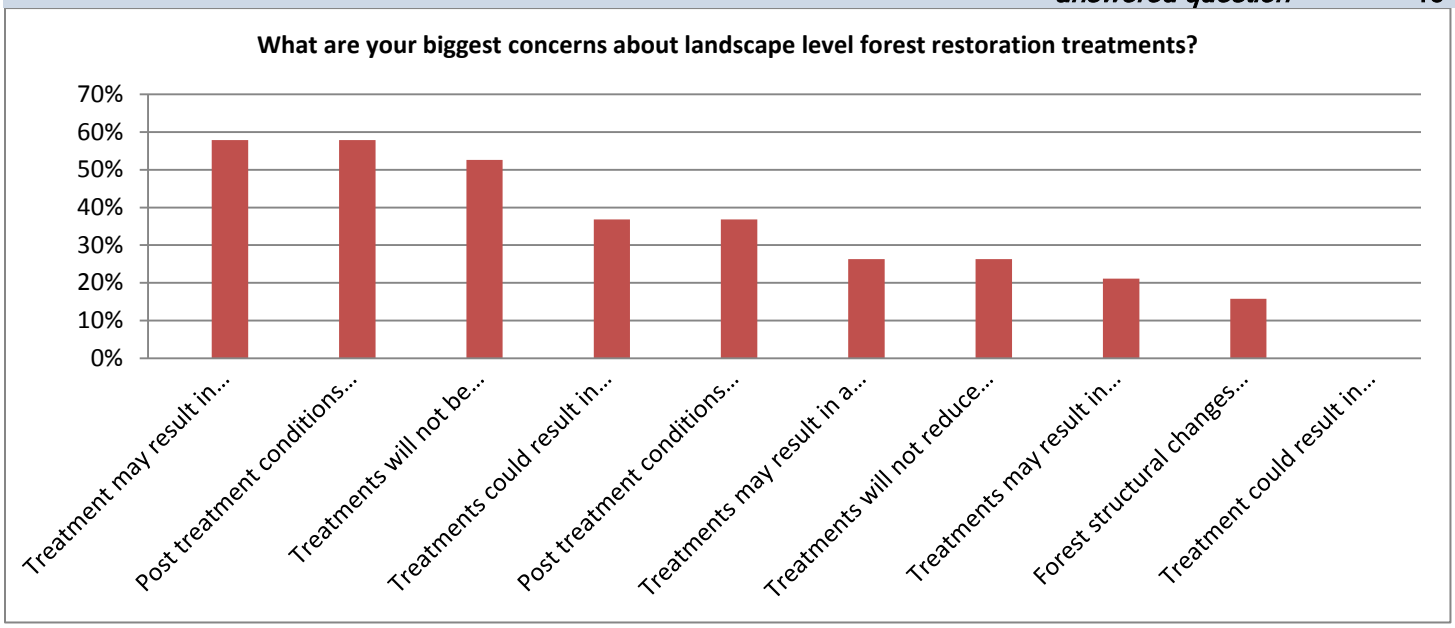
Question 3-5: In response to the new information that would come from a re-evaluation, what are the potential ways that management can respond?	
1	Add or change metrics for evaluation
2	Management can respond by evaluating what the departure is from the desired condition and find optimal ways to implement management to move the cumulative condition of the patch mosaic toward the desired condition in terms of juxtaposition
3	Evaluate if we need to change the methods or types of Rx used. Need to make sure we do not do the same treatment on every acre/projects.
4	Management can work with researchers to evaluate the assumptions in the desired conditions statements -- what range of variability, what distribution of frequencies, patch sizes, juxtaposition patterns -- using simulations and/or reconstruct

Question 3-6: Are there other questions that would inform desired conditions that are not currently addressed by the draft monitoring plan?	
1	To be useful any monitoring question must be tied directly to detailed and quantitative desired conditions so we can evaluate whether or not we are meeting objective.
2	Key monitoring variables - inform
3	Otherwise the monitoring is equivocal in terms of what it means to guide changes in management
4	Monitoring questions should be directly tied to desired conditions. In addition, the desired conditions should be linked to the ecological attribute/process of interest
5	Does habitat configuration provide functional connectivity for canopy dependent species?
6	We still need some specificity in the desired conditions to ensure that answers to monitoring questions are relevant
7	There seems to be monitoring questions associated with the open state of the forest and ways to measure them. Pronghorn would be an example of a species that would respond. But, there are not monitoring questions associated with the closed state
8	Validation monitoring is essential to test the assumptions in the desired contains and guide the refining and improvement of the desired conditions
9	What are the relevant variables and how would they inform management?
10	No real monitoring questions associated with closed canopy species
11	How are wet meadows managed/restored/monitored?
12	Relevant variables -- in the context of validation monitoring we would evaluate the linkage between the variables in the desired condition and the sustainability objective
13	No metrics to make sure that tree species diversity is maintained within mixed conifer
14	Desired conditions that focus on proxy on proxy relationships should identify the actual attribute of interest to allow research to evaluate the relationship between the proxy and the attribute of interest
15	Oak is not really measured as part of monitoring
16	Are gaps/openings/interspaces affecting wildlife movement?
17	Models both for occupancy and connectivity represent hypotheses that continue to require data to refine and validate
18	How are benchmarks set in the absence of "historic conditions"? How are we evaluating whether historic forest conditions are relevant under current conditions of climate, land use, etc.?
19	How will mutually exclusive desired conditions be addressed?
20	How will evaluate of multiple desired conditions be optimized simultaneously -- management to meet multiple objectives
21	Aspen treatment options are not extensive enough in the plan, therefore monitoring of those types of treatments are limited

Appendix A: Kaibab NF Pre-workshop Survey: Monitoring and Adaptive Management

1. What are your biggest concerns about landscape level forest restoration treatments? Please identify up to 4.

Answer Options	Response Percent	Response Count
Treatment may result in unacceptable increases noxious weeds that could alter ecosystem function.	57.9%	11
Post treatment conditions will be more homogenous than desired at the fine scale.	57.9%	11
Treatments will not be intense enough to effectively reduce the potential for active crown fire.	52.6%	10
Treatments could result in a loss of habitat connectivity and configuration for wildlife associated with forested communities.	36.8%	7
Post treatment conditions will have an appropriate balance between residual fuel loading and ecosystem services provided by down woody debris (microhabitat conditions, soil protection, nutrient cycling.	36.8%	7
Treatments may result in a loss of "old growth" and associated habitat components (snags, logs, large trees).	26.3%	5
Treatments will not reduce tree densities enough to increase sunlight and moisture that are needed for a robust understory and resistance/resilience in times of drought.	26.3%	5
Treatments may result in unacceptable levels of soil compaction and erosion.	21.1%	4
Forest structural changes could result in a reduction in populations of Grace's warbler, ruby-crowned kinglet, western bluebird (Kaibab Management Indicator Species), or other bird species.	15.8%	3
Treatment could result in inadvertent damage to archeological resources.	0.0%	0
	answered question	19



2. Do you have other priority concerns that would rank in your top 4 that are not listed above? If Yes, please state in terms of cause and effects.

Emerging Themes from Responses

Timely Implementation vs. Cost Effectiveness
Scientific Rigor
Homogeneity vs. Heterogeneity
Forest Type Conversion
General Public Concerns
Forest Patterns that optimize snow pack
Habitat needs for dense canopy, open canopies, and connectedness between the two
Industry equipment and knowledge to minimize disturbances
Implementation consistency with treatment prescriptions

3. If you checked items 5 or 6 above, what specific species do you have concerns about? If Yes, please state in terms of cause and effects.

Emerging Themes from Responses

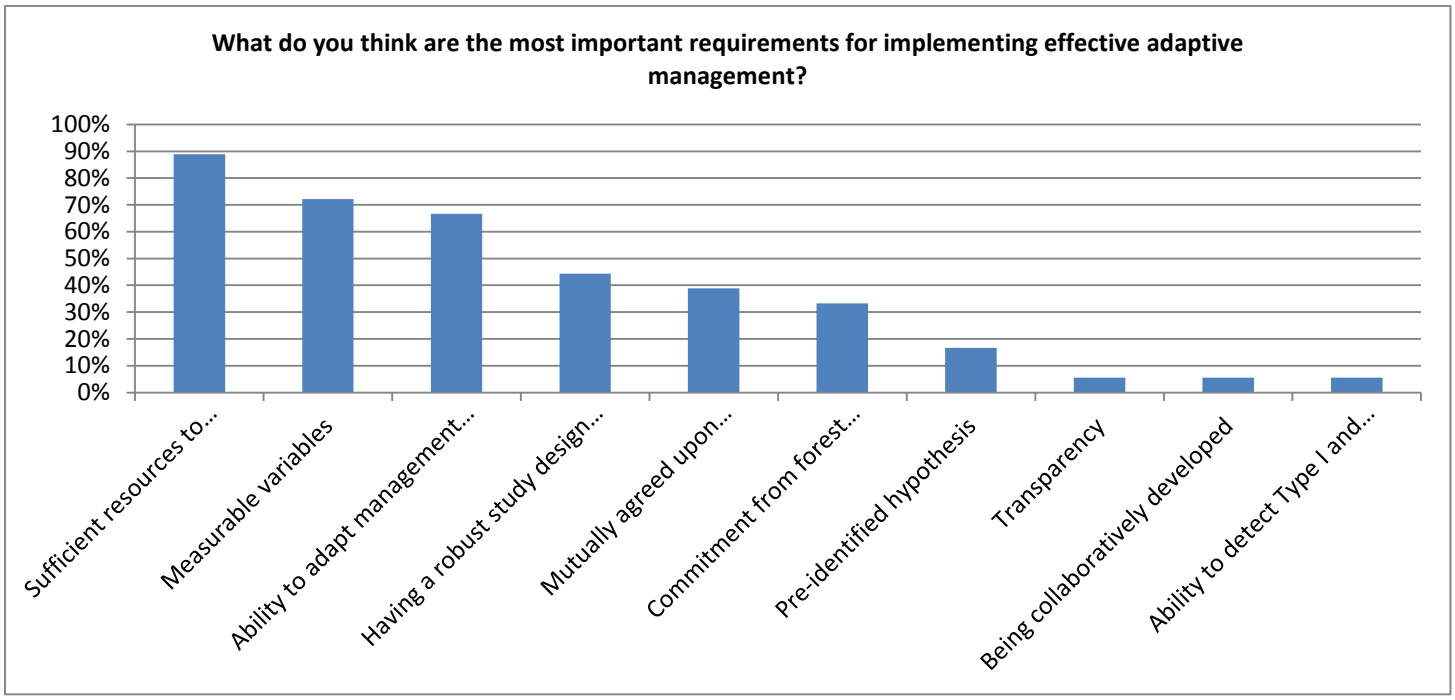
Species that need open and more closed canopy forests for movement across the landscape

Federally listed species

Species habitat and connectivity between habitat types

What do you think are the most important requirements for implementing effective adaptive management? Please identify up to 4.

Answer Options	Response Percent	Response Count
Sufficient resources to accomplish the identified monitoring and assessment tasks	88.9%	16
Measurable variables	72.2%	13
Ability to adapt management in response to new information.	66.7%	12
Having a robust study design that provides statistically valid conclusions	44.4%	8
Mutually agreed upon thresholds, benchmarks and triggers	38.9%	7
Commitment from forest leadership	33.3%	6
Pre-identified hypothesis	16.7%	3
Transparency	5.6%	1
Being collaboratively developed	5.6%	1
Ability to detect Type I and Type II errors and evaluate their trade-offs	5.6%	1
answered question		18



Are there other important considerations related to implementing adaptive management that would rank in your top 4 that are not listed above?

Emerging Themes from Responses

Flexibility and clearly defined process to respond to and incorporate new information into decision-making process
Sufficient time period for monitoring
Navigation NEPA requirements with each management approach
Monitoring for un-planned events

Survey Open Responses:

1. What are your biggest concerns about landscape level forest restoration treatments? Please identify up to 4.

Treatments will not be implemented quickly enough due to market conditions. Treatments will not be cost effective.

The science underlying restoration is variable and inexact

Post treatment conditions may be more homogenous that desired at all scales.

Forest cover type conversion

The large scale of the work may start to raise aesthetic, safety (e.g., more logging trucks) or other concerns among the general public. Still, it clearly has to be done.

2. Do you have other priority concerns that would rank in your top 4 that are not listed above? If Yes, please state in terms of cause and effects.

Not enough attention will be given to forest pattern so that there will be lost opportunities for optimizing snowpack, which would lead to less than optimal forest resilience.

That the best available science will not be used.

Implementation of treatments is not consistent with prescriptions. Success requires strong oversight, good contractors, and implementation reviews.

Enough won't be done in a timely manner across the at-risk ecosystems.

Treatments could result in a lack of future nest/roost habitat for Mexican spotted owls and other species that require patches of dense canopy forest.

I would like to ensure that we are adequately addressing the effects of treatments as the accumulate on the landscape

For monitoring the expectation of the extent and the level of expected scientific rigor will be unattainable

Existing or developing industry doesn't have enough of the "light on the land" skill set or technical equipment to mitigate for disturbances.

Lack of robust analysis of multiple scale historic range of landscape structure information to guide desired conditions at broad scales.

My main concern is that the work won't happen as fast as it needs to happen.

A minor secondary concern is that there may be less focus on the restoration of riparian and other sensitive areas than I think is desirable because of what I at least perceive to be the heavy emphasis on harvesting small diameter trees in uplands. Might the heavy emphasis on tree harvesting take human and resources from other types of restoration?

3. If you checked items 5 or 6 above, what specific species do you have concerns about? If Yes, please state in terms of cause and effects.

I have concerns about species that need open and more closed canopy forests for movement across the landscape. The treatments may result in homogenous forest that is too closed for species such as pronghorn and too open for species such as spotted owls to move easily across the landscape.

I do not have any specific species in mind.

Federally listed species; conservation agreement species; degradation of species habitat through reduction of habitat components; loss of species habitat through type conversion

After working with the White Mtn Stewardship project I have observed that original treatment plans avoided certain dense patches due to slope, distance from roads, soil type, etc. However, there was little planning to figure out a way to connect these patches together, or to have a system of connected, denser patches of forest for those species dependent upon denser forests. Dense forest, then, was left "by default" and not really incorporated into a meaningful landscape plan. After some wildlife habitat connectivity analyses, the ASNF did work to modify some treatments to allow for denser corridors that connected larger patches of dense forest (however, the effects were unknown due to the Wallow fire and we never had a chance to test them).

4. What do you think are the most important requirements for implementing effective adaptive management? Please identify up to 4.

(Hard to choose just 4. These all matter.)
Identifying measurement parameters for monitoring which will be cost effective and timely.
Ability to monitor impacts of un-planned events (like wildfires)
Related to all 3, too much bickering over "small" things, leading to no real action on "big" things.
These are all very important!
I think these are actually all critical with the exception of Type I vs. Type II errors as this information is dependent upon the question being asked and the methodology used to address them
All are critical!

5. Are there other important considerations related to implementing adaptive management that would rank in your top 4 that are not listed above?

There needs to be flexibility so that if the data tells us the system is responding differently than we expected we can create new, meaningful thresholds for adaptive management.
Identification of measurement parameters for monitoring which are cost effective and timely.

There needs to be a clear process that is consistently followed in order to insure new information is actually utilized in the decision-making process.

Being able to run the monitoring for a sufficient period of time to see responses. One year is definitely not adequate; 5 is perhaps sufficient for many types of responses, but 10 years might be needed to see development of understory species that are not early seral, and wildlife associated with vegetation that establishes later.
Identifying the problem to be addressed
Specifying assumptions about resource structures and functions
Identifying key uncertainties

Ideally the need to change management approaches should not automatically require new NEPA as the reluctance to do this often stalls adaptive management

Clearly defined links between detailed and specific desired conditions statements, monitoring design explicitly designed to measure condition and trends relative to desired conditions with high precision, formal thresholds to trigger adaptation of management to move toward desired conditions.

Appendix B: Chapter 5: Monitoring and Evaluation

Introduction

Monitoring and evaluation are required by the 1982 Planning Rule provisions. Monitoring and evaluation document and report how well a plan is being implemented, how well it is working, and if its direction is still appropriate. Evaluation examines altered conditions that result from management, identifies possible reasons desired conditions are not being met, and proposes alternative solutions. Monitoring is essential to provide information to the responsible official so they may decide if a change in plan components or other plan content may be needed to be responsive to changing conditions and issues. Monitoring is the feedback that enables adaptive management.

Monitoring and evaluation are fundamental to good program management and they:

- Provide data on project implementation and effectiveness
- Improve decision making
- Allow for accountability to stakeholders
- Help identify needed changes in management
- Inform further information needs

The monitoring plan outlines the general framework for achieving forest plan monitoring objectives. It is strategic in nature and contains specific questions that ask how well the Kaibab NF is moving toward and achieving its desired conditions and objectives within a given resource area. The monitoring plan uses a multi-scaled approach to monitor short and long-term changes. Monitoring is not completed on every activity. It does not address project level compliance monitoring, which is conducted to evaluate consistency with law, regulation, or policy; unless such monitoring answers a forest-wide question. It is not intended for research purposes and may have varying degrees of statistical rigor.

This monitoring plan is intended to be adaptive in nature and incorporates strategies which are holistic, collaborative, and grounded in science. This approach should provide the Kaibab NF with the best chance for achieving long-term sustainability of its natural resources, as well as the natural resources of the greater landscape. A more detailed discussion on the relationship between monitoring, evaluation, and adaptive management can be found in the project record.

An interdisciplinary team developed this monitoring plan to: (1) meet legal requirements, (2) be consistent with corporate data standards and protocols, and (3) address the various aspects of forest management in an integrated manner.

The monitoring framework has three components:

1. **Forest Plan Direction** that provides broad, strategic guidance, and specifies the monitoring requirements in the forest plan itself. It provides the overall monitoring strategy including specific questions that need to be answered, what will be monitored, timetables for reporting, and other information.
2. **A Monitoring and Evaluation Implementation Guide** that provides specific, technical guidance. It describes how, where, and when to accomplish the monitoring prescribed in the forest plan and provides the specific methods, protocols, and analytical procedures. The guide is intended to be flexible so that it can be modified in response to new information, updated procedures, emerging issues, and budgetary considerations without amending the forest plan.

3. **An Annual Monitoring Evaluation Review** that provides a process to review the current year findings and evaluate the need for modifications.

Monitoring Strategies

These strategies employ and build on existing methodologies and sources of information, but when additional need and capacity arise, they can be expanded and modularized to increase the robustness and comprehensiveness of data

collection and processing. Furthermore, these strategies should strive to achieve statistically valid outputs through transparent data collection, processing, and analysis processes.

Critical to this design is a framework and associated methodology which is systematic, transparent, and can be analyzed using contemporary statistical approaches. This design should facilitate consistency in data collection methods by partners (e.g., adjacent landowners, stakeholders, tribes, etc.), in turn, fostering greater efficiency, accountability, comparability of data, and the ability to better leverage monetary resources.

Information Management
Data will be designed and collected according to appropriate data standards and entered into corporate databases such as Natural Resource Inventory System (NRIS), or Geographic Information System (GIS). The information can then be accessed and analyzed to produce information products such as monitoring reports that would be available for internal and external review, and should provide the information necessary to make informed management decision.

Monitoring and Evaluation Implementation Guide
A more prescriptive implementation guide will be developed prior to plan implementation. The implementation plan will provide "the how" in terms of specific sample designs and strategies, identify indicator variables and models to be used, and determine any appropriate target thresholds/benchmarks to be met. The implementation guide is not part of the plan, rather it is supplemental information to improve effective implementation of the plan. As such, it can be updated easily to be adaptive and responsive to emerging issues, new science, changes to recommended survey methodologies and techniques, and fluctuations in budget. The guide will be developed collaboratively with area experts and statisticians so that it reflects the best available science and yields statistically valid, robust, and contemporary data sets to the extent possible.

Monitoring Matrix
This monitoring matrix contains the plan decisions of the monitoring plan. It includes a combination of effectiveness and implementation monitoring. It is organized by five primary methods of data acquisition. Each matrix subheading is described in detail below. The order of monitoring items within each subheading follows the order of each resource area within the forest plan.

In many cases, data collected on one metric may help to answer several questions, improving efficiency and utility of the data. Efficiency is also achieved by leveraging existing and complimentary data sources from internal as well as external parties to the extent practicable. Frequency of data collection, evaluation, and reporting varies by resource area and monitoring question. That is, not every item identified in the matrix is monitored or reported out on every year.

Data Acquisition Methods
Specific monitoring questions require that data be gathered at multiple scales. As a result, a combination of strategies for obtaining data are used including existing methodologies and sources of information, rigorous field assessment protocols, remote sensing techniques, and existing monitoring efforts and other sources of information. Additionally, data collected for other purposes that can be used to answer monitoring questions are specified, obtained, and evaluated as part of the monitoring plan.

Rapid Plots indicate status of key ecological attributes for a focal ecological resource at the mid to fine spatial scales although measurements in multiple locations may provide wide spatial coverage. Data includes relatively simple field based metrics. Examples include snags, down logs, large trees, presence of nonnative invasive species, and soil conditions. Rapid plots data would be collected on key parameters using a systematic sampling framework superimposed across the entire forest. Planned and existing forest projects would help guide the plot placement process. With the intent that data collected at the project level would be aggregated with other rapid plot data to make inferences at the forest level.

Remotely Sensed indicates status of key ecological attributes for a focal ecological resource at landscape scales and/or at coarser spatial resolution. Data sources include GIS and remote sensing imagery, which would indicate changes in

land cover across an entire forest. Examples include landscape composition, pattern, and fragmentation. Some data collected through rapid plots may be used to validate and improve the accuracy of remote sensing data.

Existing Sources are existing data the forest or its partners already collect and report out on. Much of this data is managed under the Natural Resource Manager (NRM) system, a system of database tools for managing Agency data across the Forest Service. Natural Resource Manager includes Forest Service Activity Tracking System (FACTS), Infrastructure (Infra), and the Natural Resource Information System (NRIS), among others. Data routinely collected by the Arizona Department of Environmental Quality, Arizona Game and Fish Department, and USDA Animal and Plant Health Inspection Service (APHIS) are other sources of existing data sources which can be leveraged to answer forestwide questions.

Interviews are largely qualitative in nature and may be subjective. These may include questions posed to resource specialists, partners, or during tribal discussions with some followup interpretation of the results to obtain information.

Intensive indicates status of key ecological attributes for focal ecological resources at fine spatial scales or spatial resolution although measurements in multiple locations can provide wide spatial coverage. Data sources might include simple to complex field based metrics that are usually quantitative and collected within a statistical sampling design. Examples include surveys of birds to assess density levels, analyses involving specific soil and water chemistry parameters, and quantitative vegetation structure measurements.

Matrix Data Fields

Resource area: A quantitative or qualitative resource, use, or activity parameter that can be assessed, e.g., vegetation communities, wildlife species, invasive species, recreation, etc.

Monitoring question: Specific monitoring questions were developed to ensure that the information essential to measuring progress toward meeting the forest plan objectives and desired conditions was collected and evaluated. Monitoring questions focus on key plan components where carrying out projects and activities are planned and changes are likely to result over time.

Metric: Metrics are key attributes for a particular resource area. Indicators were selected that were specific and measurable, occasionally including multiple metrics. In some cases, one metric can answer several different questions. These attribute measurements can be quantitative and/or qualitative and should provide enough information to answer the monitoring question(s). Indicators should be conducive to effective and systematic repeatable monitoring with existing survey methodology and within budgetary constraints.

Driver: Monitoring driver(s) identify the reason(s) for monitoring a particular item. Drivers can be: (1) legal and regulatory requirements and Forest Service Manual direction; (2) forest plan desired conditions, goals, objectives, standards, and guidelines; (3) validation of assumptions and predictions; or (4) court rulings or legal and regulatory compliance.

Measurement interval: Describes how often monitoring information is collected. This varies based on the resource area, monitoring drivers, and questions.

Evaluation and reporting interval: Describes how often monitoring information is evaluated and reported. Data will be assessed after 2 years to establish a “baseline” through which to compare change. A comprehensive review would be conducted approximately every 5 years. This would allow the forest to evaluate the overall monitoring program and management actions and to identify if any conditions that would trigger a change in management or prompt further investigation.

Precision and Reliability: Two categories of precision and reliability are appropriate at the forest plan scale:

> **Class A** (Quantitative) are methods appropriate for modeling or quantitative measurement.
> Results have a high degree of repeatability, reliability, accuracy, and precision.
>
> **Class B** (Qualitative) are methods based on project records, personal communications, ocular estimates, pace transects, informal visitor surveys, and similar types of assessments. The degree of repeatability, reliability, accuracy, and precision are not as high as Class A methods, but they still provide valuable information and are more appropriate for some resource areas.

Table 5. Matrix for the Kaibab NF Monitoring Plan

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
		RAPID PLOT					
01	**Ponderosa Pine and Frequent Fire Mixed Conifer**	Are snags, coarse woody debris, downed logs and large old trees at desired levels at the midscale (100-1,000 acre average)?	Number per acre	**Vegetation Midscale Desired Condition (DC):** Snags 18 inches d.b.h. or greater average 1 to 2 snags per acre. Snags and green snags of variable size and form are common. Downed logs (greater than12 inches diameter at mid-point and greater than 8 feet long) average 3 logs per acre within the forested area of the landscape. Coarse woody debris greater than 3 inches in diameter (including downed logs) ranges from 3 to 10 tons per acre (PIPO). Coarse woody debris, including downed logs, ranges from 5 to 15 tons per acre (FFMC). **Vegetation Landscape DC:** Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris), and structural diversity. **Soils DC:** Logs and other woody materials are distributed across the surface to maintain soil productivity. **MSO Recovery Plan**	1-5	2-5	A
02	**Ponderosa Pine and Frequent Fire Mixed Conifer**	Is the fuel loading within the desired range?	Tons per acre	**Midscale DC Ponderosa Pine:** Coarse woody debris greater than 3 inches in diameter (including downed logs) ranges from 3 to 10 tons per acre. **Midscale DC Frequent Fire Mixed Conifer:** Coarse woody debris, including downed logs, ranges from 5 to 15 tons per acre.	1-5	2 -5	A

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No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
06	**Nonnative Species**	What is the percent cover of noxious weeds[1] by species?	Percent cover	**Nonnative Invasive DC:** species are contained and/or controlled so that they do not disrupt the structure or function of ecosystems. **Nonnative Invasive Guideline:** New populations are detected early, monitored, and treated as soon as possible.	1-5	2-5	A
	REMOTELY SENSED						
07	**Ponderosa Pine and Frequent Fire Mixed Conifer**	How many acres of the forest is in an uneven aged open state, at the midscale (above 100 acres)?	Acres	**Landscape DC:** The ponderosa pine forest vegetation community is a mosaic of forest conditions composed of structural stages ranging from young to old trees. The forest is generally uneven aged and open. **Midscale DC:** The ponderosa pine forest vegetation community is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The mosaic of tree groups generally comprises an uneven-aged forest with all age classes and structural stages present. **Midscale DC:** Forest conditions in some areas contain 10 to 20 percent higher basal area in mid-aged to old tree groups than in the general forest (e.g. goshawk post-fledging family areas, Mexican spotted owl protected areas, drainages, and steep north-facing slopes). **Other:** Mexican Spotted Owl (MSO) Recovery Plan	3-5	3-5	A/B
08	**Ponderosa Pine and Frequent Fire Mixed Conifer**	How many acres are predicted to support active crown fire as modeled under typical peak fire danger conditions at the midscale.	Acres	**Midscale DC:** Fires burn primarily on the forest floor and typically do not spread between tree groups as crown fire. **Obj (PIPO):** To reduce the potential for active crown fire in ponderosa pine communities: • Mechanically thin 11,000 to 19,000 acres annually. • Burn an average of 13,000 to 55,000 acres annually using a combination of prescribed fire and naturally ignited wildfires. **Obj (ffMC):** burn an average of 1,000 to 13,000 acres annually using prescribed fire and/or naturally ignited wildfires. Mechanically thin 1,200 to 2,100 acres per year.	3-5	3-5	A
09	**Ponderosa Pine and Frequent Fire Mixed Conifer**	Is the stand density within a range that will allow for a robust understory?	Acres, SDI[2]	**Landscape DC:** Organic ground cover and robust herbaceous vegetation provide protection for soil and moisture infiltration, and contribute to plant and animal diversity and to ecosystem function.	3-5	3-5	A/B
10	**Ponderosa Pine, Mixed Conifer, Spruce fir, and Pinyon-juniper Communi-ties.**	How many acres are at high risk for insect outbreaks?	Acres, SDI	**Ponderosa Pine Landscape DC:** The landscape is a functioning ecosystem that contains all its components, processes, and conditions associated with endemic levels of disturbances (e.g. fire, dwarf mistletoe, insects, diseases, lightning, drought, and wind). Forest vegetation conditions are resilient to the frequency, extent, and severity of disturbances and climate variability.	Annual	2-5	A/B
11	**Ponderosa Pine and Frequent Fire Mixed Conifer**	What is the total area within the desired range for basal area? Openings?	BA, Open: Canopy	**Midscale DC:** Basal area within forested areas generally ranges from 20 to 80 sqft/acre. Openings with grass/forb/shrub vegetation are variably shaped and typically range from 10 to 70 percent.	3-5	3-5	A

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
12	**Aspen**	What is the areal extent and configuration of aspen on the Kaibab NF?	Acres	**Aspen DC:** Where aspen is present, it is stable or increasing in ponderosa pine and frequent fire mixed conifer forests.	3-5	3-5	A
13	**Grasslands**	What percent of the grassland PNVT has <10 percent canopy cover?	Percent cover	**Grassland DCs:** Tree canopy cover ranges from 0 to 9 percent, depending upon specific site conditions.	3-5	3-5	A/B
14	**Wildlife**	Does habitat configuration provide functional connectivity for pronghorn?	Suitability Index[3]	Wildlife DCs: Interconnected habitats allow for movement of wide ranging species. Habitat configuration and availability allows wildlife populations to adjust their movements (e.g. seasonal migration, foraging, etc.) in response to climate change and promote genetic flow between wildlife populations.	3-5	3-5	A/B
	EXISTING SOURCES						
15	**Fire Adapted Ecosystems**	How many acres were burned with desired fire behavior and effects?	Acres	**Finescale DC:** Fires generally burn as surface fires, but single tree torching and isolated group torching is not uncommon. **Midscale DC:** Fires primarily burn on the forest floor and typically do not spread between tree groups as crown fire. **Landscape DC:** Fire and other disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris loads, and nutrient cycling. Frequent, low severity fires (Fire Regime I) occur across the entire landscape with a return interval of 0 to 35 years.	Annually	5	A

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
16	**Fire Adapted Ecosystems**	How many acres were treated with mechanical thinning by PNVT?	Acres	**Objective Ponderosa Pine:** To reduce the potential for active crown fire in ponderosa pine communities: • Mechanically thin 11,000 to 19,000 acres annually. **Objective Frequent Fire Mixed Conifer:** Mechanically thin 1,200 to 2,100 acres per year. **Objective Grasslands:** Reduce tree density to less than 10 percent on 5,000 to 10,000 acres of historic grasslands annually.	Annual	2-5	A
17	**Aspen (Tusayan and Williams RD)**	What was the total area of aspen fenced?	Acres	**Aspen Objective:** Fence 200 acres of aspen within 10 years of plan approval.	Annual	2-5	A
18	**Aspen**	How many acres treated for conifer encroachment?	Acres	**Aspen Objective:** Reduce conifer encroachment on 800 acres of aspen within 10 years of plan approval.	Annual	2-5	A
19	**Grasslands**	What is the relative composition and cover of grasslands?	Frequency	**Grassland DCs:** Vegetation is composed of a mix of native grasses and forbs. The structure, composition, and distribution of vegetation are within the range of natural variability and occur in natural patterns of abundance. Grass/forb/shrub canopy cover is typically above 25 percent, with less than one quarter of any grassland below this range.	1-5	2-5	A/B

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
20	**Grasslands**	How many miles of fence were modified for pronghorn?	Miles	**Grasslands Obj:** Modify fences and/or install pronghorn crossings on 50 miles of fence within 10 years of plan approval.	Annual	2-5	A
21	**Ponderosa Pine, Mixed Conifer, Spruce-fir, and Pinyon-juniper**	What is the acreage of outbreaks of insects and disease?	Acres	**Ponderosa Pine Landscape DC**: The landscape is a functioning ecosystem that contains all its components, processes, and conditions associated with endemic levels of disturbances (e.g. fire, dwarf mistletoe, insects, diseases, lightning, drought, and wind). Forest vegetation conditions are resilient to the frequency, extent, and severity of disturbances and climate variability.	Annual	2-5	A
22	**Wildlife (MIS[4])**	What is the estimated population trend of pronghorn?	Trend	FSM Policy: Population trends of the management indicator species will be monitored and relationships to habitat changes determined. This monitoring will be done in cooperation with state fish and wildlife agencies to the extent practicable.	Annual	2-5	A/B
23	**Nonnative Invasive Species**	What is the areal extent of priority nonnative invasive plants on the KNF?	Acres	**Invasive Species DC:** New populations are detected early, monitored, and treated as soon as possible.	Annual	2-5	A
24	**Nonnative Invasive Species**	How many acres of invasive plants were treated?	Acres	**Invasive Obj:** Treat 2,000 to 3,000 invaded acres annually.	Annual	2-5	A
25	**Natural Waters**	How many springs were protected and restored?	Count	**Natural Waters Obj:** Protect and/or restore at least 10 individual springs within 5 years of plan approval.	Annual	2-5	A

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
26	**Natural Waters**	How many acres of wetlands were restored?	Acres	**Natural Waters Obj:** Restore native vegetation and natural water flow patterns on at least 6 acres of wetlands within 5 years of plan approval.	Annual	2-5	A
27	**Natural and Constructed Waters**	Are there any water bodies not meeting Arizona water quality standards?	Count	**Watershed DC:** Water quality meets or exceeds State of Arizona or Environmental Protection Agency water quality standards for designated uses. Water quality meets critical needs of aquatic species.	2-5	2-5	A
28	**Air Quality**	How many days did forest activities contribute to exceeding State standards for visibility and public health?	Count	**Air Quality DC:** Air quality above the Kaibab National Forest meets State air quality standards for visibility and public health.	Annual	2-5	A
29	**Recreation**	Is the forest providing adequate recreational opportunities for the public?	Visitor Use	**Recreation DC:** The forest provides a range of recreation settings and corresponding high quality scenery for the public to engage in developed and dispersed recreation activities in concert with other resource management and protection needs. Recreation opportunities are balanced with the ability of the land to support them. Minimal user conflicts.	5	5	B
30	**Recreation**	How many miles of trails were maintained to standard?	Miles	**Recreation DCs:** Recreation use levels are compatible with other resource values including scenery, cultural, soil, vegetation, water, and wildlife. The biological, cultural, recreation, and scenic environment is sustained and enhanced for present and future generations.	Annual	2-5	A

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
31	**Cultural Resources**	How many acres of non-project related cultural resource surveys were conducted?	Acres	**Cultural Resource Objective:** Non-project related cultural resource survey is conducted in areas with a high likelihood of historic properties on at least 100 acres per year.	Annual	2-5	A
32	**Forestry and Forest Products**	How many acres of suitable timberlands were managed (TSI, harvest, etc.) for timber production?	Acres	**National Forest Management Act 1976**	Annual	2-5	A
33	**Forestry and Forest Products**	Have much wood was offered?	CCF[5]	**Forestry and Forest Products DC:** A sustained level of timber outputs is available from suitable timberland in an economically efficient manner to support local dependent industries and local communities. A sustainable wood harvesting and utilization industry exists of a size and diversity required to effectively and efficiently restore and maintain the ponderosa pine vegetation community.	Annual	2-5	A
34	**Forestry and Forest Products**	How many direct jobs does the forest support/provide from harvesting and utilization of wood products?	Number of jobs	**Forestry and Forest Products DC:** A sustainable wood harvesting and utilization industry exists of a size and diversity required to effectively and efficiently restore and maintain the ponderosa pine vegetation community.	2-5	2-5	A

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
35	**Forestry and Forest Products**	Have there been significant investments in the wood harvesting and utilization infrastructure in the operating area?	Producti on capacity	**Forestry and Forest Products DC:** A sustainable wood harvesting and utilization industry exists of a size and diversity required to effectively and efficiently restore and maintain the ponderosa pine vegetation community.	2-5	2-5	B
36	**Forestry and Forest Products**	What was the average cost per acre to the Forest Service for mechanical treatments?	Dollars/ acre	**National Forest Management Act (1976)**	2-5	2-5	A
37	**Forestry and Forest Products**	What is the ratio of costs to revenues for mechanical thinning activities?	Cost: revenue	**National Forest Management Act (1976)**	2-5	2-5	A
		INTERVIEWS					
38	**Ponderosa Pine, Mixed Conifer, Spruce-fir, and Pinyon-juniper Communi-ties.**	Were there any incidences of insect outbreaks in recently treated areas? If so, where?	Presence/ absence, location	**National Forest Management Act (1976)**	Annual	2-5	A/B

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
39	**Pinyon-Juniper Woodlands**	Was a robust crop of pinyon nuts produced on any of the districts?	Presence / absence, location	**PJ DC:** A robust crop of pinyon pine nuts are regularly produced.	Annual	5	B
40	**Recreation and Transpor-tation**	Are there areas of the forest where recreation or vehicle use is causing detrimental resource effects that are in need of management? Where is it occurring?	Presence/ absence, location	**Recreation DC:** The forest provides a range of recreation opportunities for forest users and is balanced with the ability of the land and management to support them. **Transportation DCs:** Roads and culverts do not contribute to headcuts or downcuts in ephemeral drainages. Roads allow for safe and healthy wildlife movement in areas of human development. Vehicular collisions with animals are rare.	2-5	2-5	A/B
41	**Cultural Resources**	Are cultural resources being protected in place?	Yes or no	**Cultural Resource DC**: Cultural resources, including known traditional cultural properties, are preserved, protected, or restored.	Annual	2-5	B

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
42	**Livestock Grazing**	Are livestock numbers balanced with forage capacity on each allotment?	Yes or no	**Livestock grazing DC:** Grasses and forbs provide adequate forage for permitted livestock consistent with other desired conditions.	Annual	1-5	B
43	**Tribal Traditional and Cultural Uses**	Are plant species of known medicinal and cultural value being depleted?	Yes or no	**Tribal Traditional and Cultural Use DC:** Traditional tribal uses, such as the collection of medicinal plants, wild plant foods, basketry materials, and firewood, are recognized as important uses and are supported by the forest. Traditionally used resources are not depleted and are available for future generations.	1-2	2-5	VB
44	**Arizona Bugbane Botanical Area**	Were the monitoring requirements met as identified in the AZ Bugbane conservation agreement?	Yes or no	**DC for Bugbane Botanic Area:** Arizona bugbane has a sustainable population and is at low risk for extirpation. The character of this area is maintained. **Other**: Arizona Bugbane Conservation Agreement	5	5	B
45	**Pediocactus Conserva-tion Area**	Were the monitoring requirements met as identified in the Pediocactus conservation agreement?	Yes or no	**Pediocactus Conservation Area DC:** Paradine plains cactus (*Pediocactus paradinei)* has a sustainable population and is at low risk for extirpation. **Other**: Pediocactus Conservation Agreement	5	5	B

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
		INTENSIVE					
46	**Aspen**	Is aspen regenerating and becoming established in treated areas?	Regener-ation and recruit-ment	**Aspen DC:** Aspen is successfully regenerating and recruiting into older and larger size classes. Size classes have a natural distribution, with the greatest number of stems in the smallest classes. Where aspen is presen, it is stable or increasing in ponderosa pine and frequent fire mixed conifer forests.	2-5	5	A/B
47	**Natural and Constructed Waters**	What is the functional condition of the lakes and wetlands on the KNF?	PFC[6]	**Natural Waters DC:** Water levels, flow patterns, groundwater recharge rates, and geochemistry are similar to reference conditions. **Constructed Waters DC:** Reservoirs maintain high quality for parameters such as temperature, dissolved oxygen, and water levels within the seasonal range of variable conditions.	3-5	5	A/B
48	**Natural Waters**	In treated/ protected areas, are waterflow patterns and vegetation intact?	Yes or no	**Natural Waters DC:** Water levels, flow patterns, groundwater recharge rates, and geochemistry are similar to reference conditions.	2-10	2-10	B
49	**Wildlife (TES[7])**	Are Mexican spotted owls present in PACs?	Occu-pancy	**Mexican Spotted Owl Recovery Plan**	1-5	2-5	B

No.	Resource Area	Monitoring Question	Metric	Driver (desired conditions, objectives, policy, etc.)	Measure-ment Interval (years)	Evaluation/ Report Interval (years)	Precision
50	**Wildlife (MIS)**	What is the estimated population density and trend for Graces warbler, western bluebird and ruby-crowned kinglet?	Density and trend	**FSM Policy:** Population trends of the management indicator species will be monitored and relationships to habitat changes determined. This monitoring will be done in cooperation with state fish and wildlife agencies to the extent practicable.	1-5	5-10	A/B
51	**Double A Wild and Free Roaming Horse and Burro Territory**	What is the estimated burro population within the area?	Count	**DC for Wild and Free Roaming Burro Territory:** A biologically sound burro population is in balance with native wildlife, permitted livestock, and other resource values. **Other:** Wild Free-Roaming Horses and Burros Act of 1971: Forest Service Handbook sections 2263.1 Territory Plans and 2265.3 - Removal of Excess Animals.	3-5	3-5	B

Key:

[1] Noxious weed is a legal term applied to plants or plant parts regulated by Federal and State laws. Arizona Administrative Codes R3-4-244, R3-4-245 (Arizona Department of Agriculture 1999) regulate certain invasive species in the state: "A noxious weed is defined as any species of plant that is detrimental or destructive and difficult to control or eradicate and includes plant organisms found injurious to any domesticated, cultivated, native, or wild plant."

[2] Stand density index (SDI) is a relative measure of stand density that converts a stand's current density into a density at a reference size (Reineke 1933).

[3] Based on connectivity modeling (Hurteau 2010)

[4] Management indicator species

[5] CCF: Wood volume (hundred cubic feet)

[6] Proper functioning condition

[7] Threatrened, endangered, and sensitive species