Chapter 4. Monitoring

Introduction

Under the 2012 Planning Rule (36 CFR 219.12(a)(5), monitoring consists of two elements: the plan monitoring program and broader-scale monitoring strategies (FSH 1909.12-2015-1). Together, these should enable the responsible official to determine if a change in plan components or other plan content that guide management of resources on the plan area may be needed. The Regional Forester develops broader-scale monitoring strategies; however, at this time those strategies have not yet been completed.

The plan monitoring program is to be developed collaboratively with other agencies, organizations, and individuals, in consultation with Tribes, while coordinating with Forest Service Research and State and Private Forestry. Monitoring is continuous and provides feedback for the planning cycle by testing relevant assumptions, tracking relevant conditions over time, and measuring management effectiveness. It should also use the best available scientific information and be within the financial and technical capabilities of the agency. The plan monitoring program is informed by the assessment phase; developed during plan development; and implemented after plan decision. Biennial monitoring evaluation reports document whether a change to the plan or change to the monitoring program is warranted based on new information, whether a new assessment may be needed, or whether there is no need for change at that time. The monitoring strategy provides a framework for subsequent monitoring and evaluation designed to inform adaptive management.

In addition to the requirements above, a plan monitoring program must contain at least one monitoring question and associated indicator to address each of the eight following elements. These are the minimum monitoring requirements as specified in the 2012 Planning Rule (36 CFR 219.12(a)(5).

1. The status of select watershed conditions;
2. The status of select ecological conditions, including key characteristics of terrestrial and aquatic ecosystems;
3. The status of focal species to assess ecological conditions required under 36 CFR 219.9;
4. The status of a select set of ecological conditions required under 36 CFR 219.9 to contribute to recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern;
5. The status of visitor use, visitor satisfaction, and progress toward meeting recreation objectives;
6. Measurable changes within the plan area related to climate change and other stressors that may be affecting the plan area;
7. Progress toward meeting desired conditions and objectives in the forest plan, including providing for multiple-use opportunities; and
8. The effects of each timber management system, to determine they do not substantially and permanently impair the productivity (soils) of the land.
9. Address the plan contributions to communities, social and economic sustainability of communities, multiple use management in the plan area, or progress toward meeting the desired conditions and objectives related to social and economic sustainability (FSH 1909.12, Chapter 30, section 32.13f).

Social, economic, and cultural sustainability will also be addressed in the monitoring program because sustainability is an inherent part of several required monitoring items listed above. The purpose for monitoring social, cultural, and economic indicators is to; inform managers and the public of changes in social, cultural, and economic conditions that are influenced by the plan; monitor contributions of the management of the plan area toward meeting social, cultural, and economic attributes of desired

conditions; and provide feedback for adaptive management toward expected and potential contributions to social, cultural, and economic sustainability.

Focal Species

Focal species are not selected to make inferences about other species. Focal species are selected because they are believed to be responsive to ecological conditions in a way that can inform future plan decisions. Forest Service handbook direction (FSH 1909.12 chapter 30, section 32.13c) for focal species further specifies that every plan monitoring program must identify one or more focal species and one or more monitoring questions and associated indicators addressing the status of the focal species. The purpose for monitoring the status of focal species over time is to provide insight into the following:

1. Integrity of ecological systems on which focal species depend,
2. Effects of management on those ecological conditions,
3. Effectiveness of the plan components to provide for ecological integrity and maintain or restore ecological conditions, and
4. Progress towards achieving desired conditions and objectives for the plan area. It is not expected that a focal species be selected for every element of ecological conditions.

Monitoring methods for evaluating the status of focal species may include measures of abundance, distribution, reproduction, presence or absence, area occupied, survival rates, or others. The objective is not to choose the monitoring technique(s) that will provide the most information about the focal species, but to choose a monitoring technique(s) for the focal species that will provide useful information with regard to the purpose for which the species is being monitored. The expectation is that monitoring ecosystem and watershed conditions along with monitoring the status of a set of well-chosen focal species will provide timely information regarding the effectiveness of plan components related to plant and animal diversity.

The following section describes the recommended focal species and how they provide information regarding ecological integrity and ecosystem diversity. These species were selected because they will inform management about the status of ecological conditions, diversity, and integrity. Detected population changes are most likely to indicate the effects of management for the selected species.

Red brome (*Bromus rubens*)

Red brome is an invasive species that has substantial influences on fire regimes and behavior. It is particularly problematic in low desert, non-fire-adapted systems found in the Sonoran desert where decreasing fire return intervals and greater intensity burns may result in mortality of native species. Because it is a major stressor on a significant portion of the Tonto National Forest, the presence or absence of red brome is a powerful indicator of ecological health.

Uncharacteristic fire, especially in low desert systems, is a chief management concern and focus of vegetative and fire management in these systems. Other activities that may result in the introduction of invasive, non-native grasses are also managed. As the species itself is a management priority, its response to management in the desert southwest has been studied and is relatively understood. USDA provides a management guide.

Under active management, we would expect to see lower infestation rates and a reduction in red brome, and ultimately fewer and lower intensity fires in desert systems with a return towards reference conditions for fire return intervals.

Precipitation patterns and prior burns may play a large role in the efficacy of weeds treatments. However, the interaction between weather, fire, and active weed management is still useful in providing information regarding the overall condition of the systems in question.

This species is not particularly difficult to observe or identify, neither is it rare on the landscape. The forest has a number of established monitoring programs in which monitoring for this species does or may occur. Specifically, the forest has an active weeds program that monitors and tracks red brome, with both internal and external funding. Additionally, there are a number of local volunteer organizations actively engaged in monitoring for invasive species, of which red brome is consistently a high priority target.

Mexican spotted owl (Strix occidentalis lucida)

As federally listed species under the Endangered Species Act, a great deal of information has been acquired regarding effects of forest conditions and management activities on these owls, thus the species' relationship to ecological conditions on the ground are relatively well understood. Many plan components for forested ecological response units in the revised forest plan were specifically designed with Mexican spotted owls in mind. While a number of activities may threaten these owls, uncharacteristic fire is considered the most important factor, and this aligns with many of the priority vegetation and fire management goals on the Tonto National Forest.

While somewhat rare and cryptic, surveying for spotted owls on the forest is largely successful and widely accepted protocols are available. Resources are generally available to monitor owls, and the forest participates in regional programs to work with partners to monitor to protocol. As such, a continued focus on spotted owls is useful to assess the overall conditions of many forested ecological response units on the Tonto National Forest while contributing to larger scale assessments of Mexican spotted owls throughout the region.

These focal species are indicators of species diversity and ecological integrity of desert ecosystems.

Monitoring Plan and Strategy

The monitoring plan is made up of monitoring questions and indictors that may address more than one of the required monitoring topics. Monitoring questions are evaluative in design and address two topics:

- Status and trends related to desired social, economic, and ecological conditions identified in the forests plan and,

- Effectiveness of management actions in contributing to the sustainability of affected social, economic, and ecological systems in the plan area. Indicators are selected for each monitoring question that are responsive to activities and that when monitored, would enable answering the monitoring questions. Tables 1 through 7 display monitoring questions, the required monitoring topics addressed, associated plan components, indicators, and measurement frequency or interval required to answer the monitoring questions by resource area.

Monitoring elements also address key ecosystems services for the Tonto National Forest. Key ecosystem services on the Tonto National Forest include: water for consumption; water for recreation; habitat for hunting, fishing, and watchable wildlife; sustainable and productive rangelands; and cultural heritage. These key ecosystem services are important in the broader landscape outside of the plan area and are influenced by the forest plan. The monitoring questions that address key ecosystem services are notated in Table 21 through Table 27.

A plan monitoring implementation guide will be developed after the revised plan goes into effect. It will, separate from the revised plan, describe the "how" in terms of specific approaches or strategies for measuring and analyzing plan monitoring indicator variables, models to be used, and appropriate target thresholds/benchmarks to be met to address the plan monitoring questions, as identified in the tables on the following pages. The Plan Monitoring implementation guide will help in the development of the biennial monitoring report, the first report being due two years after the revised plan goes into effect.

Table 21. Monitoring topics, questions, plan components, indicators, and measurement interval for watersheds and riparian areas.

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
1: Status of select watersheds **4**: Status of ecological conditions for at-risk species **6**: Ecosystem resiliency and climate change	What are the trends in watershed condition among sentinel[51] watersheds?	Desired conditions for proper functioning and resilient watershed conditions capable of buffering climate change impacts (WW-DC-3, WAT-DC-5) Desired conditions that at-risk species have good habitat conditions and are resilient to maintain viable populations (WFP-DC-1, WFP-DC-2)	Assessments on water quality (e.g., macroinvertebrate surveys), ground cover, stream flow, streambank stability, and groundwater levels Watershed condition classification Percent of streams classified as stable or functioning properly (e.g., Proper Functioning Condition or similar metric) Changes in hydrographs, tree and shrub encroachment rates, and changes in water temperature in sentinel wilderness watersheds relative and other sentinel watersheds to assess climate change impacts	2-15
1: Status of select watersheds **2**: Status of terrestrial and aquatic ecosystems **4**: Status of ecological conditions for at-risk species *Key ecosystem service: water for recreation*	Are management actions effective in maintaining or improving watershed integrity in priority watersheds?	Objectives to improve the conditions of priority watersheds (WAT-O-1 and WAT-O-2) Desired conditions that ecological conditions support at-risk species and conditions support good habitat conditions to maintain viable populations (WFP-DC-1)	Assessments for example, water quality (e.g., macroinvertebrate surveys), ground cover, stream flow, streambank stability, and groundwater levels. Watershed condition classification Essential projects implemented	2
1: Status of select watersheds **2**: Status of terrestrial and aquatic ecosystems *Key ecosystem service: water for consumption*	How are stream conditions trending on the forest?	Desired conditions for water quality conditions to meet or exceed State standards to support multiple uses and wildlife and plants (WAT-DC-2)	Percentage of surveyed streams in non-impaired condition	4

[51] Sentinel watersheds are a subset of forest watersheds chosen based on the management influence, ecosystem type, and distribution that can be used as indicators of forest-wide watershed health. These watersheds are a subset of watersheds more intensely monitored that can but does not have to include priority watersheds.

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
2: Status of terrestrial and aquatic ecosystems	Are management activities effective in maintaining or improving riparian and or spring ecosystems?	Desired conditions that riparian areas, springs, and wetlands are properly functioning and resilient (RMZ-DC-1, RMZ-DC-2, RMZ-DC-3)	Acres of riparian areas improved or maintained and number of springs maintained or improved. Abundance and diversity of riparian obligate species in treatment areas Age class diversity (multiple cohorts/age groups) in treatment areas	2
2: Status of terrestrial and aquatic ecosystems	Do grazing schedules allow for adequate rest for riparian vegetation recovery following grazing?	Guideline to allow sufficient time for plant development and recovery following grazing and that livestock grazing allows for healthy rangeland conditions (RERU-G-2, GRZ-DC-3).	Length of use and length of time between grazing Range utilization monitoring in riparian areas	2

Table 22. Monitoring topics, questions, plan components, indicators, and measurement interval for vegetation, fire, and forest products.

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
2: Status of terrestrial and aquatic ecosystems **6**: Ecosystem resiliency and climate change **8**: Timber management and impacts to productivity (soils) *Key ecosystem service: sustainable and productive rangelands*	How are key characteristics of vegetation structure, function, soil productivity, and vegetation composition changing over time in relation to desired conditions and reference conditions at the ecosystem and landscape scale?	Desired conditions that forests, woodlands, shrublands, and grasslands are functioning properly and resilient to disturbance (ERU-DC-2, ERU-DC-5, ERU-DC-9).	Vegetation departure using sources such as: Midscale, or other remote sensing products. Key sites monitored where treatments have been completed. Soil condition assessments at key sites where timber harvest operations have occurred.	5-10
2: Status of terrestrial and aquatic ecosystems **4**: Status of ecological conditions for at-risk species	Is there an increase in the acres of undesirable effects from wildfires?	Desired conditions that wildfire behavior and effects are within the natural range of variability and posse minimal threats to public safety, property, infrastructure, habitat conditions for species, watersheds and other values (FF-DC-5, ERU-DC-1, ERU-DC-13).	Acres of undesirable fire effects and effects from fire management activities (e.g., dozer lines). Severity of wildfires (RAVG data or other suitable data). Patch size of wildfires (RAVG data or other suitable data). Frequency of wildfires (RAVG data or other suitable data).	2

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
2: Status of terrestrial and aquatic ecosystems	To what extent is fire (both planned and unplanned) used to achieve desired ecological, social, or economic conditions?	Desired conditions that fire management activities improve maintain and improve public safety, improve ecosystem function, wildlife habitat, and other socio-economic values (FF-DC-4).	Number and acres of unplanned natural fire ignitions managed for ecological, social, or economic reasons. Number and acres of unplanned fire ignitions managed with the primary strategy of suppression. Number and acres of planned fire ignitions managed for ecological, social, or economic reasons Evaluation and classification of areas by wildfire strategic response (e.g., proportion in "maintain" category using PODS).	2
2: Status of terrestrial and aquatic ecosystems **4**: Status of ecological conditions for at-risk species	Are treatment objectives for forest, woodland, and shrubland ecological response units making progress towards desired conditions?	Mechanical and fire treatment objectives to improve conditions for ecological response units (ERU-O-1, ERU-O-2) Desired conditions that habitat conditions support viable populations of at-risk species and habitats are resilient (WFP-DC-1, WFP-DC-2)	Acres treated	4
2: Status of terrestrial and aquatic ecosystems **3**: Status of focal species and ecological conditions *Focal species: Mexican spotted owl*	Are snags, downed logs and large old trees at desired conditions at the midscale (100-1000 acre average) level?	Desired conditions that old growth occurs throughout the landscape and includes snags, coarse woody debris, and structural diversity (ERU-DC-1, ERU-DC-2, ERU-DC-3, ERU-DC-14)	Number of snags, downed logs, and large old trees per acre Presence/absence of Mexican spotted owls in associated habitats.	1-5
2: Status of terrestrial and aquatic ecosystems	What is the status/condition of semi-desert grasslands?	Desired conditions that grasslands are diverse, productive, and resilient; and objectives to improve conditions (ERU-SDG-DC-3, ERU-SDG-DC-4, ERU-SDG-DC-5, ERU-O-3)	Acres of grasslands treated Acres of grasslands evaluated as restorable Acres of grasslands evaluated as highly departed (e.g., highly encroached) Key sites monitored for treatment effectiveness.	2
2: Status of terrestrial and aquatic ecosystems	What is the status/condition of invasive grasses in the desert	Desired conditions that invasive species do not increase undesirable fire effects in	Acres of areas surveyed of desert ecological response units occupied by focal species, red brome (*Bromus rubens*)	2

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
3: Status of focal species and ecological conditions *Focal species: red brome*	capable of disrupting ecological processes?	deserts and impair ecological conditions (ERU-DES-DC-4)	Assessment of the extent and distribution of invasive grasses on the forest.	
7: Progress towards desired conditions, objectives, and providing multiple-use opportunities **9**: Address the plan contributions to social and economic sustainability	Is the national forest providing a sustainable, predictable level of forest products to communities?	Desired conditions that a sustainable supply of commodities are available to businesses and individuals (FP-DC-3)	Number and volume of forest products permits issued Annual timber volume offered and annual timber volume sold.	2

Table 23. Monitoring topics, questions, plan components, indicators, and measurement interval for wildlife, fish, and rare plants

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
4: Status of ecological conditions for at-risk species **5**: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities *Key ecosystem service: habitat for hunting, fishing, and watchable wildlife*	To what extent are management activities maintaining or improving habitats necessary for wildlife (including at-risk species and species important for hunting, fishing, and watchable wildlife activities)?	Desired conditions that ecological conditions support wildlife and the associated socio-economic opportunities, such as watchable wildlife and hunting (REC-WR-DC-1)*	Acres of wildlife habitat enhanced or improved. State economic impact reports on angling, hunting, and watchable wildlife. Number of outfitter guide permits administered per year related to wildlife based recreation.	2
4: Status of ecological conditions for at-risk species **5**: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities	What is the status/condition of rare and at-risk plants and unique plant communities and how is management providing opportunities for public involvement?	Desired conditions that the location and status of at-risk, rare, and endemic plant species are known (WFP-DC-6) Objectives to complete products or activities that educate the public about wildlife, fish, and rare plants,	Progress and status of special area designation for recommended botanical areas Site inventories completed for recommended botanical and research natural areas	4

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
Key ecosystem service: habitat for hunting, fishing, and watchable wildlife		and activities that contribute to the recovery of listed species (WFP-O-1, WFP-O-2)	Public engagement activities; volunteer opportunities for rare plant surveys and inventories Baseline data (e.g., surveys and research) for rare plants that inform management Species surveyed and new occurrences of at-risk species that provide information on ecological conditions and threats Conservation measures in conservation agreements initiated or completed	

Table 24. Monitoring topics, questions, plan components, indicators, and measurement interval for recreation

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
5: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities **9:** Address the plan contributions to social and economic sustainability	What is the trend in visitor use and satisfaction?	Desired conditions for sustainable recreation, adapting to latest science and management and objectives to meet public satisfaction based on national monitoring use surveys, and objectives to maintain recreation sites (REC-DC-3, REC-O-4, REC-O-5, REC-O-6, REC-O-7)	Satisfaction levels from USDA national visitor use monitoring survey results.	5
5: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities	Is unsustainable recreation infrastructure being identified and addressed?	Desired condition for sustainable recreation, adapting to latest science and management (REC-DC-3, REC-DIS-WB-DC-4, RD-DC-1)	Revenue at developed recreation sites Property condition assessment Return on investment of recreation infrastructure. Ratio of special use permits administered to standard	2

Table 25. Monitoring topics, questions, plan components, indicators, and measurement interval for cultural resources and sustainability

Monitoring Topics Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
5: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities	Is management successful at providing recreational opportunities for cultural resources?	Desired condition that heritage-based recreation opportunities are available allowing the public to learn about, appreciate, and understand cultural resources. (CUH-DC-3) Desired condition that buildings and infrastructure listed on or eligible for the National Register of Historic Places (NRHP) continue to preserve any of the characteristics that qualify the property for listing in the NRHP. (CUH-DC-5)	Number of recorded sites on the forest. Acres surveyed per current professional standards. Trends in the number of recorded cultural sites.	10
5: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities	Are sites being evaluated for eligibility, are new sites being categorized as PHAs, and are condition assessments being done on current PHAs?	Desired condition that cultural resources and historic properties are stable and preserve the integrity of the property's location, design, setting, materials, workmanship, feeling, or association (CUH-DC-1) Desired condition that heritage-based recreation opportunities are available allowing the public to learn about, appreciate, and understand cultural resources. (CUH-DC-3)	Number of sites evaluated for national historic register. Verification of legacy sites as eligible for national historic register. Number of new sites categorized as PHAs Number of condition assessments on Priority Heritage Assets completed.	2
5: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities *Key ecosystem service: cultural heritage*	Are the trends in visitation levels sustainable at key heritage locations?	Desired condition that cultural resources and historic properties are stable and not damaged and preserve the integrity of the property's location, design, setting, materials, workmanship, feeling, or association, (CUH-DC-1, REC-DIS-MO-DC-3)	Number of people visiting heritage resources (as determined by the heritage program) on the forest. Assessment of damage to heritage sites.	2
5: Visitor use, satisfaction, and recreation **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities *Key ecosystem service: cultural heritage*	How is the forest providing opportunities for experiencing heritage resources (e.g., passport in time)?	Desired conditions that access and use of cultural resources are available for cultural practices, heritage-based recreation opportunities are available, and historic properties and landscapes are considered when working with other resources. (CUH-DC-2, CUH-DC-3, CUH-DC-7)	Number of outreach activities accomplished per fiscal year. Volunteer hours tied to heritage activities	2

Table 26. Monitoring topics, questions, plan components, indicators, and measurement interval for range

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
7: Progress towards desired conditions, objectives, and providing multiple-use opportunities **9:** Address the plan contributions to social and economic sustainability	Are rangelands providing adequate forage resources to sustain traditional lifestyles, socioeconomic diversity, and cultural identity of local communities?	Desired conditions that sustainable livestock grazing and associated management activities support healthy range conditions that then support long-term socioeconomic diversity and stability of local communities (GRZ-DC-1, GRZ-DC-3)*	Number of livestock (e.g., AUMs) Number of active allotments	2-4
2: Status of terrestrial and aquatic ecosystems **7**: Progress towards desired conditions, objectives, and providing multiple-use opportunities	Is herbaceous cover and diversity maintained and/or increased?	Desired condition that livestock grazing allows for healthy, diverse plant communities, satisfactory soil conditions, and minimizes impacts to wildlife habitat. (GRZ-DC 3)	Range condition assessments (e.g., reading the range, Parker three steps)	2-4

Table 27. Monitoring topics, questions, plan components, indicators, and measurement interval for partnerships and volunteers

Monitoring Topics and Key Ecosystem Services Addressed	Monitoring Question	Selected Plan Components (plan component code)	Associated Indicators	Measurement Interval (years)
7: Progress towards desired conditions, objectives, and providing multiple-use opportunities	How has the general public gained knowledge on FS management and opportunities for the public to be involved?	Desired condition that partners and volunteers provide a collaborative network to increase capacity for managing forest resources, staff and leadership work effectively, and there is open communication between parties (FW-PV-DC-1, FW-PV-DC-2, FW-PV-DC-3)	Outreach events at public schools, public meetings, stakeholder meetings, and other events	2
7: Progress towards desired conditions, objectives, and providing multiple-use opportunities **9:** Address the plan contributions to social and economic sustainability	How are partnerships and volunteers helping the forest to achieve desired conditions?	Desired condition that responsibility and stewardship between the Tonto National Forest and our partners leads to greater outcomes and benefits to forest users and the communities we serve.(FW-PV-DC-5, FW-PV-DC-5)	Total number of volunteer agreements. Total number of partnership agreements. Monetary value of partnership and volunteer efforts on the forest.	2