

Wildlife Appendices

Appendix 1. Forest-wide direction for Vegetation Management, Mexican spotted owl, and northern goshawk common to the Coconino and Kaibab Forest Plans

Mexican Spotted Owl

- Standards (CNF Forest Plan, pp. 65-65-1, Kaibab NF Forest Plan, pp. 22-26):
- Provide three levels of habitat management - protected, restricted, and other forest and woodland types to achieve a diversity of habitat conditions across the landscape.
- Protected areas include delineated protected activity centers; mixed conifer and pine oak forests with slopes greater than 40% where timber harvest has not occurred in the last 20 years; and reserved lands which include wilderness, research natural areas, wild and scenic rivers, and congressionally recognized wilderness study areas.
- Restricted areas include all mixed-conifer, pine-oak, and riparian forests outside of protected areas.
- Other forest and woodland types include all ponderosa pine, spruce-fir, woodland, and aspen forests outside protected and restricted areas.
- Survey all potential spotted owl areas including protected, restricted, and other forest and woodland types within an analysis area plus the area 1/2 mile beyond the perimeter of the proposed treatment area.
- Establish a protected activity center at all Mexican spotted owl sites located during surveys and all management territories established since 1989.
- Allow no timber harvest except for fuelwood and fire risk abatement in established protected activity centers. For protected activity centers destroyed by fire, windstorm, or other natural disaster, salvage timber harvest or declassification may be allowed after evaluation on a case-by-case basis in consultation with US Fish and Wildlife Service.
- Allow no timber harvest except for fire risk abatement in mixed conifer and pine-oak forests on slopes greater than 40% where timber harvest has not occurred in the last 20 years.
- Limit human activity in protected activity centers during the breeding season..
- In protected and restricted areas, when activities conducted in conformance with these standards and guidelines may adversely affect other threatened, endangered, or sensitive species or may conflict with other established recovery plans or conservation agreements; consult with US Fish and Wildlife Service to resolve the conflict. Monitor changes in owl populations and habitat needed for delisting.

The Forest Plans describes guidelines within Protected, Restricted Threshold and Target Threshold lands in the following forest stratified MSO habitats:

Restricted Areas (Mixed conifer, pine-oak, and riparian forests) (CNF Forest Plan, pp. 65-3 -65-5, Kaibab NF Land Management Plan, pp. 25-26)

- Manage to ensure a sustained level of owl nest/roost habitat well distributed across the landscape. Create replacement owl/roost habitat where appropriate while providing a diversity of stand conditions across the landscape to ensure habitat for a diversity of prey species.
- Emphasize uneven-aged management systems. However, both even-aged and uneven-aged systems may be used where appropriate to provide variation in existing stand structure and species diversity.
- Save all trees greater than 24 inches dbh.
- In pine-oak forests, retain existing large oaks and promote growth of additional oaks.
- Encourage prescribed fire and fire for resource benefits to reduce hazardous fuel accumulation. Thinning from below may be desirable or necessary before burning to reduce ladder fuels and the risk of crown fire. (add pages where found)
- Retain substantive amounts of key habitat components: snags 18 inches in diameter and larger, down logs over 12 inches midpoint diameter, hardwoods for retention, recruitment, and replacement of large hardwoods (add pages where found)
- Riparian areas: Emphasize maintenance and restoration of healthy riparian ecosystems through conformance with forest plan riparian standards and guidelines. Management strategies should move degraded riparian vegetation toward good condition as soon as possible. Damage to riparian vegetation, stream banks, and channels should be prevented.

Forest Plan Vegetation Treatment Requirements by Habitat Type

- **Pine-Oak Restricted MSO Habitat:** Twenty percent of the pine-oak forest type (by area) provides MSO nest/roost characteristics – basal area > 150 ft², Gambel oak basal area > 20 ft², twenty 18”+ trees per acre, and 45% of stocking in trees > 12” diameter. All trees > 24” diameter, substantive amounts of snags > 18” diameter, down logs > 12” midpoint diameter, and large hardwoods are retained following management treatments.
- **Pine-Oak Protected MSO Habitat:** Trees greater than 9” dbh are retained following management treatments.

Forest Plan Target Stand Densities within Restricted Threshold and Target Threshold Lands:

- **Pine-oak stands** –manage for 150 square feet of basal area in mature forest structure with the following distribution; (15% -trees 12-18” dbh, 15% -trees 18-24” dbh, 15% - trees > 24” dbh)

Northern Goshawk

Forest plan direction that relate to northern goshawk forest habitat apply to the forest and woodland communities described below that are outside of Mexican spotted owl protected and restricted areas (CNF Forest Plan, pp. 65-7 to 65-11, Kaibab NF Forest Plan, pp. 27 to 31):

- Manage for uneven-age forest conditions for live trees and retain live reserve trees, snags, downed logs, and woody debris levels throughout woodland, ponderosa pine, mixed conifer, and spruce-fir forest cover types. Manage for old age trees such that as much old forest structure as possible is sustained over time across the landscape. Sustain a mosaic of vegetation densities (overstory and understory), age classes and species composition across the landscape.
- Limit human activity in or near nest sites and Post-Fledgling Family Areas (PFAs) during the breeding season (March 1 through September 30).
- The distribution of vegetation structural stages (VSS) for ponderosa pine, mixed conifer and spruce-fir is 10% grass/forb/shrub (VSS 1), 10% seedling-sapling (VSS 2), 20% young forest (VSS 3), 20% mid-aged forest (VSS 4), 20% mature forest (VSS 5), 20% old forest (VSS 6). Distribution of habitat structures should be evaluated at the ecosystem management area level, at the midscale such as drainage, and at the small scale of site.

Within Nesting Areas

- **General:** Provide unique nesting habitat conditions for goshawks. Important features include trees of mature to old age with high canopy cover.
- The structure of the vegetation within nest areas is associated with the forest type, and tree age, size, and density, and the developmental history of the stand. Table 5 of RM-217 presents attributes required for goshawks on locations with “low” and “high” site productivity.
- Preferred treatments to maintain the desired structure are to thin from below with non-uniform spacing and use of hand tools and fire to reduce fuel loads. Lopping and scattering of thinning debris is preferred if broadcast fire cannot be used. Piling of debris should be limited. When necessary, hand piling should be used to minimize compaction within piles and to minimize displacement and destruction of the forest floor and the herbaceous layer. Do not grapple or Dozer pile debris. Manage road densities at the lowest level possible to minimize disturbance in the nest area. Use small, permanent skid trails in lieu of roads for timber harvesting.
- **Spruce-Fir, Mixed Conifer and Ponderosa Pine Cover Types:** The nesting area contains only mature to old forest (VSS 5 & 6) having a canopy cover (measured vertically) between 50-70% with mid-aged (VSS 6) trees 200-300 years old. Non-uniform spacing of trees and clumpiness is desirable.
- **Woodland:** Maintain existing canopy cover levels.

Within Post-Fledgling Family Areas

General: Provide for healthy sustainable forest environment for the post-fledgling family needs of goshawks. The principle difference between “within the PFA” and “outside the PFA” is the

higher canopy cover within the PFA and smaller opening size within the post fledgling family area. Vegetative Structural stage distribution and structural conditions are the same within and outside the PFA.

Ponderosa Pine: Canopy Cover for mid-aged forest (VSS 4) should average 1/3 60+% and 2/3 50+%. Mature (VSS 5) and old forest (VSS 6) should average 50+%.

Woodland: Maintain existing canopy cover levels.

Foraging Areas - Landscapes Outside Goshawk Post-Fledgling Family Areas

General: The distribution of vegetation structural stages for ponderosa pine, mixed conifer and spruce-fir forests is 10% grass/forb/shrub (VSS 1), 10% seedling-sapling (VSS 2), 20% young forest (VSS 3), 20% mid-aged forest (VSS 4), 20% mature forest (VSS 5), 20% old forest (VSS 6).

The distribution of VSS, tree density, and tree age are a product of site quality in the ecosystem management area. Use site quality to guide in the distribution of VSS, tree density and tree ages. Use site quality to identify and manage dispersal PFA and nest habitat at 2 to 2.5 mile spacing across the landscape.

Snags are 18" or larger dbh and 30 feet or larger in height, downed logs are 12 inches in diameter and at least 8 feet long, woody debris is 3 inches or larger on the forest floor, canopy cover is measured with vertical crown projection on average across the landscape.

The order of preferred treatment for woody debris is: 1) broadcast burning, 2) lopping & scattering, 3) hand piling or machine grapple piling, 4) dozer piling.

Canopy Cover: Canopy cover guidelines apply only to mid-aged to old forest structural stages (VSS 4, VSS 5, and VSS 6) and not to grass/forb/shrub to young forest structural stages (VSS 1, VSS 2, and VSS 3).

Ponderosa Pine: Canopy cover for mid-aged forest (VSS 4) should average 40+%, mature forest (VSS 5) should average 40+%, and old forest (VSS 6) should average 40+%. Opening size is up to 4 acres with a maximum width of up to 200 feet. 1 group of reserve trees, 3-5 trees per group, would be left if the opening is greater than an acre in size. Leave at least 2 snags, 3 downed logs, and 5-7 tons of woody debris per acre.

Woodland: manage for uneven age conditions to sustain a mosaic of vegetation densities (overstory and understory), age classes, and species composition well distributed across the landscape. Provide for reserve trees, snags, and down woody debris.

Human Disturbance (CNF Forest Plan pp. 65-11, Kaibab NF Forest Plan, p. 31):

- Limit human activities in or near nest sites and post-fledging family area's during the breeding season so that goshawk reproductive success is not affected by human activities.
- The breeding season extends from March 1 through September 30.

- Low intensity ground fires are allowed at any time in all forested cover types, but high intensity crown fires are not acceptable in the post-fledging family area or nest areas. Avoid burning the entire home range of a goshawk pair in a single year. For fires planned in the occupied nest area, a fire management plan should be prepared. The fire management plan should minimize the risk of goshawk abandonment while low intensity ground fire burns in the nesting area. Prescribed fire within nesting areas should be planned to move with prevailing winds away from the nest tree to minimize smoke and risk of crown fire developing and driving the adults off or consuming the nest tree.

Ground Surface Layer (All forested cover types) (CNF Forest Plan, pp. 65-11 to 65-12, KNF Forest Plan, p. 31)

- Manage road densities at the lowest level possible. Where timber harvesting has been prescribed to achieve desired forest condition, use small, skid trails in lieu of roads.
- Piling of debris should be limited. When necessary, hand or grapple piling should be used to minimize soil compaction within piles and to minimize forest floor and herbaceous layer displacement and destruction.
- Limit dozer use for piling or scattering of logging debris so that the forest floor and herbaceous layer is not displaced or destroyed.

Note: The Coconino NF and Kaibab NF forest plan standards and guidelines do not describe desired even-aged stand conditions for goshawk non-PFA area habitat. The desired condition is to convert all foraging area even-aged stands to the uneven-aged structural conditions shown in table 4 and convert all goshawk PFA/nest stands to the desired uneven-aged structural conditions shown in table

Nonstructural Wildlife Habitat Improvement (CNF Forest Plan, p. 66, Kaibab NF Forest Plan, p. 31)

- Improve vegetation conditions through seeding a mixture of species of grass, forbs, forage, and browse species desirable to wildlife.
- Improve forage conditions by using prescribed fire where environmental analysis shows beneficial effects and in line with approved burning plans.
- Manage forage to increase threatened and endangered species and management indicator species where it is determined appropriate through the IRM and NEPA process.

T&E Nonstructural Wildlife Habitat Improvement (CNF Forest Plan, p. 66)

- Improve T&E and sensitive species habitat. Improvement projects give priority to recovery of T&E species. Conform to approved recovery plans.

Insect and Disease Management (CNF Forest Plan, p. 70)

- Habitat requirements for threatened, endangered, and sensitive species take precedence over insect and disease control.

10,000-Acre Blocks (10K Blocks) (Coconino NF Forest Plan, p. 70)

- Minimum Management Requirements are exceeded where it is good multiple-use management to do so, such as greater density of snags adjacent to meadows, riparian areas, and key water sources.
- Wildlife habitat objectives for each 10K Block are evaluated on an individual stand basis as well as for the entire block.
- Evaluate the need for wildlife forage in the 10K Blocks using the Habitat Capability Index, other available data and professional judgment and, where needed, adjust prescriptions to obtain it. These areas are stands of up to 10 acres with reduced GSL.

Old-Growth (Coconino NF, pp. 32-33, Kaibab NF, pp. 32-33)

Guideline: Consider the effects of spatial arrangement on old-growth function, from groups to landscapes, including de facto allocations to old-growth such as goshawk nest sites, Mexican spotted owl protected activity centers, sites protected for species behavior associated with old-growth, wilderness, research natural areas, and other forest structures managed for old-growth function.

Coconino NF Management Area Direction

MA 3

Manage habitat for the following indicator species through ISM (p.117)

- Turkey
- Goshawk
- Pygmy nuthatch
- Elk
- Abert squirrel
- Red squirrel
- Hairy woodpecker
- Spotted owl

Raptors (pp. 123-124):

Maintain a current inventory of nest locations. A nest group consists of nest tree and adjacent trees and is maintained at least as follows unless environmental analysis indicates either more or less is needed:

- Cooper's hawk -- 15 acres of uncut area around active nests.
- Sharp-shinned hawk -- 10 acres of uncut area around active nests.
- Other raptors -- An area extending to 50 feet from active nests is left uncut.

- Bald eagle winter roosts -- Protect with a 300-foot radius uncut zone around the roost. Road development should avoid the roost and uncut zone.

Ospreys -- At the start of Forest Plan implementation, the only known osprey nesting area is at Lake Mary. The following Standards and Guidelines apply to this nesting area. As additional nesting territories are discovered, environmental analysis is done to determine if, and to what extent, these Standards and Guidelines apply:

- Restrict all logging activities within one-fourth of a mile of active nests from March 1 through August 15.
- Provide a 20-acre nest site of uncut area around each existing (occupied or unoccupied) nest.
- Provide at least 3 potential nest sites in preferred nesting habitat within Designated Bald Eagle/Osprey Emphasis Area(s). This potential nest site should be at least 5 acres of mature and overmature trees with at least 2 snags per acre greater than or equal to 20 inches. Use of uneven-age stands is optimal.
- Construct artificial nesting platforms as needed for habitat maintenance and improvement.
- Forest-wide, during 10K Block planning, give high priority to managing for snags within potential osprey habitat. Snags and old growth managed for osprey habitat contribute to the 10K Block requirements.
- Manage for at least 2 snags per acre of 20" or greater. Snags should be the height of the canopy or taller, on at least percent of the acres along the shorelines. Where necessary to provide sufficient perches and nest sites, take actions to create snags.
- Road construction or reconstruction should avoid osprey nest sites.
- New roads should not be constructed within 660 feet of nests.
- Where human disturbance is causing reproductive failure, evaluate the need to close the area from March 1 to at least August 15.
- In cooperation with the Arizona Game and Fish Department, develop an implement an osprey and wintering bald eagle public education program.

Wildlife Cover (pp.: 124-125)

- Manage for at least 30 percent cover in 10K Blocks. Of this total at least one third is in thermal cover, one third is in hiding cover, and the remaining one third is in either thermal or hiding cover.
- Emphasize maintaining some thermal cover in known travelways and bedding areas. Emphasize maintaining some hiding cover adjacent to dependable water and key openings, along known travelways, and in pine stringers. Cover areas should be at least 200 feet wide; however, pine stringers less than this width may still be managed for hiding and thermal cover.
- Evaluate existing and potential cover on a stand by stand basis. Consider open road densities, topography, and non-commercial tree, shrub, and herbaceous species to determine effective cover.

- Protect and manage to include hiding and thermal cover known fawning and calving areas and defer logging activities from May 15 to June 30 in these areas.

Species Size Class Acceptable Range

Ponderosa Pine - Hiding Cover

- 1 – 5” dbh 150 – 170 GSL
- 5 – 9” dbh 150 – 180 GSL
- 9 – 12” dbh 160 – 200 BA
- Area Size 15 – 25 acres

Ponderosa Pine - Thermal Cover

- 5 – 9” dbh 180 – 200 GSL
- 9 – 12” dbh 180 – 210 BA
- 12 – 15” dbh 200 – 240 BA
- Area Size 30 – 40 acres

Squirrel Habitat (p. 125):

- Manage for at least 20 percent of potential habitat capability for red squirrels in 10K Blocks as determined by the Forest Habitat Capability Model. As needed to meet habitat capability, protect red squirrel primary caches at a density of one cache per 2 acres. Retain all trees within a 26-foot radius from the cache (1/20th acre) (mixed conifer only).
- Manage for at least 20 percent of potential habitat capability for Abert squirrels in 10K Blocks as determined by the Forest Habitat Capability Model.

Spotted Owl and Bear Habitat (pp. 125-126):

- Whenever possible, areas managed for old-growth, bear, and spotted owls are the same. Evaluate owl and bear habitat needs **as well as cover** during project planning.
- In key mixed conifer bear habitat, manage for at least 30 percent of the mixed conifer to meet hiding cover needs. Give priority for cover management in drainage bottoms, heads of drainages, and isolated pockets of mixed conifer. Defer logging activities from April 15 to June 30 in known bear maternity areas.

Turkey Nesting and Roosts (p. 126):

- Defer timber harvesting and slash treatment activities in turkey nesting areas from April 15 through June 30.
- Leave scattered patches of untreated slash within 1/2 mile of dependable water in actual or potential turkey nesting areas. Patches are at least 1/4 acre in size and cover at least 10 percent and not more than 20 percent of the harvested area.

- Slash is left untreated for at least 5 years, longer if it is determined that nesting is still occurring in the area. These guidelines will be evaluated and adjustments made, if necessary.
- Retain and/or develop an average of at least two turkey roost tree groups per section, in actual or potential turkey habitats.
- Retain and/or develop an average of at least four turkey roost tree groups per section in identified key turkey winter range.

Gambel oak management direction – see silviculture

MA 4

Manage for the following indicator species:

- Turkey
- Goshawk
- Pygmy nuthatch
- Elk
- Abert squirrel
- Red squirrel
- Hairy woodpecker
- Spotted owl

Spotted Owl and Bear Habitat (p. 140):

Whenever possible, areas managed for old-growth, bear, and spotted owls are the same. Evaluate owl and bear habitat needs during project planning.

MA 5

Manage for the following indicator species (p.141):

- Yellow bellied sapsucker
- Mule deer

Structural Wildlife Habitat Improvements (p. 141)

Wildlife Fence to protect aspen regeneration from grazing or wildlife where necessary

MA 6

Manage for the following indicator species (p.145):

- Elk
- Abert Squirrel

- Mule Deer
- Hairy Woodpecker

Turkey Habitat: Manage to retain and/or develop an average of at least four turkey roost tree groups per section in identified turkey winter range (p.147).

MA 7 p. 148

- Wildlife habitat management emphasizes forage production on 0 to 15 percent slopes, in conjunction with firewood harvest using Integrated Stand Management (ISM). Old-growth, cover, and snags are generally provided on slopes greater than 15 percent. However, exceptions will occur if dispersion requirements for habitat components are not met on these steep slopes. Where necessary to meet 10K Block requirements or specific habitat needs, one or more of these components can be obtained through management emphasis on the gentler slopes.

Manage for the following indicator species:

- Plain titmouse
- Mule deer
- Elk
- Areas needing additional forage for elk and mule deer are given first priority in scheduling firewood/wildlife habitat treatments. Treatments are usually done in areas remote from intensive development and high road densities.
- Evaluate bear habitat needs during project planning in dense pinyon-juniper, areas adjacent to steep pinyon-juniper, or pinyon-juniper associated with chaparral species (p. 151).
- Created openings in areas that have been identified as historic big game winter range are designed so that an animal will be no more than 10 chains (660 feet) from hiding cover at any location within the opening. Harvested areas are separated from adjacent areas by at least an 8 chain wide untreated strip (p. 152).
- Cover corridors are laid out to connect treated areas or breaks in terrain to provide interconnecting cover corridors. Known or suspected routes of game travel are used to lay out cover corridors. Corridors are managed to create at least 60 percent crown cover, and are at least 8 chains wide (p. 152).
- Use steep, rocky, or otherwise unmanaged areas useable by game to satisfy wildlife cover requirements to the extent possible (MA 8). Cover requirements are considered on a 10K Block basis (p. 152).
- An average of three unburned piles per acre are left on areas with piled slash to provide cover for birds and small animals or leave lopped and scattered slash on 30 percent of treatment area (p. 153).
- Manage for at least 30 percent cover (p. 153).
- Emphasize cover management in travelways, bedding areas, reproductive areas, and adjacent to dependable waters and key openings (p. 153).

- Cover is managed to provide at least 60 percent crown cover and at least 8 chains wide. Manage for hiding and thermal cover in known fawning and calving areas (p. 153).
- Manage for small game and nongame by leaving an average of one slash pile per 3 acres in the woodland type and/or leave lopped and scattered slash on 30 percent of area harvested (p. 153).
- Manage pine stringers to emphasize wildlife habitat needs by maintaining turkey roosts and big game cover (p.154).

Management Area 9 – p. 158

Manage for the following indicator species:

- Antelope
- Elk

Management Area 10

Manage for the following indicator species (p.162)

- Antelope

Control invasion of undesirable plant species when necessary to improve and protect wildlife habitat values. Prescribed burning will be one specific practice used, especially where needed to improve wildlife habitat (p. 164)

Management Area 12

Emphasize wildlife habitat, visual quality, fish habitat, and watershed condition on the wetlands, riparian forest, and riparian scrub (p.172).

Manage for the following indicator species (p. 172)

- Cinnamon teal
- Lincoln's sparrow
- Yellow breasted chat
- Lucy's Warbler
- Macroinvertebrates

Wetlands and open water containing emergent vegetation which provide nesting habitat are protected from disturbing uses that will harass nesting birds, such as activities that are noisy or would damage nests or nesting habitat from May 1 to July 15 (p.173).

Evaluate bear habitat needs during project planning. Defer logging activities from April 15 to June 30 in known bear maternity areas (p. 176).

Management Area 13

Management Indicator Species for this MA are mule deer, pygmy nuthatch, and hairy woodpecker (p. 179).

Management Area 14

Support research efforts that further define the habitat requirements of native fish and bat populations. Protect and/or restore habitat conditions that may be limiting these populations (p.185)

Management Area 15

Evaluate bear habitat needs during project planning (p. 190).

Management Area 18

No direction

Management Area 20

On-the-ground design of the recovery area and adjacent stands will include maintenance of large animal movement to and from areas on either side of the highway. Factors such as density of trees, location of right-of-way fence and topography will be considered (p.206-4)

Management Area 28 (p. 206-54)

Protect key elk, peregrine falcon, turkey and deer winter habitat. Protect turkey roosts from recreational activities, especially dispersed camping and motor vehicle traffic.

FLEA p. 206-67

Restrict human activities within approximately one-half (½) mile of occupied peregrine falcon nest sites March 1st through August 15th. The ½ mile protection distance may vary depending on local topography, potential for disturbance, and location of important habitat components. Monitor peregrine nesting success to determine if restrictions are effective.

Restrict human activities where active raptor nests are located. Species potentially impacted include the golden eagle, prairie falcon, Mexican spotted owl, and zone-tailed hawk. Protection distance will vary depending on the species, local topography, potential for disturbance, and breeding season for the species. Raptor surveys will be completed on site specific areas to determine protection distance.

Wildlife Habitat p. 206-72-73, 75-76

Habitats support diverse, healthy populations of native plants and animals. A natural variety of plant species, age classes, and structures are present. The impacts of non-native plant and animal species are controlled and the introduction and maintenance of undesirable non-natives is discouraged. Threatened, endangered, sensitive, and management indicator species are maintained or recovering in the majority of the habitat.

Maintain wildlife travelways to help animals travel between summer and winter ranges, feeding and nesting areas, maternity areas, and dispersal areas. Travelways help ensure genetic mixing necessary for healthy populations.

Mexican Spotted Owl

Guidelines

Do not identify target threshold stands within the Urban/Rural Influence Zone. The allocation of target threshold habitat within the Lake Mary Watershed and Shultz Management Areas would better provide for long-term management of roost/nest habitat for the Mexican spotted owl. Approximately 26 percent of the Shultz Management Area and 11 percent of the Lake Mary Watershed should be managed for target-threshold conditions in the future, due to not allocating target threshold conditions in the URIZ. Within the FLEA area, survey habitat that potentially could be used for nesting, roosting, or breeding, and is within ½ mile of a proposed site-specific project boundary.

Northern Goshawk

Guidelines

In the Urban/Rural Influence Zone, where possible, limit human activities within the 30-acre goshawk nest stand during the breeding season. In general however, do not curtail human activity such as informal dispersed recreation activities within the Post Fledging Family Areas (PFA). Social trails are likely to occur within portions of PFA's in the urban and rural influenced areas. Locate Forest Service system trails to avoid nest sites within PFA's, within the Urban/Rural Influence Zone. Emphasize the need to control pets on Forest Service system trails through education and enforcement.

Bald Eagles

Guidelines

Bald eagle winter roosts and perch habitat will be evaluated for long-term viability. Silvicultural methods that encourage regeneration and growth of desirable trees may be used near roost sites. Groves of trees may be maintained to provide screening for roost and perch areas. Silvicultural practices will result in the growth of large diameter trees with open crowns in multi-layered stands. Prescribed fires to improve and protect roost areas may be used with effective protection of large trees and snags. Human activities will be managed so that disturbance does not interfere with the eagles' ability to use the site.

Threatened and Endangered Species

Guidelines

Seek opportunities to add to our base of knowledge about human disturbance to T&E species. This could be a variety of methods that could include but are not limited to, monitoring, survey of habitat, survey of recreation uses, or trail counters. Consider options to gather information when planning, or implementing, or monitoring site-specific projects, or approving special uses or outfitter guides. Consider partnership opportunities with organizations or agencies to gather information outside of site-specific project planning. A variety of methods could be used to gather information including, but not limited to: monitoring, survey of habitat, survey of recreation uses, or trail counters. Share results and data among resource personnel and line officers for consideration in future projects with wildlife biologists and recreation staff to incorporate lessons learned into the next project. If analysis shows a need, management changes that could include, but are not limited to, relocating roads or trails, limiting season of use, designating types of activities, or reducing numbers of users could result if analysis shows a need.

Maintain connected patches of denser vegetation that, along with topography, provide travel corridors for wildlife to move through the FLEA area. Maintain the two corridors that occur in the Urban/Rural Influence Zone. They are in the vicinity of A1 Mountain/Fort Valley, Naval Observatory, and along the Rio de Flag.

For all the Management Areas in FLEA, Management Indicator species will be the same as they currently are for each original MA, which is based on vegetation type and slope. For example, lands that are covered with ponderosa pine on less than 40% slope will have the Management Indicator Species described for Management Area 3 in the *Forest Plan*.

Within the Urban/Rural Influence Zone, and in the Wildland Urban Interface (IU) as depicted on the Fire Management Analysis Zones map, do not apply the hiding and thermal cover guideline that requires 30 percent cover within a 10K Block. Distribute wildlife cover where needed within the FMAZ IU without accruing unacceptable wildfire threat to nearby neighborhoods. Wherever possible, projects should retain cover conditions within wildlife travelways, MSO protected activity centers (PAC's), along canyon rims, and on steeper slopes. Projects within the FMAZ IU, should attempt to retain 15 percent cover within a given section.*

Dense stand conditions on steep slopes and within MSO PAC's contribute to the targeted 15 percent cover condition. Cover conditions might exceed 15 percent per section due to the presence of steeper slopes or MSO PAC's. In the absence of steep slopes or MSO PAC'S site-specific projects could retain a maximum of 15 percent cover condition to maintain a wildlife travelway through a section. Projects do not have to retain cover conditions of 15 percent, if a given section poses a high fire hazard to nearby neighborhoods

Management Area 31

Management Indicator Species (MIS) should be referenced by vegetation and landform type. For example, in pinyon/juniper woodland areas MIS are those listed for MA7 (p. 206-84)

Management Area 32

Management Indicator Species (MIS) should be referenced by vegetation and landform type. For example, in pinyon/juniper woodland areas MIS are those listed for MA7 (p. 206-88)

Management Area 33 p. 206-92

MIS should be referenced by vegetation and landform type. For example, in pinyon/juniper woodland areas MIS are those listed for MA7.

Management Area 34

No direction

Management Area 35 p.206-98, 100

MIS should be referenced by vegetation and landform type. For example, in ponderosa pine lands less than 40 percent slope MIS are those listed for MA3.

Management Area 36

Take actions at Marshall Lake to continue use and enjoyment of Marshall Lake and to maintain important waterfowl nesting habitat. Continue maintenance of the Marshall Lake wetland in cooperation with the Arizona Game and Fish Department through such actions as matting, mowing or other actions that create waterholes in the reeds. Maintain the current boat ramp and enhance wildlife viewing opportunities. Consider making a portion of the lake and adjacent forested areas, an enclosure that prohibits dogs, people, and hunting during the waterfowl-nesting season of May 1 to July 15 to increase nesting success of upland game birds.

Refer to more recent management guidelines and conservation assessments that exist for bald eagle winter habitat management.

The designated bald eagle/osprey emphasis area should be expanded to include future perch and roost trees in key areas.

Management Area 37 (p 206-111)

In the Primitive, Semi-primitive Non-motorized, and Semi-primitive Motorized ROS settings maintain large tracts of unfragmented habitat for turkey and bear.

Management Area 38 (p 206-111, 116)

In the Fort Valley and A-1 Mountain areas, maintain the wildlife travelway that connects A-1 Mountain, Observatory Mesa, and the slopes of the San Francisco Mountain. Lands west of A-1 Mountain in Semi-primitive Non-motorized ROS setting maintain large tracts of unfragmented habitat for turkey and bear

Avoid or limit human disturbance to rare species such as peregrine falcon and Arizona bugbane.

Kaibab NF Land Management Plan – management unit direction GA 1 (pp. 50, 69-78)

Management Direction for Wildlife and Fish Resources

Provide for intensive management of wildlife and fish habitats. Make habitat surveys, analyses, and formulate plans in concert with the Arizona Game and Fish Department to ensure moderate level of habitat diversity and capability. Provide wildlife and fish resource integration and coordination in land and resource management planning. Formulate and execute habitat investments to improve habitat components and diversity through vegetative manipulations. Improved habitat diversity and capability accrue through the coordinated interaction of other planned resource practices with planned habitat vegetative manipulations. Develop resource habitat management plans for all threatened and endangered and sensitive plant and animal species. Maintain habitat inventory and management record system.

Standards and Guidelines

Wildlife, Surveys, Planning, Prescriptions, Monitoring, Coop, and Administration

Habitat management for Federally listed species will take precedence over unlisted species. Habitat management for endangered species will take precedence over threatened species. Habitat

management for sensitive species will take precedence over non-sensitive species. Survey, inventory, monitor, and evaluate habitat diversity; species composition; impact of management activities; and the distribution and density of management indicator species, threatened and endangered species, and sensitive species. Evaluate habitat for those species in Threatened Native Wildlife in Arizona. Monitor management practices and evaluate their impact within occupied and potential habitats of Apache trout, bald eagle, and peregrine falcon. Determine need for consultation with USDI Fish and Wildlife Service. Implement recovery plans for threatened and endangered species. Prepare and implement an area management plan to conserve and protect the peregrine falcon in a manner consistent with recovery goals. Monitor management practices and evaluate their impact within occupied and potential habitats of candidate species. Manage habitats to sustain species viability and prevent listing as threatened and endangered. Take all reasonable precautions, consistent with policies regarding jeopardy to human life and property, during fire suppression, search and rescue, or other emergency operations to conserve and protect threatened and endangered species, candidate species, sensitive species and their habitats. Apply standards and guidelines on an assessment area basis, (approximately 10,000 acres) except for old-growth habitat, to ensure distribution of habitat components throughout the range of dependent species. Improve stand diversity an habitat for wildlife through Integrated Resource Management.

Survey and evaluate assessment areas during IRM. Design projects to achieve the following habitat standards:

1. Forage.
 - a. Provide forage cover ratios of 40:60 to 60:40. in areas where TES species habitat requirements do not conflict.
 - b. Give priority to areas in need of additional forage for elk and mule deer when scheduling pinyon-juniper fuelwood special cutting for wildlife habitat nonstructural improvement. Treatments are usually done in areas removed from disturbance to maximize habitat effectiveness.
 - c. Increase efforts to resolve conflict with livestock grazing in all critical wildlife habitats to achieve resource management objectives. In areas of conflict, new winter grazing use by livestock will be allowed when such use does not adversely affect wildlife objectives. Allocate forage to (a) maximize habitat capability for threatened and endangered species and (b) provide habitat capability for indicator and harvest species in the range specified in the State Comprehensive Wildlife Plan. d. When determined that wildlife populations are damaging the range resource, the Forest Supervisor will advise the Arizona Game and Fish Department to address Wildlife population numbers and, or wildlife management to correct the problem.
2. Cover.
 - a. Provide for at least 40 percent cover where TES species habitat requirements do not conflict.
 - b. Emphasize cover in travelways, bedding areas, reproductive areas, and areas adjacent to water sources and openings. Cover areas will be at least 10 chains in width.
 - c. Provide for hiding and thermal cover in fawning and calving areas. Restrict logging activities from May 15 to July 1 for elk and from June 15 to August 10 for mule deer.
 - d. Provide for not less than 10 percent thermal cover in assessment areas. Emphasize thermal cover management in travelways, reproductive areas, and bedding areas.

- e. Provide for not less than 10 percent hiding cover in assessment areas. Emphasize hiding cover adjacent to water sources and openings, along travelways, and in pine stringers. Hiding cover shall not be less than 10 chains in width.
- 3. Snags and cavity, cull, and damaged trees.
 - a. Provide for the following snag and other tree objectives:
 - (1) Regionally consistent Standards and Guidelines apply for snag management in ponderosa pine, mixed conifer and spruce-fir cover types.
 - (2) Pinyon-juniper type: not less than 100 snags et al., 9 inches and larger DRC and 12 feet in height, per 100 acres over 65 percent of the forested area.
 - b. Select larger trees for retention from the following categories in sequence:
 - (1) Existing snags and dying trees.L
 - (2) Living trees with cavities.
 - (3) Trees with dead tops, spike tops, and damaged tops.
 - (4) Living cull and damaged trees.
 - (5) Living diseased trees, excepting mistletoe infected trees, not accounted for in 1 through 4 above.
 - (6) Living healthy trees.
 - (7) Avoid retention of mistletoe infected trees.
 - (8) Intensively manage emphasis areas (forest opening edges, water sources) to meet snag et al. objectives.

Turkey habitat.

- a. Leave not less than four turkey roost-tree groups per section in turkey winter range.
- b. Leave not less than two turkey roost-tree groups per section in turkey summer range.
- c. Emphasize turkey winter habitat in areas within 40 chains of pine stringers (pine stringers are defined as non-contiguous, linear communities of predominately ponderosa pine, up to 40 chains in width, that extend into pinyon-juniper woodland).
- d. Provide not less than 10 acres of untreated slash for nesting habitat within one-half mile of water. Consider slope, canopy distribution and distance to water in the selection of treatment areas.
- e. Restrict activities in nesting areas from April 15 to July 1.

Peregrine falcon habitat.

- a. Prohibit activities which disturb nesting birds between March 15 and August 15. If birds arrive in their territories before March 15, suspend disturbing activities immediately. Extend this period if the birds are strongly attached to the nest site after August 15.
- b. Take all reasonable precautions, consistent with policies regarding jeopardy to human life and property, during fire suppression, search and rescue, or other emergency operations from March 15 through August 15 to protect peregrine nesting sites and their confidentiality.

Raptor habitat except northern goshawk and Mexican spotted owl.

- a. Retain raptor nest tree-groups and a nonactivity buffer around raptor nest sites as follows:
 - (1) Cooper's hawk: 7-chain buffer zone around the nest.
 - (2) Sharp-shinned hawk: 6-chain buffer zone around the nest.
 - (3) Bald eagle:
 - (a) Provide a 10-chain uncut buffer zone around existing and potential bald eagle winter roosts.
 - (b) Identify and protect foraging perches and potential roost sites.
 - (4) Osprey:
 - (a) Provide an 8-chain uncut buffer area around existing (occupied or unoccupied) nests.
 - (b) Restrict logging activities within 20 chains of active nest sites between April 1 and August 15.
 - (c) Provide, for every ten surface acres of water, not less than five acres of not less than four snags, with heights, equal to, or greater than, the surrounding trees, and not less than 20 inches in DBH, per acre, for potential osprey nesting sites.
 - (d) Provide uneven-aged and, or irregular-aged stand conditions within a 10-chain zone around aquatic areas with five or more surface-acres of water.
 - (e) Provide artificial nesting platforms as needed for habitat improvement.
 - (f) Prohibit road construction in roost areas and buffer zones.
 - (5) Others: 3-chain buffer zone around the nest.

Tassel-eared squirrel habitat.

- a. Manage for at least 40 percent of potential habitat capability for tassel-eared squirrels in assessment areas as determined by the Forest Habitat Capability Model. To maintain habitat capability, retain one nest tree group per five acres. Retain all trees within a 26-foot one-half chain radius from the nest (1/20 acre ponderosa pine only). This does not apply in regeneration areas.

Red squirrel habitat.

- a. Manage for at least 40 percent of potential habitat capability for red squirrels in assessment areas as determined by the Forest Habitat Capability Model. As needed to meet habitat capability, protect red squirrel primary caches at a density of within a 26-foot one-half chain radius from the cache (1/20 acre mixed-conifer

Pronghorn antelope habitat.

- a. In key antelope ranges, maintain existing openings and create additional openings as provided for in Wildlife Non-structural Habitat Improvement. Provide for high forb composition (25 percent).
- b. In antelope range, remove all net wire fences; in the interim, modify every one half mile of such fence to facilitate movement.

Wildlife Non-structural Habitat Improvement

Do non-structural wildlife habitat improvement as specified in project level analysis and the following guidelines using special cutting, burning, seeding, and planting.

1. Created openings in pinyon-juniper woodland.
 - a. Opening is not larger than 40 acres.
 - b. The maximum width of the opening is 10 chains.
 - c. The maximum sight distance within the opening is 15 chains.
 - d. The minimum distance between any two openings is 10 chains.
 - e. Retreat these areas by burning and seeding at 20 to 40 year intervals.
 - f. Coordinate identification and planning of treatment areas with the Arizona Game and Fish Department.
 - g. Protect cliffrose plants larger than 4 inches DBH or 8 feet tall to the extent possible when prescribe burning. Protect where possible during prescribe burning activities stands of cliffrose where densities exceed 100 plants per acre and plants are at least 2 feet tall.
 - h. Exclude livestock from seeded areas for not less than two of three growing seasons immediately following treatment.
2. Gambel oak.
 - a. Manage Gambel oak for increased hard mast production, cavities, and deciduous foliage volume to promote and enhance wildlife habitat.
 - b. Retain all standing oak trees eight inches and larger at DBH.
 - c. Personal and commercial cutting of oak will be done in designated areas only from May 15 to October 15 inclusive
 - d. Consider age class distribution in project planning.
3. Alligator juniper.
 - a. Retain live, large alligator juniper for wildlife habitat where it occurs with ponderosa pine.
4. Quaking aspen.
 - a. Treat aspen using special cutting methods.
 - b. Optimum size of the treatment area is four acres although in some situations larger areas (10 acres+) can be treated.
 - c. Prohibit grazing of improvement areas for not less than one growing season immediately following treatment.
 - d. Remove coniferous understory during treatment.
5. Sagebrush.
 - a. Periodically burn drainage bottoms dominated by sagebrush.

Structural Habitat Improvement

1. Do structural habitat improvement as specified in project level analysis and the following guidelines:

2. Install protective fences, watering structures, brush piles, road closure devices, nesting structures and pothole developments.
3. Prevent livestock access to 70 percent of the shoreline of the stock tanks that have stable water levels with the capacity to grow emergent aquatic vegetation. In addition, fence up to five acres and seed to low height cover species.
4. Provide for one permanent water source per square mile.
5. Install structures to promote recharge of wet meadows and riparian areas.
6. Construct, improve, and, or stabilize lakes to improve aquatic habitat for desirable fish species.
7. Maintain or improve nesting cover and waterfowl forage on existing waterfowl islands and shorelines and in conjunction with construction of waterfowl islands.

Also see silviculture and fire sections which provide wildlife-related direction

GA 2 (pp. 35-36)

Standards:

Formulate and portray, describe, or quantify management objectives and desired conditions for the landscape. In landscapes that involve habitat for threatened, endangered, or sensitive plant or animal species, formulate management objectives and desired conditions for each designated management territory. Formulate, design, and implement resource operations or improvements that contribute to the achievement or maintenance of these management objectives and desired conditions.

Formulate, design, and propose resource operations or improvements that contribute, over time, to the achievement or maintenance of desired resource or ecological conditions in landscapes. Consult when applicable: a. Survey and inventory protocols for TE&S species. b. Recovery plans and conservation strategies for TE&S species. c. Formal Consultation Reports.

Prepare a biological assessment and evaluation (BA&E) to document the effect of the selected action on the habitat and on each individual in the population of threatened or endangered species

For selected actions that require preparation of an environmental analysis or environmental impact statement, prepare a biological assessment and evaluation (BA&E) to document the effect of the selected action on the viability of the population of the sensitive species in the EMA.

Planning Guidelines (pp. 39-40):

Planning guidelines provide guidance for planning resource operations or improvements in *EMAs* or landscapes.

Geographically identify and locate, the analysis area (aka affected area) relevant to each proposed intervention or resource improvement action.

Guidelines for Wildlife and Fish Resource Operations and Improvements (pp. 41-42):

1. In other coniferous forest timberland:
 - a. Encourage and promote oak and aspen.

- b. Encourage diversity of plant species in the overstory, understory, and ground cover.
 - c. Turkey summer and winter home ranges.
 - (1) Provide not less than four roost-tree groups per 640 acres in winter range.
 - (2) Provide not less than two roost-tree groups per 640 acres in summer range.
 - (3) Minimize human disturbance in turkey nesting areas from April 15 to July 1.
 - d. Provide one permanent water source per 640 acres.
2. In seral grassland.
- a. Maintain existing openings and create additional openings with high forb composition (25 percent).
 - b. Provide one permanent water source per 640 acres.
3. Establish an osprey nesting territory around existing nesting trees. Provide the following desired forest conditions in osprey nesting territories.
- c. Provide, for every ten surface acres of water, not less than five acres of mature and overmature trees with not less than four snags, with heights, equal to, or greater than, the surrounding trees, and not less than 18 inches in dbh, per acre, for potential osprey nesting sites.

Also see silviculture and fire sections which provide wildlife-related direction

GA 3 (pp. 69-78)

Same as described for GA 1

GA 8 (pp. 69-78)

Same as described for GA 1

GA 10 (pp. 36-38)

Standards, Planning Guidelines, and Direction for Wildlife and Fish Resource Operations and Improvements – see GA 2

- b. Minimize adverse activities within active nesting territories between April 1 and August 15.
- c. Provide uneven-aged or irregular-aged stand conditions within a 10-chain zone around aquatic areas with five or more surface-acres of water.

Also See silviculture and fire sections which provide wildlife-related direction

Appendix 2. Interagency Meeting History [Under Development]

DRAFT

Appendix 3. Evaluation of the Status of Mexican Spotted Owl Habitat in Protected Activity Centers within the 4 Forest Restoration Initiative Treatment Area

See pages 15 and 16 for a description of the data reviews for 117 individual PACs occurring in and near the 4FRI project area. The results of this review indicated that 18 of 117 PACs were candidates for management treatments to reduce fire risk and improve the development and maintenance of habitat components important to MSO and their prey. See the MSO recovery plan for details on the habitat needs and current conditions for MSOs and their prey (USDI USFWS 1995).

Following this review, a series of field visits to individual PACs were conducted. Potential management objectives were defined based on site specific observations. Notes and photographs from the field reviews are included below.

Friday, May 6, 2011

4FRI PAC Assessment Field Trip: Mayflower Tank, Bear Seep, & Red Raspberry

Attendees: Shaula Hedwall (USFWS), Bill Austin (USFWS), Cary Thompson (Flagstaff District Biologist/4FRI Wildlife), Preston Mercer (Mormon Lake AFMO), Mary Lata (4FRI-Fire), Neil McCusker (4FRI-Silviculture), Bill Noble (4FRI-Wildlife), Henry Provencio (4FRI-Team Lead) attended the 1st stop.

Objectives: Treatments must improve MSO habitat; reducing fire threat alone is not adequate reason for treating within PACs; achieving both is ideal.

Discussion: All PACs are available for burning. The desire is for cooler burns when CWD is moist. Snags are particularly important within nest cores and can provide nest structure. All decay classes of logs are used by different prey species. Topography will require staging: when S slopes are ready N slopes will be cool & damp and could have snow present. When N slopes are ready, S slopes are likely too dry.

Preston: "Schedule" basically means maintenance, or how much time passes before return burning after initial entry. Most fuel reduction generally occurs in the first burn but tree mortality is cumulative within about 5-6 yrs post-treatment. The 2nd burn and beyond = maintenance. Need good descriptions of desired conditions so fire managers can determine how cool conditions should be, when a backing fire is necessary, levels of acceptable mortality, avoidance of igniting CWD, etc. Knowing more detail on DCs is key in translating objectives to practitioners. Knowing desired tons/ac of CWD allows assigning % reduction by fuels size class. Whereas effects analysis is by the numbers, treatment is visual. Treating 100 ac nest cores will be labor intensive and costly. Burning hotter (i.e., medium to medium-high) will achieve more in terms of fuels reduction but also loss of habitat structure. This would achieve results in 1-2 entries rather than piece-mealing results from 3-4 entries. The reality note: fire will require a 30-yr window to get 2-3 treatments done. If every PAC has a different burn plan it is less likely it will all turn out as desired in the end. Can there be consistent DCs and consistent approaches to achieving them? Can flexibility be built into sec. 7 to allow for adaptive management?

Mayflower Tank PAC (#30405022):

This PAC has steep slopes with heavy dead and down (estimated to be about 60 tons/ac in one area). Heavy fuels would burn too hot. This PAC could be burned when heavy fuels are still wet, but would be expensive as we would not be looking to meet fuels objectives in first or even second entry due to risk associated with heavy fuel loads. Some discussion of whether coarse woody debris could be removed or redistributed mechanically prior to fire entry, but due to slopes and working around trees, this may be difficult. Note: Thinning from below would not achieve much in the stand we were viewing due to limited development of small trees.

There are opportunities for aspen restoration treatments.

The PAC would have to be revisited to see remaining portions for treatment evaluation.



Figure 1. Picture of southeast corner of Mayflower PAC (need to add photos from other side of PAC)

Bear Seep PAC (#30405031):

[We walked in from the 132 rd, crossed an open, forested flat, walked down into a roaded meadow, and up into the “nest draw”] Except for the nest core area, the majority of this PAC is pure ponderosa pine or pretty open pine-oak that is ready for Rx fire. We walked into the northern portion of the PAC – the flat on top is open pine-oak that hits a mostly pure pine slope and then opens up into a meadow along the 240 Road.

Shaula: openings are not bad inside a PAC. 1 - 2 ac openings could be created in the flat area on top. Below it is **relatively dense with 12-14”** and some openings there could benefit prey spp. An objective could be maintaining/releasing oak (but see Abella et al for where soil type indicates oak could benefit from the effort to release them). Openings would need to be balanced with maintaining denser forest within the PAC in general.

Adjacent to the meadow on the south side of the 240 Road is a patch of aspen that could be opened up to improve conditions for the aspen. The Bear Seep nest core area is located up the drainage in the southwest portion of the PAC. This area consists of mixed conifer and **we would not recommend mechanical or burning treatments in the nest core** (at least from the 240 Road across the drainage to the rock wall that lines the western edge of the core area). The SE arm of the PAC and areas W of the 240 rd would benefit from treatment.

In general, treatments would focus on areas of lesser habitat and avoid patches of better habitat. The PAC can be treated to promote PCE's and develop a groupy, clumpy structure (tree size and diversity); Neil commented an IT treatment would be appropriate in some stands; aspen and meadow treatments are viable options (at small scales) as are oak and presettlement pine release; openings in pure pine could enhance owls and their prey and contribute large down logs (areas are lacking in large (1000/hr fuels) dead and down. **A diameter cap would not make it worthwhile to treat due to the density of trees > 9" dbh.**



Figure 2. Open, pine-oak flat on northern end of Bear Seep PAC.



Figure 3. Slope between 132A and 240 Road in Bear Seep PAC. This slope contained some oak, but area is transitioning to pine in flat below.



Figure 4. Meadow along 240 Road in Bear Seep PAC. The meadow could use some work to repair drainages and impacts from recreationists and other impacts (large dispersed camping area). Improving meadow condition could improve prey habitat for MSO.



Figure 5. Pure pine area between meadow and slope in Bear Seep PAC. Area definitely has potential for treatment (e.g., create groups/clumps, small openings to improve prey habitat).

Red Raspberry PAC (#30405003):

This PAC contains very diverse topography with many knobs and valleys that would seem to offer mechanical treatment opportunities in some areas and not others. Treatments could work with topography to protect microclimates, e.g., treat south facing slopes to protect drainages and north/northwest facing slopes from fire (avoid mechanical thinning in drainages). The southwest corner of the PAC contains pine-oak habitat that could be treated to enhance openings, reduce competition between pines (i.e., create, retain and enhance larger trees), and enhance Gambel oak patches on south-facing slopes. Leave denser patches of trees on north-facing aspects and drainages. This corner of the PAC would be easy to tie into treatments in the adjacent habitat to the southwest.

The nest core area is mixed conifer and would not be recommended for mechanical treatment. However, the meadow area/swale that contains Raspberry Tank could be treated to remove encroaching pine. The area north of the meadow is a fairly, open productive site consisting of many large ponderosa pines and some Gambel oak. This area is ready to burn without mechanical treatment. However, the historic BA was probably 40 - 60 and existing BA is in the 120 - 140 range. There are opportunities to enhance openings, open-up the oak, and overall to reduce basal area.

In general, areas that warrant treatment should result in oak and aspen release, meadow and seep restoration, creating gaps or releasing presettlement pine in the thickets of VSS 3s & 4s (except in

known nest/roost areas). **Mechanical treatments would require thinning over 9” dbh to meet objectives.** It looks like at least trees 12”-14” would need to be cut.



Figure 6. Meadow area east of Raspberry Tank in the Raspberry Tank PAC.



Figure 7. Fairly open pine-oak slope in northeast corner of PAC. Area consists of larger pines, but has little in the way of vertical heterogeneity.

Red Raspberry PAC Burn Discussion-

- Need a plan for communicating specific ideas to those implementing treatments
- Lining of logs is not realistic or effective
- Burning technique and timing of burning (fuel moistures) are more important/effective
- Don't expect conditions to be met in first burn entry
- Initial entry reduces the most tons/acre, maintenance burns needed every 5-6 yrs
- Identify % mortality acceptable and/or % reduction needed
- If you exclude nest core there would be escalated fire behavior if nest core fuel density is higher than the area immediately adjacent and outside nest core
- Operational – need 20 year window for burning
- Rx generally shoot for 10,000 tons/ac outside of PACs
- May need to burn in nest cores from an operational standpoint in some PACs

Monday, May 9, 2011

4FRI PAC Assessment Field Trip: Knob Creek, T-Six, & Foxhole

Attendees: Shaula Hedwall (USFWS), Bill Austin (USFWS), Bill Noble (4FRI-Wildlife), Cary Thompson (Flagstaff District Biologist), Linda Wadleigh (Regional Fire Ecologist), Roger Joos (Kaibab South Zone Biologist), John DeLuca (Kaibab South Zone Biologist)

Knob Creek PAC (#30405029):

Walked north from 226E to hilltop and then north to the road and then southwest back to 226. PAC is very limited in terms of MSO habitat and there are no nest or roost locations documented. There are patches that contain Gambel oak, but oak is sparse in the majority of the PAC. The current core area does not meet Recovery Plan guidance and should be redrawn to include the entire length of the south-facing slope that runs along the drainage (drainage along the 226 Road). We recommend treating (mechanical and/or fire) the majority of the PAC. If fire is allowed to burn in the nest core, some mechanical treatment is recommended to enhance existing openings and create some breaks in the canopy. We do not want fire to result in torching or and want to minimize loss of CWD (see Graham et al. for guidance based on soil types – note that in PACs we'd generally be looking at the upper end of the recommended ranges). There are many pre-settlement pines throughout this PAC, including some nice groups of yellow pines within the nest core (especially once it is redrawn as the west end of the drainage), but they are commonly set amongst dense doghair thickets. Groups of yellow pine within the nest could perhaps be enhanced, but this would be a very specific prescription that should be created with the biologists and silviculturist to ensure protection of key habitat components in this relatively small area. The majority of the PAC is pure pine and very open. Treatments could be more aggressive, relative to other PAC recommendations, in the areas of non-MSO habitat.

In general, treatment objectives would include:

- Treating about 70% of PAC that really is not owl habitat

- Redraw nest buffer to include south-facing slope up to hilltop and westerly This is where most of the larger oak is located. There are three areas along the lower southern ridge that might provide nest/roost habitat.
- Enhance oaks
- Create openings among large groups of pine in the existing thickets (can go up to 2 acres)
- Manage for patches and larger groups
- Use natural features, such as swales, for openings
- Thin around yellow pines and larger oaks
- 7-20 tons/acre of large 1000/Hr fuels to maintain healthy soils in ponderosa pine (1 snag = about 10 tons/ac)
- Needs 2 years of survey (if owls are detected) to determine nest buffer
- Treat outside breeding season
- Abundant large snags throughout
- Could meet many objectives by thinning up to 9" but this would limit the ability to meet all objectives

These areas might not have resident owls due to existing conditions and enhancing prey habitat could benefit overall production in neighboring PACs.

*****This PAC should be a survey priority to help ascertain use/occupancy*****



Figure 8 and Figure 9. The pictures are very representative of most of the habitat within the Knob PAC. There are many pre-settlement pines, but also many small, deformed pines. The area is very rocky, and also contains alligator juniper with some Gambel oak interspersed throughout.



Figure 10. Area on slope in nest core that could benefit from limited mechanical treatment to enhance key habitat components.

T-Six PAC (#30405016):

Entire PAC, including nest core, is likely a candidate for mechanical and fire treatments. The core area where the historic roosts are located is currently in a state of degradation. Presettlement pines and large Gambel oaks occur throughout core area, but many trees of both spp are falling over due to stand conditions resulting from very dense regeneration, including many “whips,” that limits owl roost habitat value. Nest buffer is very decadent and in need of treatment, but as is, fire would likely kill presettlement trees. Mechanical treatments could focus on creating patches of habitat around pre-settlement trees that could be used for roosting by thinning, and in some cases, removal of dense patches of small diameter pine. [Note: Cary described work in Fort Valley where small trees were left around presettlement trees and snags to provide perches for fledglings.] Also need to focus treatment on how to maintain Gambel oak on this roost slope. Outside the roost area, the PAC is a mixture of very open, pre-settlement trees where fire alone could meet objectives except for some areas of dense ponderosa pine doghair thickets that could be thinned out to develop future owl habitat. Abundant, large snags throughout the rest of the PAC. Some portions of PAC either burned in Birdie Fire or were result of actions taken to suppress Birdie Fire. These areas really do not need additional treatment other than maintenance burning.



Figure 11 and Figure 12. Historic roosts located in this area. Note Gambel oaks falling down and density of pine. Pre-settlement pines can be seen amongst undergrowth in second photo. This core area could definitely benefit from mechanical treatment.



Figure 13. Area east of core area on flat. Many pre-settlement pines in this area with dense patches of smaller pines scattered around them.

Foxhole PAC (#30405038):

(Approached PAC from bridge across Bar M canyon) The western PAC area south of Bar M Canyon, sans steep slopes, is a candidate for mechanical treatment. The area consists of dense thickets of ponderosa pine with some oak – the oak need to be opened up if they are to persist. Abundant large snags exist throughout the area. We saw fewer oak and oak/alligator juniper in the lower slopes and more oak & juniper on the upper slopes. There are natural openings, including at the top of the hill in the SW ¼ of section 5. Parts of this area have large alligator juniper and some of the openings look like they were once open oak areas before the release of pine (from fire exclusion). There is also an extensive network of dispersed camping sites in this section of the PAC. Dwarf mistletoe infection is high in this area and there is currently very little in terms of what we would consider nesting/roosting MSO habitat. Treat mistletoe by strategically placing openings to put space between un- and less-infected trees and heavy mistletoe trees. Though we did not walk the portion of the PAC along Bar M Canyon, we did discuss leaving a buffer area along the canyon rim as a wildlife movement corridor.

Walked loop, coming out the 9469D. PAC has a mixture of dense stands and open stands. Would need to thin area before burning and reduce VSS 2 ladder fuels.

Treatments should:

- Protect snags
- Create groups of 20-60 trees
- Enhance oaks



Figure 14. Dense ponderosa pine in SW of section 5 in Foxhole PAC.



Figure 15. One of many dispersed camping sites off the 9469D road within the Foxhole PAC.

Wednesday, June 15, 2011

4FRI PAC Assessment Field Trip: Archies & Crowdad

Attendees: Bill Noble, Neil McCusker, Cary Thompson

Archies PAC (#03040534):

This PAC is primarily pine-oak with a strong oak component. We parked along the 132 rd, near the junc with the 132D, and walked along the ridge top and overlooked the southwest facing slope. The slopes were dominated by VSS4s & 3s with scattered 5s. There were more large trees before and near the nest core and more younger trees as we worked our way towards the NE. There was a lot of oak >5" drc scattered through the pine, but few large-sized oak.

The ridge top is rocky with open pine-oak which becomes more of an oak savannah and less rocky as you leave the nest core and follow the ridge top to the northwest. There were pockets of heavy mistletoe infestation and bark beetle outbreaks along the flat ridge and southern slopes. These were more common at the start of the walk than they were at the far end of the ridge. Crowns were reduced, in poor shape and not providing much canopy cover.

There is not much treatment needed on the ridge top other than **removing 5-12" pine** from within and around clumps of oak. There are opportunities for mechanical treatment along the southwestern slopes. Mechanical and burning treatments could help protect the nest stand located on the northwestern slopes. There are opportunities to release oak and improve sustainability of the stand.



Figure 16. Picture of the southwest ridge taken from the ridge top.

We dropped off the northeast slope and walked back along the 132D road. Parts of this were more oak savannah like but there were also pockets of trees with many trees under 9" diameter. There were more large oak associated with the smaller pine. "Shelves" or small flat areas associated with the flanks of the ridge were pretty open, lacking large diameter pine, and supporting small-sized oak. Large herd of elk bedded down in the oak savannah. Trees along the base of the ridge were in large groups defined by sinuous openings. Some groups were thick with little pine, including a lot of bending whips. Individual trees were in a much healthier condition along the northwestern slopes. Forest on easterly side of rd is similar to the flats between the rd & the ridge – **9" dbh limit not a problem** in terms of improving health/habitat with mechanical treatments.

Aspen stand along 132 on the lower slopes near Weimer Spring stretches the length of the drainage. Aspen overstory is dying out with no regeneration below. There is opportunity to restore this aspen stand and associated meadow to improve habitat for MSO prey.

Weimer Spring (located immediately adjacent to the PAC): There is a fence around Weimer Tank which Weimer Spring drains into. The fence is down in several places and is in need of repair. The spring is not fenced although meadow habitat could be restored to improve prey habitat. The tank was full of tiger salamander larvae.



Figure 17. Oak provides the vertical heterogeneity in this PAC



Figure 18. Picture of area with many trees under 9" diameter.



Figure 19. Picture taken along FR132D facing west



Figure 20. Picture of oak savannah taken by FR 132D. Also depicts habitat along portions of the ridge top.

Crawdad PAC (#03040547):

We walked northwest from the junction of FR132 and FR133 along the southwestern slope and came around the second knob to the drainage. Headed east above the drainage and then south back to the road junction. Much of the southwestern slopes supports dense trees 12-18" diameter forming a single story stand with essentially no understory development. Oak was represented by

a range of size classes, but not as prevalent in this PAC and is suppressed by the higher densities of pine. Treatments could build gaps around the oak and release individual oak trees amongst the groups. In this area we would likely **need to cut trees greater than 9” diameter (even a 12” dbh limit would be a challenge to create gaps)**. Bark beetle mortality occurred in groups as did mistletoe. Neil discussed thinning from below until you meet the desired basal area while featuring dominant and co-dominant trees. This would also reduce fire risk to the eastern slope where the majority of roosts are located. Small natural openings were present throughout and could be opened up a little more to enhance habitat for MSO prey.

Further up the slope dominant trees were more VSS 3s than 4s and forest was a bit more open. Still consistent but scattered oak and some pre-settlement pine. Near the 1st (main) knob the forest dominated by VSS 3s with fewer and smaller oak. A 2-track rd runs through the area. As we approached the saddle between knobs there were bigger pine + VSS 3s + successive openings. Oak clumps are largely overgrown with pine. Passed through the saddle and followed the drainage down where we saw a lot of old stumps, indicating an open forest where it’s currently relatively dense dominated by “stubby” trees. Potential to thin here (improve tree health, increase growth rates, open understory for prey). Followed the drainage down and forest opened more with small oak and more yellow pine. Slope was gentle, merging into flats where there was more understory and a young overstory, looking like small opening/meadow encroachment. Moved onto steeper slopes and circled back below ridge top: trees much denser, bigger (12 – 24+ dbh), and oak widely scattered.



Figure 21. West hillside showing pre-settlement trees and openings with grass understory



Figure 22. Picture taken at same point facing south with a majority of trees 9"-18" diameter.



Figure 23. Picture of Crawdad PAC taken along the northeast slope.



Figure 24. Taken along the north slope of Crawdad PAC.

Tuesday, June 28, 2011

4FRI PAC Assessment Field Trip: Sawmill Springs

Attendee: Cary Thompson

Sawmill Springs PAC (#0304070):

This PAC is Ponderosa pine with a strong Gambel oak component. Oak is present in all size classes with a large amount of oak regeneration. All size classes of ponderosa pine are also represented in this PAC and are growing in a clumpy groupy structure in many areas. Treatments could enhance groups of various sizes of pine and oak including younger ages of both species. This PAC has more regeneration than those previously assessed. In addition to oak regeneration Arizona rose and locust are present in the understory. Although there are pockets of dwarf mistletoe the PAC is healthy overall.

This is a structure we would want to maintain and treatments should focus on enhancing growth of young oak and maintaining this diversity of size classes. These areas have moderate levels of dead and down trees with mostly older, decaying large dead trees. This could probably be prescribed burned without thinning.



Figure 25. Clumpy structure with small openings interspersed along FR 683

I walked north to Sawmill Tank, then west to Sawmill Spring and along the drainage and up the slope. The slopes to the west of the spring are thick with pine trees (VSS4 and VSS5) and have a northerly aspect while the ridgetops are relatively rocky and open. Treatments to the south should focus on protecting these northerly slopes.

Overall, MSO habitat objectives cannot be met with a 9” cutting limit. While there is variability across the PAC, some areas need the flexibility of larger dbh size classes to enhance and maintain owl habitat characteristics.



Figure 26. Northerly slope west of Sawmill Spring

The slopes south of Sawmill Tanks had areas of dense VSS3 and VSS4 that did not have as much oak. Treatments in this area should focus on enhancing oak.

I would recommend thinning and burning treatments in the area east of the nest core and south of Sawmill Tank. There are large stands of dense areas of VSS3 and VSS4. Treatments should focus on developing larger trees and releasing oak.



Figure 27. Area south of Sawmill Spring with dense VSS3 and VSS4

Treatments adjacent to Sawmill Spring should focus on improving spring conditions. The vegetation in the area of the spring and tanks was in good condition and did not appear to have impacts from livestock. No leopard frogs were detected although the tanks and area leading from the spring appeared to be good habitat. No crawfish were found. I counted 6 species of butterflies in the area and 3 species of dragonflies. Monkeyflower, watercress and mint edge the spring with a large amount of emergent vegetation and bulrushes along the banks of the tanks. Large amounts of down woody debris blanket the stream. Rocky bluffs west of the spring and large woody debris likely provide additional habitat for MSO prey.



Figure 28. Sawmill Tank (east Tank)



Figure 29. Sawmill Tank (west tank)



Figure 30. Sawmill Tank (west) looking west to Sawmill Spring



Figure 31. Looking east to Sawmill Tanks



Figure 32. Creek leading from spring to tanks



Figure 33. Sawmill Spring

Wednesday, August 10, 2011

4FRI PAC Assessment Field Trip: Clarke

Attendees: Patty Ringle, Shaula Hedwall, Cary Thompson, BN

Limestone soils make for very high site productivity, but many stands have very little oak. This is not representative of typical MSO habitat, but the birds are here. The owls could be here due to the lush understory supporting larger prey species populations.

Comments:

- Leave bigger groups in draws, on N-slopes, and smaller groups on S-facing slopes
- Suppressed trees under dripline of yellow pine serve as great MSO roosts
- Owls don't roost in stands with CC < 60% due to thermoregulation issues
- An interspace of 50' is not likely to support much regeneration; interspaces of 150' may be full of regeneration within 20 yrs
- Openings of ½ ac vs ≥ 1 ac are very similar in terms of regeneration; areas that can support regeneration will need retreatment to maintain tree-less space.

Table 1. Field reviews for PACs proposed for treatment

PAC Name	Date	Participants
Mayflower Bear Seep Red Raspberry	5/6/2011	Preston Mercer – Mormon Lake AFMO Neil McCusker- 4FRI Silviculturalist Mary Lata- 4FRI Fire Ecologist Bill Austin- USFWS Shaula Hedwall-USFWS Bill Noble-4FRI Biologist Cary Thompson- Flagstaff District Biologist Henry Provencio-4FRI Team Leader
Knob T-Six Foxhole	5/9/2011	Linda Wadleigh – Regional Fire Ecologist Bill Austin- USFWS Shaula Hedwall-USFWS Bill Noble-4FRI Biologist Cary Thompson- Flagstaff District Biologist John Deluca – Williams/Tusayan District Biologist Roger Joos - Williams/Tusayan Biologist
Archies Crawdad	6/15/2011	Bill Noble, Neil McCusker, Cary Thompson
Sawmill Springs	6/28/2011	Cary Thompson
Iris Tank	7/12/2011	Cary Thompson
Bar-M	7/14/2011	Cary Thompson
*Clark	8/11/2011	Patty Ringle – FS Silviculturalist Shaula Hedwall Bill Noble Cary Thomspen

*The Clark PAC is not included in the 4FRI analysis. The field review was to assess a prescription with a 16" cap.

PAC Review Summary

Mayflower:

- Thin from below won't accomplish much due to the lack of small trees;
- Some areas have very heavy fuel loads (est'd at 60 tons/ac);
- Opportunity for aspen restoration which would enhance prey habitat, foraging opportunity, and help with overall aspen ecology.

Bear Seep:

- Flats along the 132 rd would benefit from 1 to 2 ac openings (Shaula) for prey/foraging/oak release;

- Some areas are dense in the 12” to 14” dbh range and could use thinning and potentially some openings;
- In general, we saw areas that would benefit from a groupy/clumpy approach;
- Small scale aspen and meadow restoration opportunities within PAC;
- Oak and presettlement pine encroached and would benefit from release;
- Cannot meet above objectives with a 9” cap in this PAC;
- Nest core is MC, dense, and great owl habitat – don’t burn this nest core!

Red Raspberry:

- Lots of small scale topography allows treating dry south slopes heavier to help protect north slopes that could be left dense;
- Enhance openings in pine-oak to benefit oak;
- Yellow pine in drier sites would benefit from an overall BA reduction to enhance sustainability;
- Opportunities for oak & aspen release and meadow restoration;
- Would require increasing diameter cap to something like 12-14” dbh;
- Nest core = MC and should not be burned.

Knob Creek:

- Mechanical treatments recommended for most of the PAC, *including the nest core*;
- Many yellow pine and large oak are currently in dog hair thickets of young trees and would greatly benefit if released from competition;
- This PAC has a lot of pure pine that can be managed as groups & gaps, but make the groups large;
- Can use natural features such as swales for delineating openings;
- Work to retain snags that are abundant in this PAC;
- Many objectives could be met with 9” cap, but increasing this limit would allow more ecologically-based treatments.

T-Six:

- Presettlement pine and large oak are falling over from competition as these stands unravel – dense regeneration includes many “whips” that limit value of owl habitat;
- **Recommend mechanical treatment in the nest core;**
- Many other stands are open and would not require mechanical treatments;
- Other stands would benefit from thinning or small group removal where pockets of dog hair pine exist.

Foxhole:

- Oak will not persist in overly dense stands of young pine – much of the western portion of the PAC would benefit from mechanical treatment (except, of course, along the steep slopes);
- Need to protect snags and enhance oak;
- Groups of pine could range from 20 to 60 trees.

Archies:

- This PAC has a strong oak component and the pine is dominated by VSS 3s and 4s;
- Releasing oak and removing some pine from pockets of oak savanna along ridge top would benefit owl habitat;
- Ridge top also had pockets of mistletoe and bark beetle and pine with reduced canopies – may be able to thin (with a light touch) for general forest health reasons to sustain the stand and speed development of larger trees;
- There are opportunities to release oak, which would require cutting at least up to 12” dbh;
- Other side of ridge would do fine with 9” dbh limit and thinning pockets of unraveling dog hair pine would improve stand health/sustainability;
- Small areas of aspen and meadow need restoration.

Crawdad:

- Stands needing treatment include single story, dense pine of 12 to 18” dbh with no understory and suppressed oak – this needs thinning and creation of gaps to create sustainable owl habitat – 9” dbh would preclude meeting these objectives;
- Bark beetle mortality and mistletoe present;
- Small natural openings could be enhanced for tree rooting zone and prey habitat;
- Further up slope forest opens but near top small oak are overtopped by pine;
- A couple other stands looked like historic meadows and open forest that are now encroached by VSS 3ish pines.

Sawmill Springs:

- Much of the area is in good condition and benefit from a light touch to define tree groups;
- Treatments in other areas could aid in enhancing and retaining oak;
- Opposing slopes of drainage near spring have N & S aspects – treating the south slope could benefit this drier aspect and help protect the denser north slope;
- While much of the PAC is in relatively good shape, owl habitat objectives cannot be met by restricting treatments to 9” dbh.

Appendix 4. Wildlife corridors for habitat connectivity.

Wildlife corridors were developed by the AGFD and include the pronghorn migration route from Garland Prairie to the west boundary of the treatment area, passing south of Bill Williams Mountain. Also see the Arizona Game and Fish Department 2011 report: The Coconino County Wildlife Connectivity Assessment: Report on Stakeholder Input (52 pages).

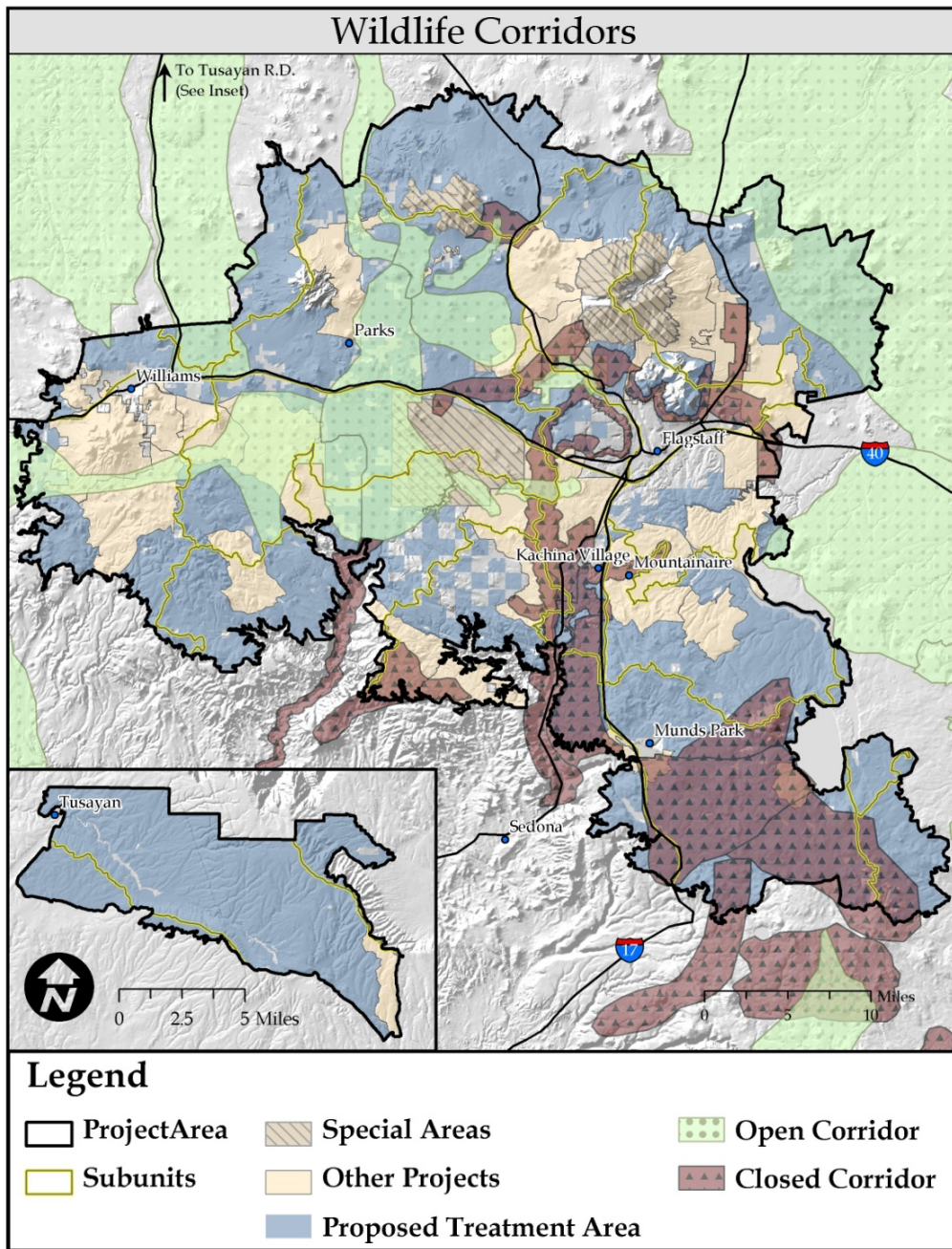


Figure 34. Proposed Wildlife Habitat Wildlife Corridors for the 4 Forest Restoration Initiative

Appendix 5. Hiding and Thermal Cover Values by Subunit for All Alternatives

Table 2. Alternative A

Alternative A		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
Pine-Oak	112,546	52,678	59,196		671	46,561	62,743	2,885	356	14,472	84,967	12,883	223
COF	85,482	37,664	47,329		490	33,990	48,432	2,885	175	2,992	69,562	12,883	45
1	61,231	27,485	33,453		293	24,133	35,060	1,907	130	2,496	48,479	10,256	
1-1	1,434	961	391		82	776	635	24		148	1,287		
1-2	588	423	165			423	165				588		
1-3	15,957	7,056	8,901			5,698	9,978	281		430	13,716	1,811	
1-4	3,598	1,601	1,996		0	1,598	1,990	11		58	2,753	787	
1-5	39,653	17,444	21,999		210	15,638	22,292	1,591	130	1,859	30,135	7,658	
3	21,678	8,973	12,659		46	8,709	12,126	798	45	204	19,583	1,847	45
3-3	3,493	1,294	2,153		46	1,145	2,014	289	45	121	2,821	507	45
3-4	4,722	2,317	2,405			2,053	2,495	174			3,965	757	
3-5	13,463	5,362	8,101			5,510	7,617	335		84	12,797	582	
4	547	257	290			149	367	31			439	108	
4-3	277	140	137			62	214				200	77	
4-4	82	82				51		31			51	31	
4-5	188	36	153			36	153				188		

Alternative A		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover
5	2,026	948	927		151	999	880	148		292	1,061	673	
5-1	1,166	653	513			593	425	148		141	758	267	
5-2	861	295	414		151	407	454			151	303	406	
KNF	27,063	15,015	11,868		181	12,571	14,311		181	11,480	15,405		178
3	25,476	14,274	11,203			12,035	13,441			10,993	14,484		
3-1	7,600	4,463	3,137			3,952	3,647			3,680	3,920		
3-2	5,745	3,090	2,655			2,349	3,396			2,056	3,689		
3-3	12,132	6,721	5,411			5,733	6,398			5,256	6,875		
4	1,587	741	665		181	536	870		181	488	921		178
4-3	116	116					116				116		
4-4	1,471	625	665		181	536	754		181	488	805		178
Pine	399,633	147,677	129,961	27,098	94,897	150,633	176,271	53,441	19,288	41,141	201,327	152,364	4,801
COF	237,289	71,291	78,515	17,152	70,332	85,175	102,005	42,091	8,019	24,915	101,111	111,263	
1	84,562	31,820	30,685	5,818	16,240	35,069	37,639	8,002	3,852	8,199	43,390	32,974	
1-1	7,480	2,675	2,984	294	1,527	2,743	3,738	941	58	1,262	2,700	3,519	
1-2	5,928	2,091	1,528	424	1,885	2,327	2,926	448	227	396	3,023	2,509	
1-3	22,279	7,705	7,292	1,279	6,003	9,134	9,347	1,687	2,112	2,953	11,401	7,926	
1-4	13,687	7,229	3,479	266	2,712	7,816	5,004	444	424	981	7,970	4,736	
1-5	35,188	12,119	15,401	3,555	4,113	13,049	16,625	4,483	1,032	2,608	18,297	14,283	
3	36,649	11,793	19,341	1,967	3,548	12,544	19,970	2,881	1,253	2,829	22,190	11,630	
3-2	165	60	70	3	33	81	70	3	12	23	73	70	
3-3	11,559	3,603	6,345	324	1,286	3,840	6,429	840	450	622	7,694	3,243	

Alternative A		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
3-4	4,198	973	2,237	589	399	898	2,398	807	95	210	1,880	2,107	
3-5	20,727	7,157	10,689	1,051	1,830	7,726	11,073	1,232	697	1,974	12,542	6,211	
4	56,434	17,296	20,970	4,953	13,215	19,884	27,107	7,121	2,323	5,709	22,975	27,750	
4-3	24,954	5,707	9,452	1,904	7,891	7,358	12,310	3,498	1,788	3,138	7,395	14,421	
4-4	25,064	9,752	8,762	2,566	3,984	10,318	11,176	3,086	485	1,768	12,423	10,873	
4-5	6,417	1,837	2,755	483	1,341	2,208	3,622	537	50	803	3,158	2,457	
5	59,644	10,383	7,519	4,414	37,328	17,679	17,288	24,087	590	8,179	12,557	38,909	
5-1	19,449	5,046	4,418	1,309	8,677	9,339	6,413	3,375	322	5,262	5,924	8,263	
5-2	40,195	5,338	3,101	3,104	28,651	8,340	10,875	20,712	268	2,917	6,632	30,646	
KNF	162,344	76,386	51,447	9,946	24,565	65,458	74,267	11,350	11,269	16,226	100,216	41,101	4,801
3	45,422	14,529	17,113	5,215	8,565	11,620	23,293	6,129	4,380	2,343	23,920	17,441	1,718
3-1	11,205	4,506	4,268	1,034	1,397	3,640	5,544	1,113	907	1,153	6,403	3,271	378
3-2	16,975	2,737	7,129	2,816	4,293	2,157	9,300	3,523	1,994	606	6,844	8,994	530
3-3	17,242	7,287	5,716	1,366	2,874	5,822	8,449	1,492	1,479	584	10,672	5,176	811
4	75,733	29,026	28,647	4,731	13,329	22,420	41,203	5,221	6,889	3,776	45,934	22,940	3,083
4-2	7,381	2,836	1,759	833	1,953	1,871	3,404	1,222	884	319	4,275	2,587	201
4-3	29,965	14,327	9,047	1,375	5,217	11,432	14,252	1,201	3,080	1,491	20,146	6,731	1,598
4-4	38,386	11,862	17,841	2,523	6,160	9,116	23,546	2,799	2,925	1,966	21,514	13,622	1,284
6	41,188	32,831	5,687		2,671	31,418	9,771			10,107	30,362	720	
6-2	5,069	4,198	539		332	3,290	1,779			677	4,392	0	
6-3	32,635	25,844	4,526		2,265	25,285	7,351			7,270	24,646	719	
6-4	3,484	2,789	622		74	2,843	641			2,160	1,325		

Alternative A		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
Total	512,178	200,355	189,158	27,098	95,568	197,194	239,015	56,325	19,644	55,614	286,294	165,247	5,024

Table 3. Alternative B

Alternative B		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
Pine-Oak	112,546	52,678	59,196		671	40,466	57,679	4,220	10,181	13,824	73,292	15,311	10,119
COF	85,482	37,664	47,329		490	28,468	46,237	4,220	6,557	6,226	57,447	15,311	6,498
1	61,231	27,485	33,453		293	20,593	33,230	3,243	4,164	4,755	39,853	12,516	4,105
1-1	1,434	961	391		82	874	358	24	179	126	1,130	0	179
1-2	588	423	165			329	171	0	88	92	408	0	88
1-3	15,957	7,056	8,901			4,622	9,699	466	1,170	869	11,791	2,127	1,170
1-4	3,598	1,601	1,996		0	1,298	2,073	95	132	55	2,536	874	132
1-5	39,653	17,444	21,999		210	13,470	20,929	2,658	2,595	3,613	23,988	9,516	2,536
3	21,678	8,973	12,659		46	6,914	11,697	798	2,269	1,201	16,194	2,013	2,269
3-3	3,493	1,294	2,153		46	726	2,243	289	235	159	2,446	654	235
3-4	4,722	2,317	2,405			1,510	2,671	174	367	143	3,455	757	367
3-5	13,463	5,362	8,101			4,677	6,783	335	1,667	899	10,294	603	1,667
4	547	257	290			187	300	31	28	0	410	108	28
4-3	277	140	137			62	214	0	0	0	200	77	0
4-4	82	82				51	0	31	0	0	51	31	0

Alternative B		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
4-5	188	36	153			74	86	0	28	0	160	0	28
5	2,026	948	927		151	774	1,010	148	95	270	989	673	95
5-1	1,166	653	513			528	456	148	35	141	723	267	35
5-2	861	295	414		151	247	554	0	60	129	266	406	60
KNF	27,063	15,015	11,868		181	11,998	11,442	0	3,624	7,597	15,845	0	3,621
3	25,476	14,274	11,203			11,468	10,769	0	3,239	7,203	15,035	0	3,239
3-1	7,600	4,463	3,137			3,495	3,015	0	1,090	2,356	4,154	0	1,090
3-2	5,745	3,090	2,655			2,266	2,778	0	700	1,239	3,806	0	700
3-3	12,132	6,721	5,411			5,707	4,976	0	1,449	3,608	7,075	0	1,449
4	1,587	741	665		181	530	672	0	385	395	810	0	382
4-3	116	116				74	29	0	13	0	103	0	13
4-4	1,471	625	665		181	456	644	0	372	395	708	0	369
Pine	399,633	147,622	129,885	27,098	95,027	87,944	73,716	42,140	195,833	17,608	107,796	115,777	158,452
COF	237,289	71,291	78,515	17,152	70,332	37,572	48,084	37,249	114,384	1,624	49,771	86,479	99,415
1	84,562	31,820	30,685	5,818	16,240	8,710	13,153	13,877	48,822	1,173	13,020	28,711	41,657
1-1	7,480	2,675	2,984	294	1,527	1,258	951	1,204	4,067	236	1,614	2,826	2,803
1-2	5,928	2,091	1,528	424	1,885	317	853	386	4,373	70	728	1,329	3,801
1-3	22,279	7,705	7,292	1,279	6,003	2,058	1,281	3,189	15,751	494	2,333	5,980	13,472
1-4	13,687	7,229	3,479	266	2,712	1,294	2,597	1,460	8,336	112	2,765	3,873	6,937
1-5	35,188	12,119	15,401	3,555	4,113	3,784	7,470	7,639	16,295	262	5,580	14,703	14,644
3	36,649	11,793	19,341	1,967	3,548	4,996	8,866	5,296	17,491	90	8,231	13,447	14,880
3-2	165	60	70	3	33	10	78	5	73	0	52	40	73

Alternative B		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover
3-3	11,559	3,603	6,345	324	1,286	1,160	1,725	1,965	6,708	2	2,162	3,819	5,576
3-4	4,198	973	2,237	589	399	196	669	1,057	2,276	15	285	1,860	2,037
3-5	20,727	7,157	10,689	1,051	1,830	3,630	6,394	2,269	8,434	73	5,731	7,728	7,194
4	56,434	17,296	20,970	4,953	13,215	8,016	12,022	7,660	28,736	330	11,163	20,277	24,665
4-3	24,954	5,707	9,452	1,904	7,891	4,261	4,976	2,766	12,952	126	5,389	8,698	10,741
4-4	25,064	9,752	8,762	2,566	3,984	2,400	5,057	4,090	13,517	204	3,986	9,059	11,816
4-5	6,417	1,837	2,755	483	1,341	1,355	1,989	804	2,268	0	1,788	2,520	2,109
5	59,644	10,383	7,519	4,414	37,328	15,850	14,043	10,416	19,334	32	17,357	24,043	18,212
5-1	19,449	5,046	4,418	1,309	8,677	8,347	4,266	2,844	3,992	7	8,934	7,187	3,321
5-2	40,195	5,338	3,101	3,104	28,651	7,503	9,777	7,572	15,342	25	8,422	16,856	14,892
KNF	162,344	76,331	51,371	9,946	24,696	50,372	25,631	4,891	81,449	15,984	58,025	29,299	59,037
3	45,422	14,474	17,037	5,215	8,696	7,489	6,432	2,277	29,224	4,657	6,425	9,849	24,490
3-1	11,205	4,506	4,268	1,034	1,397	2,970	1,586	557	6,092	1,939	2,224	2,327	4,715
3-2	16,975	2,682	7,054	2,816	4,424	2,009	2,126	1,014	11,826	1,207	1,827	4,375	9,565
3-3	17,242	7,287	5,716	1,366	2,874	2,511	2,720	706	11,305	1,511	2,374	3,148	10,209
4	75,733	29,026	28,647	4,731	13,329	13,317	13,484	2,559	46,374	5,709	20,631	18,768	30,625
4-2	7,381	2,836	1,759	833	1,953	1,563	583	238	4,997	860	1,422	1,332	3,767
4-3	29,965	14,327	9,047	1,375	5,217	6,780	6,237	764	16,185	1,973	12,970	6,337	8,685
4-4	38,386	11,862	17,841	2,523	6,160	4,974	6,663	1,557	25,192	2,876	6,238	11,100	18,172
6	41,188	32,831	5,687		2,671	29,566	5,716	55	5,851	5,617	30,969	681	3,922
6-2	5,069	4,198	539		332	4,338	151	0	580	578	4,049	0	442
6-3	32,635	25,844	4,526		2,265	22,640	5,374	55	4,566	4,986	23,546	681	3,422

Alternative B		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
6-4	3,484	2,789	622		74	2,588	191	0	705	53	3,373	0	58
Grand Total	512,178	200,300	189,082	27,098	95,698	128,410	131,394	46,361	206,013	31,432	181,088	131,088	168,571

Table 4. Alternative C

Alternative C		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
Pine-Oak	112,546	52,678	59,196		671	42,641	55,314	4,685	9,906	16,731	70,038	15,932	9,844
COF	85,482	37,664	47,329		490	30,606	43,794	4,685	6,397	8,067	55,145	15,932	6,338
1	61,231	27,485	33,453		293	22,312	31,137	3,708	4,074	6,173	37,959	13,084	4,015
1-1	1,434	961	391		82	874	358	24	179	126	1,130	0	179
1-2	588	423	165			329	171	0	88	92	408	0	88
1-3	15,957	7,056	8,901			5,142	9,079	655	1,081	1,469	11,124	2,283	1,081
1-4	3,598	1,601	1,996		0	1,298	2,073	95	132	55	2,536	874	132
1-5	39,653	17,444	21,999		210	14,669	19,456	2,934	2,594	4,431	22,760	9,927	2,535
3	21,678	8,973	12,659		46	7,333	11,347	798	2,199	1,625	15,787	2,067	2,199
3-3	3,493	1,294	2,153		46	888	2,081	289	235	332	2,219	707	235
3-4	4,722	2,317	2,405			1,726	2,455	174	367	360	3,238	757	367
3-5	13,463	5,362	8,101			4,719	6,811	335	1,597	933	10,330	603	1,597
4	547	257	290			187	300	31	28	0	410	108	28

Alternative C		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover
4-3	277	140	137			62	214	0	0	0	200	77	0
4-4	82	82				51	0	31	0	0	51	31	0
4-5	188	36	153			74	86	0	28	0	160	0	28
5	2,026	948	927		151	774	1,010	148	95	270	989	673	95
5-1	1,166	653	513			528	456	148	35	141	723	267	35
5-2	861	295	414		151	247	554	0	60	129	266	406	60
KNF	27,063	15,015	11,868		181	12,035	11,520	0	3,509	8,664	14,893	0	3,506
3	25,476	14,274	11,203			11,505	10,847	0	3,124	8,270	14,083	0	3,124
3-1	7,600	4,463	3,137			3,495	3,015	0	1,090	2,356	4,154	0	1,090
3-2	5,745	3,090	2,655			2,305	2,810	0	630	1,674	3,441	0	630
3-3	12,132	6,721	5,411			5,706	5,023	0	1,404	4,240	6,489	0	1,404
4	1,587	741	665		181	530	672	0	385	395	810	0	382
4-3	116	116				74	29	0	13	0	103	0	13
4-4	1,471	625	665		181	456	644	0	372	395	708	0	369
Pine	399,633	147,677	129,961	27,098	94,897	77,063	76,521	42,216	203,833	6,775	109,473	116,688	166,696
COF	237,289	71,291	78,515	17,152	70,332	36,188	50,409	37,399	113,292	0	51,022	87,137	99,131
1	84,562	31,820	30,685	5,818	16,240	7,537	13,203	13,858	49,964	0	13,025	28,736	42,801
1-1	7,480	2,675	2,984	294	1,527	1,022	951	1,204	4,303	0	1,614	2,826	3,039
1-2	5,928	2,091	1,528	424	1,885	246	853	386	4,443	0	728	1,329	3,871
1-3	22,279	7,705	7,292	1,279	6,003	1,564	1,332	3,170	16,214	0	2,338	6,005	13,937
1-4	13,687	7,229	3,479	266	2,712	1,182	2,597	1,460	8,448	0	2,765	3,873	7,049
1-5	35,188	12,119	15,401	3,555	4,113	3,522	7,470	7,639	16,557	0	5,580	14,703	14,905

Alternative C		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
3	36,649	11,793	19,341	1,967	3,548	4,923	10,012	5,179	16,535	0	8,636	13,783	14,230
3-2	165	60	70	3	33	10	78	5	73	0	52	40	73
3-3	11,559	3,603	6,345	324	1,286	1,158	2,188	1,906	6,307	0	2,507	3,812	5,240
3-4	4,198	973	2,237	589	399	181	669	1,057	2,290	0	285	1,860	2,052
3-5	20,727	7,157	10,689	1,051	1,830	3,574	7,077	2,211	7,865	0	5,792	8,070	6,865
4	56,434	17,296	20,970	4,953	13,215	7,910	13,151	7,946	27,428	0	12,004	20,575	23,855
4-3	24,954	5,707	9,452	1,904	7,891	4,223	5,351	2,839	12,541	0	5,668	8,774	10,512
4-4	25,064	9,752	8,762	2,566	3,984	2,332	5,810	4,303	12,619	0	4,548	9,282	11,234
4-5	6,417	1,837	2,755	483	1,341	1,355	1,989	804	2,268	0	1,788	2,520	2,109
5	59,644	10,383	7,519	4,414	37,328	15,818	14,043	10,416	19,366	0	17,357	24,043	18,244
5-1	19,449	5,046	4,418	1,309	8,677	8,340	4,266	2,844	3,999	0	8,934	7,187	3,328
5-2	40,195	5,338	3,101	3,104	28,651	7,478	9,777	7,572	15,367	0	8,422	16,856	14,916
KNF	162,344	76,386	51,447	9,946	24,565	40,874	26,112	4,817	90,540	6,775	58,451	29,551	67,566
3	45,422	14,529	17,113	5,215	8,565	3,553	6,565	2,234	33,071	747	6,719	9,841	28,116
3-1	11,205	4,506	4,268	1,034	1,397	1,516	1,586	557	7,546	379	2,224	2,327	6,275
3-2	16,975	2,737	7,129	2,816	4,293	1,075	2,211	1,001	12,687	176	2,012	4,356	10,431
3-3	17,242	7,287	5,716	1,366	2,874	962	2,768	675	12,838	192	2,483	3,158	11,409
4	75,733	29,026	28,647	4,731	13,329	9,223	13,831	2,528	50,150	1,470	20,764	19,030	34,470
4-2	7,381	2,836	1,759	833	1,953	893	583	238	5,667	132	1,422	1,332	4,496
4-3	29,965	14,327	9,047	1,375	5,217	5,483	6,237	764	17,481	708	12,970	6,337	9,950
4-4	38,386	11,862	17,841	2,523	6,160	2,846	7,011	1,527	27,002	630	6,371	11,361	20,024
6	41,188	32,831	5,687		2,671	28,098	5,716	55	7,319	4,559	30,969	681	4,980

Alternative C		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover
6-2	5,069	4,198	539		332	4,086	151	0	832	457	4,049	0	563
6-3	32,635	25,844	4,526		2,265	21,462	5,374	55	5,744	4,084	23,546	681	4,324
6-4	3,484	2,789	622		74	2,550	191	0	743	18	3,373	0	93
Grand Total	512,178	200,355	189,158	27,098	95,568	119,704	131,835	46,901	213,739	23,506	179,511	132,620	176,541

Table 5. Alternative D

Alternative D		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/ Thermal	Thermal Only	Not Cover
Pine-Oak	112,546	52,678	59,196		671	38,144	60,164	4,024	10,213	16,841	70,437	15,234	10,033
COF	85,482	37,664	47,329		490	27,186	47,683	4,024	6,589	7,470	56,366	15,234	6,412
1	61,231	27,485	33,453		293	19,944	34,043	3,047	4,197	5,530	39,242	12,439	4,020
1-1	1,434	961	391		82	615	616	24	179	186	1,069	0	179
1-2	588	423	165			360	141	0	88	92	408	0	88
1-3	15,957	7,056	8,901			4,564	9,757	466	1,170	1,180	11,480	2,127	1,170
1-4	3,598	1,601	1,996		0	1,399	2,035	32	132	163	2,429	874	132
1-5	39,653	17,444	21,999		210	13,006	21,495	2,525	2,627	3,908	23,856	9,439	2,450
3	21,678	8,973	12,659		46	6,258	12,353	798	2,269	1,587	15,808	2,013	2,269
3-3	3,493	1,294	2,153		46	752	2,216	289	235	159	2,446	654	235
3-4	4,722	2,317	2,405			1,763	2,418	174	367	252	3,346	757	367

Alternative D		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
3-5	13,463	5,362	8,101			3,742	7,719	335	1,667	1,177	10,016	603	1,667
4	547	257	290			129	359	31	28	15	396	108	28
4-3	277	140	137			62	214	0	0	0	200	77	0
4-4	82	82				51	0	31	0	0	51	31	0
4-5	188	36	153			16	145	0	28	15	145	0	28
5	2,026	948	927		151	856	928	148	95	338	920	673	95
5-1	1,166	653	513			502	481	148	35	210	654	267	35
5-2	861	295	414		151	354	447	0	60	129	266	406	60
KNF	27,063	15,015	11,868		181	10,958	12,481	0	3,624	9,371	14,072	0	3,621
3	25,476	14,274	11,203			10,503	11,735	0	3,239	8,956	13,282	0	3,239
3-1	7,600	4,463	3,137			3,386	3,124	0	1,090	3,152	3,358	0	1,090
3-2	5,745	3,090	2,655			2,051	2,994	0	700	1,636	3,409	0	700
3-3	12,132	6,721	5,411			5,066	5,617	0	1,449	4,168	6,516	0	1,449
4	1,587	741	665		181	456	746	0	385	415	790	0	382
4-3	116	116				0	103	0	13	0	103	0	13
4-4	1,471	625	665		181	456	644	0	372	415	687	0	369
Pine	399,633	147,622	129,885	27,098	95,027	109,689	84,746	39,174	166,023	41,329	106,210	105,651	146,442
COF	237,289	71,291	78,515	17,152	70,332	51,868	53,374	33,642	98,405	15,833	48,063	81,561	91,833
1	84,562	31,820	30,685	5,818	16,240	17,531	15,720	11,254	40,058	10,158	13,040	25,182	36,183
1-1	7,480	2,675	2,984	294	1,527	1,973	1,116	1,364	3,027	1,233	1,041	2,787	2,419
1-2	5,928	2,091	1,528	424	1,885	1,135	775	376	3,642	543	892	1,096	3,399
1-3	22,279	7,705	7,292	1,279	6,003	3,963	1,672	3,135	13,509	3,212	2,082	5,115	11,870

Alternative D		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
1-4	13,687	7,229	3,479	266	2,712	3,660	3,114	556	6,356	2,127	3,552	2,641	5,367
1-5	35,188	12,119	15,401	3,555	4,113	6,800	9,042	5,822	13,524	3,043	5,473	13,544	13,128
3	36,649	11,793	19,341	1,967	3,548	6,654	9,246	5,780	14,968	1,946	7,991	12,536	14,177
3-2	165	60	70	3	33	10	80	3	73	10	42	40	73
3-3	11,559	3,603	6,345	324	1,286	1,827	1,629	2,457	5,646	254	2,065	3,819	5,422
3-4	4,198	973	2,237	589	399	349	836	1,000	2,013	276	349	1,690	1,883
3-5	20,727	7,157	10,689	1,051	1,830	4,468	6,702	2,321	7,237	1,406	5,535	6,987	6,799
4	56,434	17,296	20,970	4,953	13,215	10,906	13,092	7,332	25,104	3,132	10,133	19,825	23,345
4-3	24,954	5,707	9,452	1,904	7,891	5,241	5,311	3,165	11,236	1,173	4,966	8,582	10,233
4-4	25,064	9,752	8,762	2,566	3,984	3,972	5,967	3,360	11,765	1,707	3,508	8,739	11,109
4-5	6,417	1,837	2,755	483	1,341	1,692	1,815	807	2,103	252	1,658	2,504	2,003
5	59,644	10,383	7,519	4,414	37,328	16,777	15,316	9,276	18,275	597	16,900	24,018	18,129
5-1	19,449	5,046	4,418	1,309	8,677	8,755	5,368	2,009	3,317	464	8,503	7,187	3,295
5-2	40,195	5,338	3,101	3,104	28,651	8,022	9,948	7,267	14,957	133	8,397	16,831	14,834
KNF	162,344	76,331	51,371	9,946	24,696	57,820	31,372	5,533	67,618	25,496	58,147	24,091	54,610
3	45,422	14,474	17,037	5,215	8,696	9,348	8,906	2,712	24,456	7,698	7,134	8,052	22,539
3-1	11,205	4,506	4,268	1,034	1,397	3,403	2,397	610	4,795	2,759	2,323	1,850	4,273
3-2	16,975	2,682	7,054	2,816	4,424	2,393	3,608	1,375	9,600	1,901	2,101	3,857	9,117
3-3	17,242	7,287	5,716	1,366	2,874	3,552	2,901	728	10,062	3,038	2,710	2,345	9,149
4	75,733	29,026	28,647	4,731	13,329	17,672	17,930	2,820	37,311	9,539	22,208	15,427	28,559
4-2	7,381	2,836	1,759	833	1,953	1,857	1,173	263	4,088	1,369	1,462	1,074	3,477
4-3	29,965	14,327	9,047	1,375	5,217	8,730	6,795	789	13,652	3,254	13,512	5,084	8,116

Alternative D		2010 Hiding/Thermal				2020 Hiding/Thermal				2050 Hiding/Thermal			
Subunit	Total Acres	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover	Hiding Only	Hiding/Thermal	Thermal Only	Not Cover
4-4	38,386	11,862	17,841	2,523	6,160	7,085	9,962	1,768	19,571	4,916	7,234	9,270	16,966
6	41,188	32,831	5,687		2,671	30,801	4,537	0	5,851	8,259	28,806	612	3,512
6-2	5,069	4,198	539		332	4,221	267	0	580	764	3,994	0	311
6-3	32,635	25,844	4,526		2,265	23,960	4,109	0	4,566	7,291	21,586	612	3,146
6-4	3,484	2,789	622		74	2,619	161	0	705	204	3,226	0	55
Grand Total	512,178	200,300	189,082	27,098	95,698	147,833	144,911	43,198	176,236	58,170	176,648	120,885	156,476

Appendix 6. Status of Game Species and Their Potential Response to Treatments Within the Four Forest Restoration Initiative

The Arizona Game and Fish Department offered to participate in the planning related developing mechanical and prescribed burning treatments for the Four Forest Restoration Initiative. Their participation included updating population trends for game species that serve as Management Indicator Species on the Coconino and Kaibab National Forests. Summaries on species biology, ecology, and population trends were created by Sara Reif, Region 2 Habitat Program Manager, Arizona Game and Fish Department 2012

Tassel-eared squirrels



Tassel-eared squirrels (*Sciurus aberti*) are an indicator of early seral ponderosa pine habitat in both the Coconino and Kaibab Forest Plans. Preferred habitat structure is composed of intermediate to older aged forest (trees 9-22+ inches dbh; Dodd et al. 1998, Elson 1999). The tassel-eared squirrel is considered a ponderosa pine “obligate” species. It relies on ponderosa pine and associated hypogenous fungi (Keith 1965, Stephenson 1975, States et al. 1988, Austin 1990, Snyder 1992) for most of its diet, and its nests are placed almost exclusively in these pines (Halloran and Bekoff 1994, Snyder and Linhart 1994), which also provide escape cover from predators and movement corridors created by interlocking tree canopies (Stephenson and

Brown 1980). Additional information on tassel-eared squirrels is available in the Forestwide MIS Status Reports for both the Coconino NF (USFS 2002) and the Kaibab NF (USFS 2010).

Population Trend

Population estimates have not been directly measured for tassel-eared squirrel on the Coconino or Kaibab NF. Global heritage rating is G5, indicating populations are demonstrably secure, although they may be rare in part of its range. Heritage rating in Arizona is S5, indicating a secure population in the state (NatureServe 2002). AGFD data of statewide tree squirrel harvest indicate inherently variable but stable trends in hunter harvest from 1995 – 2004, and from 2004 – 2009 (AGFD 2011; Figure 35). However, these data are compiled for all species of tree squirrels not just tassel-eared squirrels, and indicate the popularity of hunting squirrels rather than an index of density. AGFD biologists also postulate that since tassel-eared squirrels favor forests with tree densities, BA, and canopy cover less-frequently documented in the historic range of variability, current numbers are likely inflated compared to what might have been expected prior to European settlement (personal communication, S. Reif). However, squirrel density information from the 1800s is not available.

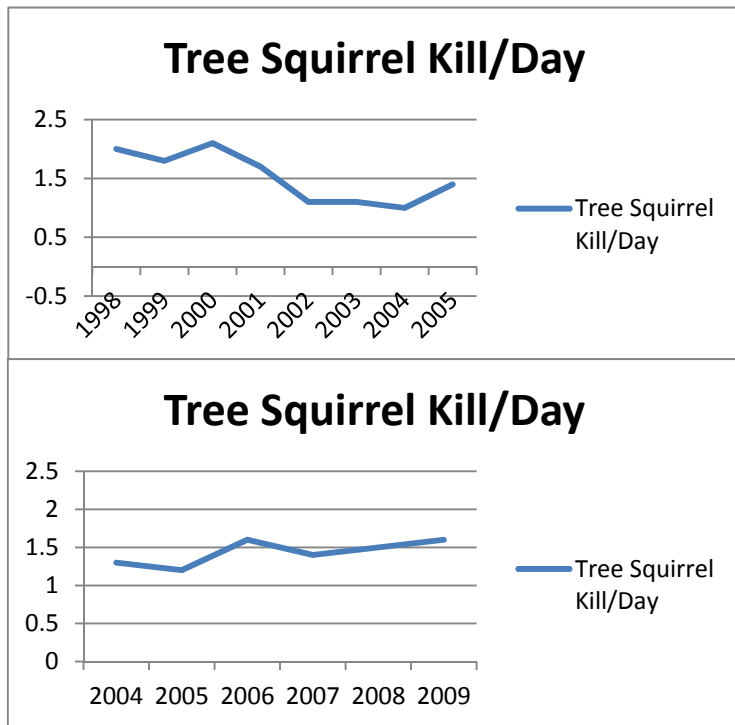


Figure 35. Tree squirrel harvest per day in Arizona from 1998 – 2004, and from 2004 – 2009. Note: harvest rates between the two time periods are not directly comparable because different survey methodologies were used beginning in 2004 (though both methodologies were conducted simultaneously 2004-2005). Harvest rates do not include junior harvest and therefore likely underestimate annual harvest of tree squirrels.

Additional population trend information is available for the Coconino NF, where AGFD feeding sign surveys were conducted from 2005 - 2010 in association with Forest Service vegetation management projects in the Flagstaff wildland-urban interface (Yarborough et al. 2010). Feeding sign survey results indicate a stable trend in tassel-eared squirrel abundance on the Forest (Figure 36).

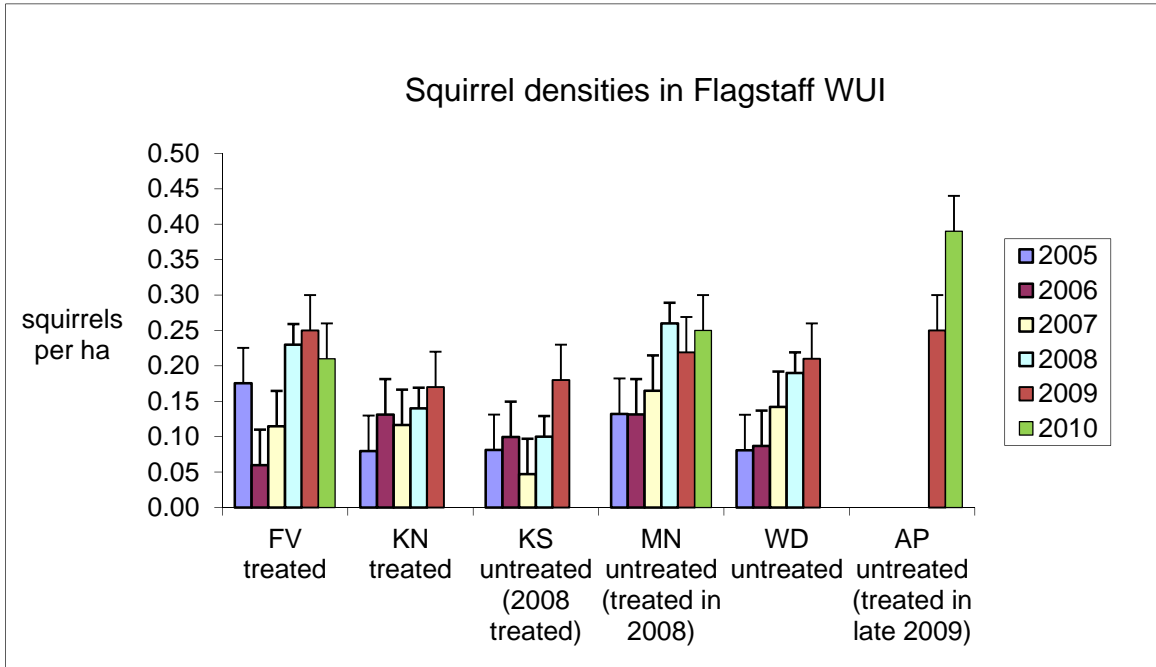


Figure 36. Feeding sign survey results from 2005- 2010 in Fort Valley (FV), Kachina North (KN), Kachina South (KS), Mountaineer (MN), Woody Ridge (WD), and Airport (AP) study sites in the Flagstaff Wildland-Urban Interface. Treated refers to areas having received recent fuels reduction treatment in the form of mechanical thinning and/or prescribed fire. Untreated refers to areas not having received recent fuels reduction treatment. There is no difference between bolded and unbolded error bars in this graph.

Squirrel data are also available for the Kaibab NF, where the Rocky Mountain Bird Observatory (RMBO) collected incidental observations of squirrels and their feeding sign during songbird surveys on the forest from 2005 – 2009 (Pavlacky 2011). In a report of the temporal trend in squirrel feeding sign on the Kaibab NF, RMBO found an increasing trend in squirrel sign from 2005 – 2009 (Figure 37). Inferences about local squirrel density on the South Kaibab NF are limited by the small sample size ($n = 5$) of this study.

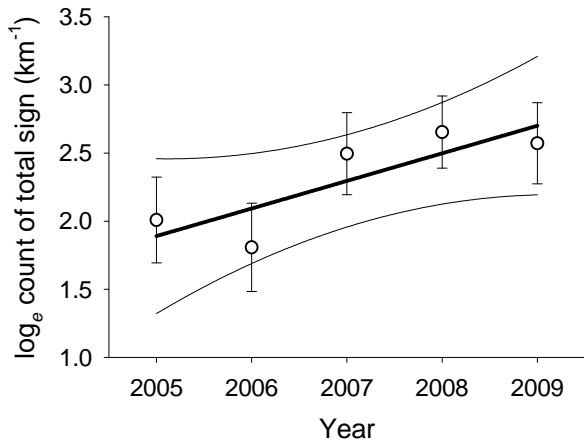


Figure 37. The temporal trend for the \log_e count of tassel-eared squirrel total sign (km^{-1}) from 2005 to 2009 (Pavlacky 2011). The bold trend line is the predicted \log_e count of total sign (km^{-1}) and the upper and lower lines are 95% confidence limits. The open circles are the mean \log_e count of total sign (km^{-1}) for each year and the error bars are one standard error of the mean.

Habitat Use and Trend

Forest structure and composition is probably the most important habitat attribute for tassel-eared squirrels. Tassel-eared squirrels select for groups of older, larger ponderosa pine trees with high canopy density. They are not wide-ranging species; their home ranges vary from 4 ha up to 70 ha, with juvenile dispersal distances ranging between 0.5 – 0.89 miles (Farentinos 1979).

AGFD feeding sign survey data shows that areas with higher basal area and canopy cover as well as interlocking canopies contain the highest densities of squirrels (Yarborough et al. 2010). The squirrel's ability to access the growing pine shoots it depends on for food, as well as its ability to escape predators, is dependent on interlocking tree canopies especially during winter when snow accumulation can impede ground travel (Stephenson & Brown 1980). When snow is absent, tassel-eared squirrels will forage on the forest floor primarily for mycorrhizal fungi ('truffles') associated with pine tree roots (States et al. 1988). Tassel-eared squirrels also depend on ponderosa pine cones to meet their nutritional demands.

Nest trees are generally taller and larger than surrounding trees (62 ± 9 ft versus 44 ± 16 ft tall and 15 ± 3 in versus 11 ± 7 in dbh) (Halloran and Beckoff 1994). Prather et al. (2006) found that local basal area explained squirrel density in 9 northern Arizona studies, and Dodd et al. (1998) estimated optimal basal area for squirrels to be greater than 150 ft^2 per acre. Stand-level canopy cover of 40-50% probably represents a threshold for optimal tree squirrel habitat and is particularly important for recruitment (Dodd et al. 1998; Prather et al. 2006; Loberger et al. 2011). At the scale of the stand and the restoration unit, a continuously dense forest is not required for squirrels as long as denser patches of forest are retained for foraging, nesting, and escaping predators. Dodd et al. (2006) postulated that up to 75% of a forested landscape could be treated and still provide suitable squirrel habitat if treatments were applied as a mosaic of patches and areas of optimal habitat were retained.

Effects of Thinning

Forest tree thinning under the goshawk guidelines should result in a mosaic of vegetative structural stages, interrupt canopy closure, and allow more sunlight to reach the forest floor. In the moderate- to high-intensity treatments, the reduction in canopy connectedness will reduce safe travel routes for tassel-eared squirrels and expose them to higher rates of predation. These higher-intensity treatments will also expose more of the forest floor to direct sunlight which could remove the microsite habitat for mycorrhizal fungi production, thereby reducing an important food source for squirrels. However, tassel-eared squirrels may shift their patterns of nesting and foraging habitat use in response to restoration treatments because there will be a patch mosaic that includes untreated or lightly-treated areas. A ratio of optimal to sub-optimal patches that is skewed toward a more open condition will be less desirable to the squirrel and could lead to a short-term reduction in current squirrel populations. However, long-term, post-treatment conditions will include tree growth and increased canopy connectedness which should have a positive impact to squirrel populations when viewed over longer time horizons.

Despite the proposed reduction in dense forest conditions, sustainable forests that include large, cone-bearing trees either as individual legacy trees or in groups and clumps of mature and old-growth trees interspersed with patches suitable for fungi production still provide squirrel habitat. Canopy connectivity can be retained in small groups rather than across whole landscapes. In the long term this should provide for more sustainable squirrel habitat over time because the risk of stand-replacing fire and therefore long-term degradation or loss of squirrel habitat will be significantly reduced (USFS 2010).

Proposed thinning treatments may cause visual or auditory disturbance to individual squirrels, although these effects would be short-term and limited in scope. Best management practices will direct operators to avoid removal of trees containing squirrel nests.

The inclusion of the Large Tree Retention Strategy (LTRS) and the incorporation of wildlife research will allow for higher basal area and canopy cover contributions from large-diameter trees, which should benefit tassel-eared squirrels for nesting and for winter cover. The larger forest patches created in the wildlife research project will increase the amount of optimal squirrel habitat available as well.

Effects of Prescribed Burning

Disruption of normal behavioral patterns could occur to tassel-eared squirrels during burning activities, particularly since the proposed action calls for burning up to 60,000 acres annually. Effects would likely be due to direct disturbance by human presence during burning activities as well as smoke inhalation. However, human disturbance and smoke effects should be transitory in nature and short-term. Prescribed fire maintenance treatments would occur every 2 to 10 years, which would increase the frequency of fire disturbance on tassel-eared squirrels. However, this fire frequency approximates the historic fire return interval with which squirrels evolved and should not result in dramatic shifts in squirrel behavior or habitat use.

Effects of Aspen Treatments

Tassel-eared squirrel associations with aspen are not well-documented. Aspen treatments are not expected to impact this species.

Effects of Stream/Spring Restoration

Tassel-eared squirrel associations with ephemeral streams and springs are not well-documented. Stream and spring restoration is not expected to impact this species.

Effects of Road Closure/Obliteration

Little documentation exists to demonstrate that tassel-eared squirrels avoid or select for roads, so the effect of closures is unknown but assumed to be of benefit to the species since road-killed squirrels are commonly observed on both Forests.

Pile burning on steep slopes could disrupt normal behavioral patterns. Effects would likely be due to direct disturbance by human presence during burning activities as well as smoke inhalation. However, human disturbance and smoke effects should be transitory in nature and short-term and only in isolated patches across the project area. Grasslands are not selected for by tassel-eared squirrels, therefore the direct and indirect effects of this burning on squirrels are expected to be minimal.

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Elk



Elk (*Cervus elaphus*) are an indicator of early-seral ponderosa pine for the Coconino and Kaibab NFs, and is an economically and socially important species. Elk are habitat generalists. In addition to occupying ponderosa pine forests, they graze grassland and woodland habitats as well as aspen and riparian areas. On both the Kaibab and Coconino NFs, elk occupy mountain meadows and forests in summer and move to lower-elevation pinyon-juniper woodland, conifer forest, and grasslands in winter (Hoffmeister 1986, USFS 2002, USFS 2010). Elk prefer grasses, and they also eat forbs, shrubs, and trees such as Gambel's oak and quaking aspen (Boyd 1978, Burt and Grossenheider

1976, Hoffmeister 1986). They are a wide-ranging species; a recent study of elk movements on Camp Navajo indicates minimum convex polygon home range sizes for elk between 61.8 and 169.8 mi², with average daily movements of 3.1 miles (Partridge and Ingraldi 2007). Therefore, individuals will likely respond to changes in forest management at the scale of the restoration unit and the project area.

According to the Arizona Game and Fish Department (AGFD), the 4FRI project area includes portions of four elk herds (Figure 38; T. McCall, personal communication, October 2011). One herd includes Game Management Unit (GMU) 5A/5B/6A and occurs on the Coconino NF. The second herd includes 6B, 8, and Camp Navajo, which overlaps with both the Coconino and Kaibab NFs. The third is contained within GMU 7, which overlaps with both Forests. GMU 7 has some population exchange with the fourth herd in GMU 9, which occurs primarily on the Tusayan Ranger District of the Kaibab NF. It is important to note that elk that intermix among herds do not always go back to their respective GMU after winter, which complicates interpretation of both population- and habitat-utilization data for this species.

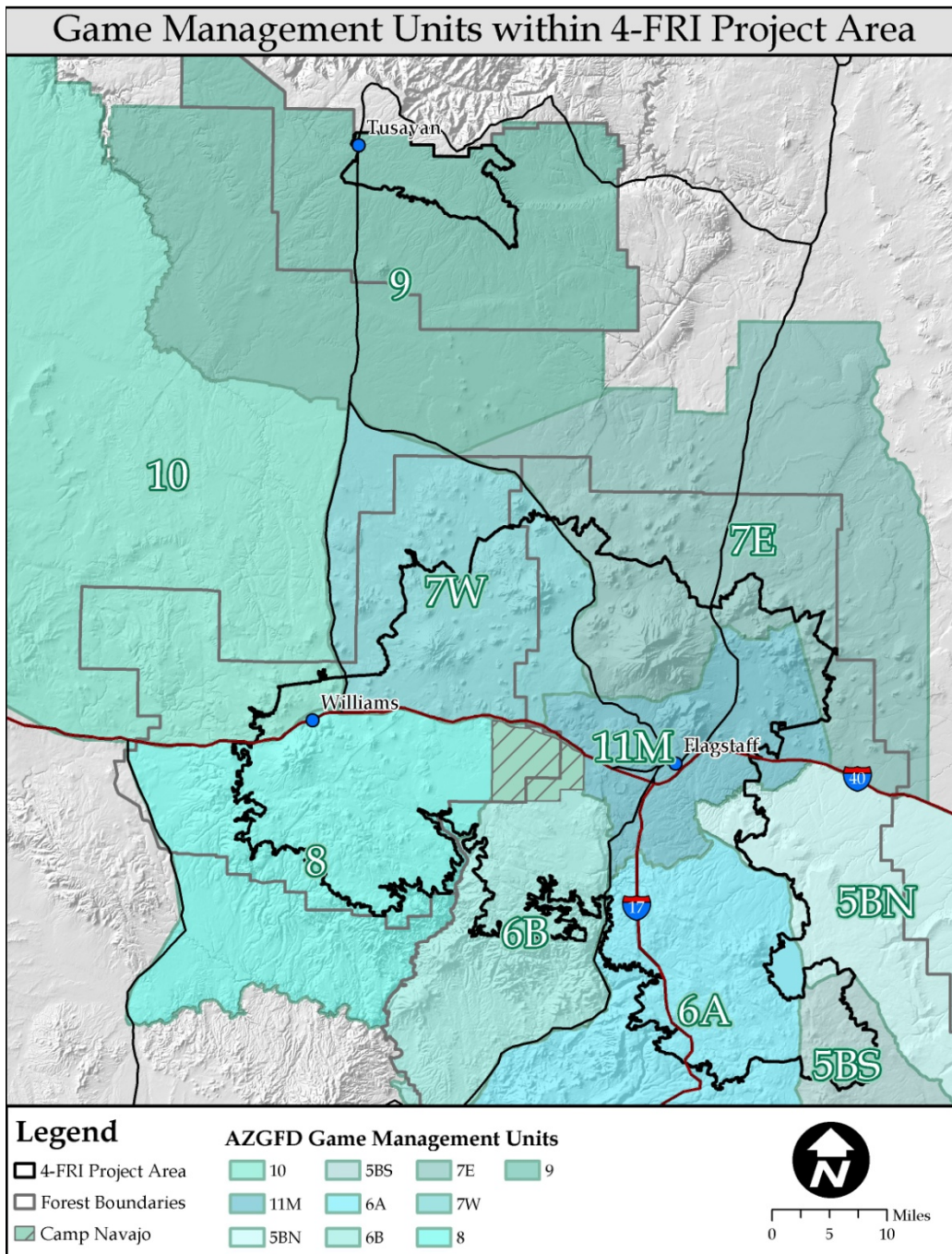


Figure 38. Arizona Game and Fish Department Game Management Units within the 4FRI Project Area.

Population Trend

Because of their primary responsibilities for managing wildlife, the main data source for elk population trend comes from AGFD survey and hunt data, which shows a stable to decreasing

trend in elk populations. Data used in this analysis were collected by game managers using a variety of methods including fixed-wing aircraft and helicopter surveys, and ground-based driving and horseback surveys when dense forest conditions precluded aerial counts. Survey methods vary across GMUs, and some methods vary across years for certain GMUs. The lack of consistency in survey methods is due in large part to the difficulty in detecting elk in heavy forested cover and because patterns of elk distribution are not consistent over time but rather move in response to shifts in precipitation patterns. However, this inconsistency makes interpretation of population data more difficult than it would be if methodologies and effort were consistent across GMUs and across years.

AGFD evaluates trends in elk populations based on 1) annual surveys (Figure 39), and 2) population estimates derived from a model that takes cow-calf ratios, bull:cow ratios, harvest, and estimated annual background mortality into consideration (Figure 40). Modeled mortality rates are based on limited available data from Brown (1994) and J. Gagnon unpublished data (AGFD; 2010). One limitation of this model is that it requires modelers to select a beginning population size for bulls and cows for which reliable data are lacking. Modelers must set beginning population size using anecdotal inference from earliest known survey numbers. For this reason, AGFD recommends greater emphasis on trends rather than absolute numbers. Population trend estimates are available from 1988 through 2009.

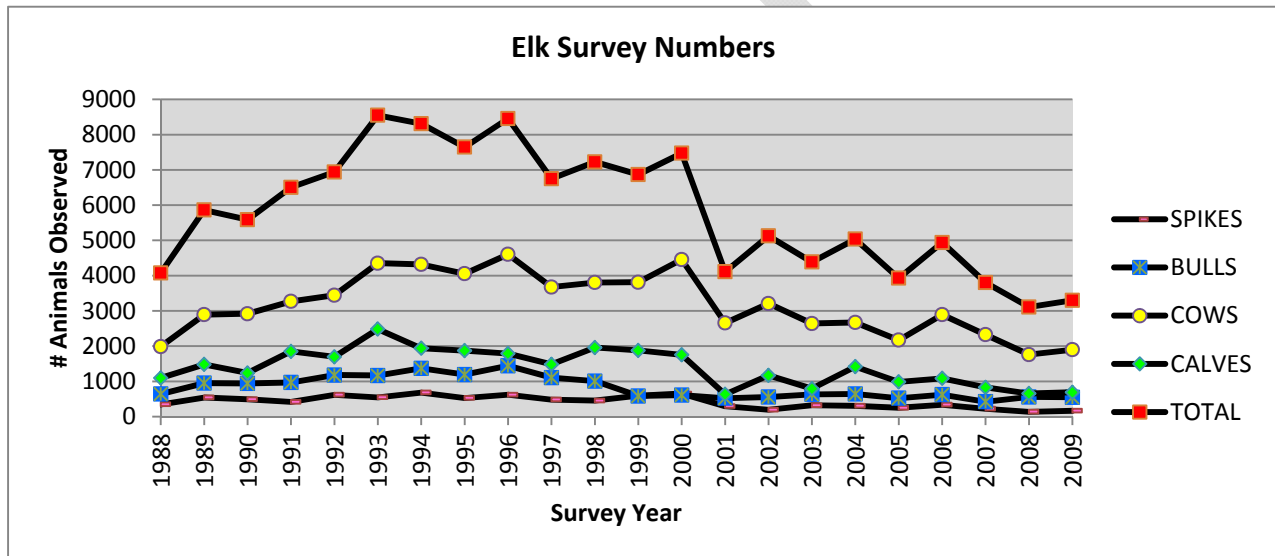


Figure 39. Elk survey trends on the Coconino and Kaibab National Forests. Numbers are collected during annual surveys. Data are unpublished but available from AGFD Flagstaff Regional Office (C. Lutch, personal communication, November 2011).

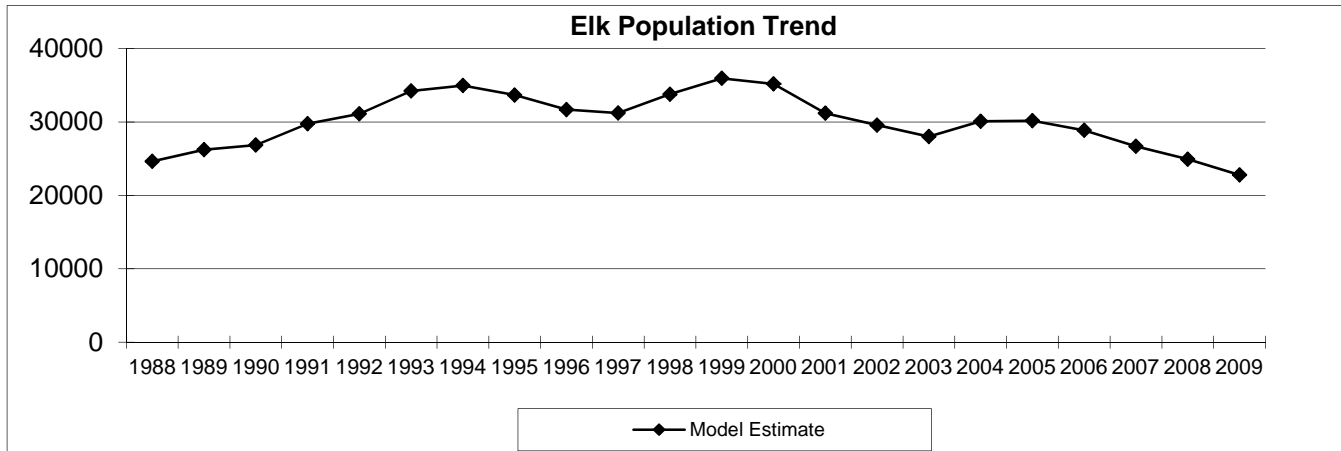


Figure 40. Trend in estimates elk populations for the Coconino and Kaibab National Forests from 1988 – 2009. Includes Game Management Units 5A, 5B, 6A, 6B, Camp Navajo, 7, 8, and 9. Data are unpublished but available from the AGFD Flagstaff Regional Office (C. Lutch, personal communication, November 2011).

Figure 39 and Figure 40 show a stable to decreasing trend in elk numbers over time on the Coconino and Kaibab National Forests, with a peak in the mid 1990s. From 1988 to 2008 elk populations increased by 9%, however more recent efforts to reduce populations in response to declines in habitat quality have led to a 33% decline in estimated elk numbers from 2000 – 2011 (with the last two years based on projected trend).

Habitat Use

Elk select their habitat based on a relatively even ratio of forest (cover) to openings (forage) (Dealy 1985, Brown 1994). Forested cover is thought to be important for elk to protect against changes above and below critical tolerances (thermoregulation; Dealy 1985), and to provide places for elk to hide from human disturbance particularly along roadways or in areas of timber harvest (Ward 1976). Elk typically select hiding and thermal cover in stands with high canopy density (70%) and a low canopy-base height (6.5 feet) (Brown 1994). Tree size class is less important to elk as long canopy requirements are met, though elk bedsites are often found in early seral forests with a high percentage of VSS 2 and 3 tree groups (Brown 1994). However, recent studies postulate thermal cover is not as important for elk as forage availability in terms of maintaining good body condition (Cook et al. 2004). Foraging areas are primarily openings in the forest canopy where perennial grasses and forbs are more readily available (Reynolds 1966). Elk also forage in stands dominated by Gambel's oak and quaking aspen where they feed on sprouts and ramets. Forest management practices that create an interspersed forest tree groups and openings tend to improve habitat conditions for elk by increasing grassland primary productivity while still providing cover nearby (Johnson and Matchett 2001, Van Dyke and Darragh 2007).

High levels of elk utilization can have negative impacts on sensitive areas within the project area including aspen stands (Fairweather et al. 2008), springs and other montane riparian areas including ephemeral stream channels (Neary and Medina 1996). In aspen stands, elk utilization contributes to the overall lack of aspen recruitment from the young sucker stage into larger size classes. In springs, wet meadows, and stream channels, elk hoof action and vegetation

trampling/removal contributes to geomorphic changes that cause erosion, channel widening, and overall degradation of those riparian systems (Neary and Medina 1996).

Current trends in elk habitat on both Forests are stable to increasing, due in large part to the increase in fuels reduction projects aimed at opening forest canopies which increases elk forage availability (USFS 2002, 2010). AGFD contemporary efforts to reduce elk populations have also contributed to the stable trend in habitat condition across the two forests, with the exception of aspen areas where ramet browse remains high (Fairweather et al. 2008).

Habitat Changes

Continuing the current forest growth trajectory would continue to provide large patches of trees with higher basal area, canopy density, and interlocking crowns would provide thermal and hiding cover for elk. However, pine encroachment into grassy openings and meadows will continue to limit foraging habitat for elk. The current unnatural stand densities will threaten sustainability of elk habitat over time by limiting understory production and creating risk for uncharacteristic, high-severity fire.

Effects of Mechanical Thinning

Thinning small-diameter trees and prescribed burning in ponderosa pine would open the canopy and decrease fine fuels on the forest floor. The result would be increased growth of herbaceous and shrub-level vegetation, which would provide increased forage in the long term, with expected benefits as soon as 1-2 years following prescribed fire (Canon et al. 1987 in Pilliod et al. 2006). Reducing tree densities and ladder fuels will reduce available thermal and hiding cover for elk. However, thermal protection for elk will continue to be available in areas maintained for higher BA and canopy density including MSO nesting and restricted habitat, NOGO nest stands, bald eagle roosts, caves, and areas excluded from mechanical treatment such as wilderness of slope >40%.

Thinning small-diameter trees and burning in gambel oak thickets could also reduce hiding and thermal cover for elk in the short term. This risk however, must be weighed against the risk of stand replacing fire events. Project design criteria for both habitats include tree thinning under the goshawk guidelines. This should result in a mosaic of interspersed vegetative structural stages including early-seral habitat, and will provide necessary habitat characteristics, such as bedding sites and open areas with increased forage for elk in the long term.

The inclusion of the LTRS would retain higher basal area and canopy cover contributions from large-diameter trees, which should benefit elk for thermal cover. Similarly, the larger forest patches retained in the watershed and wildlife research areas could provide additional areas for elk thermal and hiding cover.

Since elk also select for grasslands where increased herbaceous productivity provides foraging opportunities, the grassland treatments proposed in Alternative C will likely benefit elk.

Proposed thinning treatments may cause visual or auditory disturbance to individual elk, although these effects would be short-term. Best management practices will place seasonal restrictions on logging activities in known elk calving areas to reduce the likelihood of direct impacts.

Effects of Prescribed Fire

Disruption of normal behavioral patterns could occur to elk during burning activities. Prescribed fire maintenance treatments would increase the frequency of fire disturbance on elk. Effects would likely be due to direct disturbance by human presence during burning activities as well as smoke inhalation. However, human disturbance and smoke effects should be transitory in nature and short-term. Since elk are capable of moving several miles in any given day, it is likely they will be able to move out of smoke paths in the event of prescribed burns.

Effects of Aspen, Spring, and Ephemeral Channel Restoration

Exclusion of elk from aspen, springs, and ephemeral channels will limit their ability to access those forage and water resources. However, the increased herbaceous productivity resulting from forest thinning is likely to offset elk utilization of aspen and riparian areas. Springs and ephemeral channels do not represent reliable water sources for elk and exclusion of these areas should not have an impact given the relatively high availability of permanent, artificial water sources across the project area.

Effects of Road Closure/Obliteration

Closure and obliteration of unauthorized roads will positively impact elk. Elk are known to avoid roads and heavily used recreational areas (Ward 1976).

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Mule deer

Mule deer (*Odocoileus hemionus*) are an indicator of early-seral aspen and pinyon-juniper for the Coconino and Kaibab NFs, and is an economically and socially important species. Mule deer typically summer at higher elevations in aspen, mixed conifer, and ponderosa pine forests, and transition to winter in pinyon-juniper woodlands found at lower elevations (Hoffmeister 1986). Mule deer are browsers and prefer leaves and twigs from shrubs and trees over grasses. Home range size varies, depending upon availability of forage and cover. Mule deer in the vicinity of the Tusayan and Williams Ranger Districts (Kaibab NF) have an estimated home range 141.1 mile² (± 48.3) (Dodd et al. 2010). Since mule deer are relatively wide-ranging species, they are likely to respond to changes in forest management at small and large spatial scales.

Population Trend

Mule deer are currently listed as G5, N5, and S5 (NatureServe 2010). The species is considered to be demonstrably widespread, abundant, and secure, globally, nationally (USA), and statewide (AZ).

Mule deer populations have fluctuated throughout history due to influences of precipitation, habitat quality, predation, and hunting pressure (Heffelfinger and Messmer 2003). Annual statewide survey data from 1946 – 2008 demonstrate this fluctuation in mule deer abundance, and show a contemporary decline in mule deer surveyed that began in the mid 1990s but has stabilized since 2004 (AGFD 2011, Figure 41). This is consistent with the Forestwide population trend determinations for both Forests (Coconino NF – decreasing (USFS 2002); Kaibab NF – stable to decreasing (USFS 2010)).

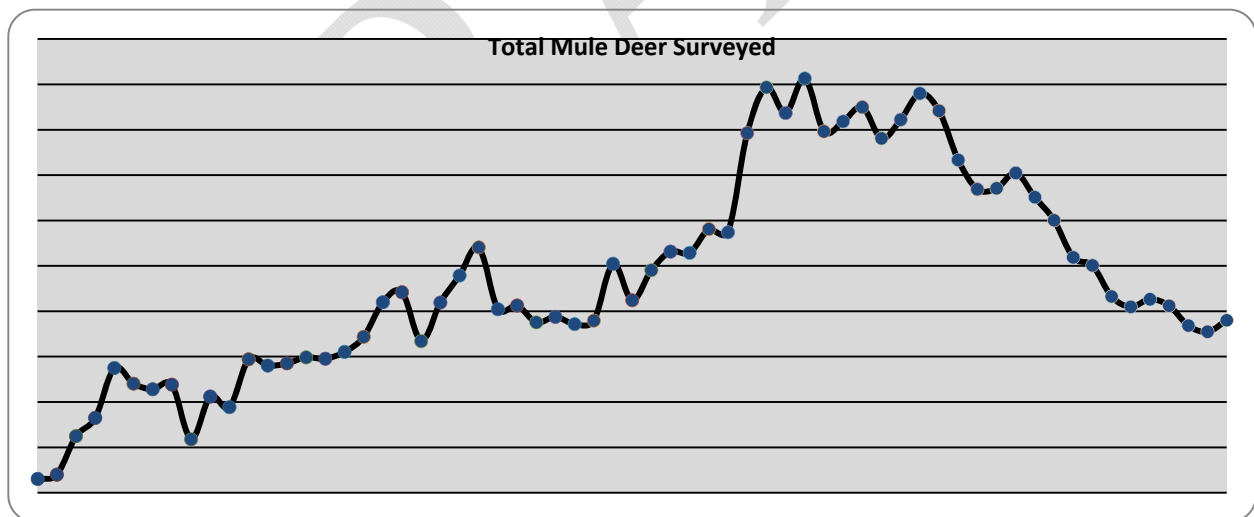


Figure 41. Results of annual statewide mule deer surveys 1946 – 2010 (AGFD 2011).

For the purpose of this analysis, data were compiled from files at the Flagstaff Regional Office of the Arizona Game and Fish Department in order to determine population trends on the Coconino and Kaibab NFs (T. McCall, AGFD, unpublished data, November 2011). The two best indicators for mule deer population trend are 1) the number of mule deer observed during annual surveys, and 2) number of fawns per 100 does. These two indicators are used because they are more reliable than population modeling estimations for mule deer. Given the inconsistency of survey

methodologies, population model outputs and deer observed/hour of survey are less reliable than actual survey numbers (Tom McCall, personal communication, November 2011). Data are displayed by Game Management Unit (GMU; Figures 2-4). For the Coconino NF, data are relevant from GMUs 5A and 5B (combined only for mule deer analysis), 6A, 6B, 7, and 8. For the Kaibab NF, data are relevant from GMUs 6B, 7, 8, and 9. All GMUs are relevant to the 4FRI project area.

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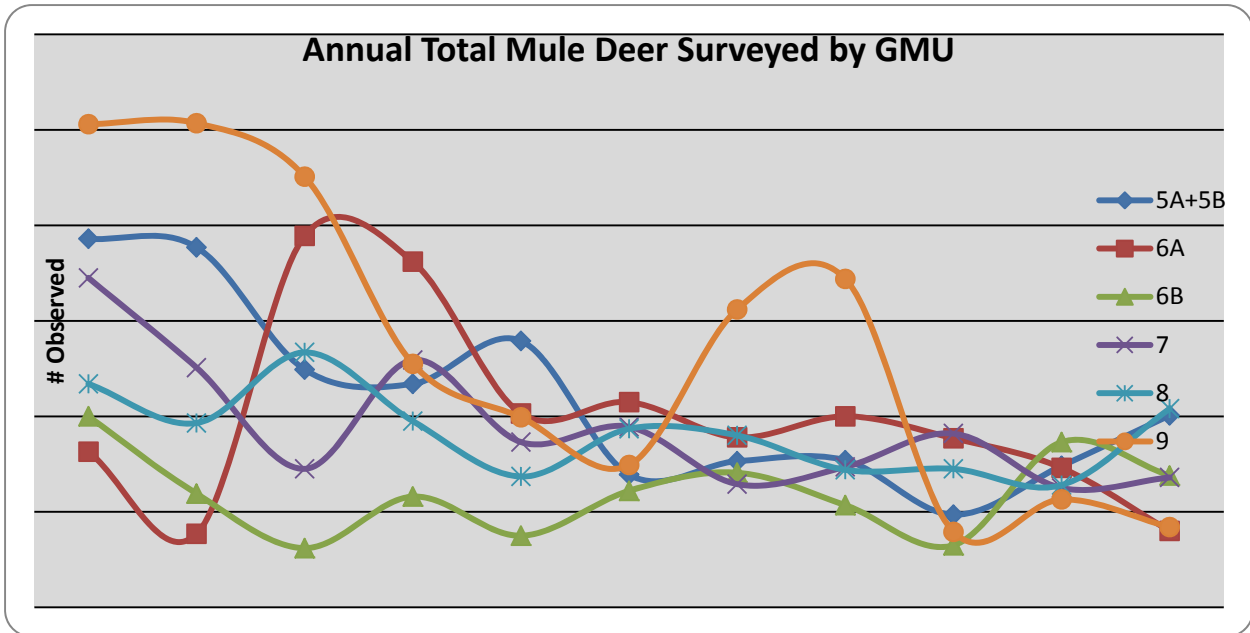


Figure 43. Total number of mule deer surveyed by GMU, 2000 – 2010.

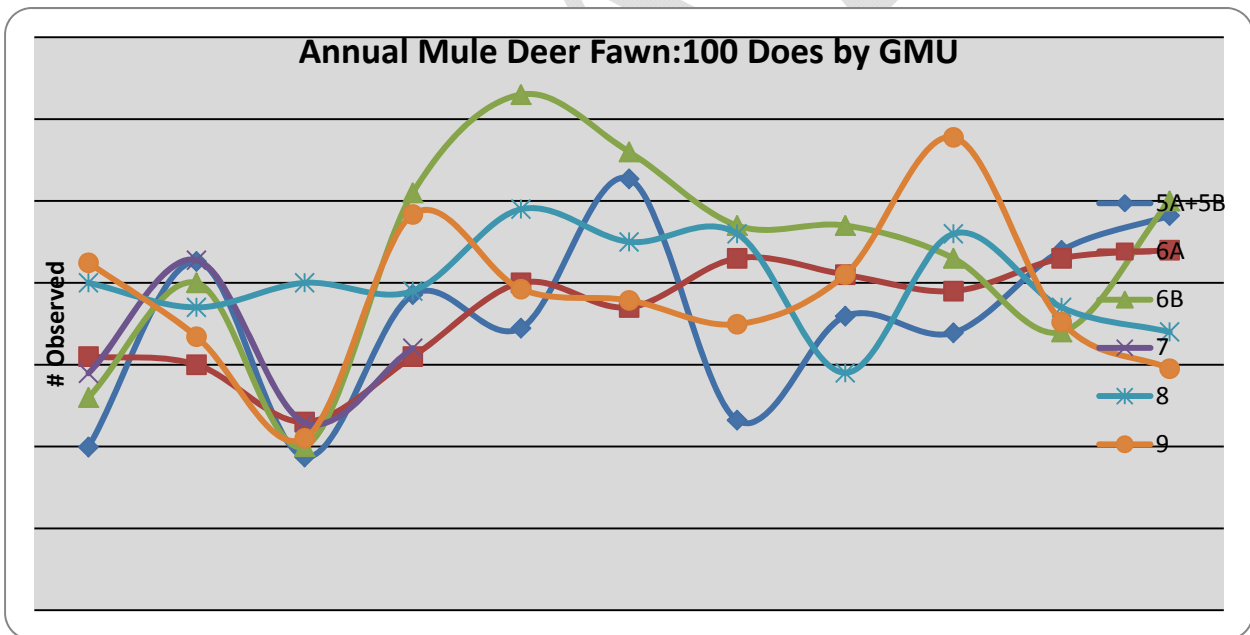


Figure 44. Ratio of mule deer fawns per 100 does by GMU, 2000 – 2010.

The declining to stable trend in mule deer surveyed over the last decade on the Coconino and Kaibab NFs is consistent with the statewide trend. The fawn:doe ratios indicate relatively stable trends in doe productivity over time across both Forests. Though currently stable, survey data suggest that overall mule deer populations are lower than they were a decade ago. Regional

experts have attributed contemporary mule deer population decline to declines in the quality of their habitat (Mule Deer Working Group 2004).

Habitat Use and Trend

Unlike cattle and elk, mule deer are not adapted to digest a diet high in grass; instead they rely primarily upon browse and forbs to meet their nutritional needs, particularly on their winter range when snow limits access to herbaceous ground cover (Wallmo and Regelin 1981). Important plants in a mule deer's diet include sagebrush (*Artemisia spp.*), cliffrose (*Cowania mexicana*), mountain-mahogany (*Cercocarpus ledifolius*), buckbrush (*Ceanothus cuneatus*), buckthorn (*Rhamnus spp.*), quaking aspen (*Populus tremuloides*), juniper (*Juniperus spp.*), and Gambel's oak mast (*Quercus gambelii*). High diversity and productivity of shrubs and young trees are important habitat components for mule deer, best represented within early-successional forests and maintained by natural disturbances such as fire (Mule Deer Working Group 2004).

Carrying capacity of winter range habitats is often the limiting factor for mule deer populations (Wallmo et al. 1977). Winter range for mule deer occurs primarily in pinyon-juniper communities which are largely outside the scope of the 4FRI project. However, summer range for mule deer occurs throughout the project in areas of ponderosa pine, pine-oak, pine-sage, aspen, and at springs and ephemeral channels particularly when water is available.

High levels of interspersion of forested cover and openings are favored by mule deer, particularly when a shrub, oak, or aspen component is present (Germaine et al. 2003, Wightman and Yarborough 2005). When openings or low-density forests are present in a matrix of higher-density forest patches, mule deer will forage in open and sparsely-treed areas at night but spend the majority of their daylight hours on bedsites located within denser hiding and thermal cover (Wightman and Yarborough 2005). In addition, mule deer prefer smaller openings and show higher fidelity to forested edge relative to elk and cattle (Dealy 1985). As such, landscape-scale forest restoration practices that favor heterogeneity in forest:opening ratios and promote oak, sage, and aspen should improve habitat for mule deer in the short- and long-term.

Mule deer commonly browse on aspen within the 4FRI project area. Aspen stands are declining on both Forests, due a combination of factors including drought, heavy frost events, disease and pathogens, fire suppression and ungulate herbivory (Fairweather et al. 2008). Aspen continues to be lost as successional processes result in pine, spruce or fir trees overtopping many of the stands. Some early seral stage stands are being created through wildfire and management activities, which should benefit mule deer. However, management activities have not been implemented to a level, or over enough area, to prevent loss of aspen patches in the landscape and provide for adequate aspen recruitment.

Current conditions on both Forests do not provide optimal cover and foraging conditions for mule deer. Fire suppression over the last century has led increased tree densities and canopy closure, reducing forest openings, meadows, and grasslands. These changes have reduced both groundcover and the shrub layer, likely decreasing the carrying capacity of lands on both Forests. Deer may also be negatively affected by competition with elk and livestock on shared forage species if widespread hedging (e.g., shrubs on the Tusayan Ranger District) or actual elimination of forage occurs (e.g., aspen regeneration on the Peaks Ranger District (Coconino NF) and Williams Ranger District (Kaibab NF)).

Potential Effects

Maintaining current conditions would continue to provide large patches of trees with higher basal area, canopy density, and interlocking crowns thereby providing thermal and hiding cover for mule deer. However, overstory suppression of browse diversity and productivity will continue to limit forage habitat for mule deer. Tree encroachment into openings and meadows will also limit mule deer foraging habitat. Early-seral aspen will continue to decline in the absence of natural disturbances such as fire and without management intervention. The current unnatural stand densities would threaten sustainability of mule deer habitat by creating risk for uncharacteristic, high-severity fire.

Effects of Mechanical Thinning

Weather patterns such as precipitation are the primary driver of deer populations in the short term, but landscape scale habitat improvements such as 4FRI will make long term gains in deer abundance over time (Mule Deer Working Group 2004).

Thinning under the goshawk guidelines would result in a mosaic of interspersed vegetative structural stages that provide both bedding sites and foraging areas for mule deer. Cutting in early-seral pinyon-juniper on the Tusayan Ranger District would positively influence forage abundance by opening up the tree canopy and allowing sunlight to reach the forest floor. Thinning and burning in the pine-sage, pine-oak, and pure pine will also provide opportunities for browse increase which should positively influence mule deer populations over time.

Reducing tree densities and ladder fuels will reduce available thermal and hiding cover for mule deer. However, thermal protection will continue to be available in areas maintained for higher BA and canopy density, including MSO nesting and restricted habitat, NOGO nest stands, bald eagle roosts, caves, and areas excluded from mechanical treatment such as wilderness and where slope >40%. Thinning small-diameter trees and burning in Gambel oak thickets could also reduce hiding and thermal cover for mule deer in the short term. This risk however, must be weighed against the increased likelihood for stand replacing fire events and mass habitat loss over larger areas.

Fencing around aspen will allow for recruitment of new ramets and creation of early-seral conditions but will preclude foraging mule deer unless fences are removed. Reduction in aspen forage will have localized impacts on deer but is not expected to have impacts at the population level given that other understory forage plants will likely increase following overstory reductions.

The inclusion of the LTRS and the incorporation of watershed and wildlife research areas would retain higher basal area, higher canopy cover, and larger forest patches because of the combined contributions from large-diameter trees. This should benefit mule deer in terms of cover and additional areas for mule deer daybeds.

Since mule deer also select for the forested edges of grasslands where increased herbaceous productivity provides foraging opportunities, grassland treatments should benefit mule deer.

Proposed thinning treatments may cause visual or auditory disturbance to individual mule deer, although these effects would be short-term. Best management practices will place seasonal restrictions on logging activities in known fawning areas to reduce the likelihood of direct impacts.

Effects of Prescribed Fire

Landscape-scale application of prescribed fire will more closely simulate historic fire regimes, restoring disturbances that work to create patches of early seral forest, particularly enhancing areas of aspen. Enhancement of these features across the landscape will benefit mule deer.

Mule deer evolved in southwestern ponderosa pine forests that were characterized by frequent, low-intensity fire. This frequent fire helped maintain herbaceous openings and meadows, which are important for mule deer foraging. Disruption of normal behavioral patterns could occur to mule deer during burning activities and prescribed fire maintenance treatments would increase the frequency of fire disturbance on mule deer. Effects would likely be due to direct disturbance by human presence during burning activities as well as smoke inhalation. However, human disturbance and smoke effects should be transitory in nature and short-term. Since mule deer are capable of moving several miles in any given day, it is likely they will be able to move out of smoke paths in the event of prescribed burns.

Cheatgrass has a profound negative impact on mule deer habitat quality through a process of invasion, competition with-, and eventual elimination of shrubs through unnatural acceleration of fire frequencies in pinyon-juniper and ponderosa pine systems (Mule Deer Working Group 2004). The risk of cheatgrass invasion following restoration treatments (McGlone et al. 2009) has the potential to negatively impact mule deer habitats in the long-term.

Effects of Aspen, Spring, and Ephemeral Channel Restoration

Exclusion of mule deer from aspen, springs, and ephemeral channels will limit their ability to access those forage and water resources. However, the increased shrub and herbaceous productivity resulting from forest thinning is likely to offset mule deer utilization of aspen and riparian areas. Springs and ephemeral channels do not represent reliable water sources for mule deer and exclusion of these areas should not have an impact given the relatively high availability of permanent, artificial water sources across the project area.

Effects of Road Closure/Obliteration

Closure and obliteration of unauthorized roads will positively impact mule deer. Mule deer are known to avoid roads and heavily used recreational areas (Mule Deer Working Group 2004).

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Wild turkeys



Wild turkeys (*Meleagris gallopavo*) are an indicator of late-seral ponderosa pine forests, and are an economically and socially important species. Turkey roosts and nests are associated with groups of large pine trees on steep slopes, and they select foraging and loafing habitats within a mix of meadows, oak, and juniper. Turkeys are migratory in parts of their range, moving between lower elevations for wintering to higher elevations for breeding. Timing of movements can differ annually, depending upon snowfall and tree mast production (Wakeling 1991, Hoffman et al. 1993). Forage includes cone crops produced by mature

ponderosa pine trees, hard mast from oak trees, juniper berries, seeds from grasses and forbs in early seral habitat, and invertebrates. Pine-oak habitats are particularly important for turkeys in the winter (Wakeling and Rogers 1995). Core home range size for turkeys is roughly 26-30 mi² (Wakeling 1991). Since turkeys are a relatively wide-ranging species, they are likely to respond to changes in forest management at small and large spatial scales.

Population Trend

Wild turkeys are currently listed as G5, N5, and S5 (NatureServe 2010). The species is considered to be demonstrably widespread, abundant, and secure, globally, nationally (USA), and statewide (AZ).

Turkey populations in Arizona were fairly robust in the 1960s, but have been in steady decline since that time. Current estimates number the population between 15,000 and 20,000 birds, depending on climatic conditions (AGFD 2011a). Factors contributing to this decline include logging practices, increased human recreational use, fall hunting, disease, grazing, and long-term changes in climatic patterns (Wakeling 1991). Annual statewide survey data from 1960 to 2010 demonstrate a fluctuation in numbers with an overall declining trend (Figure 45; AGFD 2011a). The Coconino and Kaibab NFs represent the core of the turkey's distribution in Arizona, and unlike the statewide declining trend, populations on the two forests have been stable to increasing for the last several years (USFS 2002, 2010).

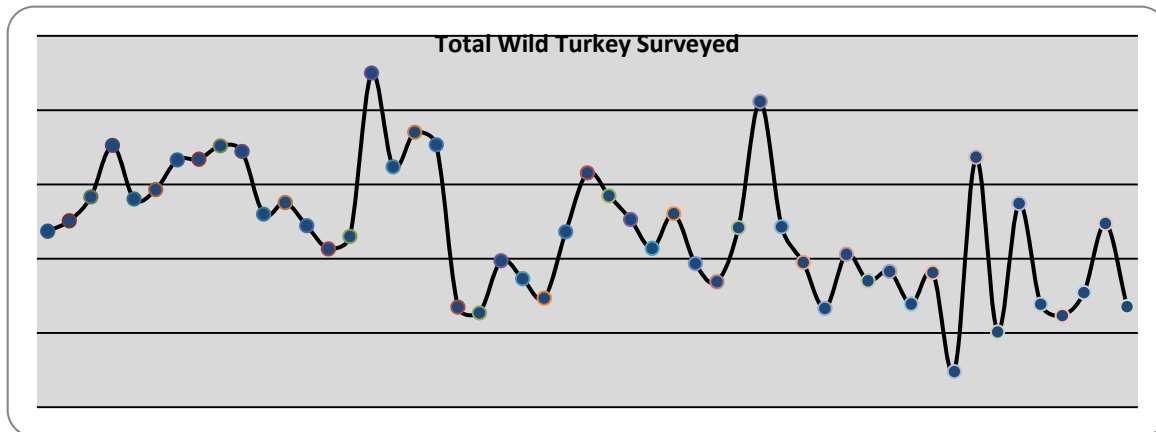


Figure 45. Results of annual statewide turkey surveys 1946 – 2010 (AGFD 2011).

Because of their primary responsibilities for managing wildlife, the main data source for turkey population trend comes from AGFD survey and hunt data. Up until the late 1960s, AGFD conducted standardized driving surveys for turkey. When turkey densities began decreasing, standard survey procedures did not provide good data because of the low number of observations along survey routes (Wakeling 1991). Since that time, AGFD has gotten more consistent and reliable information by using 1) the percent of archery hunters seeing turkeys during archery elk hunts, and 2) the number of turkeys harvested during the spring (T. McCall, AGFD, personal communication, November 2011). Data on percent hunters observing turkey and harvest data are available for 1997 – 2010 (Figures 2 and 3).

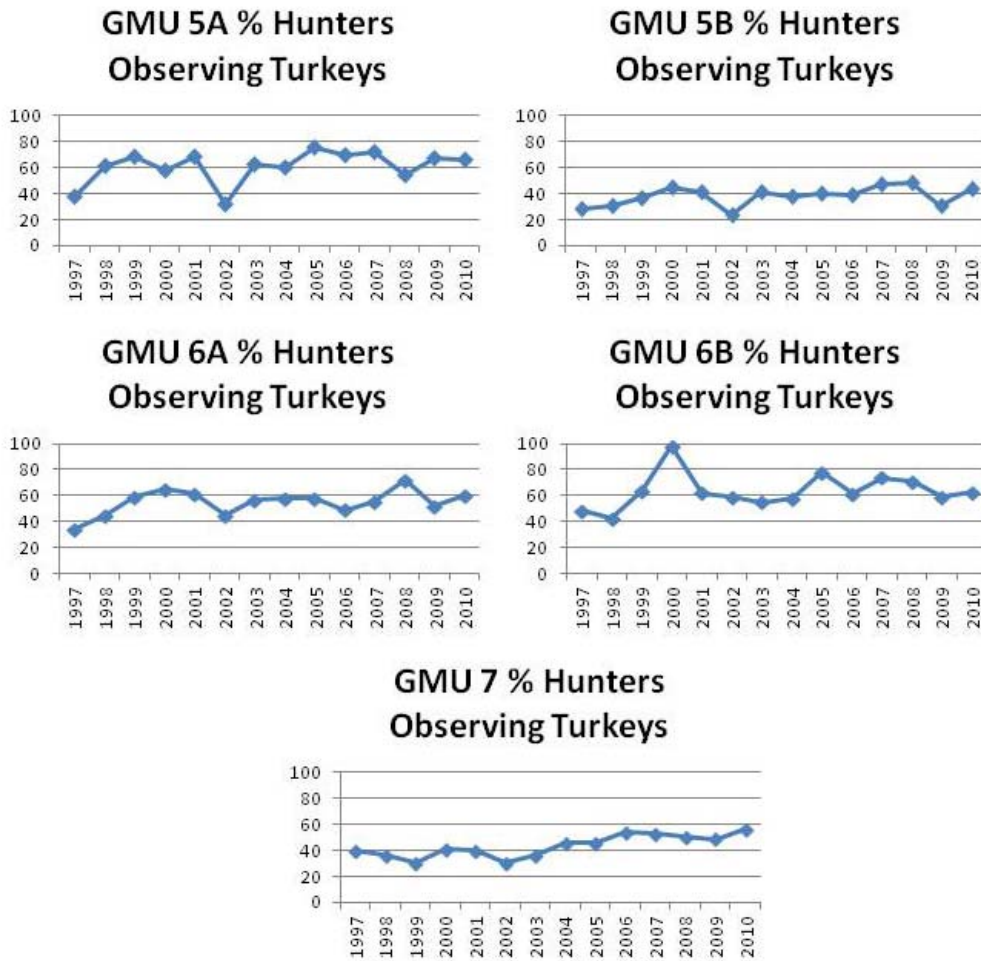


Figure 46. Annual percentage of archery hunters observing wild turkey (1997 – 2010). Coconino National Forest, including Game Management Units 5A, 5B, 6A, 6B, and 7.

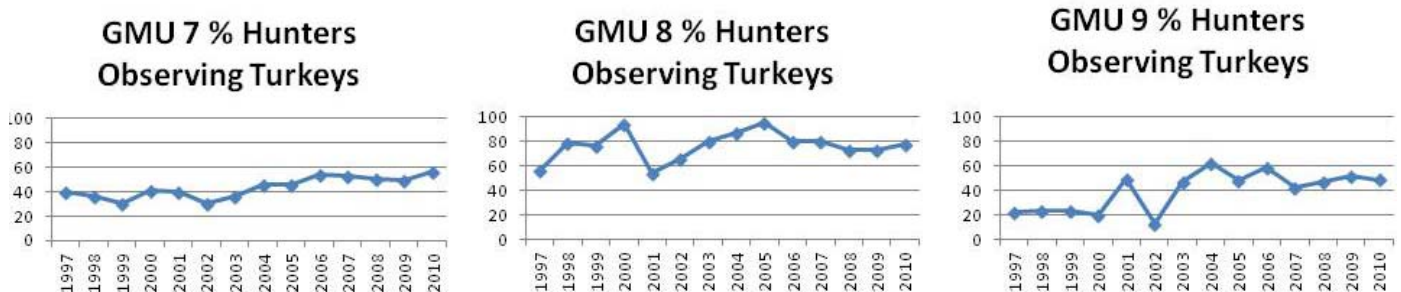


Figure 47. Annual percentage of archery hunters observing wild turkey (1997 – 2010). Kaibab National Forest, including Game Management Units 7, 8, and 9.

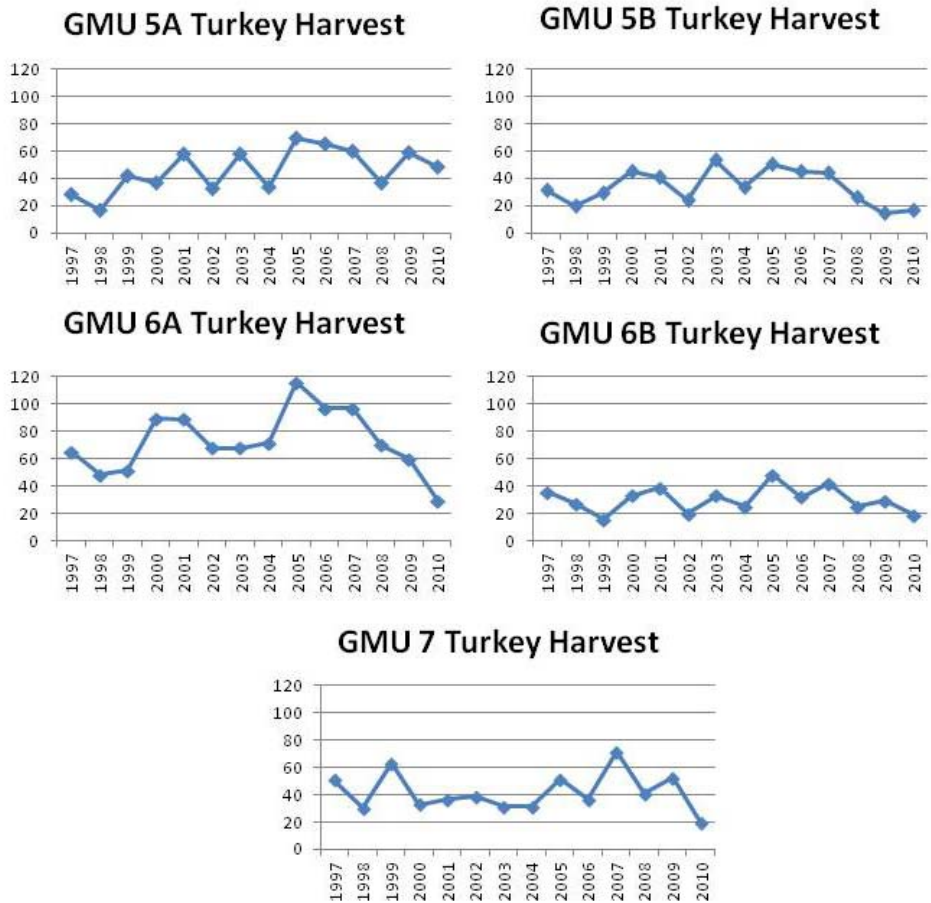


Figure 48. Annual harvest rates for wild turkey (1997 – 2010). Coconino National Forest, including Game Management Units 5A, 5B, 6A, 6B, and 7.

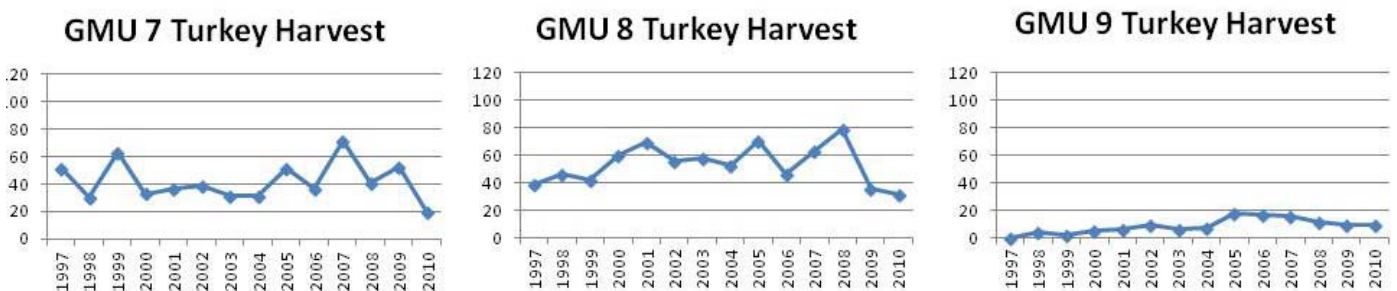


Figure 49. Annual harvest rates for wild turkey (1997 – 2010). Kaibab National Forest, including Game Management Units 7, 8, and 9.

Both indicators for turkey suggest a variable yet stable population trend within the 4FRI project area, on both National Forests.

Habitat Use and Trend

Turkey habitat is typically described for four behaviors: nesting, roosting, foraging, and loafing. There have been several studies examining turkey habitat selection in ponderosa pine on the Mogollon Rim, primarily just east of the 4FRI project area within Arizona Game Management Unit 4A on the Apache-Sitgreaves National Forest (Wakeling 1991, Mollohan et al. 1995, Wakeling and Rogers 1995). The habitat description below is based on these references.

Nesting habitat is best characterized by steep slopes (>40%), with a clumpy-groupy forest structure dominated by trees in the VSS 5 and 6 size class. Turkeys nest on the ground up against rock cliffs, on the uphill side of large trees, or in slash. Canopy cover is typically high (50%) within 0.1 acres of the nest, with dense horizontal cover in the form of a low tree canopy base height, shrubs, or slash.

Roosting habitat is similar to nesting habitat in terms of steep slopes (again >40%), typically in the upper strata of canyons and drainages. Turkeys roost in tree groups that average 36 trees with DBH > 16", where the roost tree is often >24" DBH. The high tree and canopy density within roosts is important for thermal protection, particularly in the winter. Uneven-aged canopy structure also helps provide thermal protection, however unlike in their nesting habitats turkeys select for a higher canopy base height (>24') when roosting.

Clumpy-groupy forest structure is also important for turkeys in their foraging habitats, where they select for small forest openings (0.28 – 0.31 acres) for feeding. Openings can be natural meadows or early seral forests created by logging or natural disturbance, typically located on flatter terrain relative to nesting and roosting habitats. Turkeys select areas with a higher percent cover of forbs and grasses for feeding, and they select for areas of higher plant species richness (and higher invertebrate richness) during the poult-rearing phase. Acorn mast from Gambel's oak can significantly increase the probability of overwinter survival and is connected to productivity in the following year.

Loafing is a behavior common among gallinaceous birds; it is a time when turkeys rest, preen, and take dust baths. Turkey loafing occurs in small (<1 ac) forested patches, adjacent to openings (within 100 ft), dominated by sapling and pole-sized trees, with higher TPA and BA relative to feeding or nesting sites. Course woody debris and fallen snags are commonly used in loafing habitats. Turkeys will also loaf in recently-thinned areas with broadcasted slash, as long as the residual tree density remains high.

Potential Effects

Weather patterns such as precipitation are a driver of turkey populations in the short term, but landscape scale habitat improvements such as 4FRI will make long term gains in turkey abundance over time. Continuing on the current trajectory, forests would continue to provide large patches of trees with higher basal area, canopy density, and interlocking crowns thereby providing thermal and hiding cover for turkey. However, overstory suppression of oak, grass, and forb diversity and productivity will continue to limit forage habitat for turkey. Tree encroachment into openings and meadows will also limit turkey foraging habitat. Late-seral ponderosa pine will

continue to be threatened by unnatural stand densities, creating risk for uncharacteristic, high-severity fire.

Effects of Mechanical Thinning

Avoidance of mechanical thinning on slopes >40% will allow for maintenance of turkey nesting and roosting habitat, although risks from loss to fire will remain. Turkey roosting habitat characteristics overlap with MSO PAC characteristics, and the proposed thinning within the proposed PACs will improve turkey roosting habitat by raising canopy-base height and protecting larger trees from loss from fire. Treatments within NOGO nest stands, where occurring on steeper slopes, will also improve roosting habitat for turkeys. Areas with a high density of sapling and pole-sized trees will be thinned in order to meet desired conditions which will have lower trees per acre than turkey loafing sites. This will significantly reduce availability of turkey loafing habitat. However, loafing sites will still be provided in deferral areas and when site-specific conditions indicate appropriate designation of large groups of VSS 2 and 3 trees. Coarse woody debris requirements set forth in the Forest Plans will continue to provide substrates for turkey use in nesting and loafing areas.

Thinning under the goshawk guidelines will result in a mosaic of interspersed vegetative structural stages and openings that will provide increased understory production and therefore increased foraging habitat quality for turkey. The emphasis on creation of clumpy-groupy forest structure will improve a key component of nesting, roosting, and foraging habitat.

Mechanical thinning will be used to reduce overstory competition with Gambel oak, where appropriate. This action is expected to help increase acorn mast production (Okonburi 1999), a critically important food source for overwintering turkeys.

The use of AGFD connectivity data has been used inform spatial arrangement of mechanical thinning treatments that favor late-seral forest dwelling species such as turkey (AGFD 2011b). This treatment design, used in combination with soils information and historic evidences, will enhance connectivity for turkey populations.

Proposed thinning treatments may cause visual or auditory disturbance to individual turkey, although these effects would be short-term. Best management practices will place seasonal restrictions on logging activities in known nesting and roosting areas to reduce the likelihood of direct impacts.

The inclusion of the LTRS and the incorporation of watershed and wildlife research areas would retain higher basal area and canopy cover contributions from large-diameter trees, which should benefit turkeys for nesting and for roosting habitat. Similarly, the larger forest patches retained in the watershed and wildlife research areas could provide additional areas for turkey loafing, nesting, and roosting.

Since turkeys select for forested edges of grasslands where increased herbaceous productivity provides foraging opportunities, grassland treatments will likely benefit turkeys.

Effects of Prescribed Fire

Landscape-scale application of prescribed fire will more closely simulate historic fire regimes, restoring disturbances that work to create openings, and increase resiliency in late-seral ponderosa pine forests. This is expected to benefit turkeys.

Burning shrubs, slash, and understory vegetation will reduce hiding and nesting cover for turkeys in the short term. Thinning and burning in Gambel oak thickets could reduce nesting and foraging habitat for turkeys in the short term. However, low-intensity fire can increase diversity and productivity in grasses and forbs, in turn increasing the likelihood of higher invertebrate diversity, which will benefit turkeys especially in the poult-rearing phase. Benefits could be expected as soon as 1-2 years following prescribed fire (Canon et al. 1987 in Pilliod et al. 2006).

Less prescribed fire would reduce the direct impacts of burning and smoke. However, turkeys evolved in southwestern ponderosa pine forests that were characterized by frequent, low-intensity fire. This frequent fire helped maintain herbaceous openings and meadows, which are important for turkey foraging. Reduced burning would also limit the quality of turkey habitat within the project area.

Disruption of normal behavioral patterns could occur to turkeys during burning activities. Prescribed fire maintenance treatments would occur every 2 to 10 years, which would increase the frequency of fire disturbance on turkey. Effects would likely be due to direct disturbance by human presence during burning activities as well as smoke inhalation. However, human disturbance and smoke effects should be transitory in nature and short-term. Since turkeys are capable of moving several miles in any given day, it is likely they will be able to move out of smoke paths in the event of prescribed burns. Best management practices will place seasonal restrictions on burning activities in known nesting and roosting areas to reduce the likelihood of direct impacts.

Effects of Aspen, Spring, and Ephemeral Channel Restoration

Fencing aspen, springs, and ephemeral channels will allow for recruitment of new aspen and creation of early-seral conditions. Turkeys could likely fly over fences when the protected area is large enough to allow them to negotiate the barrier, as in aspen stands. Fences would likely present barriers in small areas, such as spring exclosures. Ephemeral channels may be a mix of both. Reduction in forage will have localized impacts on turkey who will use those areas for foraging, but this is not expected to have impacts at the population level. Exclusion of turkey from springs and ephemeral channels will limit their ability to access those forage and water resources. However, the increased herbaceous and tree mast productivity resulting from forest thinning is likely to offset turkey utilization of riparian areas. Springs and ephemeral channels are less reliable water sources for turkey and exclusion of these areas should not have an impact given the relatively high availability of permanent, artificial water sources across the project area.

Effect of Road Closures/Obliteration

Closure and obliteration of unauthorized roads will positively impact turkeys. Turkeys are known to avoid roads and heavily used recreational areas (Wakeling 1991).

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Pronghorn



Pronghorn (*Antilocapra americana*) is an indicator of grassland habitats and an economically and socially important species. Pronghorn are associated with grasslands, meadows, and savannahs on the Coconino and Kaibab National Forests and are typically found in flat or rolling areas, along foothills, in mountain valleys, and on plateaus. Pronghorn prefer ecosystems with a mixture of grasses, forbs, and shrubs to provide for forage requirements and fawning areas (Yoakum 2004). They evolved to avoid predation through sight and flight; habitats with low-growing vegetation and/or sparse tree density are important for pronghorn. Pronghorn avoidance of areas with high tree density and cover differs markedly

from deer and elk patterns of habitat selection within the 4FRI project area. Home ranges have been measured in the vicinity of Wupatki and Sunset Crater National Monuments which are adjacent to the Coconino NF, and were estimated between 22.8 and 50.2 mi² for females and males, respectively (Ockenfels et al. 1997). Since pronghorn are relatively wide-ranging species, they are likely to respond to changes in forest management at small and large spatial scales.

Population Trend

Pronghorn are currently listed as G5, N5, and S5 (NatureServe 2010). The species is considered to be demonstrably widespread, abundant, and secure, globally, nationally (USA), and statewide (AZ).

A number of factors have been identified that affect pronghorn populations including severe weather, amount and timing of precipitation, habitat fragmentation, diet overlap with other grazers, reductions in fawn hiding cover, woody vegetation encroachment, predation, and nutritional concerns (Neff 1986, Ockenfels 1996). Annual statewide survey data from 1946 – 2010 demonstrate this fluctuation in pronghorn abundance, and show an expansive increase in pronghorn during the 1970s and 1980s, followed by a contemporary decline in pronghorn surveyed that began in the mid 1990s but has stabilized since 2005 (Figure 50; AGFD 2011a). Based on the contemporary decline, the determinations in both Forest Plans indicate a variable to decreasing population trend (USFS 2002, 2010).

Locally, there has been substantial focus on declining pronghorn populations on Anderson Mesa, an area which is included in GMUs 5A and 5B (Yoakum 2002). Pronghorn populations and productivity on Anderson Mesa have been declining significantly since the 1940s (Yoakum 2002). However, significant efforts have been taken to restore higher quality habitat for pronghorn in this area since 2002. The 4FRI project includes a portion of Anderson Mesa.

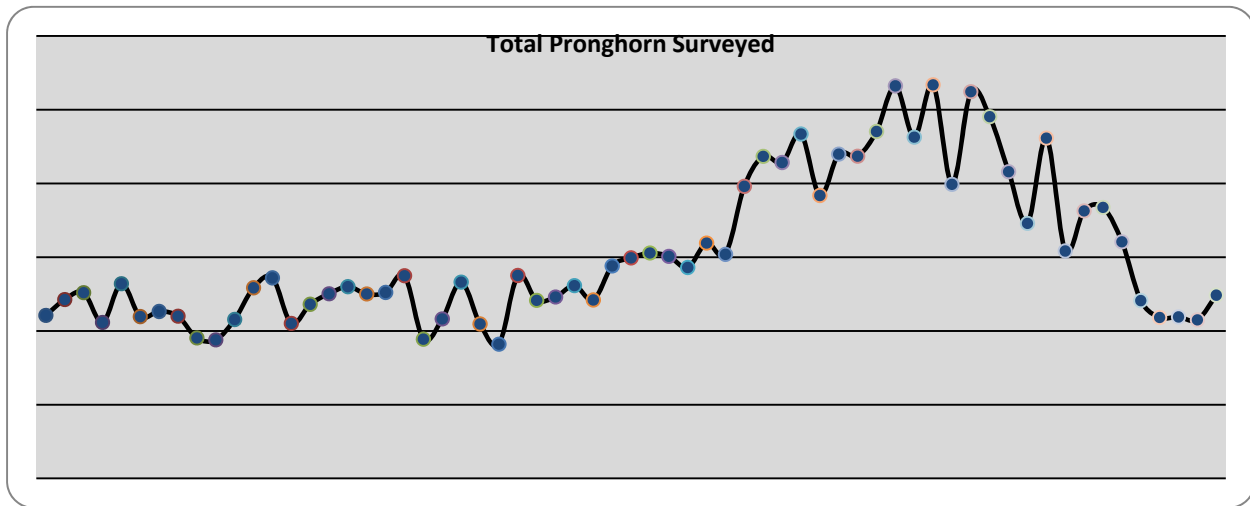


Figure 50. Results of annual statewide pronghorn surveys 1946 – 2010 (AGFD 2011).

Because of their primary responsibilities for managing wildlife, the main data source for pronghorn population trends comes from AGFD survey and hunt data. Data used in this analysis were collected by game managers using fixed-wing aerial surveys. Detection rates for pronghorn are highly variable across years depending on weather, annual green-up (affects surveyor's ability to see animals against an otherwise brown back-drop), and how pronghorn shift their distribution in response to localized precipitation patterns. This inconsistency makes interpretation of population data difficult and uncertain (T. McCall, personal communication, November 2011).

AGFD evaluates trends in pronghorn populations based on 1) annual surveys, and 2) model-derived population estimates. Data are displayed by Game Management Unit (GMU; Figure 51). The two best indicators for pronghorn population trend are 1) the number of pronghorn observed during annual surveys (Figure 52), and 2) number of fawns per 100 does observed during annual surveys (Figure 53). These two indicators are more reliable than population modeling estimations for pronghorn because of the uncertainty in certain model parameters such as starting population size and annual mortality rates (Tom McCall, personal communication, November 2011). For the Coconino NF, data are relevant from GMUs 5A, 5B, 6A, 6B, and 7. For the Kaibab NF, data are relevant from GMUs 7, 8, and 9. There is some intermingling of pronghorn herds across the two Forests, primarily between GMUs 6B and 8 as well as GMUs 7 and 9. All GMUs are relevant to the 4FRI project area.

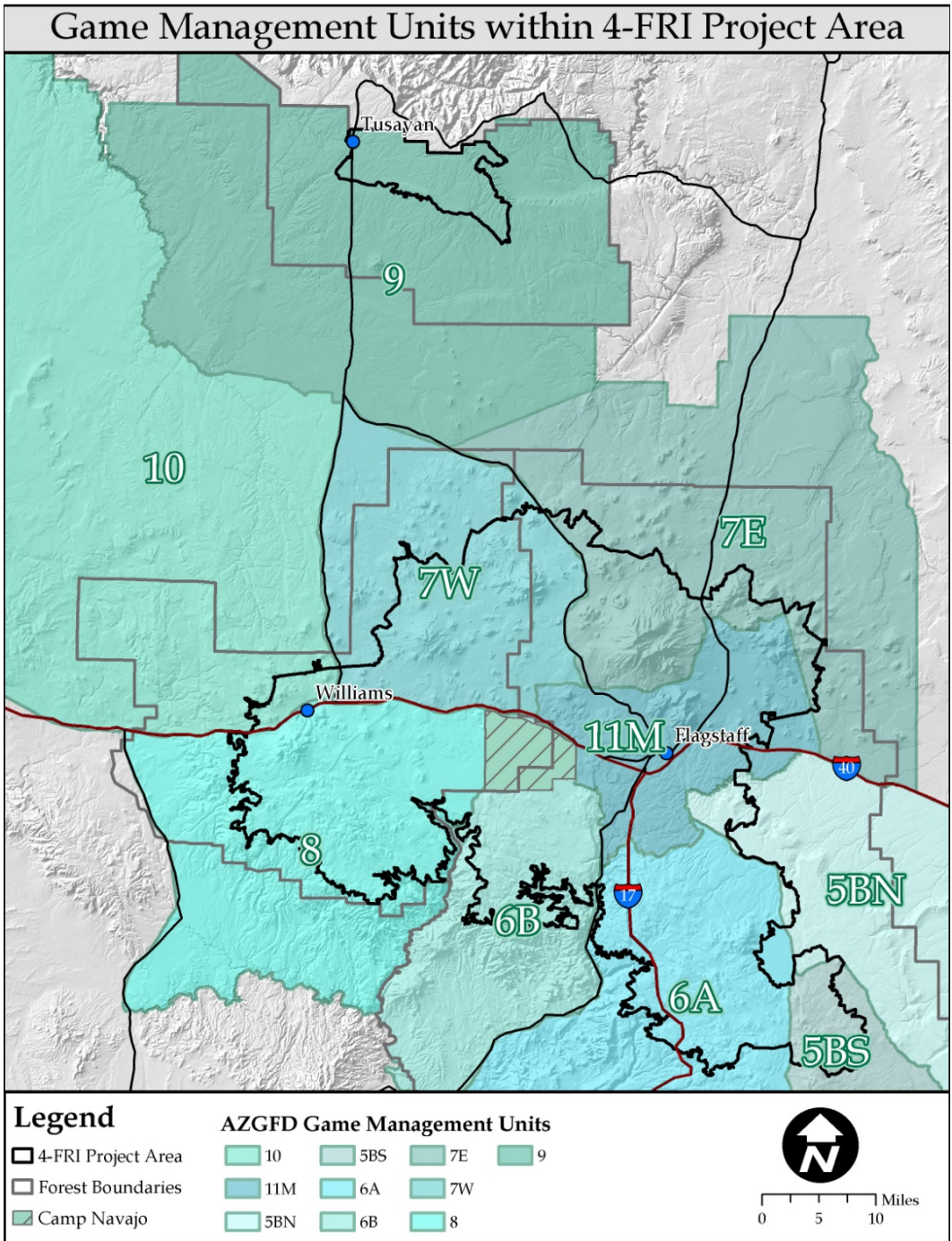


Figure 51. Arizona Game and Fish Department Game Management Units within the 4FRI Project Area.

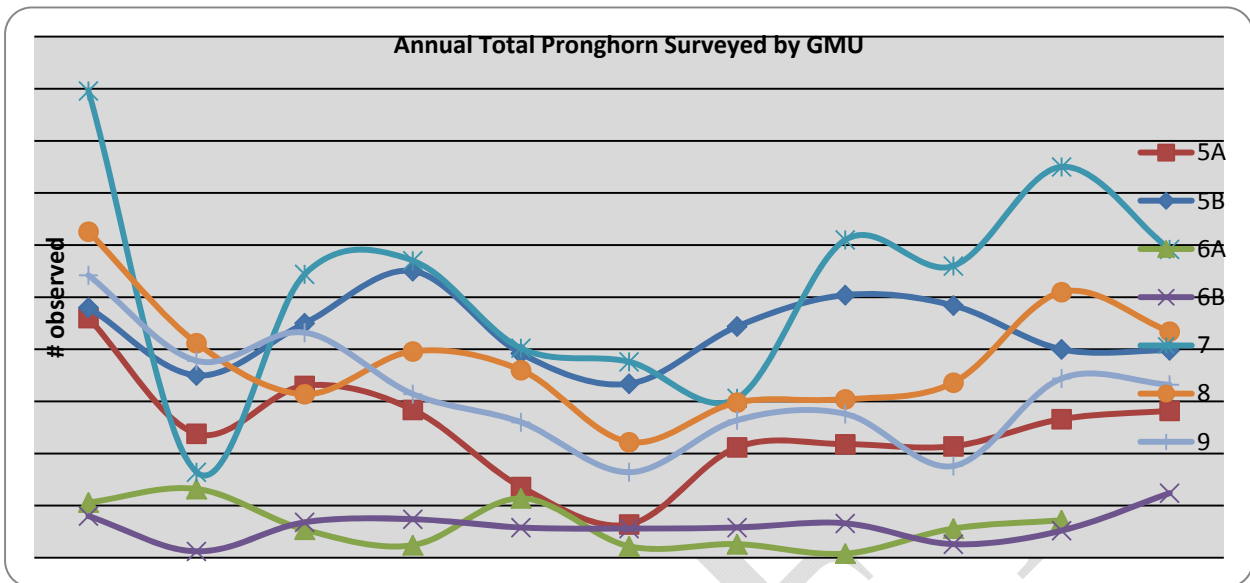


Figure 52. Total number of pronghorn surveyed by Game Management Units within the 4FRI Project Area, 2001 – 2011.

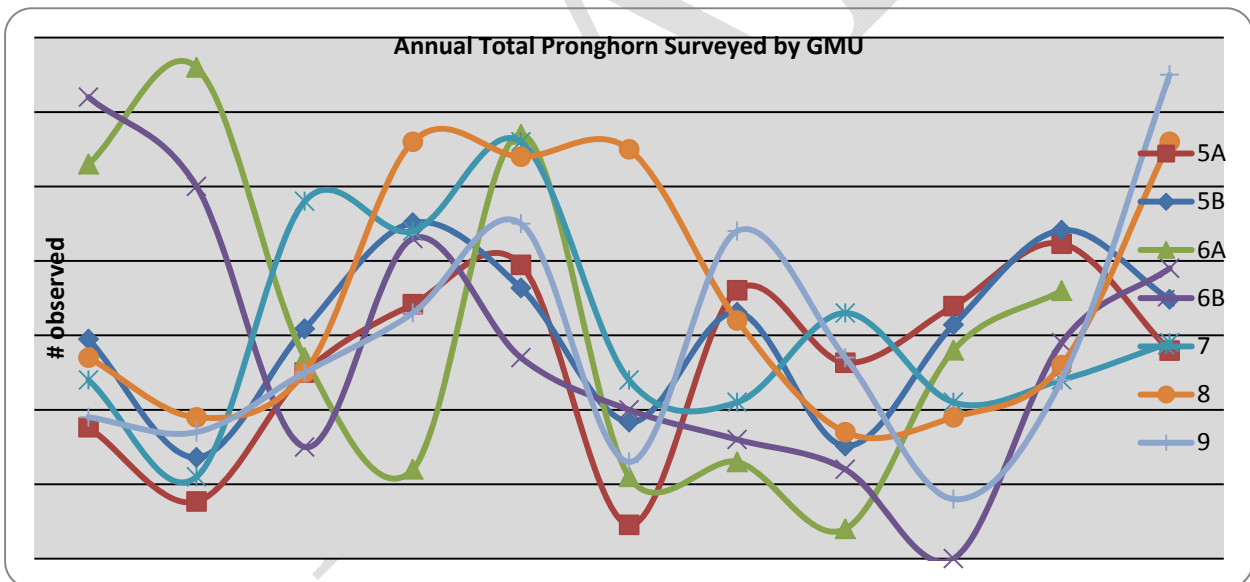


Figure 53. Fawn:100 Does ratios for pronghorn surveyed by Game Management Units within the 4FRI Project Area, 2001 – 2011. Fawn:Doe ratios are an indicator of annual productivity, which is considered to be the limiting factor for pronghorn populations within the 4FRI project area.

AGFD population estimates are then derived from a model that takes annual surveys, fawn:doe ratios, buck-doe ratios, harvest, and estimated annual background mortality into consideration. Modeled mortality rates are based on limited available data from AGFD. One limitation of this model is that it requires modelers to select a beginning population size for bucks and does for

which reliable data are lacking. Modelers must set beginning population size using anecdotal inference from earliest known survey numbers. For this reason, AGFD recommends greater emphasis on trends rather than absolute numbers. Population trend estimates are available from 2002 through 2011 for both Forests (Figure 54 and Figure 55).

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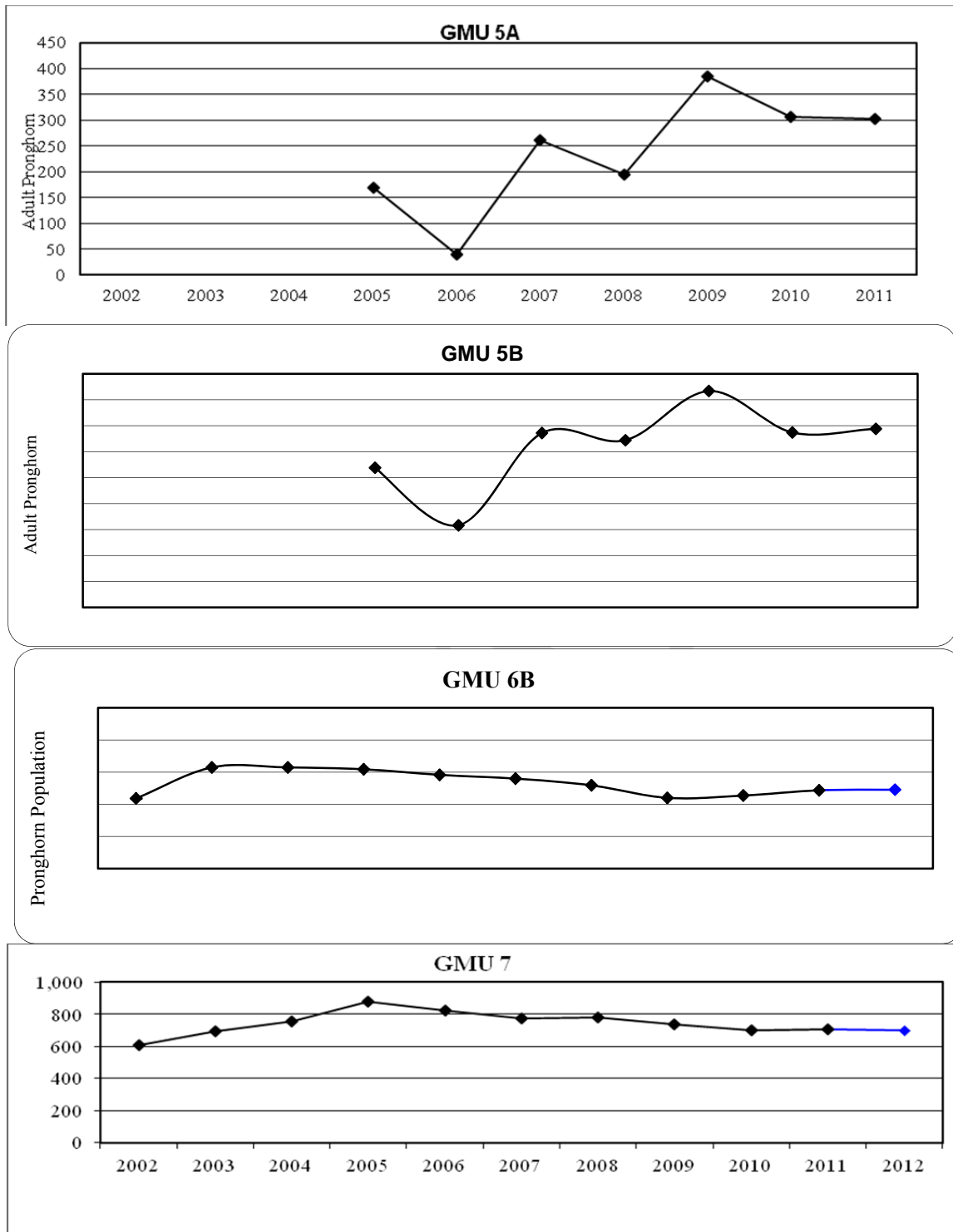


Figure 54. Estimated population trends for pronghorn, 2002-2011, on the Peaks Ranger District of the Coconino National Forest, including Game Management Units 5A, 5B, 6B, and 7. (6A data were unavailable). Data are unpublished but available from the AGFD Flagstaff Regional Office (T. McCall, personal communication, October 2011).

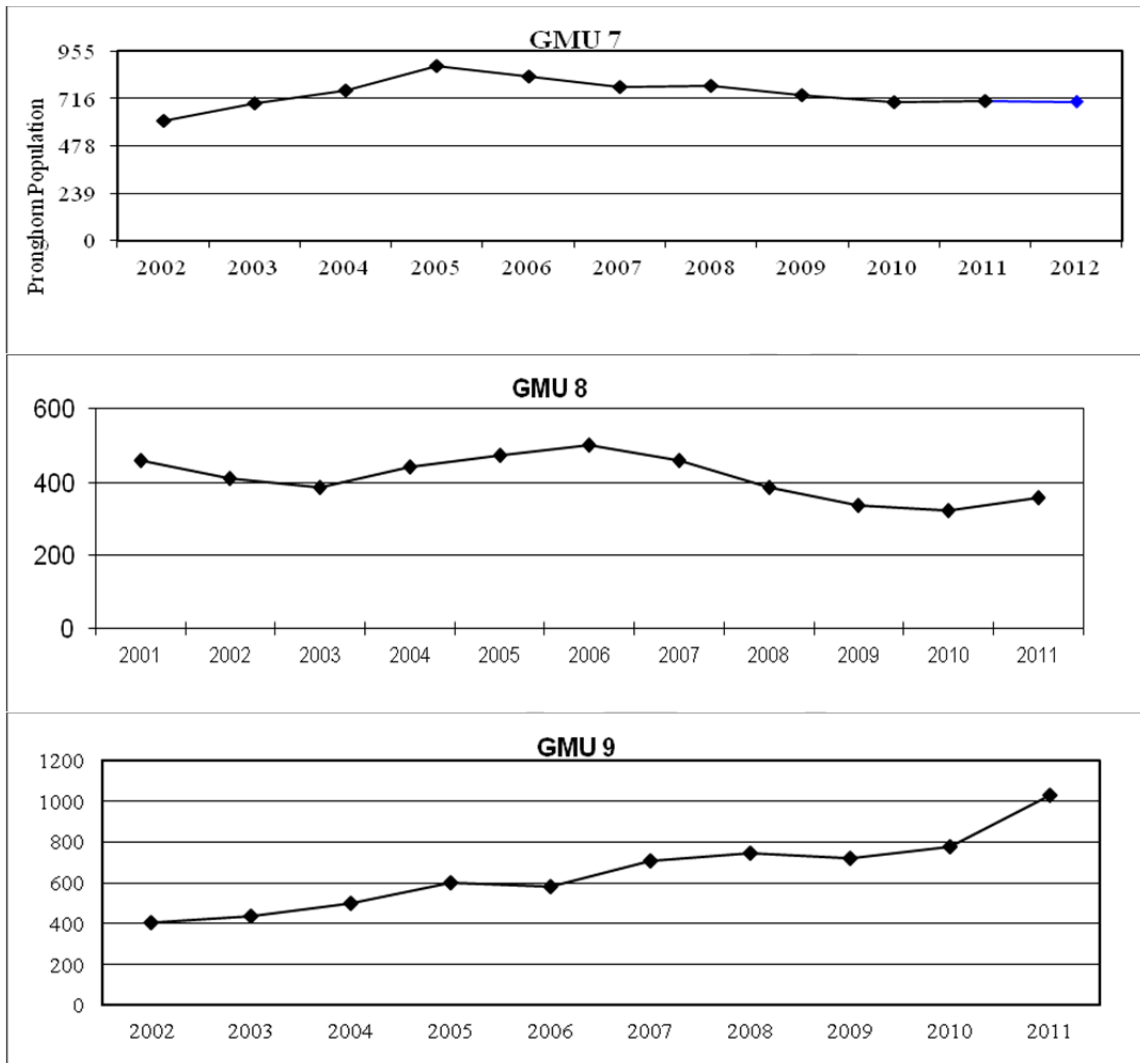


Figure 55. Estimated population trends for pronghorn, 2002-2011, on the Kaibab National Forest, including Game Management Units 7 and 8 for the Williams Ranger District and Unit 9 for the Tusayan Ranger District. Data are unpublished but available from the AGFD Flagstaff Regional Office (T. McCall, personal communication, October 2011).

Overall, population models for all GMUs within the 4FRI project area indicate a stable trend over the last decade.

Habitat Use and Trend

Pronghorn are adapted for sight and flight; visibility and an ability to run at full speed in open, gentle terrain are crucial for predator avoidance. Pronghorn avoid areas of high tree and/or tall shrub density, preferring areas with <30% tree/shrub cover and where vegetation height is less than 0.61 m tall (Ockenfels et al. 1994). Woody plant invasion into grasslands and meadows has been identified as one of the leading factors reducing habitat quality for pronghorn, sometimes

leading to isolation of populations when combined with other sources of habitat fragmentation such as fences and roads (Neff 1986, Ockenfels et al. 1994, Ockenfels et al. 1996, AGFD 2002, Waddell et al. 2005). A recent study of habitat quality in and around Camp Navajo Army National Guard, which is centrally located within the 4FRI project area, found that pronghorn habitat quality was significantly limited by high ponderosa pine densities and encroachment into meadows and grasslands (Waddell et al. 2005). Of particular note was the encroachment of pine trees into Garland Prairie; a critically important grassland used for pronghorn fawning.

Tree and shrub cover are occasionally used by pronghorn, indicating some selection for savannah conditions as well as grasslands. Isolated, large trees will receive some use by pronghorn for shade during hot summer months (Ockenfels et al. 1994). And low shrubs can play a key role as hiding cover for fawns (AGFD 2002).

Several local studies and plans have recognized the importance of grass, forb, and shrub diversity for sustaining pronghorn nutritional needs throughout the year as well as providing hiding cover for fawns (Ockenfels et al. 1994, Ockenfels et al. 1996, AGFD 2002, Yoakum 2002, Waddell et al. 2005). These studies recommend removal of encroaching woody tree species from grasslands and savannahs as well as prescribed burning to reinvigorate production and diversity of understory forbs which have the highest nutritional value during fawning. Availability of water is also important for pronghorn, particularly for lactating females (Ockenfels et al. 1994).

Potential Effects

Effects of Mechanical Thinning

Availability of grasslands, meadows and savannahs would continue to be limited for pronghorn use under current conditions. Tree density and canopy cover within historic meadows and grasslands continue to limit sighting distances and suppress productivity of grasses and forbs for foraging and fawn hiding cover. Connectivity of pronghorn habitat would continue to decline under this alternative. Grassland habitats will continue to decline in the absence of natural disturbances such as fire and without management intervention.

The restoration of historic grasslands and meadows and savannah by thinning encroaching pines will benefit pronghorn habitat connectivity and invigorate productivity of grasses and forbs. Specifically, grassland restoration activities in the vicinity of Garland Prairie would be beneficial for pronghorn because of the crucial role Garland Prairie serves as fawning habitat. Thinning would improve sight distances and grass-forb species diversity. Grass-forb cover is expected to increase within 1-2 years post-treatment, which should improve pronghorn foraging and fawning habitats. Restoring large areas to open conditions preferred by pronghorn (<30% in forested cover) would significantly contribute to increases in pronghorn habitat.

The AGFD connectivity data can inform spatial arrangement of mechanical thinning treatments that favor grassland wildlife such as pronghorn (AGFD 2011b). This treatment design, used in combination with soils information and historic evidences, would enhance connectivity for pronghorn populations.

Proposed thinning treatments may cause visual or auditory disturbance to individual pronghorn, although these effects would be short-term.

Effects of Prescribed Fire

Landscape-scale application of prescribed fire would more closely simulate historic fire regimes, restoring disturbances that work to maintain grasslands, meadows, and savannahs. Low-intensity fire is expected to increase growth and diversity of herbaceous vegetation, which would provide increased forage in the long term, with expected benefits as soon as 1-2 years following prescribed fire (Canon et al. 1987 in Pilliod et al. 2006). These actions would benefit pronghorn.

Reducing acres of prescribed fire would reduce the direct impacts of burning and smoke. However, pronghorn evolved in southwestern grasslands and savannahs that were characterized by frequent, low-intensity fire. This frequent fire helped maintain grassland boundaries, herbaceous openings, and the inherent connectivity of these habitats historically.

Disruption of normal behavioral patterns could occur to pronghorn during burning activities. Prescribed fire maintenance treatments would increase the frequency of fire disturbance on pronghorn. Effects would likely be direct disturbance by human presence during burning activities as well as smoke inhalation. However, human disturbance and smoke effects should be transitory in nature and short-term. Since pronghorn are capable of moving several miles in any given day, it is likely they will be able to move out of smoke paths in the event of prescribed burns. Burning in known fawning areas between April 15 and June 15 could impact young, less-mobile fawns.

Non-native, invasive plants can negatively impact pronghorn habitat quality through a process of invasion, competition, and eventual elimination of native grasses and forbs through unnatural acceleration of fire frequencies in pinyon-juniper and ponderosa pine systems. The risk of non-native plant invasion following restoration treatments has the potential to negatively impact pronghorn habitats in the long-term. Following Best Management Practices for noxious weed prevention should mitigate this threat.

Effects of Aspen, Spring, and Ephemeral Channel Restoration

Pronghorn do not select for aspen habitats and would therefore not be affected by aspen restoration. Since pronghorn are highly mobile and relatively wide ranging, the small size of fence projects for aspen, spring, and ephemeral channel restoration activities will not impact pronghorn movement. Spring restoration, if located adjacent to grassland or savannah, is expected to improve habitat quality for pronghorn by improving available water sources in the long term.

Effects of Road Closure/Obliteration

Closure and obliteration of unauthorized roads will positively impact pronghorn. Pronghorn are known to avoid roads and heavily used recreational areas (Ockenfels et al. 1996).

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Appendix 7. Mexican Spotted Owl Biology and Ecology in Relation to the 4 Forest Restoration Initiative



**Bill Noble, 4FRI Wildlife Biologist
April 2012**

Introduction

This report summarizes current the status and ecology of the Mexican spotted owl (MSO) within the Upper Gila Mountains Recovery Unit (UGM RU). It includes a review of the scientific literature. In particular, it includes summaries from the recent Rocky Mountain Research Station General Technical Report 256 (Ganey et al. 2011) which was written at the request of U.S. Forest Service personnel associated with the Four Forests Restoration Initiative (4FRI). 4FRI occurs entirely within the UGM RU which supports over half of the known population of Mexican spotted owls. Consequently, the UGM population is viewed as important to stability within the overall range of the owl, and management that impacts owls within the UGM RU could affect owl populations beyond that RU.

Existing Conditions

The primary administrator of lands supporting MSOs in the Southwest is the FS. Most MSOs have been found in the 11 NFs of Arizona and New Mexico (Region 3 of the FS).

The MSO is widespread and the threats facing the owl vary by location. MSO densities, food habits, degree of isolation, and other aspects of their biology differ in different locations. For these reasons, the USFWS described 6 Recovery Units within the Southwest United States (Figure 56). Recovery Units were delineated based on the following information, presented in order of importance: (1) physiographic provinces, (2) biotic regimes, (3) perceived threats to owls or their habitat, (4) administrative boundaries, and (5) known patterns of owl distribution (USDI FWS 1995). The Coconino and Kaibab NFs occur in the UGM RU.

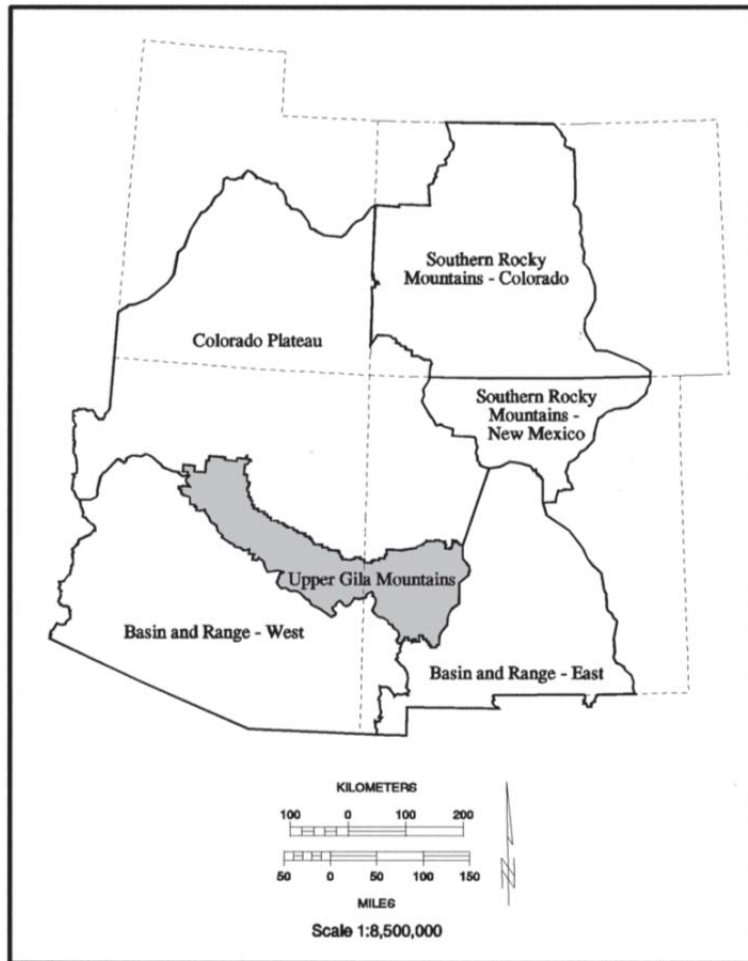


Figure 56. Recovery Units within the United States recognized in the Mexican spotted owl Recovery Plan (USDI FWS 1995).

MSO Habitat

MSOs are described as nocturnal “perch and pounce predators” that locate prey from an elevated perch by sight or sound, then pounce on the prey, capturing it with their talons (USDI 1995). They commonly eat small- and medium-sized rodents such as woodrats, peromyscid mice, and microtine voles, but also consume bats, birds, reptiles, and arthropods. Their diet varies by geographic location. The vegetation within UGM RU has been described as a zonal pattern of grasslands within woodland and forest cover types (USDI 1995). Combined with the diverse topography, this creates abundant and widespread forest-meadow interfaces. Because of this interspersed of meadows and grasslands, MSOs in the UGM RU have a higher reliance on voles compared to other prey species and MSOs in other RUs (USDI 1995).

MSOs most commonly occur in mixed-conifer forests and canyons within the UGM RU. They also occur in ponderosa pine forests with developed Gambel oak understories. Gambel oak is considered a long-lived seral species in these forests (USDI 1995). A study on the Coconino NF found the presence of mature and old-growth oak an important factor in distinguishing MSO nest sites from all other plots types (May et al. 2004). They found MSO primarily nested in Gambel

oak greater than 18 inches dbh (May et al. 2004). Alligator, Rocky Mountain, one-seed, and Utah juniper and pinyon pine also occur in pine and pine-oak forests of the Southwest.

Abella (2008) reported small Gambel oak have escalated since settlement in the late 1800s, with densities increasing from 4- to more than 63-fold. There are three basic growth forms in Gambel oak: shrubby thickets of small stems, pole-sized clumps, and large trees. Top-killed oak resprout prolifically and this can maintain the shrub form (Abella and Fule 2008). Historical fire return intervals in southwestern pine-oak often averaged less than 10 yrs (Abella and Fule 2008). Local research documented oak can be maintained during low-intensity burning with more than 66 percent of oak less than six inches dbh alive at least five years after two prescribed burns (Abella and Fule 2008). Oak less than two inches dbh had survival rates less than 20 percent (Abella and Fule 2008) but resprouted vigorously (Fule et al. 2002).

Soil properties, species richness, plant cover, and the distribution of cool- and warm-season grasses are canopy-type specific (Abella 2009). Research on the Coconino NF found three to eight times greater plant cover in openings than any tree canopy type, supporting species that were infrequent below trees (Abella 2009). Similarly, some understory species occurred more frequently beneath Gambel oak canopies. There were no species that were most frequent below ponderosa pine (Abella 2009). Thinning pine can recreate canopy openings and maintain productive and diverse understories on this landscape (Abella 2009). Thinning pine also consistently increases oak diameter growth for promoting large oaks (Abella 2008).

The following section was extracted from Ganey et al. 2011: Although Forest Service managers do not manipulate populations of native wildlife directly, understanding life history and habitat use is fundamental for informed conservation planning. Conservation of wildlife populations requires information about the factors that influence vital rates and ultimately population growth. Similar to other spotted owl subspecies, average reproductive rates are generally low in MSO populations. Mexican spotted owls breed sporadically and do not nest every year (Gutiérrez and others 1995, White and others 1995, Stacey 2010). Reasons for this pattern of sporadic breeding are unknown, but temporal variation in food resources and weather are suspected to influence both the proportion of pairs nesting and the proportion fledging young. Survival estimates for MSOs within the UGM RU generally indicate relatively high survival rates for adult owls, intermediate survival rates for subadult owls, and relatively low survival of juvenile owls. While this pattern has been observed in the better-studied northern (Burnham and others 1996, Anthony and others 2006) and California subspecies of spotted owls (Franklin and others 2004, LaHaye and others 2004), temporal variation in survival rates appears to be greater in MSOs (Seamans and others 2002) than in the other subspecies. In a study of 2 MSO populations, Seamans et al. (2002) found that on the Coconino NF precipitation from the previous year explained 73% of temporal variation in reproductive output, and precipitation from the previous monsoon season explained 53% of the temporal variation in survival. In New Mexico, precipitation from the previous monsoon explained 42% of temporal variation in reproductive output, and precipitation from the previous winter explained 56% of temporal variation in owl survival. For both study areas, reproductive output varied more than survival across years. This life history strategy allows owls to reproduce when conditions are favorable and to survive unfavorable periods with little or no reproduction.

The amount and arrangement of suitable habitat likely drives patterns of owl distribution (UDSI FWS 1995: 83). In most spotted owl populations studied, however, differences in habitat composition and configuration among owl territories explained less of the variation in owl vital

rates among these territories than did weather (Franklin and others 2000, Olson and others 2004, Blakesley and others 2005, Dugger and others 2005). These studies suggest that temporal variation in climate is more variable than spatial variation in habitat among occupied owl territories, and that climate therefore is an important driver of vital rates within occupied owl habitat. The studies focused on areas that owls had already selected as home ranges. These areas presumably represent high-quality spotted owl habitat. There is far less variability in habitat among these territories than between these territories and randomly available areas on the landscape. In at least some cases, aspects of within-territory habitat configuration that were optimal for survival were suboptimal for reproduction (Franklin and others 2000).

MSO Prey Species

MSOs in the UGM RU take more microtine voles and fewer woodrats than owls in other RUs (USDI 1995). Peromyscid mice are another key prey species, perhaps because they are ubiquitous in distribution and occupy variable habitats (USDI 1995). The inherent interspersed forest and meadow as well as historical patterns of open pine-oak forest may have influenced available prey and the MSOs diet.

Graminoid species function as both food and cover for Mogollon voles. They select areas with high grass cover and selectively feed on grasses with C₃ photosynthetic pathways (“cool season” grasses that flower in late spring or early summer; Chambers and Doucett 2008). Conversely, microhabitat characteristics do not appear to explain deer mouse distribution as well as simpler macrohabitat features (Coppeto et al. 2006). When small mammal populations were measured against forest basal area (BA), both Mogollon voles and deer mice responded negatively to increasing BA (Bagne and Finch 2009, Kalies et al. 2012). Two studies conducted within the 4FRI area concluded Mogollon voles and deer mice responded positively to reductions in overstory BA, noting strong associations with understory vegetation (Converse et al. 2006, Kalies et al. 2012). Overall, small mammal communities can benefit from thinning treatments in western fire-prone ecosystems, particularly when a variety of forest structural types are retained for dense forest obligates (Converse et al. 2006, Noss et al. 2006, Kalies et al. 2012). Interestingly, Bagne and Finch (2009) found winter precipitation could have a negative effect on deer mouse populations, but thinning treatments focused on restoring forest structure reversed this trend. The Recovery Plan notes total prey biomass may be more influential on the owl’s fitness than abundance of any particular prey species (USDI 1995).

The following section was extracted from Ganey et al. 2011: The strong link between raptors and their food is well documented (Newton 1979). Understanding a predator’s food choices along with the natural and life history of its common prey species can provide practical information for conserving and enhancing the predator’s habitat. Several studies provided information on diets of Mexican spotted owls within the UGM RU based on examination of prey remains from regurgitated owl pellets. However, soft-bodied prey (for example, insects such as butterflies and moths; Lepidoptera) may be under represented in pellets.

Several studies have estimated prey abundance within ponderosa pine or ponderosa pine–Gambel oak forests within the UGM RU (Table 6). Estimates varied among studies, but abundance typically was both greater and more variable for deer mice than for most other species. Density of deer mice was the most variable, ranging from a high of 4.9 mice per acre (12.2 ha⁻¹) during summer 1991 to a low of 1.3 mice ac⁻¹ (3.3 ha⁻¹) during winter. Relative abundance of brush mice and woodrats generally was low in all seasons and years.

Table 6. Density (range in number per acre) of selected small mammals in ponderosa pine and ponderosa pine–Gambel oak forest, Arizona.

Source	Deer mouse	Brush mouse	Mexican woodrat	Pocket gopher
Goodwin and Hungerford (1979)	2–19	6–20	2–10	<0.2
Block and others (2005)	1–5	0–2	0–0.4	
Kyle and Block (2000)	0.4–4.7			
Converse and others (2006)	2.2–12.6 ¹	2.2–12.6 ¹	0–2.5	

¹ Estimate provided in Converse and others (2006) was for deer and brush mice combined.

Ward (2001) estimated biomass of prey species during summer within cover types (mid- and late-seral stage mixed–conifer forest, grassland, and ponderosa pine forest and pinyon-juniper–oak woodland) and evaluated variability in summer biomass among years. Biomass of all species except the Mexican woodrat differed significantly ($P < 0.05$) across years, and the year effect was nearly significant for woodrats ($P = 0.059$). Cover type by year interactions were observed for brush mice and both vole species, indicating that population trends were not always synchronous in different cover types. Similar interactions were not observed for deer mice and woodrats.

A study in the Sacramento Mountains, New Mexico (Basin and Range-East RU, Ward 2001) found that reproductive output of spotted owls was influenced by abundance of smaller rodents such as mice and voles in mixed-conifer forests. Abundance of these same prey species in two other cover types (montane meadow and xeric forest) had little influence. Temporal variability in abundance of these rodents was greater than spatial variability among cover types. That is, rodent abundance varied more among years than among cover types within year.

Available data on spotted owl diet composition suggest that owls are opportunistic predators that eat a wide variety of prey but typically prey primarily on a relatively few groups of small mammals that are active at night. Significant relationships between consumption of large prey and successful breeding have not been observed in Mexican spotted owls, and efforts to link owl reproduction to consumption of particular prey species have been mostly unsuccessful. In fact, owl reproduction appears most linked to combined biomass of multiple prey species (for example, Ward 2001), as might be expected in an opportunistic predator. Given the variation in habitat relationships across the small mammal community, a diversity of various habitat features across the landscape likely will best maintain high diversity, ensure maintenance of important ecological functions in that community (Kalies and Chambers 2010), and buffer against population fluctuations of individual prey species to provide a more constant food supply for the owl (Sureda and Morrison 1998, Ward 2001, Block and others 2005). An important consideration here is that many small mammals may respond to variation in habitat features at relatively fine scales and different species may respond to habitat features at different scales.

Because total prey biomass may be more influential on MSO fitness than the abundance of any individual prey species, the Recovery Plan (USDI 1995) recommends managers provide diverse habitats to support a diverse prey base. For example, Mexican voles are found in areas with high herbaceous cover, especially dense grass cover, while Mexican woodrats are typically found in areas with high shrub or understory tree cover, high down log volumes, and little herbaceous cover. Deer mice are ubiquitous, occupying areas with variable conditions whereas brush mice

are restricted to areas with a strong oak component and dry, rocky substrates with sparse tree cover (USDI 1995).

Starvation, particularly for juveniles, was identified as a potentially important mortality factor in the Recovery Plan (USDI 1995). The Recovery Team identifies this as of particular concern where prey resources and availability are reduced in abundance.

Upper Gila Mountain Recovery Unit

Status of the Upper Gila Mountain Recovery Unit

The Apache-Sitgreaves, Coconino, Kaibab, and Tonto NFs that make up the 4FRI are within the Upper Gila Mountain Recovery Unit (UGM RU). These forests, along with 2 more in New Mexico encompass 42% of the RU (USDI 1995); the proposed 4FRI project occupies the western portion of the UGM RU. The UGM RU supports over half the known population of MSOs (Ganey et al. 2011) and is at significant risk of high-severity wildfire (USDI 1995). The Recovery Plan recommends recovery actions concentrate on: RUs with the highest owl populations and where significant threats exist; management within these RUs should emphasize alleviating the greatest threats; and that management actions should be tailored to the needs of the area under analysis (USDI 1995).

This RU lies within the largest contiguous ponderosa pine belt in the world. The owls appear to be more continuously distributed here, relative to other RUs, and show high levels of movement and gene flow. The central location of the UGM RU within the overall range of the MSO also facilitates gene flow across their range. Effects of management and effects from a lack of management within the UGM RU can impact MSOs beyond this RU. The UGM population is therefore important to the overall status of MSOs. Consequently, the 4FRI team met with the USDA FS Rocky Mountain Research Station (RMRS) and requested a summary and synthesize of existing knowledge on the status and ecology of MSOs within this RU. Dr. William Block, Program Manager and Supervisory Research Wildlife Biologist at the RMRS and also senior author of the Recovery Plan for the MSO, and Dr. Joseph Ganey, Research Wildlife Biologist at the RMRS, member of the MSO recovery team, and lead scientist on multiple projects addressing MSOs and their habitat, agreed to our request. Dr. Ganey and other MSO experts published the “Status and ecology of Mexican spotted owls in the Upper Gila Mountains recovery unit, Arizona and New Mexico” in 2011 (General Technical Report RMRS-GTR-256 WWW). The intent of this report is to aid planners in evaluating potential benefits or impacts of management actions for MSOs and their habitat.

The remaining portion of this section was extracted from Ganey et al. 2011: Historical information on Mexican spotted owls throughout their range is sparse and anecdotal but clearly documents that these owls were present in the UGM RU. Referring to what is presumably the Blue Range Primitive Area and White Mountains of eastern Arizona, Ligon (1926:422) stated that MSOs were “...by no means as scarce in favored sections of their range as one unfamiliar with their habits might believe.” Bailey (1928; see also Steele 1927) also lists several locations where spotted owls were observed in this general region. Historical data for the western portion of the RU, where the 4FRI is proposing to begin forest treatments, are sparse. Huey (1930) collected an adult female spotted owl at the base of the San Francisco Peaks in June 1929. Beyond this, little is known about the historical distribution of MSOs within the UGM RU.

Today MSOs are known to be widely distributed within the UGM RU, with most locations occurring on National Forest System lands (see also USDI FWS 1995, Ward and others 1995). They are located on all six NFs within this RU and have a relatively continuous distribution throughout the UGM RU in contrast to a patchy distribution throughout much of the rest of their range.

An estimated 2,941 territorial adult or subadult owls occupied the UGM RU (excluding tribal lands, which were not included in the sampling frame). This estimate was rigorous but imprecise, with a 95% confidence interval ranging from 833–5,049 owls. Since 1989, when USFS began using standardized procedures to identify and record occupied MSO “sites”, a cumulative total of 424 such sites have been documented in the UGM RU (USDI FWS 1995). This constitutes 55.9% of the known spotted owl sites documented range-wide (USDI FWS 1995). It is not possible to estimate abundance directly from these data, however, for the following reasons: these sites may indicate occupancy by either a single owl or a pair of owls, it is not known how many of these sites are occupied during any given year, and these surveys may not be effective at locating non-territorial individuals. These known owl sites are well distributed among the NFs comprising this RU, with the exception of the Kaibab NF. The Kaibab NF has few known owl sites, which contrasts sharply with the neighboring Coconino NF. The UGM RU contains the two forests with the greatest number of known sites (Gila and Coconino NFs) and three of the four top forests in terms of known sites (including the Apache-Sitgreaves NF).

Metapopulation dynamics in UGM RU

The distributional pattern of MSOs is disjunct relative to other subspecies of spotted owl, making MSO dispersal an important consideration (USDI 1995). Providing for connectivity could buffer MSO populations “from stochastic variability through time by providing the opportunity for local population failures to be ‘rescued’ by immigration from other populations” (USDI 1995). The following section was extracted from Ganey et al. 2011: The structure and spatial distribution of spotted owls at a range-wide scale suggests that groupings of individuals may occur as subpopulations, and that these subdivided populations may function as a metapopulation. Of the three spotted owl subspecies, the distribution of MSOs appears to most naturally resemble the metapopulation construct, with perceived subpopulations existing in useable habitat created by elevation gradients and disconnected mountain or canyon systems separated by a matrix of low-quality to non-useable habitat.

Keitt and others (1995, 1997) examined the spatial pattern of forest habitat patches across the range of the Mexican spotted owl. Patches of forest habitat in the range of the Mexican spotted owl showed a connectivity threshold of approximately 28 miles and the authors concluded that an organism capable of dispersing ≥ 28 mi (45 km) through inhospitable terrain, and with an average exponential dispersal distance of ≥ 9 mi (15 km), would perceive the landscape as a series of connected patches. They further concluded that Mexican spotted owls likely met these criteria, and that the Mexican spotted owl probably behaves as a classical metapopulation over much of its range. At this scale, the landscape consists of a set of large, more-or-less discrete habitat clusters. This suggests that owls could successfully disperse within habitat clusters with very high probability and disperse between clusters with much lower probability.

Keitt and others (1995, 1997) also attempted to identify habitat clusters most important to overall landscape connectivity, using maps based on forest and woodland cover to define clusters. The UGM RU emerged as the most important RU in this analysis because of its large area and

relatively continuous forest habitat. They next conducted a second analysis aimed at emphasizing positional effects on landscape connectivity. The UGM RU again emerged as important in this analysis, due to both its large size and central location. Some small habitat clusters also emerged as important. Because of their locations, these clusters may serve as stepping stones between other, larger clusters and thus may be important to landscape connectivity despite supporting relatively few resident owls.

Barrowclough and others (2006) investigated genetic structuring in Mexican spotted owl populations. Their data suggested substantial gene flow among populations sampled in the Mogollon Rim–Upper Gila Mountains region of central Arizona and New Mexico, with more restricted gene flow among other populations (Barrowclough and others 2006). They recognized three major haplotypes within the range of the Mexican spotted owl. One haplotype was common in populations in the northwestern portion of the range and not found in the southeastern portion. A second haplotype was most common in the southeastern portion of the range, and not found in the northwestern portion. A third haplotype was found in all populations studied, but was most common in the UGM RU and in southern Arizona. All three haplotypes occurred in populations within the UGM RU, suggesting that this area is important in facilitating gene flow across the range of the Mexican spotted owl.

These findings highlight the importance of both large patches of habitat and of some small patches based on their location and consequent influence on landscape connectivity. The UGM RU is important in both contexts. This RU includes the largest contiguous area of habitat for Mexican spotted owls, and that is reflected in the large number of documented owls in that RU (Ganey and others 2004). This RU also is centrally located relative to other areas inhabited by Mexican spotted owls. The larger subpopulation in this RU likely serves as a core source population for supplying new recruits to proximal outlying locations and for facilitating gene flow throughout the range of the Mexican spotted owl.

MSO Habitat

Protected and Restricted Habitat

The authors of the MSO Recovery Plan (“Recovery Plan”, USDI USFWS 1995) agreed that forests in the Southwest were outside the historical range of variation and are at high risk from uncharacteristic fire, insect, and disease events. They propose recovering MSO populations by sustaining adequate habitat quality and quantity through time and within the historical range of variation. They recommend managers emulate natural ecosystem processes to create landscape mosaics that balance natural variability and secure the landscape against uncharacteristic habitat loss. This coarse filter approach is expected to sustain biotic diversity, including most of the habitat conditions required by the owl and its prey, across the landscape (USDI 1995).

The Recovery Plan provides three levels of habitat management - protected, restricted, and other forest and woodland types to achieve a diversity of habitat conditions across the landscape. Protected areas include protected activity centers (PACs); mixed conifer and pine-oak forests with slopes greater than 40 percent where timber harvest has not occurred in the last 20 years; and reserved lands which include wilderness, research natural areas, wild and scenic rivers, and congressionally recognized wilderness study areas. Restricted areas include all mixed-conifer, pine-oak, and riparian forests outside of protected areas. Other forest and woodland types include all ponderosa pine, spruce-fir, woodland, and aspen forests outside protected and restricted areas.

Protected areas receive the highest level of protection. PACs are at least 600 ac in size and based on known locations of owls. Within PACs are core areas of at least 100 acres intended to protect nesting and roosting habitat. Restricted habitat is less specific and intended to operate in conjunction with ecosystem management and existing management guidelines to provide for nest and roost habitat through time. Ten percent of restricted habitat is designated T/Th and intended to identify those acres closest to currently meeting nesting and roosting habitat for the MSO. Key nesting and roosting habitat values are defined in the Recovery Plan (Table 7). It is assumed in the Recovery Plan that by meeting recommended levels for tree density and BA, adequate amounts of snags and logs (12 inches at mid-line and 8 feet long) should be present. These desired conditions must be met simultaneously for a stand to qualify as existing threshold habitat. They also represent minimum values that must be maintained in stands that meet or exceed desired conditions. In project design, no stands simultaneously meeting or exceeding these minimum threshold values should be reduced below those values unless a larger landscape analysis of restricted areas shows a surplus of acres simultaneously meeting threshold values. Treatments that reduce fire risk, lessen threats from uncharacteristic levels of insects and forest disease, or meet other ecosystem objectives are allowed as long as stands value remain at or above nesting and roosting attributes. The scale at which the evaluation occurs can add subjectivity to the decision. The Recovery Plan estimated most FS project planning occurred at about the 10,000 ac level, which they describe as a “limited spatial scale” that precluded a review of MSO habitat at more meaningful ecological scales (USDI 1995).

Table 7. Minimum values for achieving Target/Threshold stand conditions

Upper Gila Mountain Recovery Unit	% of Restricted Habitat	% stand density of trees 12-18" dbh	% stand density of trees 18-24" dbh	% stand density of trees >24" dbh	Stand basal area	Trees per acre > 18" dbh	Basal area of oak > 5" dcr
Pine-oak forest	10	15	15	15	150	20	20

Overall, MSO habitat elements are not on a sustainable trajectory within the UGM RU. Recent wildland fire history indicates wildfires are larger and are burning at higher severity. In 1910, only two crown fires were big enough to map in the ponderosa pine forests of the Kaibab Plateau. The larger of the two fires burned about 80 acres (Paxon 2011). Habitat loss from high severity wildland fire was identified as a primary risk in the Recovery Plan (USDI 1995), yet the three most active fire seasons in Arizona history have occurred since 2011, with nearly a million acres burned in 2011 alone (Paxon 2011).

Large snags cannot be created without large trees and both large trees and large snags are important to the MSO (USDI 1995). The Coconino and Kaibab forest plans call for an average of two snags per acre in ponderosa pine forests. However, these specifications may be unrealistic. Ganey (1999) found only 30% of ponderosa pine plots in un-logged sites met or exceeded USFS snag guidelines and Waskiewicz (2003) found pine snag densities well below FS guidelines in relatively undisturbed forests in northern Arizona. Fire promotes recruitment of large snags, but in one study conducted locally, 40% of fire-killed snags fell within seven years (Chambers and Mast 2005). Over 80% of ponderosa pine snags created by high severity fire fell within 10-years post-fire (Chambers and Mast pers. comm.). Similar fall rates appear to occur for beetle-killed

ponderosa pine trees (Chambers and Mast *pers. comm.*). Chambers and Mast (2005) found greater densities of large diameter snags in unburned plots vs. burned plots on the Coconino and Kaibab NFs. Holden et al. (2006) found significantly lower snag densities in the Gila NF (New Mexico) where fire had occurred 2-3 times since 1946 compared to areas that had only burned once. Bagne et al. (2008) found that in forests experiencing fire suppression for long periods of time, the greatest loss of snags occurred during initial burns, but in the long-term rate of loss decreased and eventually leveled off during subsequent burns.

Ganey and Vojta (2005) documented an increase in snag recruitment, but the greatest increase was among smaller-sized trees. This pattern is reflected in FIA data collected between 1995 and 2007 showing an overall increase in ponderosa pine snag density on the Kaibab NF, similar to results reported by Ganey and Vojta (2005; Table 8). In 2011, Ganey and Vojta reported a 74 percent increase in ponderosa pine mortality from 2002 to 2007 compared to mortality between 1997 and 2002. While more trees were dying in the smaller size-classes, proportions of dying trees were greatest in the largest size classes. Mortality of aspen and Gambel oak in pine-oak forests were also proportionally greater than expected, relative to species composition of live tree forests (Ganey and Vojta 2011).

Table 8. Number of dead Ponderosa pine trees per acre on the Kaibab National Forest portion of the 4FRI (FIA unpublished data).

Ranger District	Diameter class		
	5"-10.9"	11"-14.9"	>=15"
1995			
Tusayan	0.39	0.00	0.11
Williams	0.99	0.00	0.24
Totals	2.49	0.00	0.49
2007			
Tusayan	0.33	0.16	0.33
Williams	2.18	0.60	0.79
Totals	5.00	1.50	1.20

The proximate cause for the observed mortality observed by Ganey and Vojta (2011) was a complex of bark beetles likely mediated by long-term drought conditions. Insects and disease outbreaks are also a function of stand density. Increased stand densities create prime conditions for insect epidemics and disease outbreaks, particularly among older trees (Arno 2008). Fungi and parasitic plants weaken structural integrity of stressed trees, making them more susceptible to bark beetle attacks (Filip 2005). Historically, the western pine beetle (*Dendroctonus sp.*) was the most aggressive and damaging insect in ponderosa pine forests on the Kaibab NF (Lynch et al. 2008). On the Kaibab NF, mountain pine beetle outbreaks occurred in the 1910s and 1970s, but mortality was reported at less than 3% (Lang and Stewart 1910, Lynch et al. 2008). Since 2003, damage by *Dendroctonus* has been surpassed by the *Ips* genus, an aggressive beetle that favors denser forests. An unprecedented *Ips* outbreak damaged 60,000 acres on the Kaibab NF from 2002 to 2004 with 100% mortality occurring in some stands. In general, ponderosa pine mortality

in the southwest has increased as a result of drought and more frequent bark beetle attacks (Kolb et al. 2007, Ganey and Vojta 2011).

Most beetle activity has decreased substantially since 2002, although the western pine beetle has remained active on the Coconino NF with over 5,000 acres of mortality reported in 2007 (USDA Southwest Region Forest Health 2008). Large mortality events in northern Arizona forests are typically infrequent, followed by relatively low mortality rates (Joel McMillin, pers. comm.). However, future drought cycles would be expected to again accelerate tree mortality from bark beetles. Ponderosa pine mortality associated with Ips and other bark beetles is expected to continue to occur throughout the region as a result of high populations and dispersal distances of beetles (Allender et al. 2008). While losses of big trees will assist in meeting snag guidelines in the short-term, it decreases the likelihood of meeting large tree (i.e., trees greater than 18 inches dbh) guidance in the Recovery Plan over the long-term.

Another result of current forest health issues in southwest ponderosa pine forests is an increase in large down logs. Ganey and Vojta (2012) documented increased fall rates of trees in plots across the Coconino and Kaibab NFs since 2004. Plots with logs present increased by over eight percent between 2004 and 2009 and log length, density, volume, and area covered all increased significantly ($p < 0.001$) during that same period. However, the changes documented here represent initial results from a drought-mediated pulse in tree mortality (Ganey and Vojta 2011).

The following section was extracted from Ganey et al. 2011: Available information suggests that Mexican spotted owls use relatively large home ranges, with smaller areas of concentrated use embedded within those home ranges. There are 4 spatial scales relevant to understanding space use by resident MSOs: territory, home range, activity center, and core area. Spotted owls are described as territorial in the sense that mated pairs defend a breeding territory, at least during the nesting season. Seasonal and longer-term fidelity to territories is often strong, with many owls remaining on the same territory year after year (Gutiérrez and others 1995). No direct estimates of territory size are available for MSOs within the UGM RU, but estimates of nearest-neighbor distances between adjacent pairs indicate mean distances of 1.5 mi in Arizona ($n = 42$ pairs; May and Gutiérrez 2002; Coconino NF) and 1.3 mi in New Mexico ($n = 31$ pairs; Peery and others 1999; Gila NF). This suggests that exclusive use areas average approximately 1,115 and 855 acres, respectively.

Home ranges are usually assumed to be larger than territories, although few studies have formally evaluated differences between territories and home ranges. Home-range size varied considerably among study areas, but the factors underlying that variation are unclear. Home ranges of adjacent pairs may overlap spatially, and the entire home range typically is not defended. Research sampling regimes and sample sizes have varied and studies were conducted in different years, making direct comparisons among studies difficult (Kernohan and others 2001). Consequently, observed differences among studies could be due to differences in methodology. We assume that some of the observed variation in home-range size is real rather than an artifact of methodology. Differences could be a result of local habitat quality including abundance of prey, biogeographic effects (for example, differences in climate pattern or biogeographic region), temporal variation (studies conducted in different years), or all of the above. There is evidence from outside the UGM RU that local habitat composition and/or prey abundance can influence home-range size of spotted owls (Carey and others 1992, Zabel and others 1995, Ganey and others 2005).

Only one study within the UGM RU estimated size of seasonal home ranges (Ganey and others 1999). Home range size more than doubled from the breeding to the non-breeding season in this study (Table 9). Annual activity centers for owl pairs generally were less than half the size of home ranges, suggesting considerable concentration of activity in particular areas. This pattern also held in a comparison of seasonal activity centers of individual owls within a single study area (Table 9).

Table 9. Area of home ranges or activity centers of radio-marked Mexican spotted owl pairs and individuals in ponderosa pine–Gambel oak forest during the breeding and non-breeding seasons. Data from Ganey and others 1999: Table 1. *N* = number of owl pairs or individual owls included in estimates. Home range estimates based on the 95% adaptive kernel estimator; activity centers based on the 75% adaptive kernel estimator.

Parameter	Breeding season ¹			Non-breeding season ¹		
	<i>N</i>	Mean	<i>SE</i>	<i>N</i>	Mean	<i>SE</i>
Owl pairs						
Home-range area ²	4	1303	214	7	2772	420
Activity-center area ²	4	319	40	7	981	200
% of home range ³	4	24.5		7	35.4	
Individual owls						
Home-range area ²	8	971	173	14 ⁴	2345	363
Activity-center area ²	8	302	54	14 ⁴	808	133
% of home range ³	8	31.1		14 ⁴	34.5	

¹ Seasons: Breeding = 1 Mar–30 Aug, Non-breeding = 1 Sep–28 Feb.

² Area (acres; mean and standard error [*SE*]). To convert home-range or activity-center size to ha, divide by 2.47.

³ Percent of seasonal home range contained within the activity center, calculated from table values as: (Activity-center area/Home-range area) * 100.

⁴ Fourteen range estimates computed for 13 individual owls. One radio-marked female dispersed to a new territory during the study. Separate range estimates were computed for this owl in different years.

Resident owls concentrate activity around the nesting area during the breeding season, but they expand their range during the non-breeding season. Activity typically centers on the nest stand during the breeding season, even in years when resident pairs do not nest. Resident owls typically roost in or near the nest stand throughout the breeding season. Size of activity centers more than doubled during the non-breeding season, but overlap between seasonal activity centers was 83.3 percent of maximum potential overlap. This indicates that protection of breeding areas provides protection to areas and habitat used throughout the year.

Critical Habitat

Critical habitat is defined in section 3(5)(A) of the Act as—(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management considerations or protection and; (ii) specific areas outside the geographical area occupied by the species at the time it is listed, upon a

determination that such areas are essential for the conservation of the species. The term “conservation,” as defined in section 3(3) of the Act, means “the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary.”

The USFWS has found that designation of statutory critical habitat provides little additional protection to most listed species, while consuming significant amounts of available conservation resources (USDI 2004). They concluded that comparable conservation can be achieved by implementation of laws and regulations obviating the need for critical habitat and that “its present system has evolved into a process that provides little real conservation benefit, is driven by litigation and the courts rather than biology, limits our ability to fully evaluate the science involved, consumes enormous agency resources, and imposes huge social and economic costs” (USDI 2004).

Critical habitat must be “essential to the conservation of the species.” Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species. These are areas in which are found the primary constituent elements, as discussed below, and that may require special management considerations or protection. Critical habitat designations include, but are not limited to: space for individual and population growth and normal behavior; food, water, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, or rearing of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distribution of a species. Primary constituent elements include those physical and biological features that support nesting, roosting, and foraging.

Summary

It is important to have an understanding of the ecological relationships between MSO, their prey, and the respective habitats in order to assess the effects of proposed management. This document presents an overview that is intended to be part of the project record in support of the 4FRI effects analysis.

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Appendix 8. Understory and Arthropod Responses to Overstory Cover and Fire: a Literature Review in Support of the 4 Forest Restoration Initiative



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June, 2012**

Introduction

One of the most substantial changes to wildlife habitat that could potentially be achieved by the 4FRI would be restoration of the ponderosa pine understory. Ponderosa pine forests commonly include up to seven overstory species within the 4FRI project area, including alligator juniper (*Juniperus deppeana* Steud.), aspen (*Populus tremuloides* Michx.), Gambel oak (*Quercus gambelii* Nutt.), limber pine (*P. flexilis* James), one-seed juniper (*J. monosperma* (Engelm.) Sarg.), pinyon pine (*Pinus edulis* Engelm.), and ponderosa pine (*Pinus ponderosa* P. & C. Lawson var. *scopulorum* Engelm.). However, 84 to 95 percent of the overstory is commonly comprised of ponderosa pine trees (4FRI data, Fule et al. 2002, Bakker and Moore. 2007). In comparison, 300 to 600 plant species occur beneath the canopies of ponderosa pine forests in northern Arizona (Daniel Laughlin, personal communication 2011). Plot tallies from individual research efforts within the 4FRI area have reported 78 to 271 vascular plant species (Griffis et al. 2001, Abella and Covington 2006, Laughlin et al. 2008, Nyoka 2010, Laughlin et al. 2011, Stoddard et al. 2011).

“Ecosystem services,” such as climate regulation, air purification, water purification, crop pollination, etc., are a subset of ecosystem functions useful to humans (Kremen 2005). The services provided by ecosystem can often be characterized by the component populations, species, functional groups, food webs, or habitat types that collectively produce the service (Kremen 2005). A productive and diverse understory protects soil from erosion, creates forage and cover for wildlife, provides fuels to carry low-severity surface fires, and is the repository for much of the biodiversity in ponderosa pine ecosystems (Moore et al. 2006).

In addition to these basic ecosystem services, understory vegetation defines and supports the arthropod community. Arthropods (including insects, spiders, mites, centipedes, millipedes, isopods, and mollusks (snails and slugs)) respond to changes in habitat structure (Pellmyer 1985, Buddle et al. 2006, Stephens Wagner 2006, Moisset and Buchmann. 2011). Arthropods are also key drivers of ecosystem structure and function. They decompose organic material, aerate and enrich soil, release nutrients back into the ecosystem, maintain genetic diversity within plant species, and serve as key prey for birds and small mammals which, in turn, support populations of larger predators (Wilson 1987, Meyer and Sisk 2001, Samways 2005, Black 2005, 2007, Capinera 2010, Mooney et al. 2010). Environmental factors that alter the spatial and temporal distribution of floral resources influence arthropod community composition (Buddle 2006, Kremen 2007, Moisset and Buchmann 2011). Restoring diversity and connectivity in the herbaceous layer can restore more complex food webs (Meyer and Sisk. 2001, Samways 2005, Huffman et al. 2009, Negrón et al. 2009). These interrelations tie back to wildlife forage, cover, and ecosystem health. Moore et al. (2006) concluded that the herbaceous understory should be a prime focus of land managers involved with forest restoration and conservation biology activities in southwestern ponderosa pine forests.

Descriptions from the 19th Century

Ponderosa pine forests of northern Arizona, including both overstory structure and pattern and understory pattern and composition, have changed dramatically since the late 1800's. A century ago the pine forests were dominated by widely-spaced large trees with a more open forest floor dominated by herbaceous species (Cooper 1960). Many early expeditions described the natural conditions in what is now the 4FRI area:

- In 1851 navy lieutenant Edward Fitzgerald Beale received orders from Jefferson Davis, Secretary of War, to survey a wagon route from Fort Defiance (some thirty miles southeast of Canyon de Chelly) to the Colorado River (Davis 2001). When he approached the San Francisco Mountains and ascended into the ponderosa pine forest (on the present day Peaks Ranger District, Coconino National Forest) he commented “We traveled rapidly over lovely country of forest and mountain valley, which continually drew exclamations of delight and surprise from every member of the party ... we passed successive vales and glades, filled with verdant grass knee high to our mules, dotted with flowers, and the edges skirted by gigantic pines...” (Beale 1858 as quoted in Davis 2001).
- “The country was beautifully undulating, and although we usually associate the idea of barrenness with the pine regions, it was not so in this instance; every foot being covered with the finest grass, and beautiful broad grassy vales extending in every direction. The forest was perfectly open and unencumbered with brush wood, so that the travelling was excellent.” (Beale 1858 as quoted in Cooper 1960).
- Looking out from the north slope of Mount Sitgreaves (now the Williams Ranger District, Kaibab National Forest), Beale observed “The fine spring attracts numerous antelopes, which appear and disappear as they glance rapidly through the fine open forest” (Beale 1858 as quoted in Davis 2001).
- Beal later commented that the ponderosa pine forests were "... the most beautiful region I ever remember to have seen in any part of the world. A vast forest of gigantic pines, intersected frequently with open glades, sprinkled all over with mountains, meadows, and wide savannahs, and covered with the richest grasses ..." (quoted by Bell 1870).
- Lt. Joseph C. Ives commanded an army detachment in 1858 and marched to the north base of Bill Williams Mountain (now the Williams Ranger District, Kaibab National Forest). Like previous explorers who passed this way, he was enchanted by the extensive grass growing beneath widely spaced pines (Davis 2001).
- In July 1858, John Udell was part of a party of settlers following Beale’s wagon route along the 35th parallel, bound for California. As the train approached the eastern foothills of the San Francisco Mountain (now the Peaks Ranger District, Coconino National Forest), Udell continued to express delight over the blanket of grass clothing the highland valleys under an open forest of ponderosa pine (Davis 2001).
- C. Hart Merriam based his life zone concept largely on a study of vertical vegetation zones on the San Francisco Mountains. In describing his study area he said, "The lava plateau above about 2130 meters (7000 feet) is covered throughout with a beautiful forest of stately pines (*Pinus ponderosa*) which average at least 33 meters (100 feet) in height. There is no undergrowth to obstruct the view, and after the rainy season the grass beneath the trees is knee-deep in places, but the growth is sparse on account of the rocky nature of the surface" (Merriam 1890).

Since this time, heavy tree harvest, fire exclusion, overgrazing, and more recently, climate change, has created a 120-year anomaly in terms of fire behavior which has altered the trajectory of stand development, ecosystem function, and spatial pattern of ponderosa pine stands in northern Arizona (Pearson 1950, Arnold 1950, Cooper 1960, Covington and Moore 1994, Moore et al. 2004, Roos and Swetnam 2012).

Historical Range of Variation

Historic increases in tree density have led to increased canopy closure, fueled in part by the cessation of frequent, low-severity ground fire that limited survival of tree seedlings (Covington et al. 1997, Fule et al. 2002, Noss et al. 2006, Sanchez Meador et al. 2010). High seedling establishment rates due to an unusual distribution of moisture in 1919 contributed to today's forest conditions as did similar, lesser seed crops in 1910, 1914, and 1929 (Arnold 1950). With tree recruitment abnormally high relative to the historical record and an interruption in the fire return interval, an 8 to 21-fold increase in tree density occurred in the ponderosa pine forests within the 4FRI project area (Fule' et al. 2002). Monitoring of long-term exclosures identified a doubling of total tree canopy cover, a tripling of tree density, an increase of 40 percent in tree basal area (square feet per acre), and a predominance of smaller trees between 1941 and 2004 (Bakker and Moore 2007). Forest conditions within the 4FRI project area under the historical range of variation were estimated to have been 23 to 60 trees per acre (Covington 1993, Fulé et al. 1997, Moore et al. 2008). Post-settlement conditions within the project area include over 400 trees per acre to over 2,471 trees per acre (Fulé et al. 1997, Fule' et al. 2002, Abella and Covington 2006, Moore et al. 2008). Whereas presettlement forests were dominated by older and larger trees, today's forests are characterized by relatively small, young trees (USDI 1995, Fulé et al. 1997, Fule' et al. 2002, Moore et al. 2004, Abella and Covington 2006).

Tree group size and shape can be thought of as the building blocks of landscape-scale forest structure in the ponderosa pine system of northern Arizona (Laughlin et al. 2006). The influx of trees post-fire exclusion has altered the forest pattern as well as the forest structure. In stark contrast to today's relatively homogeneous forests, presettlement forests were relatively open and dominated by groups of trees with larger and more frequent grass openings (Covington et al. 1997, Fule' et al. 2002, Moore et al. 2004). Pre-settlement forest patches in the Gus Pearson Natural Area within the 4FRI project area averaged 0.14 ac (0.055 ha) in size with a range of 0.05-0.27 ac (0.02–0.11 ha) (Laughlin et al. 2006). These values are similar to the ranges described by White (0.05-0.72 ac [0.02–0.29 ha]; 1985) and Cooper (0.15-0.32 ac [0.06–0.13 ha]; 1960). Individual tree groups ranged from 2 to over 40 trees (White 1985). Rather than a matrix of tree groups defined by an interspersion of grassy, open patches, today's forests consist of small openings within extensive stands of dense pine trees which, in turn, exerts a negative effect on the understory community (Laughlin et al. 2006). Infilling of forests and expansion of trees into openings can affect plant community structure and composition, water and nutrient cycles, understory biomass production, wildlife habitat, biodiversity, and fire patterns across the landscape (Tausch et al. 2009).

Understory Response to Overstory Changes

A strong and inverse relationship exists between understory and overstory production (Cooper 1960 Clary and Ffolliott 1966, Clary 1969, Ffolliott 1983, Hart et al. 2005, Healy 1989, Bojorquez Tapia et al. 1990, Moore et al. 2004, Bakker and Moore 2007, Kennedy et al. 2009, Laughlin et al. 2011, Stoddard et al. 2011). In 1901 and 1902 a deficiency in seedlings and saplings was reported by forest managers in what is now the Coconino National Forest, with the forest floor being "more fully occupied by herbaceous species" (Arnold 1950). Successful seed crop years occurred in 1910, 1914, 1929, and most notably in 1919. Afterwards, an abundance of young pine became established across extensive areas northern AZ. Young pine trees filtering into virgin timber, extending into natural grassland openings, and restocking cut-over areas created an abundance of young trees across much of what is now the 4FRI project area (Arnold 1950). In

contrast to the open forest conditions described above, uncharacteristically dense pine forests began to decrease available sunlight, intercept precipitation and compete for soil nutrients throughout the 1900s (reviewed in Laughlin et al. 2005). Resulting reductions in herbaceous cover were noted by the 1930s (Arnold 1950). Herbaceous understory cover can decrease by 5-fold as canopy cover increases from 10 percent to 100 percent (Arnold 1950). Under uneven-aged ponderosa pine forests, the relationship between canopy and herbaceous density was linear but variable. In even-aged forests, each 1 percent decrease in ground cover density was equal to a loss of 150 lbs air-dry grass yield (Arnold 1950).

Local research quantified the relationship between understory and overstory basal area. Studies were conducted on different portions of the Coconino National Forest within or adjacent to what is now the 4FRI project area (Clary and Ffolliott 1966, Pearson and Jameson 1967, Bakker and Moore 2007). The Rocky Mountain Forest and Range Experiment Station described relationships between basal area and herbaceous production in both the northern and southern portions of the Coconino National Forest in the 1960s (Clary and Ffolliott 1966, Pearson and Jameson 1967). Researchers working north of Flagstaff found that as basal area increased from 0 to 50, herbaceous production dropped from greater than 650 pounds per acre to 100 pounds per acre; when overstory basal area increased above 50, herbaceous production decreased to only 45 pounds per acre (Pearson and Jameson 1967).

Clary and Ffolliott (1966) conducted research south of Flagstaff determined herbaceous production was higher when the overstory basal area was below 95 and was significantly ($p \leq 0.10$) higher when basal area was below 70. Average herbaceous production was higher on thinned plots. However, this trend reversed at levels equal to or higher than 100 basal area. While production continued to decrease with increasing basal area, unthinned plots had higher herbaceous production than thinned plots once basal area was greater than or equal to 100 (Clary and Ffolliott 1966). This may be a result of management activities releasing trees with the best growth potential that subsequently outcompeted the herbaceous layer for available water and nutrients. Another long-term study conducted on the Coconino NF found understory plant cover decreased by 21 percent and plot-level understory species richness declined an average of about two species per square yard as ponderosa pine basal area increased from an average of 17 in the early 1900s to 126 in 2007 (Laughlin et al. 2011). Predicted herbaceous production responses to basal area must be regarded as estimates because they cannot account for the distribution of basal area in the stand, e.g., trees in a northern Arizona ponderosa pine stand had equal basal area in 1876 and 1949, but density was more than 4 times greater in 1949, indicating that there were many small trees (Moore et al. 2004).

Bakker and Moore (2007) examined understory plant production relative to increased ponderosa pine abundance by using a series of five livestock grazing exclosures established in 1912 (Arnold 1950). All 5 sites were located within about 15 miles of Flagstaff. They found that, as overstory increased between 1941 and 2004, understory decreases occurred in shrubs (69 percent), graminoids (39 percent), and forbs (82 percent). Total herbaceous cover decreased by 59 percent. They determined that understory vegetation was more strongly controlled by the ponderosa pine overstory than by recent livestock grazing or by differences between years (Bakker and Moore 2007).

As research on the relationship between canopy cover and understory biomass production continued in the latter part of the twentieth century, different studies assessed the strength of different variables for evaluating overstory productivity. This work has generated different

equations to describe the relationship. Despite the number of studies, the shape and function of the resulting graphs have been the same: an increasing overstory slowly reduces the understory until a threshold in forest canopy is met, and then a sudden plunge in herbaceous production occurs as canopy density continues to increase. While the nature of the equation, slope of the line, and specific threshold values vary, the shape and response function of the curves have remained the same among studies and across decades of study. Forest cover greatly exceeding this threshold is now the normal condition in northern Arizona ponderosa pine forests. As a result, depauperate understories have also become common. Moir commented in 1966 that “Continued tree production unchecked by fire or artificial tree thinning appears to lead towards total or near-total herb suppression.” Treatments intended to move forests towards the historical range of variation, but which failed to open forest canopies enough to move below this threshold effect, were identified as limiting understory response by several researchers working in what is now the 4FRI (Bradford et al. 2009, Scudieri 2009, Stoddard et al. 2011).

Forest Floor Conditions

Uncharacteristically dense forests that change forest floor conditions potentially change the site ecology. Solar radiation under dense pine canopies can reduce ground-level light to as low as 20 percent of full daylight conditions (Meyer and Sisk 2001, Moir 1966). In graminoids, decreased solar radiation reduces inflorescence production (Moir 1966). Only high-fidelity understory species persist beneath dense canopies versus a wider range of species in more open stands, (Abella and Covington 2006).

Soil organic matter and nitrogen availability affect understory species richness and plant cover (Laughlin et al. 2007). Soils with greater nitrogen content can sustain greater understory plant abundance (Laughlin et al. 2007). However, in a long-term study in what is now the 4FRI project area, the amount of nitrogen stored in the overstory increased 600 percent between 1909 (plot establishment) and 2002 and were 31 percent higher in overstory nitrogen than the estimated level before fire exclusion in 1876 (Moore et al. 2004). Phosphorous and potassium showed similar changes: aboveground phosphorous storage in trees increased by 475 percent and 53 percent since plot establishment and fire exclusion dates, respectively; increases in potassium were 528 percent and 41 percent since plot establishment and fire exclusion, respectively (Moore et al. 2004). The changes in overstory biomass from open stands dominated by large trees to closed stands of smaller, younger trees created stands with a high proportion of foliage and leaf area compared to stands that had proportionally more stem wood (Moore et al. 2004). In general, changes in overstory nutrient storage suggest diminished nutrient turnover and decreased nutrient availability to other ecosystem components such as understory plants and non-arboreal herbivores (Moore et al. 2004). Net nitrogen transformation rates and soil microflora activity decreased under dense forests canopies (Moir 1966, Kaye and Hart 1998, Boyle et al. 2005). Soil nitrogen is strongly related to understory species richness (Laughlin et al. 2007). Decreasing nutrient concentrations in the mineral soil can lead to less palatable herbaceous plants for wildlife (Mattson 1980). Nutrients occurring in canopy biomass rather than in soil, along with the slow release of nitrogen by pine needles, might be leading to long-term shifts in the understory plant community (Laughlin et al. 2011).

Decreases in available sunlight, precipitation and soil nutrients select for slower growing shade- and stress-tolerant plants. Overstory changes may be selecting for understory species that more slowly acquire and conserve mineral nutrients (Laughlin et al. 2011). Over time these conditions,

along with decreases in available sunlight and precipitation, select for plants that are shorter, flower earlier and contain lower nutritional value for wildlife (Moir 1966, Kaye and Hart 1998, Laughlin and Abella 2007, Laughlin et al. 2011). Laughlin et al. (2011) observed long-term shifts toward communities dominated by shorter plants with larger seed mass and lower specific root length under dense forest canopies. Uncharacteristically dense overstory structure is not only reducing total herbaceous production, but is also changing understory species composition, changing floristic assemblages and reducing the amount and timing of blooms. These changes can affect seed production and availability, lead to reduced plant diversity, and reduced functional diversity of understory communities, (Laughlin et al. 2005). Moreover, they directly affect vertebrate wildlife in terms of altered forage and cover, and indirectly through altered arthropod communities.

Increased tree densities and lack of fire in the 4FRI project area have allowed increased accumulation of pine litter (i.e., freshly fallen organic material). The results of research on the effects of litter on understory species in northern Arizona have been varied. Moore et al. (2006) demonstrated that thinning-only treatments (i.e., no reduction in litter) produced equal increases in herbaceous production compared to thinning plus burning treatments (i.e., litter was reduced through the use of fire). However, they suggested their study design may have obscured the effects of litter because raking associated with the fire treatment may have affected the soil seed bank in the O horizon. Removal of the upper soil horizons can also remove concentrations of NH_4^+ (ammonium), an important source of nitrogen for many plant species in the O horizon (Gundale et al. 2005). Laughlin et al. (2007) used multivariate modeling to account for species richness and litter depth and found no significant correlation. Instead, they concluded nitrogen availability and density of the pine overstory primarily drove understory species richness. Abella and Covington (2007) detected no increase in plant cover or richness after two years of pine litter removal. They too cited soil seed bank removal combined with limited pretreatment herbaceous vegetation as potentially preventing a response. In addition, Abella and Covington (2007) described shading, belowground competition for water and nutrients, or other tree-associated factors as more strongly limiting understory communities.

However, other studies in ponderosa pine forests of northern Arizona concluded total plant cover, cover of major grass species, and overall plant species composition were negatively correlated with litter (Laughlin and Abella 2007, Laughlin et al. 2007, Scudieri 2009). Total plant cover and cover of major grass species were positively correlated with bare ground (Scudieri 2009). Laughlin and Abella (2007) concluded plant species appear to respond so strongly to pine litter that variations in litter depth alone could shift community composition. The relationship was found to be so strong that, in another study, litter depth was used as a predictor variable for herbaceous response to overstory changes (Clary 1969). In finding no significant correlation between litter depth and herbaceous species richness, Laughlin et al. (2007) hypothesized plot size may have been a factor, i.e., in ecosystem studies, the effect of litter may be lost at the 1/12 ac scale. Given the varied responses among studies, perhaps site variability as influenced by other variables such as soils or geomorphology, in addition to whether the upper soil horizons are removed, influence the degree to which litter influences understory production. In summary, litter depth appears to exert a strong negative influence on understory productions in several, but not all studies conducted in what is now the 4FRI project area.

An indirect effect of accumulating pine litter is the slowing of soil decomposition rates due to high resin, lignin, and other compounds resistant to chemical breakdown in pine needles (Moir 1966, Laughlin et al. 2011). In addition, dense forest conditions create selection pressure for

herbaceous understory species with slower decomposition rates (Laughlin et al. 2010). The decreased organic input from grasses and forbs combined with slower decomposition can alter soil properties that impose direct and indirect constraints on understory species diversity (Laughlin et al. 2007). Soil texture and pH constrain growing conditions, limiting sites where plant species might occur (Laughlin and Abella 2007). Decaying pine needles, charred wood, and leachate from needles, wood, and bark significantly reduce germination and growth rates of understory species (Lodhi and Killingbeck 1982, Abella 2006).

Litter thickness and weight are also negatively correlated with seed bank accumulation for both total and native perennial species richness in ponderosa pine forests studied within the 4FRI project area (Black et al. 2007). Seed banks are typically a reflection of the seed rain from existing vegetation, although native graminoids are more common and perennial forbs sparse in the soil seed bank (Buddle et al. 2006, Black et al. 2007, Bradford et al. 2009). Seed banks, overall and specifically for native perennials, have been found to be richer and larger in patches where aboveground understory vegetation is most abundant which, unfortunately, indicates they may be less useful for increasing native understory vegetation in dense pine stands where existing understory vegetation is already depauperate (Black et al. 2007). However, soil seed banks also vary across southwestern ponderosa pine forests with little correlation found between the seed bank and above-ground vegetation in other areas (Meyer and Sisk 2001, Buddle et al. 2006,). Patches with open canopies, typically near old trees, support larger and richer soil seed banks than patches of denser canopies containing many closely spaced small trees (Black et al. 2007). Thick duff layers can lead to higher soil temperatures when fire moves through, resulting in seed mortality in the soil bank (Buddle et al. 2006, Hart et al. 2005, Elizabeth Blaker, personal communications, 2011). Dense overstory canopies limit understory species composition and seed production and therefore will continue to reduce or prevent herbaceous recovery, thus hindering recovery of associated habitat elements essential to a host of vertebrate and invertebrate species.

In summary, dense groups of young pine trees limit sunlight, compete for water, and act as strong nitrogen sinks, creating unfavorable growing conditions for many understory species. More nutrients are being translocated into forest canopies while slower nitrogen mineralization and nitrification rates are occurring beneath the forest floor. Combined with slower decomposition rates and allelopathic qualities associated with ponderosa pine litter, current forest floor conditions are creating selection pressure for a different suite of herbaceous species than what occurred here presettlement, changing the understory community. Declines in total cover and species richness resulting from current forest conditions have been documented throughout the 20th century. The decrease in total cover and species richness resulting from current forest conditions includes selection pressures that limit total foliar production, flower production, and seed production. The net effects to wildlife are changes in vegetative cover and food quantity and quality, including reduced arthropod availability. Negative impacts reflected in the arthropod community can directly influence wildlife by reducing food availability for insectivores and omnivores. In the long-term, reduced arthropod populations can exert secondary limits or selection pressures on the plant community by decreasing the pollinator assemblage. This can further limit the understory diversity, with potential impacts moving up through community trophic levels.

Relationships of Understory Development to Arthropods

Introduction

Invertebrates occupy all forested habitats and have diverse functional roles including detritivores, fungivores, herbivores, predators and parasitoids, and pollinators (Schmidt and Jacobson 2005, Short and Negron 2003). Invertebrates, to which arthropods belong, compose over half the animal diversity across broad forested landscapes (Schmidt and Jacobson 2005). There are 26 Orders of insects within the phylum Arthropoda, but most insects in North America belong to only 8 of these (Stokes 1983). These 8 Orders, plus the Class Arachnida, are of particular importance to the wildlife species considered under 4FRI. Here “arthropod” is primarily being used to refer to key invertebrate prey items selected by birds and mammals (Martin et al. 1961, Capinera 2010). Billions of individuals representing thousands of species may reside in a single northern goshawk territory (Short and Negron 2003). Arthropods are of concern because vegetation composition affects the behavior and structure of arthropod communities (Samways 2005). Current forest conditions in Southwest ponderosa pine forests have been summarized as appearing unfavorable for most insect pollinators (Nyoka 2010).

A healthy herbaceous layer is fundamental to maintaining diverse arthropod communities. Conversely, increased homogeneity of once patchy habitat leads to loss of specialized habitat important to arthropod populations such as diversity of overstory species, variability in soil conditions, herbaceous and coniferous litter depth, snags and large woody debris, fragmentation of habitats, and decreases in herbaceous cover and species richness (Laughlin et al. 2004, Samways 2005, Schmidt and Jacobson 2005, Capinera 2010, Laughlin et al. 2010). Several studies have described the effects of thinning, thinning and burning, clear cutting, and wildfire on arthropod populations which, in many cases resulted in entire community shifts (e.g., Strohecker et al. 1968, McIver et al. 1992, Schmidt and Jacobson 2005, Buddle et al. 2006, Coleman and Rieske 2006, Matveinen-Huju and Koivula 2008, Moisset and Buchmann 2011). What is not known is to what degree current arthropod communities reflect the loss of overstory heterogeneity over the last 100-plus years. Changes in land-use and landscape structure influence arthropods, including pollinators, their target plants, and plant/pollinator interactions at individual, population and community scales (Kremen et al. 2007).

Flowering plants provide foliage, pollen, and nectar and are of significant importance to many families of arthropods (Holland 1984, Capinera 2010, Shaula Hedwall, personal communications 2011). Pollen is high in crude protein (10 to 30 percent) and contains fat and minerals; nectar is the principal source of easily digestible carbohydrates for arthropods (Chen et al. 2006, Capinera 2010). It is critically important that flowers are common throughout the growing season, i.e., they must be available both spatially and temporally to sustain many families of arthropods (Capinera 2010). Many arthropods overwinter as adults and require nectar and pollen when they emerge in the early spring while adults of other species emerge in the late summer and require nectar and pollen to mate or feed developing larvae (Stokes 1983, Mooney et al. 2010). A diversity of flowering plants that bloom throughout the spring and summer supports a diverse pollinator assemblage. However, few plant species are capable of flowering throughout the growing season. Therefore, a variety of flowering species ensures food availability for nectar generalists as well as supporting the many insects with host-specific requirements. A diverse community of insect pollinators requires diversity of native flowers and vice versa (Black et al. 2007).

Pollinators

Arthropods have been assisting plant fertilization since the radiation of the Angiospemeae during the Cretaceous Period (144-65 million years ago) by allowing these plants to exist in widely separated locations (Capinera 2010). While plants provide required foods for many insects, insects provide the mechanism for cross pollination. Cross pollination, or genetic mixing between plants, requires pollen from one flower reaching the reproductive parts of another flower. Some plants such as grasses and trees use wind to transport pollen, requiring the production of a great deal of pollen and the right circumstance to ensure it reaches other flowers of the same species (Stokes 1983). Conversely, 60 to 90 percent of wild plants require animal pollinators to collect and transport pollen (Stokes 1983, Kremen et al. 2007, Mooney et al. 2010, Nyoka 2010). Insects are the chief pollinators and flowers have evolved hundreds of different strategies designed to lure them in, providing food in exchange for genetic mixing (Stokes 1983). Pollination in the wild is mostly accomplished by bees and wasps, flies, and butterflies and moths (Waltz and Covington 2004, Black et al. 2007, Capinera 2010). Plant pollination by insects is one of the most widespread ecosystem services in terrestrial environments and is essential to maintaining biodiversity (Black et al. 2007). A study in what is now the 4FRI project area found 20 percent of the total sampled arthropods were either pollinators or their diet consisted mainly of flower parts (Huffman et al. 2009). Pollinators have been called a keystone group in terrestrial ecosystems because of the range of ecological services they provide to natural ecosystems (Black et al. 2007). Insect pollinator abundance and species richness are strongly correlated with plant cover availability of floral resources (Nyoka 2010).

The pollinator community affects wildlife directly and indirectly. Pollination of flowering plants concentrates insects, making them easier prey for wildlife (Capinera 2010). Insects can be 25 times more abundant in openings than under forest canopies, providing a primary food source for young wild turkeys and other birds (Healy 1989). The tie between invertebrate prey and their predators is strong enough that butterfly diversity can be a predictor of bird abundance and diversity (Black et al. 2007). Most plants that produce colorful flowers do so to attract insects (Capinera 2010). Each flowering plant species usually has a small guild of pollinators which coevolved with them to ensure their pollination (Mooney et al. 2010). Without pollinators, many plants would decline or disappear and the most highly coevolved mutualistic species are the most at risk (Capinera 2010). Successful pollination results in production of fruits and seeds, providing important wildlife foods (Black et al. 2007, Capinera 2010). The decline or loss of these resources would likely result in declines in the birds and mammals that depend on fruit and seed production (Williams 2011), which in turn can affect higher trophic level predators that feed on them.

The decline of pollinators and the services they provide has been described for decades, including evidence of declines at local and regional scales and evidence of elevated extinction rates across taxa (Kremen et al. 2007). Habitat loss and fragmentation in the United States has adversely affected pollinator species, particularly native bees (Mooney et al. 2010). The situation for pollinators caused sufficient concern that the National Research Council of the National Academy of Sciences issued a report titled "Status of Pollinators in North America" in 2006 and again in 2007 [<http://dels.nas.edu/Report/Status-Pollinators-North-America>]. Pollinators alter foraging behavior in response to changes in landscape structure: they follow corridors of vegetation to reach nectar or pollen sources, avoid edges created by roads, and increase energy expenditure in simplified landscapes where few alternative flower resources occur (as reviewed in Kremen et al. 2007). Fortunately, most pollinators have similar needs: open, sunny areas; high diversity and availability of host plants for food, pollen, and nectar sources; and a variety of microclimates to

provide food and shelter under changing weather and climate conditions (Julie McIntyre, personal communications). Pollinators respond to habitat restoration with evidence of species abundance, species richness, and ecosystem function being restored (Williams 2011). One sign of progress towards restored habitat is less redundancy in pollinators visiting the same plants (Williams 2011).

Connectivity (summarized from Samways 2005 except where noted)

In addition to direct habitat loss, the disruption of the herbaceous layer fragments insect habitat. Increased anthropogenic filters to arthropod movement across a landscape can result in increased population isolation. Anthropogenic filters can be a sufficiently large matrix devoid of flowers and therefore creates a barrier for pollinator movement, or decreased sunlight levels that no longer support a full array of plant species richness or adequate nesting sites (Kremen et al. 2007). One insect species may be losing the potential to disperse while another is losing a larval host plant. Population isolation can result in increased mutation/recombination, providing more phenotypic variation and potential adaptability, or increased risk of extirpation. This loss of habitat connectivity is occurring worldwide and has been described as “devastating.” Avoiding population isolation means maintaining gene flow. While inbreeding depression is commonly considered an insignificant threat compared to demographic or environmental stochasticity, it has been demonstrated to increase extinction risk in some butterflies and may be more widespread in plants and insects than previously thought.

An emerging strategy in landscape management is to move the transformed landscape back towards something resembling the structure, composition, and function of the original landscape. This encompasses habitat characteristics to which arthropods are sensitive and maintains them in as near natural a state as possible. A range of successional habitats with an emphasis on heterogeneity has been shown to maintain arthropod species richness. Conserving arthropod diversity is heavily dependent on maintaining both large and small patches of high quality habitat. “High quality” refers in part to heterogeneity. Providing both direct habitat connectivity and habitat stepping stones facilitates landscape movement. Managing for habitat stepping stones allows genetic and demographic augmentation of isolated habitat patches by immigrants and facilitates possible recolonization of unoccupied patches (Britten et al. 2003). Currently, patches of non-native invasive species such as dalmation toadflax (*Linaria dalmatica*), common mullein (*Verbascum thapsus*), and thistles (*Cirsium spp.*), all of which commonly invade sites after forest management activities, may provide the only substantial islands of pollen and nectar for insect pollinators in ponderosa pine forests undergoing initial treatments (Nyoka 2010).

Ecological Interrelations

Habitat fragmentation can result in non-random extinction of insect populations as influenced by a species’ dispersal ability (Fleishman et al. 2002, Samways 2005). Butterfly data has shown that species of intermediate mobility declined most in fragmented landscapes, followed by species of low mobility, whereas species of high mobility survived well (Samways 2005). Flight-limited species are vulnerable to local extinction as remnant patches become smaller and more isolated (Samways 2005). Worldwide an estimated 11,200 insect species have gone extinct, with an estimated 162 species disappearing within the United States (Capinera 2010).

Patch quality is additive upon patch size and isolation (Fleishman et al. 2002, Samways 2005). For many arthropods, the loss of their host plant means they also disappear (Fleishman et al.

2002, Capinera 2010). Diversity of both arthropod predators and herbivores display linear relationships with vascular plant diversity (Samways 2005). Plant species richness, plant functional groups, and most importantly, plant species composition are important determinants of arthropod diversity (Holland 1984, Fleishman et al. 2002, Samways 2005, Matveinen-Huju and Koivula 2008, Shaula Hedwall, personal communications 2011). For example, some families of bees are known as “long-tongued” and favor deep flowers while other families are short-tongued bees and only able to take advantage of shallow flowers such as those of the daisy, aster family or carrot family (Mooney et al. 2010). Heterogeneity at all levels, from local stands to landscapes and structurally as well as spatiotemporally, is important to ensure insect diversity (Strohecker et al. 1968, Samways 2005).

Arthropods are key drivers of ecosystem structure and function. They pollinate many flowering plants, decompose organic material, release nutrients back into the ecosystem, and provide the largest food source in almost every ecosystem (Waltz and Covington 2004, Wilson 1987 from Schmidt and Jacobson 2005, Kremen 2005). Arthropods include both hosts and parasites and serve as prey for a variety of animals, including birds, mammals, herptofauna, and other arthropod species (Black 2005). Arthropod communities interacting with plant communities drive trophic interactions between vertebrate predators and invertebrate prey. For example, recent evidence suggests that predators and parasites strongly influence the population dynamics of bark beetles. Natural enemies can reduce *Ips typographus* reproduction by 83 percent with woodpeckers accounting for 28 percent of mortality of low bark beetle populations, 84 percent during outbreaks, and broods were reduced by 98 percent by woodpeckers on heavily worked trees. Additional mortality was caused by bark removal, thereby increasing access of parasitoids and predators and also increasing solar radiation, thereby drying-out bark beetle larvae (reviewed in Black 2005). In general, the functional importance of an ecosystem service provider depends on both its effectiveness at performing the service and its abundance (Kremen 2005).

Community function and related ecosystem services depend in part on densities, biomass, and interactions of species within the community (Kremen 2005). Diversity confers a stabilizing effect on community structure. More diverse communities provide more stable services than less diverse or simpler communities. These compensatory responses are poorly understood at community levels. In some instances, the importance and contributions of ecosystem service providers has been measured or estimated (Table 10). It is unknown how reduced species abundance, decreasing species richness or local extinctions affect community stability and related services (adapted from Kremen 2005).

Table 10. Networks of Ecosystem Functions. Adapted from Kremen 2005.

Service	Provider/Trophic Level	Unit(s) of Measure	Spatial Scale of Services Provided
Air Purification	Micro-organisms, Plants	Biogeochemical Cycles, Populations, Species, Functional Groups	Regional - Global
Water Purification	Vegetation, Soil micro-organisms, aquatic invertebrates, Aquatic micro-organisms,	Populations, Species, Functional Groups, Communities, Habitats	Local - Regional
Drought Mitigation	Vegetation	Communities, Habitats	Local - Regional

Service	Provider/Trophic Level	Unit(s) of Measure	Spatial Scale of Services Provided
Pollination	Insects, Birds, Mammals	Populations, Species, Functional Groups	Local
Pest Control	Invertebrate parasitoids and predators, and vertebrate predators	Populations, Species, Functional Groups	Local
Detoxification/ Decomposition of Wastes	Leaf litter & soil invertebrates, Soil micro-organisms, Aquatic micro-organisms	Populations, Species, Functional Groups, Communities, Habitats	Local - Regional
Soil generation and fertility	Leaf litter & soil invertebrates, Soil micro-organisms,	Populations, Species, Functional Groups	Local
Seed Dispersal	Ants, Birds, Mammals	Populations, Species, Functional Groups	Local
Climate Stability	Vegetation	Communities, Habitats	Local - Global
Ecosystem Goods	Species Diversity	Populations, Species, Communities, Ecosystems	
Aesthetic/cultural	Biodiversity	Populations, Species, Communities, Ecosystems	Local - Global

Arthropods as Food (summarized from Capinera 2010 except where noted)

An animal's diet has a fundamental influence on its behavior and ecology, including choice of habitat associations, niche selection, foraging and dispersal behaviors, and population structure and dynamics. The potential of 4FRI to restore both the herbaceous and arthropod communities in the understory can benefit a wide range of wildlife. About 1/3 of the families (33.6 percent) within the Class Mammalia eat primarily arthropods while another 1/3 (32.7 percent) eat vegetation and over 35 percent of families in the Class Aves eat arthropods. Arthropods are not only consumed by insectivorous species, but also by omnivores and as alternate prey for carnivores when preferred prey is not available. Arthropods are highly digestible and provide a high yield of metabolizable energy per unit intake, making them a desirable food item for small mammals (Merritt 2010). Nutrition levels of arthropods are typically much higher than most plant-based foods. Based on a review of stomach analyses, key prey items for wildlife (by Order) commonly include: hymenoptera, lepidoptera, coleoptera, orthoptera, diptera, homoptera, and arachnids (Martin et al. 1961. American Wildlife and Plants: A Guide to Wildlife Food Habits. Dover Publications Incorporated, New York, NY. 500pp.). These insect families represent highly nutritious foods, consisting of 25 to 67 percent protein and 10 to 39 percent fat. In contrast, native grasses are commonly 10 to 15 percent protein (Texas A&M University). Because of the nutritional advantages of invertebrate prey, many birds and mammals select them when raising immature offspring and in autumn when foliage losses nutrition through the seasonal curing process. Arthropods are also an important component in the diets of most amphibians and reptiles. Habitat restoration can potentially redistribute arthropods which, given their importance as food resources, can affect the distribution of vertebrate wildlife populations (Meyer and Sisk 2001).

These effects have potential to cascade through the ecosystem and influence food web dynamics at many different scales (Huffman et al. 2009).

Arthropod Orders

Below is a summary of the habitat relations for key Orders of arthropod prey. Each Order of arthropod, and many specific families or species within these Orders, have specific habitat requirements. Most invertebrates occupy distinctly different habitats during their life cycle (Schmidt and Jacobson 2005). Their habitat needs are influenced by overstory structure, principally tree and canopy density. Edges are key habitat for many families of insects (Stokes 1983). Links between arthropods and vertebrate species described below principally come from Martin et al. (1961) and Capinera (2010). These authors used data determined directly from stomach analyses, or, in some cases, scat analysis (Capinera 2010) to identify predator/prey relations. This information is included here because these Orders represent key arthropod prey for a range of vertebrate wildlife species, their habitat relationships tie directly to understory health and proposed treatment effects for the 4FRI. Maintaining the interrelationships between Orders of insects are important to ecosystem function and restoration (from Stokes 1983 unless otherwise noted).

Lepidopterans (“scaly-winged,” including butterflies and moths):

Both butterflies and moths can require specific plant species as larvae and become nectar generalists as adults, encompassing a broad range of ecological niches (Waltz and Covington 2004). The female oviposits on or near a specific species or genera of plant and, once the eggs hatch, the plant serves as the species-specific food for the larvae (Stokes 1983, Waltz and Covington 2004). How the female distinguishes between plants in a given forest or meadow is unknown. Examples include the common white and sulphur butterflies (Family Pieridae) which usually oviposit on mustards (whites) or legumes (sulphurs). Once the adults emerge they feed on nectar. Mating behavior includes aerial flights above meadows or lush weeds. Work with the Nokomis Fritillary (*Speyeria nokomis apacheana*) indicated probability of occupancy increased with increasing larval host-plant abundance and percent cover of adult nectar sources, but decreased as litter reached heavy levels, perhaps as a result of impeded oviposition (Fleishman et al. 2002). The Family Nymphalidae includes species that lay eggs on willow, poplar, and nettle. The adults overwinter under loose bark and feed on sap and early blooming shrubs. Monarch butterflies (family Danaudae) are best known for their long-distance migrations. They feed on milkweed as larvae from which they collect toxins that reduce predation in their adult stage. Adults prefer open habitat with abundant flowers. However, they seek dense vegetation for mating. Because of these specific ties and the quick response to habitat change, the lepidoptera can be indicators of ecosystem change (Waltz and Covington 2004).

Butterflies preferentially forage on species with tubular bright pink or red flowers and plentiful nectar (Nyoka 2010). In the Southwest, particularly within the 4FRI area, butterflies pollinate catchfly (*Silene*, Caryophyllaceae), honeysuckle (*Lonicera*, Caprifoliaceae), phlox (*Phlox*, Polemoniaceae), cryptantha (*Cryptantha*, Boraginaceae), willows (*Salix* spp), Gambel oak (*Quercus gambelii* Nutt.), juniper (*Juniperus* spp), buckbrush (*Ceanothus fenderli* Gray), *Rumex* species, columbines (*Aquilegia* spp.), several beard-tongue (*Penstemon* spp.), paintbrushes (*Castilleja* spp.), cliffrose (*Cowania mexicana* D. Don.), buckwheat (*Eriogonum* spp.), asters (*Asteraceae* spp), legumes (*Leguminosae* spp), saltbush (*Atriplex* spp), New Mexico locust (*Robinia neomexicana*), sage (*Artemisia* spp), grasses (graminoids), and milkweed (*Asclepias*,

Asclepiadaceae) (Holland 1984, Nyoka 2010, Julie McIntyre, personal communication, 2011). Moth-pollinated plants such as evening primrose (*Oenothera*) share similar features with butterfly flowers, but open at night and are generally paler in color (Nyoka 2010).

Presence of a butterfly or moth species indicates presence of the larval host plant, as well as sufficient adult food resources (Waltz and Covington 2004). In addition to the presence of specific species, microclimate conditions have been shown to control foraging rates of many arthropods, including butterflies and moths (Meyer and Sisk 2001, Waltz and Covington 2001). Butterfly species increase proportionally with patch size and butterfly species richness is highest on heterogeneous landscapes (Samways 2005). In order to provide functional habitat so that the full diversity of moths and butterflies is retained, the right plant species need to flower at the right times with a broad enough distribution to account for individual butterflies, populations of butterflies, and their respective meta-populations.

Lepidoptera have many natural predators including frogs and lizards, birds (including hummingbirds), small mammals such as shrews (*Soricidae*) and mice (*Peromyscus spp*), and many species of carnivorous insects and spiders (Pippen 2009, Capinera 2010). Mexican spotted owls (*Strix occidentalis lucida*) will prey on moths opportunistically (Ganey et al. 2011). Hence, they are an important component of the natural food web. In addition, moths are key food items for bats on the Southwest Regional Forester's Sensitive Species list, including Allen's lappet-browed bat (*Idionycteris phyllotis*), pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*), and spotted bats (*Euderma maculatum*) which feed almost exclusively on lepidopterans (Jones and Rydell 2003, AZGFD 2001, Painter et al. 2009).

Hymenoptera (“membrane-winged,” including ants, bees, and wasps):

The Order Hymenoptera includes a wide variety of species and a wide variety of ecosystem services. Hymenopterids include decomposers, fungivores, herbivores, predators, parasitoids, and pollinators (Short and Negrón 2003). Ants are in the Family Formicidae. Nests are frequently located and sometimes even designed to absorb heat from the sun to warm the colony during the night. The presence of a canopy or lack thereof influences not only the species of ants present, but also the ecological functional groups present within the Family Formicidae (Strohecker et al. 1968). Habitat ties can be so strong amongst ant species that Stephens and Wagner (2006) concluded the maintenance of a diversity of ant functional groups and species in northern Arizona ponderosa pine forests required a diversity of forest conditions. Conversely, forest conditions outside of the range of historical variability will support a diversity of ant species and functional groups also outside the historical range of variability. The loss of functional groups can affect ecological processes, e.g., there is a linear correlation between above ground ant activity measured as the number of species and below ground decomposition processes measured as soil microbial biomass (Samways 2005).

Bees

Bees descended from wasps and are entirely vegetarian, feeding on pollen and nectar. Globally there are seven families of bees, six of which occur in North America (Shaula Hedwall, personal communications 2011). The members of the five most common families, Apidae, Halictidae, Andrenidae, Megachilidae, and Colletidae, can be found throughout the North American continent and include 4,000 species of native bees in the United States (Mooney et al. 2010). Over 99 percent of bee species are solitary (Super family Apoidea) and do not form societies like

bumblebees (native species) or honeybees (introduced from Europe). Bees are the principal pollinators in most ecosystems and are likely to be an important component of the pollinator fauna in restored ponderosa pine forests (Nyoka 2010).

Bees use a diverse range of habitats, requiring habitat components such as herbaceous diversity and density, including grasses, forbs, and shrubs, and a flower bloom succession that lasts from spring until autumn (Shaula Hedwall, personal communications 2011). The two most common bee families in the ponderosa pine forests of northern Arizona are Halictidae and Apidae (see below; David Smith, pers. comm.). All species within the Halictidae family nest in ground tunnels. Nests seem to be a limiting factor and competition may occur over a suitable site. Suitable nest sites require openings with bare patches of dry, packed earth for their burrows. Females dig burrows in the soil and collect pollen which they store along with their eggs in the burrow, sealing off the tunnel when they are done. When the eggs hatch, the larvae feed on the stored pollen. They pupate and eventually emerge as adults. In many species of solitary bees, the males may be territorial and patrol areas near flowers, fending off other male bees and even other species of insects that might feed on the flowers. Adults overwinter in underground burrows. When they emerge in early spring they rely on early blooming flowers and catkins that provide pollen and nectar for food.

Leaf-cutter bees (family Megachilidae) use conifer resin, plant hairs, mud, or a mix of the above to build nests in the ground, in hollow stems, or in holes bored in wood (Grigarick and Stange 1968). Ponderosa pine stands provide important nest substrates (snags and logs) for many leaf-cutter bee species. Specimens collected in California have been associated with over 100 different species of flowering plants distributed in 35 different families (Grigarick and Stange 1968).

The family Apidae includes bumblebees (genus *Bombus*). Bumblebees are some of the most common bee species in northern Arizona (Elizabeth Blaker, personal communications, 2011). Fertilized females overwinter and emerge in early spring when they search for nectar sources and nest sites. The most suitable nest locations are abandoned rodent and mole burrows. It is estimated that about 10 percent of all nests are taken over by other queens. Once a queen has a nest she collects herbaceous material to line the nest and also to pile around the nest entrance. This is thought to function in part as camouflage because of the typically short supply of preferred nest locations. Camouflaging nest entrances may also protect against invading queens of both *Bombus* as well as the parasitic subgenus *Psithyrus* (Family Apidae).

Within the 4FRI area bumblebees prefer meadows with high concentration of flowers (Elizabeth Blaker, personal communications, 2011). They commonly forage in meadows near springs, forest edges, and in or adjacent to aspen. Bumblebees commonly visit aspen clones, especially early in the season (Elizabeth Blaker, personal communications, 2011) where flowers often bloom prior to the trees fully leafing out. They occur in relatively open ponderosa pine forest; dense forest is not good habitat for bumblebees because there are not enough flowers to attract them. Arizona bugbane (*Cimicifuga arizonica*: Ranunculaceae), a plant species managed under a conservation agreement between the Forest Service and the U.S. Fish and Wildlife Service, occurs on the Kaibab and Coconino National Forests. It is pollinated by 3 bumblebee species. The flowering peak for *C. arizonica* coincides with the seasonal maximal colony size of bumblebees. The western bumblebee (*Bombus occidentalis*) depends upon *C. arizonica* as a pollen source (Pilliod et al. 2006). The western bumblebee was once widespread throughout the western states, but has declined in many areas.

Honeybees (*Apis mellifera*) were brought to North America by European settlers in the 1600s, underscoring the importance of pollinators to human crops (Mooney et al. 2010). They have since become naturalized and are likely contributing to the decline of native pollinators. They favor large patches of flowers from which they can make maximize the collection of pollen and nectar with the least amount of energy. While bees from the same hive will visit many different species of flowers, individual bees tend to visit the same species of flowers. This is believed to allow the efficiencies of specialization so that a bee knows how and where to collect nectar and pollen in a given flower. Bees are so flower-specific that only about three percent of an individual bee's pollen load is from more than one type of flower. Having a hive of specialized individual bees that allows for each bee to specialize on a different flower may be part of the reason why honeybees are such effective competitors with our native solitary bee species. Pollination by bees is required for 15 to 30 percent of US food production, but honey bee populations have been steadily declining for the past 50 years (Kremen 2005).

Nesting and over-wintering habitat are key elements for maintaining bees across a landscape, especially for the many solitary bee species. The availability of nesting sites or materials may be equally as important as foraging resources to solitary bees (Nyoka 2010). Like the floral resources themselves, habitat for ground burrows, i.e., open ground receiving direct solar radiation, can be a limiting factor. Ground-nesting behaviors by bees aerate and enrich soils (Mooney et al. 2010). Similarly, standing dead trees are important nesting habitats for 30 percent of native bees (Mooney et al. 2010). Snags and down wood with holes created by beetles or other insects serve as nests for species in several families, particularly in the family Megachilidae, while carpenter bees can excavate their own tunnels in soft wood (Mooney et al. 2010). As in foraging and pollinating, a diverse array of habitat components provides for diversity in the bee assemblage.

The response of bee individuals, populations and communities to land-use change is largely driven by the spatial and temporal distribution of floral, nesting and over-wintering resources (Kremen et al. 2007). Bees depend exclusively on pollen and nectar for food during both adult and larval stages and preferentially forage on plants that provide both (Nyoka 2010). Herbaceous species important to bees within the 4FRI project area include mule fat (*Baccharis* spp.), milkvetch (*Astragalus*), trefoil (*Lotus*), showy milkweed (*Asclepias speciosa*), all wild buckwheats (*Eriogonum* spp.), goldenrod (*Solidago* spp.), beardtongue (*Penstemon* spp.), yellow beeplant (*Cleome lutea*), mints (Lamiaceae), figworts (Scrophulariaceae), hyacinth, dandelions, rocky mountain iris, thistle, lavender, blueweed, yellow owl clover, yellow clover, prairie clover, sunflowers, locoweed (*Oxytropis*), silvery lupine (*Lupinus argenteus*), rabbitbrush (*Chrysothamnus* spp.), currents, gooseberries, locust (*Robinia*), and *Cimicifuga arizonica* (Stokes 1983, Pilliod et al. 2006, Shaula Hedwall, *pers. comm.* 2011). There may be some obligate plant-pollinator relationships in ponderosa pine forests as well, such as the bee *Andrena astragali* (Andrenidae) that serves as a pollen specialists for death camas (*Zigadenus*, Liliaceae) and globemallow (*Sphaeralcea*, Malvaceae) (Nyoka 2010).

Wasps

Wasps are different from bees in that they are predaceous while in the larval stage. Adult wasps feed on nectar and are important pollinators. The family Vespidae includes paper wasps and hornets or yellow jackets. They feed primarily on other insects, especially soft-bodied larvae of moths and butterflies. "Paper" nests are full of eggs, larvae, and adults, which provide easily

digestible, high protein food for mammals like black bears. Male wasps emerge in late summer or fall and feed on flower pollen.

Numerous wasp families feed on pollen and nectar as adults, but are important parasitoids on many ponderosa pine pests. The family Ichneumonidae is one of the largest families of all insects. They and the closely related family Braconidae make up the majority of parasitoid insects. Parasitoid species differ from parasitic species in that they eventually kill their hosts, while parasites may weaken, but typically do not kill their host species. Species from both families lay their eggs on or in other insects. The larvae develop inside their hosts and emerge when they are ready to pupate. Ichneumons use edge habitat and are important parasitoids of ponderosa pests such as ponderosa pine tip moth (*Rhyacionia zozana*), pandora moth (*Cloradia pandora*), and ponderosa pine budworm (*Choristongura lambertiana*). They also commonly select caterpillars like tussock moths (family Liparidae) and tent caterpillars (moth family Lasiocampidae), other butterflies, and aphids. The mechanism for locating their host is unknown. Tent caterpillars can defoliate extensive areas of aspen within the ponderosa pine zone and ichneumon wasps are an important parasitoid of the pupal stage (Batzer and Morris 1978). There are thousands of species of Braconids and each species usually seeks a specific host species. Adult braconids feed on the nectar of flowers or the honeydew secreted by aphids or treehoppers. Braconid larvae are important parasitoids on ponderosa pine beetle pests such as *Ips sp.* and *Dendroctonus sp.* Other important wasp families that prey on forest pests include Specidae and Chalcidoidea.

Hymenopterans are prey items for some Management Indicator Species of the Coconino and Kaibab National Forests as well as many of the migratory birds that occur on both forests. Management Indicator Species include red-naped sapsuckers, hairy woodpeckers, pygmy nuthatches, and turkeys; migratory birds include Lewis' woodpecker, purple martins, and olive-sided flycatchers for which hymenopterans are the primary prey item; and another pollinator group, the hummingbirds, also consume hymenoptera. Hymenopterans are food for least chipmunks (*Eutamias minimus*) and northern flickers, both of which are key prey items for Northern goshawks (Reynolds et al. 1992), another Management Indicator Species for both forests. Northern flickers prey on ants in the understory and nocturnal swarms of winged ants are preyed on by bats (Jones and Rydell 2003).

Homoptera (“same winged”, including cicadas [Cicadidae], leafhoppers [Cicadellidae] and aphids [Aphidae]):

Homopterans are primarily herbivores (Short and Negron 2003) and, in general, prefer open country like meadows, savannas, and grasslands and overwinter at the base of grasses. They represent key prey items for other arthropods, especially Hymenopterans, Coleopterans, and Arachnids. Aphids are also an important prey of hairy woodpeckers and leafhoppers are eaten by shrews.

Coleoptera (“sheath-winged”):

Beetles are the most specious and often the most abundant insects (Capinera 2010). Coleopterans perform multiple ecosystem services, including predators of other arthropods (Carabids), scavengers and detritivores that are instrumental in decomposition and nutrient cycling (Scarabaeinae and Tenebrionids), fungivores that assist in distributing fungal spores (Curculionidae), herbivores (Scarabaeinae), and bark beetles that contribute to the creation of snags and woody debris (e.g., the families Curculionidae and Scolytinae are common within the

4FRI project area) (Short and Negron 2003, Schmidt and Jacobson 2005). Many species of ground nester bees (e.g., the Families Apidae, Andrenidae, Halictidae, Megachilidae, and Colletidae) use holes in dead wood made by beetles for their nest locations (Mooney et al. 2010). Holes drilled in tree boles by beetles can provide nest sites for other species, including native bees occurring within the ponderosa pine forests of the 4FRI area (Laughlin et al. 2007). Because of the diversity in the Order Coleoptera, no single forest condition can be labeled as optimum in providing beetle habitat. However, microclimatic conditions affected by overstory conditions have been shown to control foraging rates of beetles (Meyer and Sisk 2001). Beetle species richness is highest on heterogeneous landscapes (Samways 2005, Moisset and Buchmann 2011).

Both larvae and adults in the Family Cicindelidae are predators and prefer open habitat warmed by the sun. They feed on ants, caterpillars, flies, and aphids. Members of the Families Cerambycidae (longhorned beetle), Cantharidae (soldier beetle), and Buprestidae (flat-headed borers) lay eggs in either live or dead wood. Their larvae feed on other insects in the soil or under bark and some species may take two to three years to mature. Adults feed on aphids, other insects, pollen, and nectar. Some species can specialize on certain species of moths including some that are considered agricultural pests. Particular species of flowers can function as both food and mating sites for some beetles. One species of longhorned beetle and related species in the family Buprestidae live in forested habitat and burrow into dead wood. The females seek out trees that have recently been cut or recently died and deposits their eggs in bark crevices. The larvae feed under the bark and once they pupate, the adults overwinter under the bark.

Bark beetles (Family Scolytidae) spend most of their life inside the wood. The adults emerge to find new trees, mate, and lay eggs under the bark of living trees. Some species tunnel in the cambium of the wood and some species tunnel in the bark. Within the 4FRI, the primary bark beetle species associated with ponderosa pine mortality are a complex of *Ips* beetles including: the Arizona five-spined *Ips*, *Ips lecontei* (Swaine), the pine engraver beetle, *Ips pini* (Say), *Ips calligraphus* (Germar), *Ips latidens* (LeConte), *Ips knausi* Swaine and *Ips integer* (Eichhoff) (Laughlin and Moore 2008). The probability of ponderosa pine mortality caused by bark beetles was positively correlated with tree density (Laughlin and Moore 2008). They are capable of killing trees if enough adults successfully burrow under the bark and the resulting tunnels girdle the tree. Once they are successful the adult emits a pheromone that attracts more beetles and who lay their eggs in the weakened tree. At this point it is unlikely the tree will live much longer. Once beetles successfully hatch and emerge from host trees their numbers are such that even healthy trees succumb to the onslaught of successive attacks. While the resulting snags serve as wildlife habitat, they do not persist long (Chambers and Mast, pers. comm.).

Beetles are relatively ineffective pollinators, yet they remain an important group owing to their sheer abundance on flowers. A study of soft-winged flower beetles (Melyridae, subfamily Dasytinae) in western North America suggests that species in this group contribute to the pollination of numerous plant genera common to ponderosa pine forests, including forbs such as cinquefoil (*Potentilla*, Rosaceae), yarrow (*Achillea*, Asteraceae), and fleabane (*Erigeron*, Asteraceae), as well as several shrubs, including rose (*Rosa*, Rosaceae), currant (*Ribes*, Grossulariaceae), buckbrush (*Ceanothus*, Rhamnaceae), and snakeweed (*Gutierrezia*, Asteraceae) (Mawdsley 2003).

Coleopterans are an important food for woodpeckers (including red-naped and hairy), bark foraging birds (including pygmy nuthatches), grassland birds, olive-sided flycatchers, purple martins, turkeys, hummingbirds, and northern leopard frogs (Martin et al. 1961, Kennedy et al.

2009, Capinera 2010). All life stages of some beetles provide food for woodpeckers and bark gleaners such as nuthatches, chickadees, and creepers. Beetles are an especially important prey item for small mammals, including shrews, mice, and chipmunks (Capinera 2010). Large bats with more powerful jaws will eat beetles, including big brown bats (*Eptesicus fuscus*) and the greater western mastiff-bat (*Eumops perotis*; Jones and Rydell 2003), a Sensitive Species for the Southwest Region of the U.S. Forest Service. In addition, large mammals like foxes and bears also select for beetles. Mexican spotted owls feed on beetles with relatively high frequency (USDA USFWS 1995).

Diptera (“two wings,” includes flies):

Dipterans serve in a wide range of ecosystem roles, including detritivores, fungivores, herbivores, predators, and pollinators (Short and Negron 2003). In general, fly species from this order tend to be generalist pollinators (Nyoka 2010). Kearns (1992) found 20 different fly families that visited flowers. The most abundant flower-visiting flies were hover flies (Family Syrphidae; Kearns 1992). Flies are more effective pollinators than butterflies (Waltz and Covington 2004) but less efficient pollinators than bees (Nyoka 2010). However, they replace bees as dominant pollinators at higher elevations (Kearns 1992), which may include ponderosa pine forest. Their effectiveness as pollinators is due to high visitation rates and the fact they preferentially forage on open, bowl-shaped flowers or short-tubed members of the Asteraceae (Nyoka 2010). Flies are important pollinators of some understory species such as Lewis flax (*Linum lewisii*), sandmat (*Chamaesyce*, Euphorbiaceae), buckwheat (*Eriogonum*, Polygonaceae), and some lilies (Liliaceae), such as death camas (*Zigadenus*) and mariposa lily (*Calochortus*) (Nyoka 2010).

Flies in the Family Tachinidae are the most important parasitoids of forest pests, particularly moth larvae (Arnaud 1978). Adult Tachinid flies lay eggs on moth larvae, including ponderosa pine pests such as Pandora moths and ponderosa pine tip moths. The young flies hatch, then feed upon and kill their host.

An unusual family within this Order is the robber fly (Asilidae). Adult robber flies prey on nearly all other flying insects. They are common and often beneficial in controlling insect pests. Adults intercept prey in midair, launching from perches on leaves or twigs in edge habitat. Only about 15 percent of all flights result in capture of prey and if they are unsuccessful from a particular perch, they move to a new location. While hunting, they too become the hunted and are consumed by a variety of bird species and mice, including hummingbirds and purple martins. Robber flies are one of the main foods for purple martins. Interestingly, flies made up less than 1 percent of the diet of olive-sided flycatchers (Capinera 2010). Dipterans are among the most abundant nocturnal insects in temperate climates, making them important prey for many smaller bats, including western pipistrelle (*Pipistrellus hesperus*) and various myotis (*Myotis* spp) (Jones and Rydell 2003).

Orthoptera (“straight wings”, including grasshoppers, crickets, and katydids):

Orthopterans are typically relatively large herbivores and as such, provide prey for a variety of vertebrate wildlife. The life cycles of crickets and grasshoppers are similar. Most overwinter in the egg stage and nymphs hatch from the eggs between late spring and late summer. They prefer open areas with dense vegetation. Turkeys, woodpeckers, flycatchers, martins and grassland birds feed on orthopterans. Additionally, shrews, chipmunks, and spiders feed on them too.

Class Arachnida (includes hunting spiders and web-building; from Steele (2011) unless otherwise noted):

Arachnids are one of the most species-rich and numerous taxa in the arthropod community (Buddle et al. 2006). Spiders may dwell in the ground, under rocks, among grasses, on plants, in tree branches, in caves, and on water. All of these habitats are present in the ponderosa pine forests of the 4FRI analysis area, as influenced by topography, geology, and microclimate. Hunting spiders include jumping spiders, wolf spiders, and crab spiders. They rely on stealth, quickness, and relatively acute eyesight to stalk, ambush, or directly attack their quarry. They tend to be more ground-dwelling and mobile. Web-building spiders include widow, cob web, and orb spiders and tarantulas. They typically produce silken structures (sheet, tangle, or flat radiating orb) in locations most likely to passively intercept prey. Web-building spiders tend not to travel as extensively as the hunting spiders and usually take advantage of the higher portions of the forest understory to deploy their webs. Most spiders live either one to two seasons. The diversity in spider species relates to diversity in habitat requirements. In general, relatively small changes in habitat structure can have profound effects on spider species composition and relative abundances (McIver et al. 1992). Maintaining a broad array of spider species requires a heterogeneous landscape.

Similar to herbaceous species, spiders respond to overstory-induced changes in understory structure and microclimate (McIver et al. 1992, Stephens and Wagner 2006). Prey and microenvironment are largely influenced by canopy closure, moisture, and litter depth (McIver et al. 1992, Stephens and Wagner 2006). Hunting spiders are more common in open habitats and web builders dominate dense forest habitats (McIver et al. 1992, Stephens and Wagner 2006). One reason mobile hunting spiders may be more common in open-canopy habitat is in response to ant densities, another mobile predator that is more common in open habitats (McIver et al. 1992). Grasshoppers are an abundant and common prey in open habitats (McIver et al. 1992). Hairy woodpeckers, red-naped sapsuckers, pygmy nuthatches, and turkeys, all MIS, prey on spiders. Shrews (Merriam's and the least shrew are Sensitive Species for the Southwest Region of the Forest Service) and least chipmunks (a goshawk prey item) also eat spiders.

Summary

Arthropods play multiple ecological roles, including: crucial roles in decomposition and energy and nutrient cycling; inoculating litter with fungal spores and indirectly affecting plant productivity; modifying vegetation architecture, nutrient uptake, and plant growth rates; snag creation; and they exert a tremendous influence on sympatric arthropod populations through predation and parasitism on their prey species (Short and Negron 2003, Capinera 2010). Decreases in understory biomass and shifts in plant assemblages directly affect arthropod communities. Forest overstory changes such as the loss of host plants for specific arthropod species, decrease in solar radiation reaching the ground, changes in forest floor moisture and litter depth, reduced herbaceous cover, loss of edge and meadow habitat, and fragmentation of understory connectivity all affect the arthropod community. These changes can further influence ecosystem function on many trophic levels. The arthropod community in southwest ponderosa pine forests has surely changed in association with forest habitat changes (Short and Negron 2003).

In general, human impacts have modified the landscape through fragmentation, degradation and destruction of natural habitats and the creation of new anthropogenic habitats (Kremen et al. 2007). Locally the degree of understory habitat loss and fragmentation is extreme and extensive

and further loss through attrition continues to occur. The arthropod community is tied to plant species richness, total ground cover of the understory, and changes in microhabitat. Therefore, it is reasonable to assume that environmental changes that alter the spatial and temporal distribution of floral resources have led to declines in abundance and composition of arthropod populations as well. Managing for mobile organisms and the services they provide requires considering not only the local scale where services are delivered, but also a landscape scale that reflects both the spatial distribution of resources and the foraging and dispersal movements of the organisms themselves (Kremen et al. 2007). Changes in arthropod populations may be directly affecting vertebrate wildlife species, including Threatened species, MIS, Sensitive Species, migratory birds, and key prey vertebrate prey species.

Effects of Management Treatments

Proposed actions under the 4FRI

Proposed treatments under the 4FRI largely include combinations of thinning and prescribed burning. Currently, large stands of relatively closed canopy, homogeneous, young to mid-aged forest are common across the landscape. Thinning objectives include moving forests dominated by even-aged and evenly sized trees to uneven-aged conditions defined by small groups of trees and interspersed forest gaps. Forest gaps or interspaces are not intended to regenerate trees, but are rooting zones to support tree groups. Silvicultural prescriptions include meadow, savanna, and grassland restoration, aspen restoration, and retaining and enhancing Gambel oak. Under the proposed 4FRI action alternatives, B proposes to treat 388,526 acres with mechanical and prescribed fire treatments; alternative C proposes to treat 434,038 acres with mechanical and prescribed fire treatments; and alternative D proposes to treat 388,526 acres with mechanical treatments only. There are additional burn-only treatments where the objective is to facilitate fire treatments in neighboring stands and while avoiding the creation of additional fire lines. Overall, alternative B proposes burning 587,924 acres; alternative C proposes burning 593,211 acres; and alternative D proposes burning 178,852 acres. Slash from timber operations under alternative D would be mechanically treated across about 388,427 acres.

Goals for prescribed burning include reducing surface fuels and raising crown base height to reduce the threat of future canopy fire. Additional components of the 4FRI project include restoration of 78 springs and 43 miles of ephemeral channel restoration. One of the primary project objectives is to restore conditions that allow frequent fire to return to the landscape as a relatively quickly moving, low severity ground fire.

Several metrics are commonly used in the scientific literature to describe understory response to overstory changes, including plant biomass, plant cover, species richness, and community composition. The literature summary below is drawn from studies comparing current forest conditions, thinned forest stands, stands that are thinned and burned, and post-wildfire stands.

Understory Response to Thinning and Burning (all studies occurred in northern Arizona ponderosa pine unless otherwise noted)

Understory response to overstory removal varies considerably, largely depending on the amount of residual overstory left after treatment. Clary and Ffolliott (1966) found that ground flora biomass was higher in thinned than unthinned stands with residual basal area values of 22 to 78, but there was no significant difference among treatments when post-thinning basal area exceeded

78. This threshold effect is reflected in the myriad equations used to predict understory response that display similar patterns when graphed (see Bojorquez Tapia et al. 1990 and Deiter 1990). Sabo et al. (1990) concluded that thinning basal area to less than 43.5 results in understory standing crop levels consisting of mostly native late successional plants. In addition to post-treatment basal area, other factors affecting understory response were trees per acre, time since treatment, and annual precipitation.

Light commercial thinning, with or without prescribed burning, did not significantly increase the proportion of herbaceous colonizers moving into stand understories compared to unmanaged control areas (Sabo et al. 2009). This is in agreement with other studies that have minimal treatments that retain high tree densities have little impact on plant community production or composition (reviewed in Sabo et al. 2009). Unmanaged stands in this study were characterized by high tree density, low disturbance, and few colonizing plant species (Sabo et al. 2009).

Research on changes in species richness or diversity after treatment has reached mixed conclusions. Thinning and burning in Arizona ponderosa pine increases some ground flora species, has no apparent impact on others, and negatively affects some species (reviewed in Abella 2004). However, understory changes are limited until a threshold in overstory openness is achieved. Abella and Covington (2004) found that total mean species richness did not differ significantly among control, low-, and medium-intensity thinning treatments, but a richness of about five species per square yard was twice as high in a high intensity thinning (reducing density 85 percent to 56.7 trees per acre) than in other treatments. Griffis et al. (2001) reported post-treatment mean native forb species richness was similar across treatments including control stands (mean basal area equaled 139), thinned stands (residual mean basal area equaled 83), and in thinned and burned stands (residual basal area equaled 65). They concluded remaining basal area may have been too high to affect species richness. In a study examining the effects of 30 years of repeated prescribed fires at varying frequencies on understory abundance and composition, Scudieri (2009) concluded the weak treatment response was primarily due to high overstory basal area at the study sites.

Covington et al. (1997) reported that ground flora biomass in thinning-only treatments was almost four times greater than in thin and prescribed burn treatments in patches dominated by postsettlement trees. However, measurements were taken about a year after burning and the O-horizon was raked away as part of site preparation before burning (Covington et al. 1997), potentially affecting the soil seed bank. Andariese and Covington (1986) found that in mature stands ground flora biomass did not differ significantly between burn and control plots at sites burned two and five years before sampling but did differ at a site burned seven years previously. Stoddard et al. (2011) had similar findings, concluding plant community changes were likely still occurring six years after treatments. In a rare long-term study on overstory manipulation, species richness did not differ among treatments for 10 years (Laughlin et al. 2008). Thinning alone did not increase species richness, but thinning plus repeated burning increased species richness 11 and 12 years after initial treatment (Laughlin et al. 2008). Fifteen new species were present in years 12 and 13 that were not present at the beginning of the study (Laughlin et al. 2008).

Stoddard et al. (2011) tracked understory species richness and cover across three levels of thinning intensity plus a control. They found results were highly variable among experimental blocks, but observed strong trends of increasing richness and cover in treated stands. Plant community composition was still in flux by the sixth year after treatment (Stoddard et al. 2011). Species richness was positively related to both the percent change in canopy cover ($r^2 = 0.27$, $P <$

0.0001) and basal area ($r^2 = 0.38$, $P < 0.0001$) as a result of tree removal. Total plant cover more than doubled in the low-intensity units and more than quadrupled in the high-intensity units as compared to the control units. Plant cover was positively correlated to both the percent change in canopy cover ($r^2 = 0.24$, $P < 0.0001$) and tree basal area ($r^2 = 0.28$, $P < 0.0001$; Stoddard et al. 2011). In summary, thinning the overstory can increase species richness if treatments allow enough sunlight to reach the forest floor and if conditions are monitored long enough through time.

Total biomass of herbaceous standing crop increased rapidly and was significantly higher post-treatment in another long-term ecosystem experiment. Moore et al. (2006) evaluated responses to three restoration treatments: 1) thinning from below, 2) thinning from below plus prescribed burning, and 3) an untreated control (Moore et al. 2006). While treatments yielded a significant increase in total biomass of herbaceous vegetation over the control throughout the entire post-treatment period, total biomass did not differ between thinning and thinning and burning treatments (Moore et al. 2006).

Abella and Covington (2006) evaluated community compositional differences (i.e., species presence and abundance) among treatments. They reported subtle but positive native species compositional differences between control plots and thin and burn plots three years after treatment. In another study, community composition diverged among treatments 5 years after initial treatment, and compositional changes were again greatest in the thin and burn treatment (Laughlin et al. 2008). Fire is a factor because it decreases accumulated litter and resulting smoke at ground level provides a cue for initiating seed germination in some species (Buddle et al. 2006).

Thinning indirectly affects ground flora through other interrelated ecosystem components such as soil nutrients and plant-mycorrhizae associations (Abella 2004). Arbuscular mycorrhizae are generally associated with herbaceous understory plants in pine forests and are different from the ectomycorrhizae generally associated with trees and woody shrubs (Hart et al. 2005). In a review of tree thinning and prescribed burning on understory vegetation, Abella (2004) reported arbuscular mycorrhizae more abundant on thinned and burned plots than on control plots. Abella (2004) also described the negative correlation between soil O-horizon thickness, a mix of leaf litter, minerals, and organic matter (SSSA 1996), and ground flora biomass. O-horizon thickness in ponderosa pine has increased during the past century because of fire suppression and increased tree densities; prescribed burning therefore benefits ground flora by reducing O-horizons (Covington and Sackett 1984).

Available soil nutrients often increase following burning (Covington and Sackett 1992). In Abella's (2004) review of thinning and burning in ponderosa pine forests, he concludes that availability of greater concentrations of nitrogen (N) and potassium leads to higher foliage nutrient concentrations in plants for grazers. In Montana, soil ammonium remained elevated through year three after thin-and-burn treatments in ponderosa pine forests; net N mineralization, nitrification, and NO_3^- (nitrate) concentrations were also significantly greater in the thin-and-burn treatments than all other treatments during year one and net nitrification rates remained elevated through year three (Gundale et al. 2005). Differences in N-cycling and availability among treatments can influence the composition of the biotic community that establishes following treatment. Results from plant community models suggest that net nitrification was indirectly related to plant species richness via a positive relationship between species richness and nitrifier abundance (Laughlin et al. 2010).

Laughlin et al. (2010) concluded their models indicated species-rich plant communities dominated by C3 graminoids and legumes were associated with soils that have high abundances of nitrifiers. Graminoids using C3 photosynthetic pathways dominated herbaceous response after both thinning and thinning-and-burning treatments (Moore et al. 2006). Many herbivores selectively feed on C3 plants over C4 plants, including Mogollon voles (Chambers and Doucett 2008), because C3 plants have higher nutritional content and digestibility (Gannes et al. 1998).

Actinomycetes are a broad group of bacteria that consume soil organic matter, plant litter, and simple carbon compounds, releasing the nutrients in these substances for use by living plants. Actinomycetes are particularly effective at breaking down tough substances like cell walls of plants, even under harsh soil conditions (USDI BLM 2011). Lignin, a component of cell walls, is often the most difficult portion of plant biomass to degrade (DeAngelis et al. 2011). Fire suppression activities over the past 120 years in ponderosa pine-dominated forests have resulted in large increases in pine and other conifer litter input, and a concurrent reduction in herbaceous litter inputs both above and below-ground (Kaye et al. 2005). These changes in litter quality have apparently altered the mutually dependent soil microflora (Hart et al. 2005). Management activities that change soil nutrients can shift dominance of decomposers from bacterial to fungal, leading to subsequent changes in ground flora species assemblages (USDI BLM 2011). Over the long-term, fire exclusion may have modified soil communities, including mutually dependent soil microflora, via plant-induced changes in the soil environment (Hart et al. 2005). These differences in soil characteristics may influence stand productivity and understory species composition in the future (Gundale et al. 2005). Thin-and-burn treatments can lead to increased actinomycete activity, as indicated by phospholipid fatty acid profiles (Gundale et al. 2005).

Understanding the interactions between microbial and macroscopic components of a given ecosystem function could be critical for managing for these services (Kremen 2005).

The importance of N as a structuring component of plant communities should be particularly strong in systems limited by N such as ponderosa pine ecosystems (Gundale et al. 2005). The native grass species that reportedly dominated the understory of historical ponderosa pine forests likely relied on rapid nitrogen cycling that was promoted by the frequent return of ground fire. Ponderosa pine-dominated forests have some of the shortest historical fire-return intervals of any forest type, and thus the evolutionary role of fire in shaping these forests is likely strong (Hart et al. 2005). Plant-soil feedbacks such as those described above may be even more fundamental to the long-term maintenance and stability of fire-adapted forests than direct nutrient mineralizing effects (Hart et al. 2005). Correlation analysis revealed that variation in fine fuel consumed was tightly correlated with net N mineralization and net nitrification (Gundale et al. 2005). Thinning and prescribed burning can affect microbial communities by increasing solar penetration to the forest floor, causing chemical alteration of the forest floor and associated changes in the mineral soil microclimate (Meyer et al. 2001, Hart et al. 2005). Two cycles of burning in thin-and-burn treatments reduced leaf nitrogen concentration of trees compared with the thin alone treatment (Wallin et al. 2004), suggesting more N was absorbed at or below ground level.

Soils under trees established in the last century have retained the biological, chemical, and physical imprints of the grass vegetation that occupied these areas before the pine invasion (Covington et al. 1997). The fact that pine invasion has not yet fundamentally altered the functional capabilities of the soil microbial community increases the chances that microbial communities that establish in restored grass openings following tree removal will be within the historical range of variation (Boyle et al. 2005).

Response by Taxa

While species-specific response to management is largely directed by which species are present before treatments, effects to understory vegetation can vary by taxa. Native graminoids, especially bunchgrasses, commonly dominate the herbaceous layer under dense ponderosa pine forests in northern Arizona (Griffis et al. 2001, Stoddard et al. 2011). This is true for unmanaged, thinned, and thinned-and-burned stands (Griffis et al. 2001, Stoddard et al. 2011). However, biomass response of graminoids varies by treatment intensity with one study reporting more than a 470 percent increase in graminoid cover in high-intensity units compared to a 53 percent increase in control units compared to pretreatment measurements (Stoddard et al. 2011). In this study, all three levels of thinning intensity were also treated with broadcast prescribed burning. Griffis et al. (2001) also found abundance of native graminoids increased significantly with treatment intensity through thinned and burned stands, but abundance decreased significantly in stands that experienced high-severity wildfire.

Waltz and Covington (2004) found little difference between treated and control forests in terms of species richness of forbs serving as host plant and nectar plants for butterflies two years after thinning and burning treatments. Plant communities did shift from an annual forb community 1-year post-treatment unit to more perennial forbs and grasses 3-years post-treatment. There was also an accompanying increase in diversity of flowering species (Waltz 2001). Griffis et al. (2001) reported thinning-and-burning yielded the greatest species richness value for native forbs and higher native forb abundance than either unmanaged or thinned-only stands. Reintroducing fire into northern Arizona pine forest systems was reported to increase species richness and abundance of native annuals by others as well (Laughlin et al. 2004, 2005, 2006; Moore et al. 2006). About half of the new species colonizing the area after thinning and burning were native annuals (Laughlin et al. 2008). Legumes and forbs exhibited a four to five year lag before responding to the thinning and thinning-and-burning treatments (Moore et al 2006). Annual and biennial plants showed a large biomass increase approximately five years after implementation of the composite treatment (Moore et al 2006). Native forbs constituted between 12% and 30% of the total standing crop across all treatment types ten or more years after treatment, with higher percentages of forbs related to higher treatment intensities (Sabo et al. 2009).

In general, shrubs respond negatively to fire. Many native shrub species decreased significantly with treatment intensity, although shrub response to fire intensity can vary by species (Griffis et al. 2001). In one study, burning resulted in 17 to 32 percent mortality of shrubs whereas zero to five percent of shrubs died on unburned plots (Huffman and Moore 2004). Mortality of burned plants was positively related to amount of forest floor consumed during prescribed fires. One growing season after fire, surviving burned plants responded by producing long resprouts. Current-year branches were consistently longer on burned than unburned plants only where plots were protected from mule deer and elk (Huffman and Moore 2004). Unburned plants had more current-year branches and greater biomass than burned plants. However, no seedlings emerged on unburned plots but were found on 44 percent of burned plots (Huffman and Moore 2004). Decreasing tree density was positively correlated with Fendler ceanothus (*Ceanothus fendleri* Gray) current-year branch length, biomass, and leaf area (Huffman and Moore 2004).

Response of non-native forbs varies by disturbance (Table 11). High-severity wildfire tends to favor exotic species (Griffis et al. 2001). Non-native forbs constituted 3 percent of the total standing crop on plots thinned to a low basal area and prescribed burned compared to 26 percent on wildfire stands (Sabo et al. 2009). Nonetheless, this response may be ameliorated through

time. Immediately following thinning and burning treatments, nonnative species cover comprised 6 percent of the total cover where treatment-induced disturbances were the greatest (Stoddard et al. 2011). However, the initial increase in nonnative species did not persist and was reduced by half six years after treatment (Stoddard et al. 2011).

Table 11. Understory response to forest disturbance.

Understory Characteristic	Changes Relative To Control Plots			Citation(s)
	Thinning	Thinning & Burning	High Severity Wildfire	
Plant Species Richness	Increase	Increase	Increase (but includes a higher percentage of exotic species)	Stoddard et al. 2011
Total Biomass	Increase	Increase	Increase (but includes a higher percentage of exotic species)	Moore et al. 2006
Graminoids	Increase	Greatest Increase	Decrease	Griffis et al. 2001; Stoddard et al. 2011
Forbs	Increase	Greatest Increase	Increase	Griffis et al. 2001; Laughlin et al. 2004, 2005, 2006; Moore et al. 2006
Shrubs	Increase	Increase/ Decrease	Decrease	Huffman and Moore 2004; Griffis et al. 2001
Gambel Oak	Increase	Increase	Decrease	Abella and Fulé 2008
Soil Nutrients	Increase	Greatest Increase	Increase (greater pulse in magnitude, but with lower potential to affect plant growth over time)	Meyer et al. 2001; Gundale et al. 2005; Hart et al. 2005; Covington and Sackett 1992; Abella 2004
Actinomycete	Increase (after herbaceous vegetation increases)	Increase	Decrease (patchy response depends on site-specific severity)	Gundale et al. 2005; Hart et al. 2005

Understory Characteristic	Changes Relative To Control Plots			Citation(s)
	Thinning	Thinning & Burning	High Severity Wildfire	
Arbuscular Mycorrhizae	Increase (after herbaceous vegetation increases)	Increase	Decrease (patchy response depends on site-specific severity)	Covington and Sackett 1984; Abella 2004
Community Composition	Increase	Increase	Increase	Covington and Sackett 1992; Abella 2004; Laughlin et al. 2008
Litter	Decreased Rate of Accumulation	Decrease	Decrease	Scudieri 2009
Native Plant Species	Increase	Increase	Increase (in the long-term)	Griffis et al. 2001; Laughlin et al. 2004, 2005, 2006; Moore et al. 2006
Exotic Plant Species	Increase?	Increase (in short-term)	Greatest Increase	Griffis et al. 2001; Sabo et al. 2009; Stoddard et al. 2011

Prescribed fire without mechanical alteration of the overstory reduces ground fuels, but does not appear to affect much change in understory vegetation. Only minimal effects on understory abundance and composition were detected after 30 years of repeated prescribed fires at varying time frequencies at two ponderosa pine sites in northern Arizona (Scudieri 2009). The weak treatment response was primarily due to high overstory basal area that occurred at monitored sites (Scudieri 2009). In another study, direct effects of prescribed burning included significant reductions in leaf-litter cover and depth, but no differences were significant for herbaceous cover or shrub cover the following year (Coleman and Rieske 2006).

Gambel Oak Response

Frequent fire is part of Gambel oak's evolutionary environment. Historical fire return intervals often averaged less than 19 years in pine-oak forests and multiple growth forms of the species persisted in frequently burned forests (Abella and Fule 2008). Densities of small-diameter oaks have sharply increased in the 140 years since fire exclusion following Euro-American settlement (Abella 2008a). Gambel oak densities in northern Arizona increased from 32 per acre in 1883 to 191 per acre in 1994 (summarized in Abella 2008a).

Trees affect soil moisture, nutrients, microclimates, and other environmental variables at that forest floor. Openings in oak canopies support more plant cover, more herbaceous species, and greater frequencies of some grasses compared to openings in pine forests (summarized in Abella 2009). Unlike needle-cast beneath pine, oak litter is looser, less resinous, and moister which may have resulted in decreased fire intensities (Abella and Fule 2008). Oak clumps containing

multiple, widely spaced stems appear optimal for maintaining relatively high understory species richness by facilitating the coexistence of plant species requiring either open or closed-canopy environments (Abella 2008b).

Thinning relatively homogeneous stands of ponderosa pine into groups of trees with adjacent interspaces can stimulate oak regeneration, creating highly variable patches of Gambel oak sprouts (Fule et al. 2002). Thinning pine trees likely produces the largest and most persistent enhancement of oak diameter growth compared to thinning or prescribed burning of oak (summarized in Abella 2008b). Fire can be used to manage Gambel oak densities and growth forms while maintaining large oaks during low-intensity burning. More than 66 percent of oak greater than 6 inches in diameter were alive at least 5 years after two prescribed fires. Survival was low (less than 20 percent) for small diameter Gambel oak (less than two inches diameter) after prescribed fire (Abella and Fule 2008). Waltz and Covington (2004) documented a loss of Gambel oak after restoration-based thinning and burning treatments, but variability in response across treated units prevented statistically significant results. Top-killed oaks resprout prolifically, suggesting that fire can maintain oak browse and cover for wildlife. Burning and thinning oak can temporarily reduce densities, but these treatments may result in longer term increases because of oak's prolific sprouting ability. Elevated oak density could constitute key intermediary tree structure after thinning to mediate impacts of rapid forest structure alteration to some wildlife species, especially during the time required to reestablish large-tree pine structure. There also is less evidence that elevated oak densities represent a negative ecosystem-level effect as compared to high densities of ponderosa pine.

While acorn production is cyclic, oaks 10 to 15 inches in diameter, with 80 to 100 percent live crown, yield the most acorns. Oaks less than 5 inches or greater than 18 inches in diameter produced few acorns. Management strategies that promote large oaks with vigorous crowns, such as thinning pine trees, likely will increase acorn production (summarized in Abella 2008b).

Gambel oak communities provide a diverse array of habitats. Gambel oak provides food, cover, and nesting/fawning habitat (Moir et al. 1997). Managing for low-growing forms of oak, particularly shrub thickets, will produce the greatest amount of accessible forage for ungulates. Gambel oak foliage comprised eight to 77 percent of whitetail deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*) diets in pine-oak forests (Reynolds et al. 1970 in Abella 2008). Brushy oak forms can provide fawning cover for deer (Moir et al. 1997). Densities of invertebrates and song birds are higher in Gambel oak communities. Gambel oak is used by both foliage and cavity nesters and provides roost habitat for bat species (Moir et al. 1997, Chambers, *pers. comm.*). Gambel oak is host for at least four species of butterfly larvae (McIntyre, *pers. comm.* 2011). One butterfly species, the Arizona Sister (*Limenitis bredowii*), relies on Gambel oak foliage as a caterpillar host and oak tree sap for adult nectaring. Waltz & Covington (2004) reported decreases in the Arizona Sister after restoration treatments. Gambel oak was not thinned with the restoration treatment, but mortality occurred with prescribed fire.

Forest Resiliency

Precipitation and drought appear to be the primary factors affecting total herbaceous biomass (Moore et al. 2006). Drought can overwhelm understory response to overstory thinning and prescribed fire (David Huffman, personal communication 2011). Fulé et al. (2002) reported sharp declines in understory plant cover and species richness across a spectrum of treatment intensities,

including control stands, when precipitation was only 61% of average post-treatment. They concluded that drought counteracted any detectable treatment effects. Several years later, Moore et al. (2006) described precipitation levels 75 percent below average that again reduced herbaceous biomass. In general, graminoids had been increasing several years since treatment and continued to increase until a series of severe droughts reduced standing crop to pretreatment levels (Moore et al 2006). Drought years have been common since the late 1990s (Figure 61 through Figure 63) and seem to favor graminoids with C4 photosynthetic pathways (reviewed in Moore et al. 2006). Plants with C4 photosynthetic pathways are less palatable to wildlife (Gannes et al. 1998) but are more efficient in their water-use (Moore et al. 2006).

Drought affects forest structure directly in terms of potential tree mortality and indirectly through related pathways, including changes in arthropod populations. In general, ponderosa pine mortality in the southwest has increased as a result of drought and more frequent bark beetle attacks (Kolb et al. 2007, Ganey and Vojta 2011). Severe drought from 2001 to 2004 led to increases in bark beetle populations (Negrón et al. 2009). Mortality was pervasive in ponderosa pine across northern Arizona, with a 74 percent increase of pine trees dying from 2002 to 2007 compared to the number dying from 1997 to 2002 (Ganey and Vojta 2011). A severe bark beetle outbreak represents a strong “thinning from above” disturbance (Klenner and Arsenault 2009). Mortality rates tend to be lower for smaller diameter trees and higher for larger trees (Klenner and Arsenault 2009, Ganey and Vojta 2011). Outbreaks can be extensive and have long-term consequences for canopy closure and overstory structure and significantly alter fuel complexes and fire behavior over time (Klenner and Arsenault 2009, Negrón et al. 2009). Forests with diverse tree species and age classes are less likely to develop large insect outbreaks (Black 2005). Ganey and Vojta (2011) concluded that the forests of northern Arizona are not resilient to climate change, and that treatments to increase resilience to climate change may be appropriate.

In a review of research conducted at the G.A. Pearson Natural Area, Fort Valley Experimental Forest outside Flagstaff, Moore et al. (2008) described trees greater than 140 years old responding with greater water uptake, stomatal conductance, net photosynthetic rate, and leaf nitrogen concentration in the first year after thinning. These physiological changes persisted through at least the seventh year post-treatment (Moore et al. 2008). In another study, thinning consistently increased bole basal area increment starting in the second post-treatment year and continuing for the next 10 years, except in the severe drought of 2002 (Kolb et al. 2007). Thinning also reduced crown dieback over the first 10 years post-treatment (Kolb et al. 2007). While growth was similar for trees in both thin-only and thin-and-burn treatments in most post-treatment years (Kolb et al. 2007), resin flow defense against bark beetles was consistently stimulated by only the thin-and-burn treatment (Wallin et al. 2004). Thinning and prescribed burning in ponderosa pine forests are expected to enhance understory vegetation directly and indirectly improve understory conditions by increasing old tree resiliency to drought and thus move elements of overstory structure towards the historical range of variation.

Drought affects arthropod populations too. While these changes are not often detected and the ramifications to forest health are not always understood, fundamental ecosystem pathways are affected. From 2003 to 2004 carabid ground beetle abundance decreased to only about one third of the levels measured from 1998 to 2000. This plummet in the population was ascribed to changes in annual precipitation in northern Arizona. In the extreme drought of 2002 no carabids were found within ponderosa pine sample plots (Chen et al. 2006). In dry years, small forest openings may provide cooler and moister microclimates than those in larger, more exposed meadows. These microclimates appear to maintain flowering plants required by nectar feeding

butterflies and other pollinating insects that, in some years, may be limited or absent in larger, drier meadows (Julie McIntyre, USFWS, personal communications). These islands of nectar flowers within the forest matrix may act as stepping stones, providing population connectivity and promoting dispersal and genetic exchange of pollinating insects (Julie McIntyre, USFWS, personal communications).

Arthropod Response to Management Treatments

Bark Beetles

Changes in forest structure over the last century as a result of anthropogenic factors are likely to increase susceptibility to Ips-caused ponderosa pine mortality in the Southwest (Negrón et al. 2009). These changes in forest structure have implications for species dependent on mature overstory trees and large snags for foraging and nesting, particularly in pure stands of ponderosa pine dominated by trees in larger size classes (Klenner and Arsenault 2009). Current forests that exceed the historical range of variation are at greater risks of uncharacteristic mortality levels resulting from beetle attacks (Lynch et al. 2008). In combination with past harvesting of ponderosa pine forests over the last century, this may further compromise the ability to provide future habitat conditions for wildlife associated with large trees, snags, and logs (Klenner and Arsenault 2009, Ganey and Vojta 2011). Silvicultural prescriptions can facilitate the development of mature conditions in ponderosa pine stands impacted by beetles (Klenner and Arsenault 2009, Ganey and Vojta 2011). Thinning forests to decrease tree competition can also benefit pollinating parasitoid wasps and flies which attack pine beetles and moth larvae to feed their own larvae (David Smith, pers. comm.).

Ground Beetles

Tenebrionid beetles, which are forest floor scavengers, were found at higher richness and diversity in ponderosa pine stands of northern Arizona 13 to 14 years after fuel reduction treatments (thinning alone and thinning with prescribed burning) compared to untreated stands (Chen et al. 2006). Villa-Castillo and Wagner (2002) found diversity of ground beetle species increased as the level of stand disturbance increased (unmanaged, thinned, thinned and burned, and wildfire). However, thin-only stands did not significantly vary from unmanaged stands in overall species assemblage and both had the lowest species richness values. Although species richness was low in unmanaged and thin-only stands, abundance was generally high. However, the higher abundance on unmanaged and thinned treatments was accounted for by a single species. Similarly, Chen et al. (2006) described thin-only stands as having the highest species evenness. Fuel reduction treatments consistently increased species richness and Shannon diversity measurements for carabids, but did not cause a pronounced shift in their community assemblage (Chen et al. 2006).

Stands that were thinned with a similar intensity, but with a prescribed burn applied three to four years after thinning, had significantly different ground beetle assemblages. Species richness for ground beetle species assemblages was higher on thinned-and-burned and high-severity wildfire-burned stands than either unmanaged or thin-only stands (Villa-Castillo and Wagner 2002). Chen et al. (2006) found that community assemblages of both carabids and tenebrionids had the highest species richness and diversity in high-severity wildfire-burned stands. Villa-Castillo and Wagner (2002) found a shift toward an assemblage dominated by open-area species in stands created by high-severity wildfire (Villa-Castillo and Wagner 2002). Ordinations of carabid and tenebrionid

community assemblages at two-dimensional scales showed that wildfire stands (greater than 90% basal area consumed during wildfire in 1996) were clearly separated from all other stand types for both taxa (Chen et al. 2006). Villa-Castillo and Wagner (2002) concluded a mosaic of forest conditions likely provides refugia for recolonizing beetles and prevents competitively dominant species from monopolizing resources. Chen et al. (2006) concluded mechanical fuel reduction treatments are an important management strategy to maintain high invertebrate species diversity in southwestern ponderosa pine forest ecosystems. Heterogeneity is important to species richness of all taxa although different taxa are related to different measures of heterogeneity such as structure and composition. No single forest condition can be labeled as optimum in providing habitat (Chen et al. 2006).

Spiders

Relatively small changes in habitat structure can have profound effects on spider species composition, in part because wandering spiders are largely replaced by web-building species as litter composition changes (reviewed in McIver et al. 1992). A study in Finland looked at the effects of a range of logging intensities on spider assemblages (Matveinen-Huju and Koivula 2008). Gap felling preserved some forest species while also supporting colonization of open-habitat species and thinning treatments preserve forest-floor spider assemblages found in unlogged control stands (Matveinen-Huju and Koivula 2008). Work in western Oregon documented a succession of spider species present in association with different ages of forest stands (McIver et al. 1992). Some species are present in areas without a forest canopy and others reside in old-growth stands. A mosaic of age-classes and structural characteristics supports the most diverse spider communities.

A study in Alberta looked at aspen-dominated stands within coniferous forests that were either clearcut or burned in high-severity wildfire (Buddle et al. 2006). Species abundance and species richness was greater in cut versus burned stands for almost three decades post-disturbance (Buddle et al. 2006). This is probably due, in part, to the complete or partial reduction of the organic horizon that occurs following most wildfires (Buddle et al. 2006). Spiders and other generalist predators may be re-colonizing the wildfire landscape from refugia missed by the fire. However, there is evidence that wildfire is crucial to some unique elements of litter-dwelling arthropods in young aspen forests (Buddle et al. 2006). Spiders apparently mostly recover to pre-disturbance assemblages after clearcutting in about 30 years (McIver et al. 1992). The post-disturbance assemblage continued developing 70 years after logging (Buddle et al. 2006) and it is not known how long full recovery takes (Matveinen-Huju and Koivula 2008).

Ants

Stephens and Wagner (2006) assessed changes occurring in ground foraging ant functional groups with four treatments (unmanaged, thinned, thinned and broadcast burned, and high-severity wildfire) in northern Arizona ponderosa pine-bunchgrass ecosystems. Ant functional groups and individual species differed significantly by treatment. Different functional groups were dominant under different levels of disturbance severity and suppressed or excluded other functional groups that were less suited to the particular disturbance intensity. Unmanaged forest stands were characterized by high tree densities, high basal area, and dominated by the opportunist functional group. Thinned stands, also dominated by the opportunist functional group, had a similar ant assemblage as the unmanaged stands, but the coarse woody debris functional group was more abundant in thinned stands. The generalist group was up to 25 percent more abundant in the

wildfire areas than any other treatment condition. They occurred at very low (less than five percent) abundance in the thinned stands for both years. Conversely, relative abundance of coarse woody debris specialists was highest in thinned sites and lowest in wildfire sites, being at least 10 percent more abundant on thinned sites than wildfire sites. Specialized slave makers were most abundant in unmanaged and thinned sites and were rarely or not observed in thinned-and-burned or wildfire sites (Stephens and Wagner 2006). The variety in ant functional groups among treatment types underscores how different the ecosystem composition may be in today's forests relative to the historical range of variation. Stephens and Wagner (2006) concluded that in order to maintain a diversity of ant functional groups and species in northern Arizona ponderosa pine forests, a diversity of forest conditions should be maintained. McIver et al. (2006) concluded that several species of ants made up the majority of invertebrate predator biomass in clear cuts. Only one species was present in old-growth forests (McIver et al. 2006). Maintaining a diversity of habitat types should support ecologically diverse ant functional groups (Stephens and Wagner 2006).

Butterflies

The primary threat to many butterfly species is habitat loss (Black et al. 2007, Selby 2007). In general, increased light to the forest floor increases the overall butterfly population. In addition, as specific host and nectar plants become more established in opened areas, more specialized butterfly species are also likely to move into restored forest areas (reviewed in Meyer et al. 2001, Julie McIntyre, USFWS, personal communications). Butterflies associated with open habitats are likely to be attracted to restoration treatments in Southwest ponderosa pine systems (Meyer et al. 2001).

After restoration-based treatments were implemented in ponderosa pine forest in northern Arizona, butterfly species richness and abundance were 2 and 3 times greater, respectively, in treated units than in paired control forests 1 year after treatment, and 1.5 and 3.5 times greater, respectively, 2 years after treatment (Waltz and Covington 2004). Ordination of butterfly assemblages in control and treatment units showed significant separation after restoration treatments. Waltz and Covington (2004) also reported insolation (light intensity) was significantly greater in treated forests after restoration.

Species such as *Speyeria nokomis nokomis* and *S. n. nitocris* may benefit from meadow restoration and restoration of ephemeral drainages. *S. n. nitocris* fly in open, sunny habitats but females also search out host plants in edge habitats. Their host plant, *Viola nephrophylla* Greene, is typically found in moist or spring-fed meadows (Julie McIntyre, USFWS, personal communications). Maintaining habitat supporting the host plant along with a diversity of flowering nectar sources (especially purple and yellow flowers), will help support this species (Julie McIntyre, USFWS, personal communications). Work with the Nokomis Fritillary (*Speyeria nokomis apacheana*) indicated probability of occupancy increased with increasing larval host-plant abundance and percent cover of adult nectar sources (Fleishman et al. 2002). Occupancy decreased as litter reached heavy levels, perhaps as a result of impeded ovipositing (Fleishman et al. 2002), suggesting prescribed burning could maintain their habitat. Butterflies should benefit from management that provides key micro-habitat components such as increased understory, particularly flowering forbs, and higher light intensity and higher temperatures at the forest floor (Meyers et al. 2001, Selby 2007).

Pollinators

Ponderosa pine forest conditions across the Intermountain West appear to be increasingly unfavorable for most insect pollinators (Nyoka 2010). Most pollinators have similar needs: open, sunny areas, high herbaceous diversity, and availability of host plants and nectar sources. Some early-successional disturbance-based forb communities, with a variety of microclimates, may provide refugia under changing conditions (Julie McIntyre, pers. comm.). Overstory thinning and prescribed burning have the potential to improve habitat for pollinating taxa (Nyoka 2010; Table 3). Overstory thinning and prescribed burning can increase: nest site availability, solar radiation at ground level, and the abundance and diversity of flowering plant resources, resulting in improved habitat for most pollinating insects (Black et al. 2007, Nyoka 2010).

Arthropod Response to High-Severity Crown Fire

Herbaceous species richness and abundance of native graminoids both decreased significantly in stands that experienced high-severity wildfire (Griffis 2001). Wildfire produced the greatest abundance of forbs, but also the greatest abundance of exotic forbs (Griffis 2001). Vegetative cover occurred over less than half the area after the Hochderffer wildfire in 1996 that killed over 95 percent of the trees (Sabo et al. 2009). Following the fire, native graminoids and forbs contributed the largest proportion to total herbaceous biomass (Sabo et al. 2009). Nearly half of the total native graminoid biomass occurring on wildfire plots was comprised of colonizing species. Nonnative forbs were not detected on unmanaged, thinned, and thinned and burned stands eight years later, but constituted seven percent of the total vegetative biomass on wildfire stands. In the ninth year post-fire, 22 percent of total vegetative biomass was contributed by nonnative forbs (Sabo et al. 2009). This pronounced presence of non-native forbs on wildfire sites was largely attributed to common mullein (*Verbascum thapsus* L.). In addition to mullein, other nonnative forbs, in decreasing order, were: Dalmatian toadflax (*Linaria dalmatica* (L.) P. Mill.), yellow salsify (*Tragopogon dubius* Scop.), Russian thistle (*Salsola kali* L.), prickly lettuce (*Lactuca serriola* L.), common dandelion (*Taraxacum officinale* G.H. Weber ex Wiggers), lambsquarters (*Chenopodium album* L. var. album), and bull thistle (*Cirsium vulgare* (Savi) Ten.) (Sabo et al. 2009). The most severely disturbed wildfire site supported the greatest standing crop of native and non-native colonizing species (Sabo et al. 2009).

Fire creates a nutrient pulse back into the soil. As the time between fires lengthens, the pulse of nutrients released from the fire increases in magnitude. However, the extended time between nutrient pulses means there is a lower potential to affect plant growth over the fire-free period (Hart et al. 2005). In contrast, higher frequency and low-severity fire, like those managed in prescribed burning, produces a lower magnitude nutrient pulse more frequently, enhancing soil nutrient balances and aiding herbaceous vegetation more consistently.

Fire and Arthropods

Prescribed burning primarily affects the arthropod community by changing understory conditions. In southeastern pine-oak forest, leaf-litter arthropod abundance remained low the year following an early-season, low-intensity burn (Coleman and Rieseke 2006). Recovery of leaf-litter arthropods was evident two-growing seasons after the burn. While this was low-intensity fire, it was also a first entry burn. In a paired site that had been burned three years previously, no long-term effects of multiple burning on leaf-litter arthropods were detected. Leaf-litter arthropod diversity was not affected by either burn regime but abundance was greater at multiple-burned

sites. Prescribed burning that created a mosaic, i.e., pockets of less intense or incomplete fires as well as hotter burn areas, retained higher leaf litter and supported a greater abundance of arthropods (Coleman and Rieske 2006). Three years between prescribed burns appeared adequate to replenish leaf-litter habitat and allow arthropod abundance to rebound to comparable unburned levels (Coleman and Rieske 2006).

A study in a California oak woodland habitat that tracked wildfire effects on a specific flowering forb found plants growing in burned environments were taller and pollen-tubes grew faster than plants growing in unburned sites (Travers 1999). There is a relationship between pollen-tube growth and pollen production, suggesting plants in burned environments better support pollinators and that they would have a competitive advantage in the fertilization of ovules (Travers 1999). Pollen performance appears to depend on both the genetic background of pollen recipient plants and the growth environment of pollen donors (Travers 1999). If pollen performance is limited by nutrient availability, then post-fire increases in soil nutrient content should lead to improved rates of pollen-tube growth in individuals growing after the fire (Travers 1999). If these results can be extrapolated to other flowering plants, then prescribed fire should benefit pollinators by enhancing pollen production. Overall diversity and abundance of nectar or pollen feeding arthropods may increase in response to increased nectar resources (Waltz and Covington 2004). A 50-year chronosequence of a Mediterranean pine–shrub community regenerating following fire found bee community composition closely tracked floral composition and associated rewards (Potts et al. 2003b cited in Kremen et al. 2007).

Direct impacts from high-severity wildfire can be very different from prescribed burns (Table 12). In deciduous-dominated stands (*Populus*), fewer arthropods were caught in stands originating from wildfire than in those developing after clearcutting for almost three decades post-disturbance (Buddle et al. 2006). This was probably due, in part, to the complete or partial reduction of the O-horizon that occurs following most wildfires (Buddle et al. 2006). Landscape-scale high-severity fires can create extensive areas of powdery soil substrates unsuitable for ground-nesting bees, and widely scattered patches of floral resources dominated by low-reward annual species in the short-term (Nyoka 2010). The probable outcome of continued fire suppression is an increase in high-severity, stand replacing wildfires (Covington and Moore 1994, Covington et al. 1997) as seen in the Rodeo-Chediski fire of 2002 (464,556 acres) and the Wallow fire in 2011 (538,049 acres).

Table 12. Arthropod response to management treatments.

Arthropod Species	Changes Relative To Untreated Plots			Citations
	Thinning	Thinning & Burning	High Severity Wildfire	
Bark Beetles	Decrease	Decrease	Increase (surviving trees weakened by fire are more vulnerable)	Lynch et al. 2008; Negrón et al. 2009
Ground Beetles	Increase	Increase	Increase (but dominated by open-habitat species)	Villa-Castillo and Wagner 2002; Chen et al. 2006
Spiders	Increase	Increase	Mixed (depends on burn patterns and severity)	McIver et al. 1992; Buddle et al. 2006; Matveinen-Huju and Koivula 2008
Ants	Increase	Mixed	Mixed	Stephens and Wagner 2006
Butterflies	Increase	Increase	Decrease	Meyers et al. 2001; Waltz and Covington 2004; Selby 2007
Pollinators	Increase	Greatest Increase	Decrease in the short-term; increase in long-term	Travers 1999; Kremen et al. 2007; Nyoka 2010

Understory Conditions in the 4FRI analysis Area

Historic Conditions

In 1909, research was initiated in ponderosa pine forests on the Coconino National Forest by Gus Pearson and follow-up work was completed by Moore et al. (2004). Based on detailed stand information and management history, a model was built to predict forest characteristics before logging and fire exclusion altered stand conditions. Basal area was used to estimate understory biomass from 1876, the year of the last wildfire and before any logging occurred, to present. Moore et al. (2004) also used models from other areas within the proposed 4FRI treatment area and from the Beaver Creek watershed adjacent to the 4FRI treatment area boundary to estimate historic understory biomass. Overall, they estimated a decrease in understory biomass of over 50 percent since 1876.

Current Conditions

Range managers have been monitoring forage production with a survey technique known as the Parker 3-Step. Each “step” represents a different data-collection method performed at fixed points and transects designed to be reread through time. A Parker cluster typically consisted of three 100

foot-long transects and plants were recorded every foot along each transect (step 1). Range conditions were evaluated (step 2) and photographs taken at permanent photo points (step 3). Originally, any perennial plant encountered every foot along permanent transects were tallied (“hits”). After transects had been read for years it was felt the data was not sensitive enough to accurately represent range conditions. They were modified to include plant hits and “dots.” If no plant occurred where the hit landed, the closest plant within a 180° arc off transect was included. Dots expanded the dataset, but lack of a spatial component associated with dots make them difficult to assess. While the data is not suited for rigorous analysis, they preserve a record of plant species occurring on the landscape and the frequency in which they occurred. This method was considered state-of-the-art, but in recent years it has been replaced with more ecologically sensitive measures. Nevertheless, the Parker dataset represents the most comprehensive herbaceous vegetation dataset with repeat measures in northern Arizona. The record goes back to the 1950s. Parker transects were intended to be read every decade and readings within the 4FRI treatment area occurred as recently as 2010.

There are 121 Parker cluster within the soil types occurring in the 4FRI area. Data from the original surveys for these transects were put into an electronic format (Dave Brewer, Ecological Restoration Institute). Data summaries for hits (Figure 57) show decreases in herbaceous cover since the 1980s. An obvious increase in trees occurred along transects since the 1960s, but even trees declined since the 1980s. Dots provide higher frequencies and indicate grasses and trees have increased while other plant taxa decreased during this same time period (Figure 58).

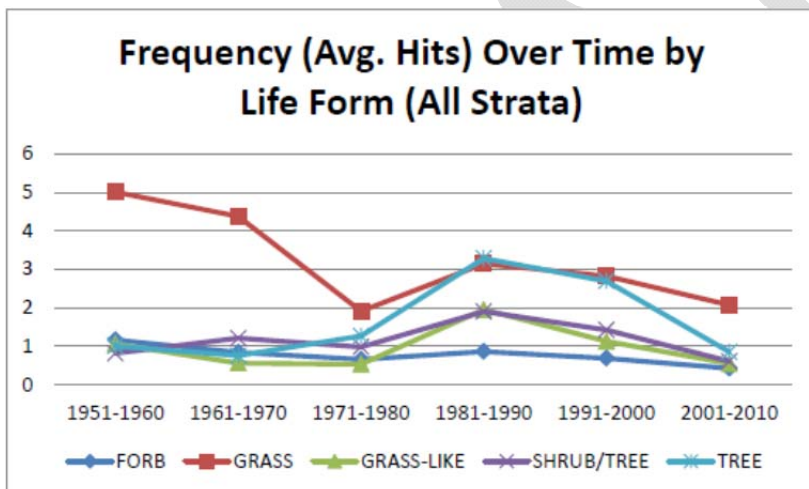


Figure 57. Plant frequency trends along Parker transects (hits) occurring in soil strata within the 4FRI area

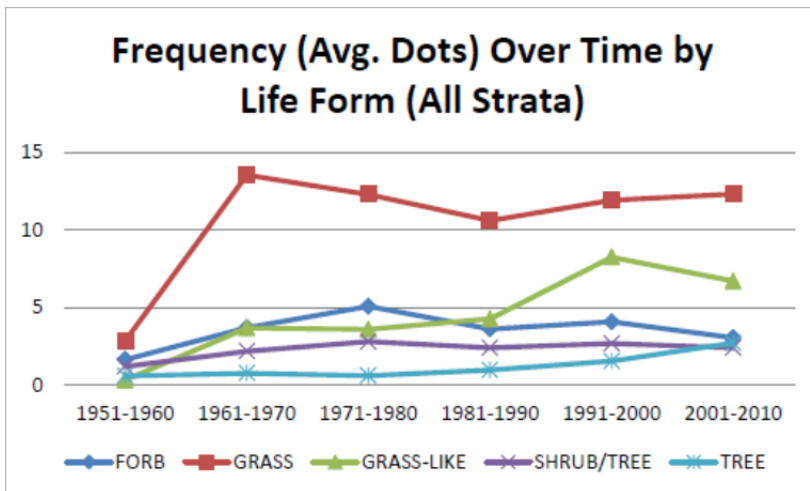


Figure 58. Plant frequency trends adjacent to Parker transects (dots) occurring in soil strata within the 4FRI area

Figure 59 displays changes in C₃ (“cool season”) and C₄ (“warm season”) plants over time based on hits. Increases for both groups occurred in the 1970s and have had decreasing trends since the 1980s. Warm season plants, primarily blue grama grass, have been dominant on the landscape, but the degree of dominance has decreased through time. Cool season plants have been decreasing at a faster rate than warm season plants since the post-1980s decline. The pattern changes when dots are used, with warm season plants continuing to increase since the 1980s and cool season plants only decreasing since the 1990s (Figure 60).

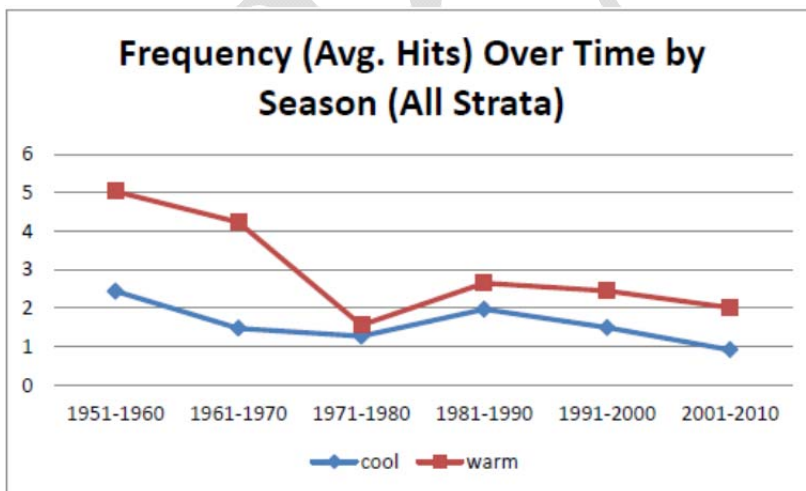


Figure 59. Plant frequency trends along Parker transects (hits) occurring in soil strata within the 4FRI area

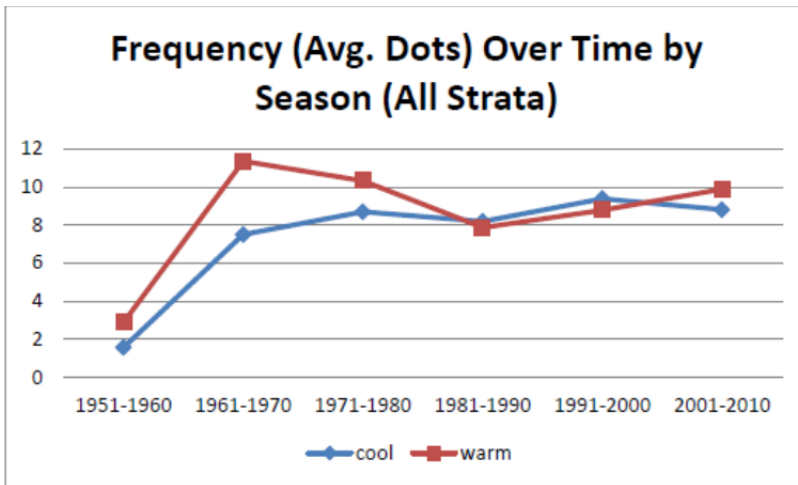


Figure 60. Trends for cool (C3 pathways) and warm (C4 pathways) season plants adjacent to Parker transects (dots) occurring in soil strata within the 4FRI area

Key to trends in vegetation is precipitation patterns. Flagstaff is relatively centrally located in the 4FRI treatment area and precipitation history for Flagstaff shows that, with exception, annual precipitation exceeded the 10-year average (Figure 61). However, annual precipitation in northern Arizona is bimodal, principally occurring as winter snow or summer (monsoon) rain. Winter precipitation is key for maintaining cool season plants while warm season plants are tied more to monsoon rains. An examination of winter precipitation illustrates the number of years with below average snowfall (Figure 62). Monsoon rains more often occurred at or above the 10-year average (Figure 63). Note that the drought that started in 2000 affected both summer and winter precipitation.

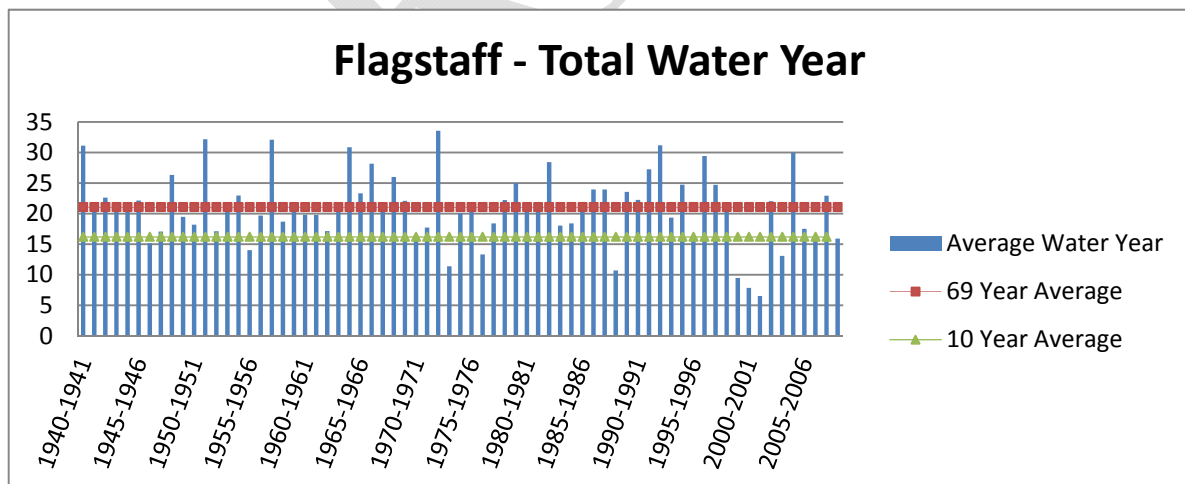


Figure 61. Annual precipitation patterns for Flagstaff, Arizona, 1940 to 2009

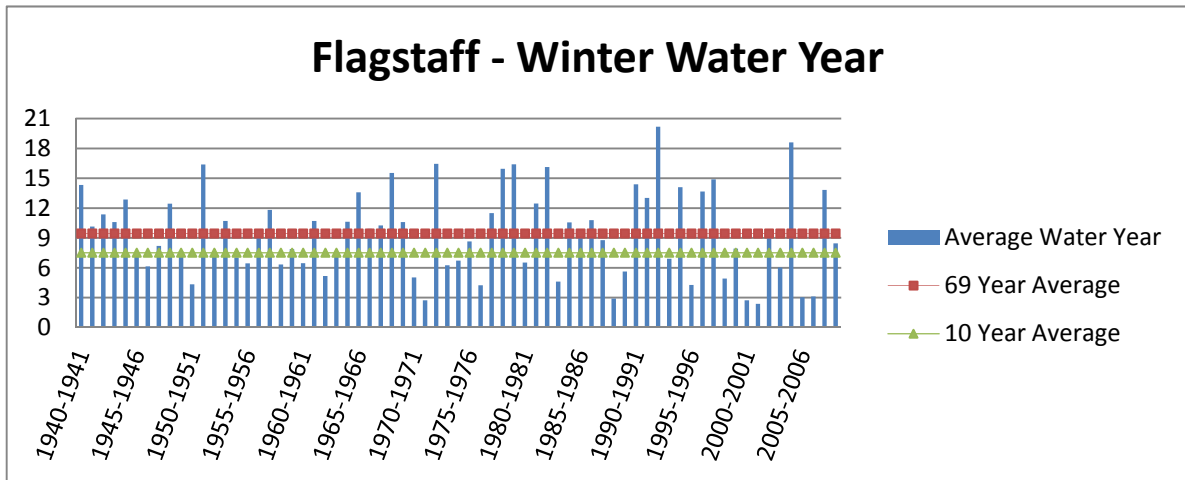


Figure 62. Winter precipitation for Flagstaff, Arizona, 1940 to 2009

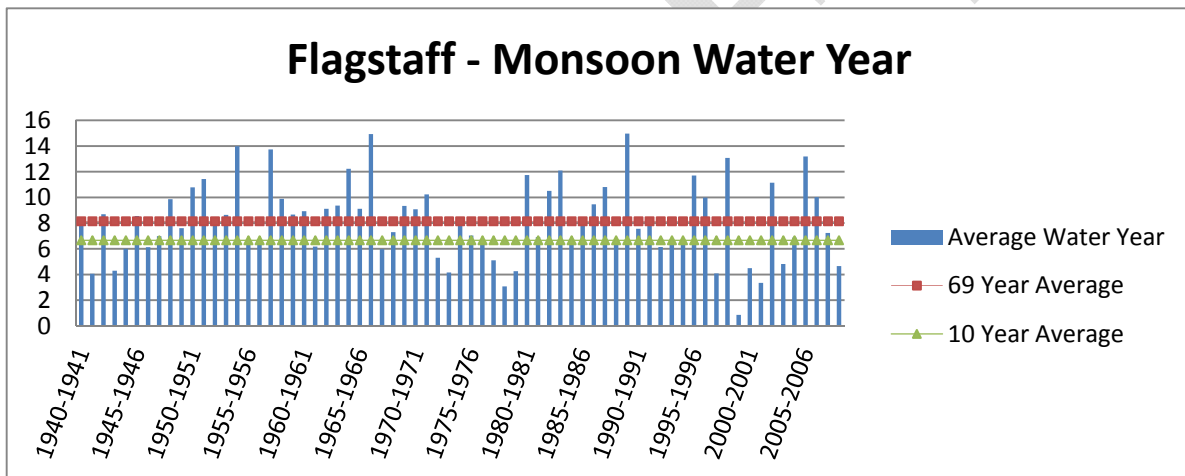


Figure 63. Summer precipitation for Flagstaff, Arizona, 1940 to 2009

Predicting Future Conditions

As described above, there is a strong and predictable relationship between overstory closure, tree density, and understory production. Decades of research using local vegetation data across the ponderosa pine forests of northern Arizona have resulted in many models for predicting understory response. While the associated Y-intercepts and coefficients vary between models, the resulting response functions are the same: the relationship between the input (forest structure) and the output (understory biomass) is inversely related and curvilinear. As forest density increases understory development decreases. The reduction in herbaceous biomass is small at first and then rapidly declines. At a certain level of forest development the rate of decrease in herbaceous production levels off, becoming nearly asymptotic in dense, closed canopy conditions as the understory response approaches zero.

Understory biomass predictions vary by soil type (Bennet et al. 1987, Ffolliott 1983, Laughlin and Abella 2007). At broad scales, most soil series within the 4FRI project area are dominated by basalt or limestone parent materials. Soil chemistry, texture, and topography all effect biomass production (Clary and Ffolliott 1966, Covington and Sackett 1992, Abella and Covington 2006, McGlone et al. 2009). However, under dense canopy cover understory biomass yield is similar between soil types (Clary and Ffolliott 1966, Bennett et al. 1987). Differences in biomass yield between different soil types is more fully expressed under open the canopy cover (Bennett et al. 1987).

A variety of approaches have evolved to classify landscapes or ecosystems. One approach uses terrestrial ecosystems, which have been defined as the conceptual representation of the obligatory relationship between soil, vegetation, and climate (Robertson et al. 2003). A Terrestrial Ecosystem Survey (TES) consists of the systematic examination, description, and classification of soil, vegetation, and climate which are integrated with other ecosystem components, such as landform, geology, and geomorphology (Robertson et al. 2003). The unique combination of terrestrial ecosystems and appropriate phase criteria (i.e., slope, texture of the surface layer, soil depth, etc.) define an ecological map unit. TES meets the requirements of the National Hierarchal Framework of Ecological Units, a land classification system for classifying and mapping of the Earth into progressively smaller areas of increasingly uniform ecological potentials. TES mapping is done at the landscape scale with a resolution of 40-acres. Identification of the soil component meets the standards and follows the policies and procedures outlined in the National Cooperative Soil Survey program. The description and classification of soils meets the criteria established in *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys* (2nd edition, 1999), the *Soil Survey Manual*, and the “National Soil Survey Handbook” (Robertson et al. 2003). A TES was completed for both the Coconino and Kaibab National Forests (Brewer et al. 1991, Miller et al. 1995).

Bojorquez Tapia et al. (1990) developed and statistically analyzed 18 herbage production/forest overstory regression equations based on over 20 years of data from the Beaver Creek drainage, a sub-watershed adjacent to the 4FRI project boundary on the Coconino NF. The area was dominated by ponderosa pine forest occurring on soils with basaltic parent material. The authors reported associated statistical measures for the equations, including the coefficient of determination, to compare how well the predictive models matched the actual data. In this application, a coefficient of determination (r^2) is the proportion of variability in a data set accounted for by the model. It reflects the goodness of fit, or how well the regression matches the actual data values. An r^2 of 0.0 indicates none of the variability in the dataset is explained by the model and a value 1.0 is when the model perfectly fits the data. An r^2 of 0.4 can indicate a reasonable fit in natural resource models. Through a series of statistical evaluations, Bojorquez Tapia et al. (1990) concluded 16 of the 18 equations did not meet their evaluation criteria. The top model was logarithmic using basal area as the measure of overstory with an r^2 of 0.703 (Table 12). The authors clarified that the intent of the model development was for long-term planning purposes and not for predicting herbage production in a particular year (Bojorquez Tapia et al. 1990).

In a similar effort, Deiter (1991) evaluated eight models for predicting understory biomass using a variety of overstory stand density measures on stands from the North Kaibab Ranger District of the Kaibab National Forest. This work was done in ponderosa pine forest on limestone soils. One of the equations was a nonlinear regression model using basal area. This equation represented a

comparable approach to Bojorquez Tapia et al. (1990) using the same overstory variable. Deiter's (1991) equation for limestone soils had an r^2 of 0.671 (Table 4).

Table 13. Selected models for relating understory production to overstory basal area in ponderosa pine forests of northern Arizona. The response variable Y equals understory production.

Regression Equation	Parent Soil	r^2	Study
$\text{Log}(Y) = 2.794 - 0.348 \times 10^{-1} (\text{BA})$	Basalt	0.703	Bojorquez Tapia et al. 1990
$\text{Square root}(Y) = 6.5894 + 32.488 \times \ln^{(-0.0511 \cdot \text{BA})}$	Limestone	0.671	Deiter 1991

The equations described above were developed from data within their respective study areas. It is not valid to extrapolate the models using the coefficients derived from the respective source data to predict understory biomass yield in other watersheds. In order to predict actual herbaceous biomass yield, site specific data should be collected to calculate new coefficient values.

Additional measures such as litter depth, topography, interactions of soil nutrients and microflora, and other factors could affect the accuracy of the predictions. Nevertheless, the models in Table 12 were used to create a **relative index** of herbaceous response to overstory manipulations across the 4FRI treatment area. The yield values do not represent actual predictions of expected pounds per acre of biomass. The output, biomass yield, represents a relative measure of change between actual treatment prescriptions based on basal area of forest stand structure before and after treatments are implemented.

This approach was pursued because of the consistently similar response function from a variety of models developed over the last several decades within the ponderosa pine forests of northern Arizona. The strong link between overstory, as assessed by basal area, and understory has been demonstrated by a variety of authors. Rather than make actual predictions, the models identified by Bojorquez Tapia et al. (1990) and Deiter (1991) were used as a means to uniformly compare understory response to changes in overstory structure. The equations were applied across the 4FRI treatment area stratified by parent soil material. This approach allows an objective comparison of management actions based on stand-by-stand treatment outputs to evaluate this fundamental aspect of wildlife habitat. These estimates of change display relative changes in biomass yield under different treatment scenarios. The relative change was generated for each individual ponderosa pine stand across the treatment area and summarized by the 19 sub-units with proposed fire or mechanical treatments. Relative indices were developed for basalt and limestone soils only as no equations were found for deep cinder soils.

Abella and Covington (2006) examined geomorphology, soils and vegetation in ponderosa pine stands on the Coconino NF near Flagstaff. They classified 10 different ecosystem types using diagnostic environmental features and characteristic herbaceous species. Black cinder soils with purplefringe (*Phacelia sericea* Graham) common in the understory had the driest surface soils, lowest plant cover, and fewest understory species of any of the classified ecosystems; next on this gradient were red cinders with yellow ragleaf (*Bahia dissecta*) (Abella and Covington 2006). The black cinder system, with gravelly, surficial volcanic cinders, typically had more open grown forest but with low ground-flora cover. The red cinder system had sandy loam soils, slow tree growth, and moderate ground-flora cover. Both systems are relatively xeric, but in addition,

movement of the cinders may further impede understory development in black cinders. Harsh growing conditions in black cinders appear to favor annual versus perennial understory plants. Growth rates of ponderosa pine were slowest in red cinders. Surface soils in the black cinders were deemed “inhospitable” and ponderosa pine growth rates were variable, but on average, once a tree became established rapid diameter growth occurred. Both systems principally occur around the San Francisco Peaks, although cinder inclusions are found across the 4FRI treatment area. While no models exist for estimating understory response after overstory thinning, we expect a limited response because of the growing conditions in cinder soils. Abella and Covington (2006) noted that the red cinder systems were rare historically, but over 30 percent of their area has been burned by crown fires since 1950, indicating a need for ecologically-based treatments despite the limited response in understory vegetation.

The equations for basalt and limestone described above were included in the database calculations and a relative understory response value was generated for each stand, for each reporting year, for each alternative. Proposed treatments under the 4FRI will occur over the course of 10 or more years. However, there is no way to predict when a particular acre might receive treatment. For the purposes of forest simulation modeling, the following assumptions were made: the year 2010 represents existing conditions; all mechanical treatments occur in the year 2012; initial burning treatments happen in 2015; maintenance burns follow in 2019; and 2020 is the first year post-treatment (see Silviculture Report for details). Modeling out to the years 2030 and 2050 was conducted to track forest changes through time. Modeling assumes no further reductions in overstory after treatments implemented under 4FRI. In order to meet the desired conditions of the 4FRI we expect further treatments will be necessary. This assumption precludes any effects of future maintenance burns or low-severity wildfire. By excluding future low-severity burning another negative bias is introduced into the model results, further dampening the biomass yield index below what could be reasonably expected.

There are several key limits to this modeling approach. One is soil based. There are 96 TES units across the 4FRI project area. These were grouped by dominant parent material and each soil TES was combined into one of three categories: basalt, limestone, or cinder (Rory Steinke, Coconino NF and Christopher MacDonald, Kaibab NF, *pers. comm.*). This greatly simplifies the variety found in the project area by assigning one output for each soil type that fell within either “basalt” or “limestone” and was used consistently for generating output across alternatives.

Another limit to this approach is basing output on basal area. The basal area value in the model represents a simple average across the stand. Using basal area alone as an overstory measure does not address tree density. Deiter (1990) provides an example of two 1-acre stands each with the same basal area. One stand has trees that average six inches dbh and the other has trees averaging 24 inches dbh. If the basal area was 44 ft² the first stand would have 229 trees and the second stand 14 trees. This translates to big differences between stands in terms of area beneath overstory canopy and the amount of area with no canopy. Where the landscape is dominated by open grown stands, the biomass yield value will be low compared to what would actually occur on the ground. This bias is likely slight for existing stand conditions (year 2010), but for post-treatment years when many of the stands will have groups of trees with intervening gaps, the index value will be increasingly biased towards underrepresenting the response values. Most of the mechanical treatments are designed to create openings among currently homogeneous stand structure. The stand basal area value represents an average of openings and tree groups, but does not account for the site-specific effects that the resulting tree groups and canopy openings will have on the understory. However, this bias is consistently applied to all stands under all

alternatives across all time periods. Therefore, the result is still a robust value in terms of comparing relative change.

Summary of Effects by Alternative

Each alternative treats slightly different acreages and contains differences between amounts of treatment types. Alternative D limits broadcast burning to less than 50 percent of the area proposed in alternatives B and C; alternative A includes no burning. The differences that fire makes on herbaceous response is not at all represented here. Therefore, effects on seed banks, changes in soil nutrients, the effects of those changes on soil micorflora and hence indirect change to plant development, and the reduction in litter layer and affects to the O-horizon are not included here. This too represents a negative bias in that the estimated biomass response will be lower than expected by not including a fire-effects component.

Finally, the results show the differences between treatments, but do not include any effects of grazing. Domestic grazing and grazing by wild ungulates may increase or decrease through time. The trend in numbers of large ungulate grazers, domestic or wild, will have direct effects on the potential improvements in understory conditions. Should overall grazing pressure increase, there may be no benefits realized in understory communities, associated arthropod communities, and their effects on vertebrate wildlife.

The number of proposed treatments times the number of alternatives times the number of time periods equals a lot of individual values. Summary graphs are presented by subunit to capture the differences between alternatives in a spatial manner across the treatment area. At the landscape level, the results of the modeling effort in terms of response function match expectations based on the scientific literature (Figure 64). The no action alternative witnesses a continued decline in herbaceous biomass. Also expected was the similar pattern for each of the action alternatives. This is the same response function described in the literature. The year 2020 shows the response to reductions in canopy and, to a limited extent (i.e., as reflected in the stand averages), the creation of interspaces and canopy openings. This response declines as the accelerated tree growth increases canopy cover through time. The rate of decline in understory development increases through time as trees continue to grow. The number of acres treated varies between alternatives. Alternative C treats the most acres and elicits the greatest response in understory. Alternatives B and D treat the same number of acres mechanically, but alternative D does not include broadcast burning across all the mechanical treatments as alternative B does and there are about 20,640 fewer acres of prescribed-burn only treatments. Alternative D treats the fewest acres of the action alternatives and generates the least response in understory biomass.

Understory response consistently varies by treatment intensity in the literature. Treatment response is more nuanced across the 4FRI landscape. While group selection consistently produced a three- to four-fold increase in understory response, other patterns were not as obvious. Treatment designs were based on individual stand conditions. More open stands were treated lighter and closed stands were treated heavier except for areas like Mexican spotted owl habitat. Management direction for Mexican spotted owl habitat followed direction in the Mexican spotted owl Recovery Plan (USDI 1995). Like treatment intensity, existing herbaceous biomass is correlated with existing overstory conditions. Stands designated for higher intensity mechanical treatments tend to have higher tree densities and so support low levels of understory development. Stands designated for lower intensity mechanical levels are already more open and so currently support higher levels of understory development. Similar post-treatment results

occurred in terms of total yield and percent increase of the herbaceous response because of the correlation that both management prescriptions and existing understory conditions have with overstory. This validates the assumption that overstory conditions in stands identified for heavier tree removal have canopy conditions that are more closed. Stands that are more open are, in turn, getting lighter treatments. This relationship between existing conditions and treatment intensity ameliorates the output. Stands identified for savanna and grassland restoration currently support higher levels of understory biomass than the forest treatments, indicating these treatments are also well placed.

Figure 64 shows average per acre understory yield through time for all treatment acres. Results below present total yield by subunit, i.e., average per acre yield multiplied by the number of acres. Individual subunits vary by size, total acres treated, kinds of treatments, and the mix of soil types within them. This leads to marked variation across the landscape, e.g., subunits within restoration units 1 and 3 have more acres of grassland and savanna treatment; subunits 4-3 and 4-4 have thousands of acres of loose cinder soil; restoration unit 6 is all limestone; and subunits with extensive areas of Mexican spotted owl habitat have different management objectives than areas outside of owl habitat.

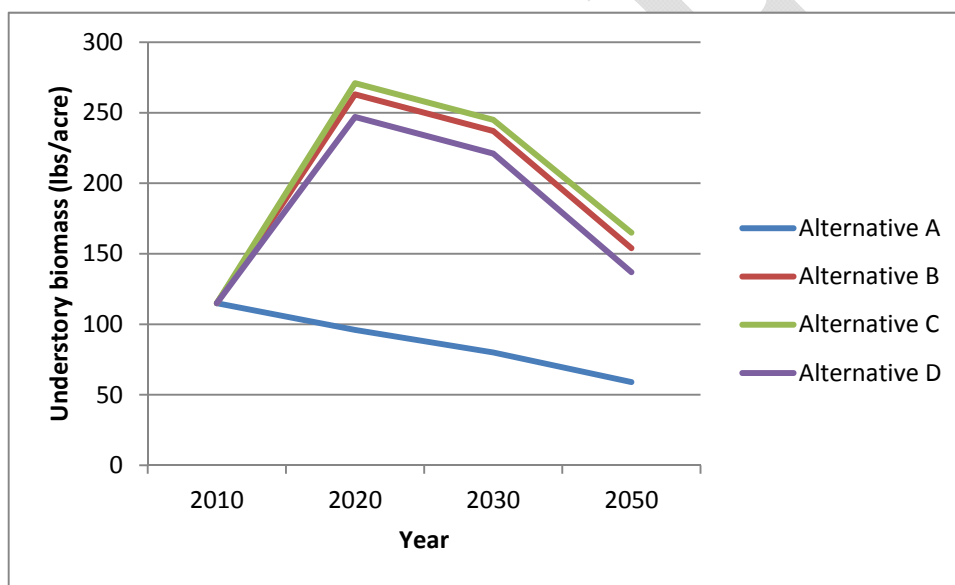


Figure 64. Average per-acre understory biomass yield (pounds) by alternative based on modeled changes in basal area under the 4FRI (see page 25 for alternative descriptions)

Restoration Unit 1

Rather than display the average response per acre, as shown in Figure 64, the values below represent total yield or the relative biomass response multiplied by the number of acres per subunit. Values are reported in units of 1000, i.e., five thousand thousands equals 5 million pounds of biomass. All graphs are scaled the same to facilitate comparisons between subunits.

Restoration Unit 1 is east of Flagstaff and south of I-40 (see pages DEIS for maps of subunits). Subunits 1-1, 1-2, and 1-4 show a similar response for the action alternatives and an apparently limited response relative to alternative A (Figure 65 through Figure 69). However, the tables beneath the graphs show a consistent doubling to tripling of forage values, totaling millions of

pounds of herbaceous biomass. Subunits 1-3 and 1-5 mirror the scale of change indicated in Figure 65 and show more separation between alternatives. These two subunits have significantly more savanna treatments than the other subunits in Restoration 1. On average, alternative D leaves denser forest conditions and hence produces lower values in understory biomass production.

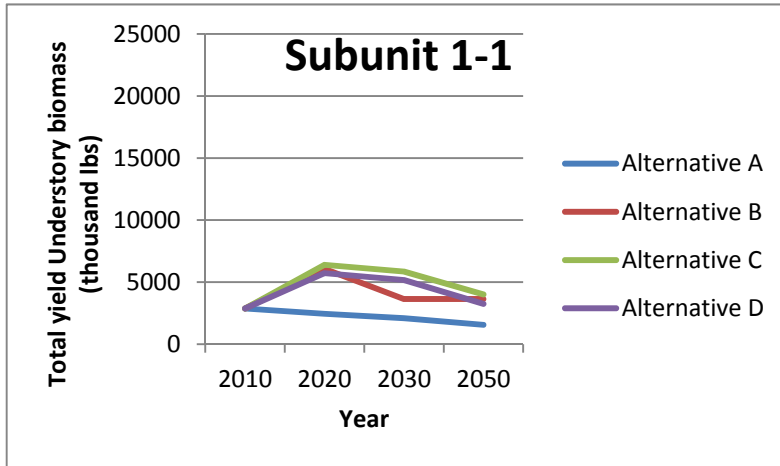


Figure 65. Total biomass yield (pounds) in Subunit 1-1, based on modeled changes in basal area

Table 14. Subunit 1-1 (10,169 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	2877.827	2450.729	2084.645	1555.857
Alternative B	2877.827	6070.893	3630.333	3630.333
Alternative C	2877.827	6396.301	5857.344	4016.755
Alternative D	2877.827	5725.147	5165.852	3254.08

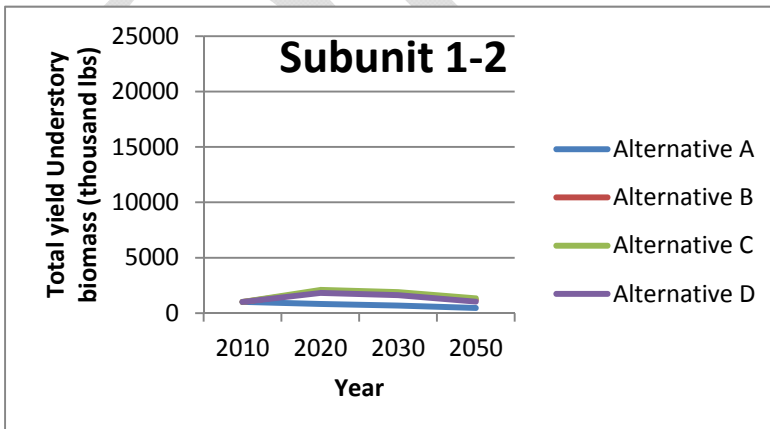


Figure 66. Total biomass yield (pounds) in Subunit 1-2, based on modeled changes in basal area

Table 15. Subunit 1-2 (8,054 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	1006.75	821.508	676.536	459.078
Alternative B	1006.75	1965.176	1763.826	1191.992
Alternative C	1006.75	2085.986	1892.69	1336.964
Alternative D	1006.75	1812.15	1610.8	1030.912

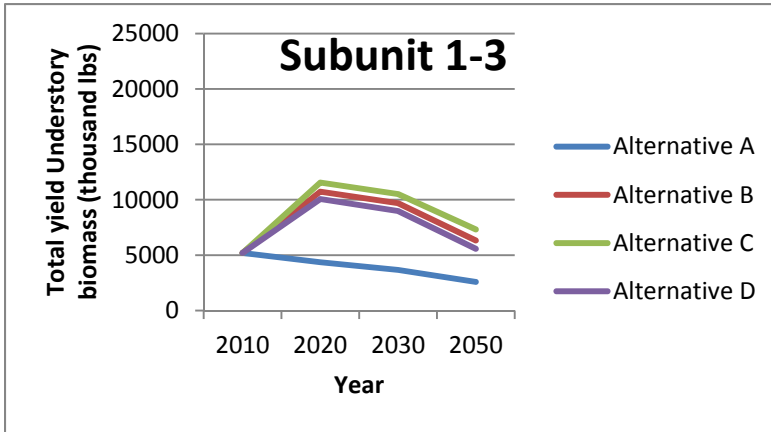


Figure 67. Total biomass yield (pounds) in Subunit 1-3, based on modeled changes in basal area

Table 16. Sub-unit 1-3 (41,577 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	5197.125	4365.585	3658.776	2577.774
Alternative B	5197.125	10726.866	9687.441	6319.704
Alternative C	5197.125	11558.406	10518.981	7317.552
Alternative D	5197.125	10061.634	8980.632	5571.318

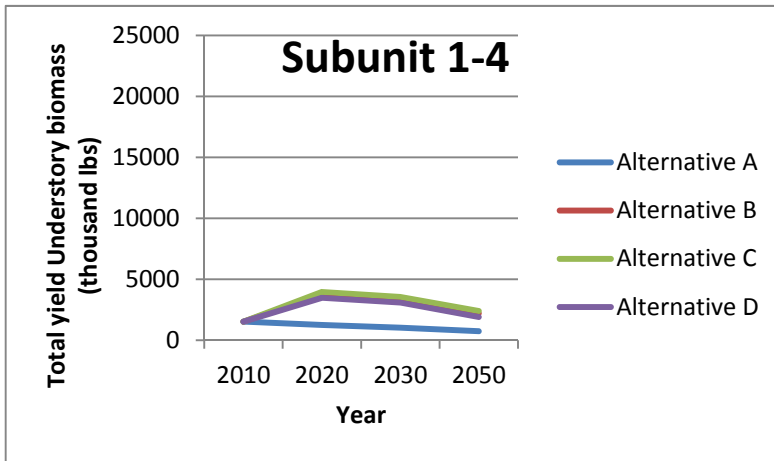


Figure 68. Total biomass yield (pounds) in Subunit 1-4, based on modeled changes in basal area

Table 17. Subunit 1-4 (18,326 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	1521.058	1246.168	1026.256	733.04
Alternative B	1521.058	3775.156	3371.984	2199.12
Alternative C	1521.058	3958.416	3555.244	2400.706
Alternative D	1521.058	3481.94	3078.768	1905.904

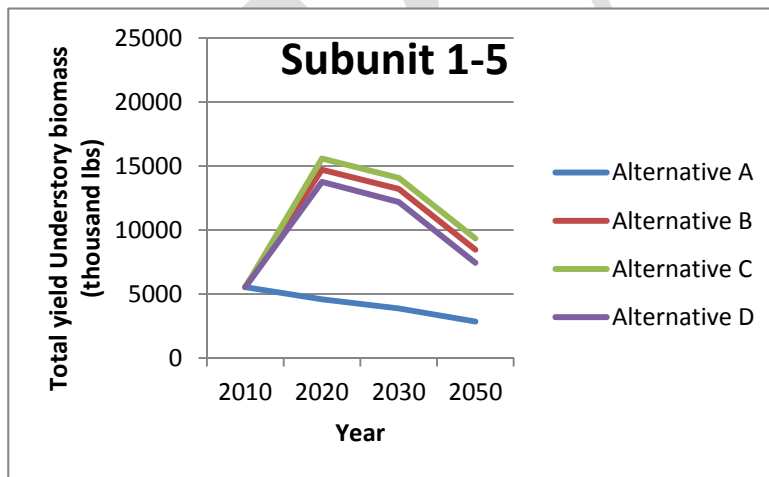


Figure 69. Total biomass yield (pounds) in Subunit 1-5, based on modeled changes in basal area

Table 18. Subunit 1-5 (79,098) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	5536.86	4587.684	3875.802	2847.528
Alternative B	5536.86	14712.228	13209.366	8463.486
Alternative C	5536.86	15582.306	14079.444	9333.564
Alternative D	5536.86	13763.052	12181.092	7435.212

Restoration Unit 3

Restoration Unit 2 was designated early in the project formulation and does not include management treatments. Restoration Unit 3 is west of I-17 and south of I-40. Biomass production is consistently much higher in each subunit in this restoration unit as a result of higher intensity mechanical treatments including more acres of grassland and savanna restoration (Figure 70 through Figure 74). This restoration unit includes work in and around Garland Prairie and an east-west open canopy corridor designed by the Arizona Game and Fish Department to facilitate seasonal pronghorn movement across much of the width of the Williams Ranger District. The corridor follows known movements of pronghorn and includes areas of young, dense forest.

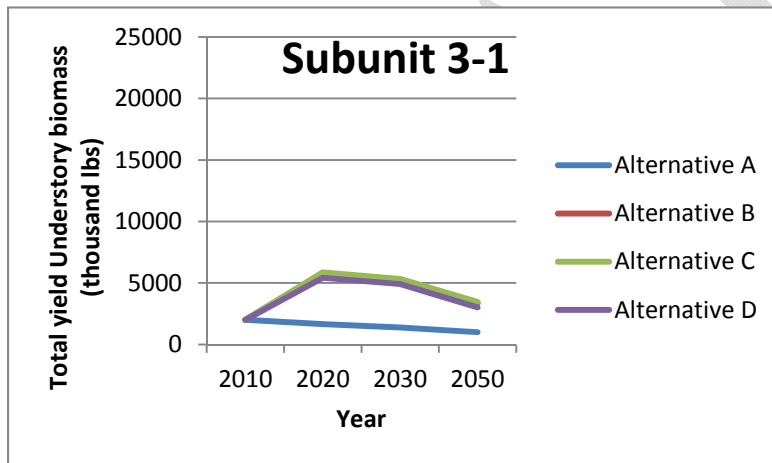


Figure 70. Total biomass yield (pounds) in Subunit 3-1, based on modeled changes in basal area

Table 19. Subunit 3-1 (23,178 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	1993.308	1645.638	1367.502	996.654
Alternative B	1993.308	5794.5	5261.406	3360.81
Alternative C	1993.308	5864.034	5330.94	3453.522
Alternative D	1993.308	5423.652	4913.736	3013.14

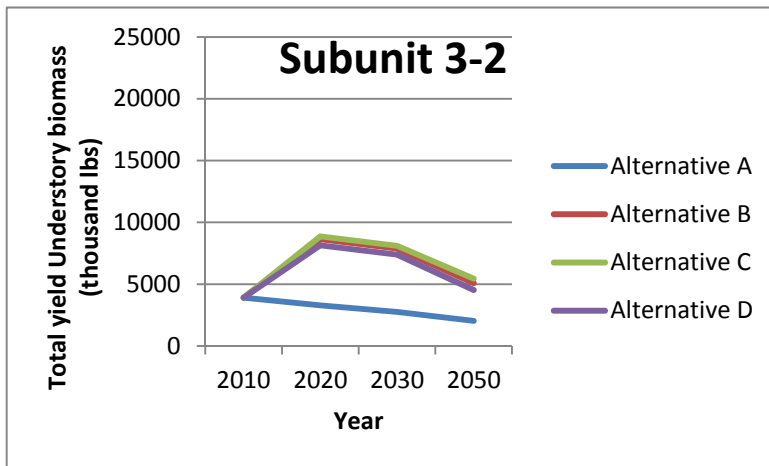


Figure 71. Total biomass yield (pounds) in Subunit 3-2, based on modeled changes in basal area

Table 20. Subunit 3-2 (32,826 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	3906.294	3282.6	2757.384	2035.212
Alternative B	3906.294	8633.238	7878.24	5088.03
Alternative C	3906.294	8863.02	8108.022	5449.116
Alternative D	3906.294	8140.848	7385.85	4529.988

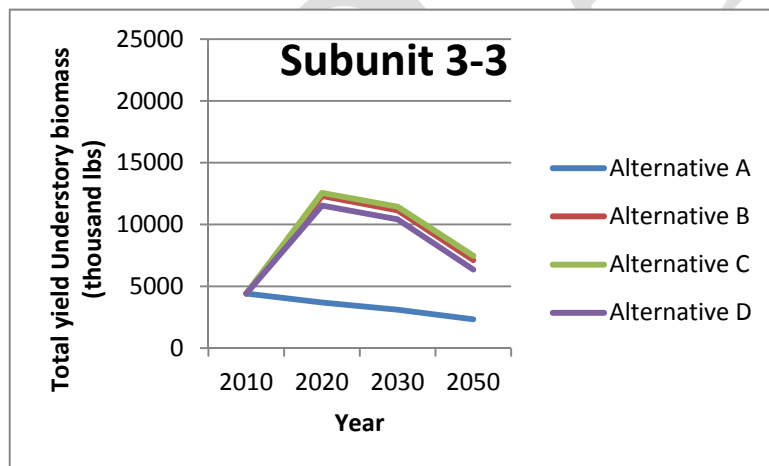


Figure 72. Total biomass yield (pounds) in Subunit 3-3, based on modeled changes in basal area

Table 21. Subunit 3-3 (48,462 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	4410.042	3683.112	3101.568	2326.176
Alternative B	4410.042	12309.348	11146.26	7123.914
Alternative C	4410.042	12551.658	11437.032	7463.148
Alternative D	4410.042	11533.956	10419.33	6348.522

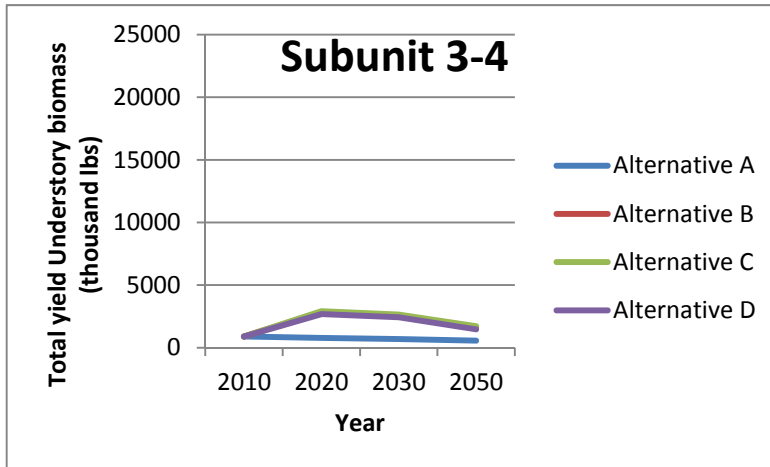


Figure 73. Total biomass yield (pounds) in Subunit 3-4, based on modeled changes in basal area

Table 22. Subunit 3-4 (9,019 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	892.881	775.634	685.444	559.178
Alternative B	892.881	2831.966	2561.396	1641.458
Alternative C	892.881	2904.118	2633.548	1713.61
Alternative D	892.881	2678.643	2417.092	1470.097

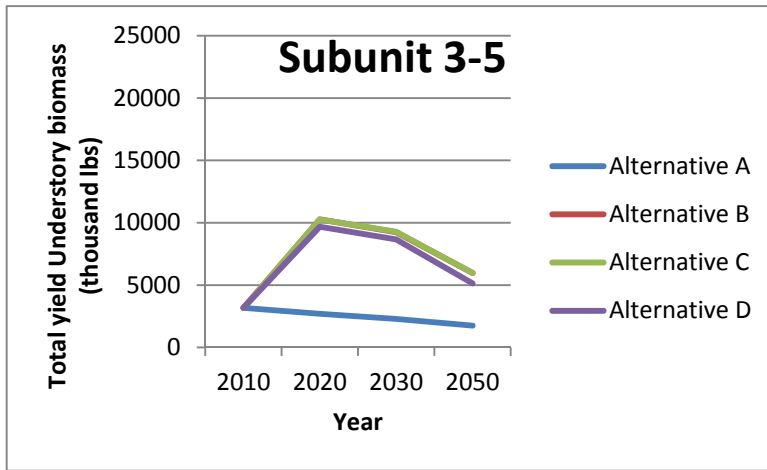


Figure 74. Total biomass yield (pounds) in Subunit 3-5, based on modeled changes in basal area

Table 23. Subunit 3-5 (36,392 acres) Total Yield (thousand pounds)

Subunit 3-5	Total Yield (Thousand pounds)				(36,392 ac)
Treatments	2010	2020	2030	2050	
Alternative A	3166.104	2693.008	2292.696	1746.816	
Alternative B	3166.104	10262.544	9243.568	5968.288	
Alternative C	3166.104	10262.544	9279.96	5968.288	
Alternative D	3166.104	9680.272	8661.296	5131.272	

Restoration Unit 4

Restoration Unit 4 is north of I-40 and mostly northwest of Flagstaff, including part of the Peaks Ranger District and much of the Williams Ranger District. There is little limestone in this Unit and, in addition, inclusions of loose cinder. Government Prairie is in this Restoration Unit as is a north-south pronghorn movement corridor developed by the Arizona Game and Fish Department. Subunits 4-3 and 4-4 are about 67,000 and 81,500 acres respectively and the potential understory response is reflected in Figure 75 through Figure 78. Similarly, subunit 4-2 and 4-5 are about 10,200 and 7,000 acres respectively. The contrast in multiplying biomass yield by acres can be seen below. At this scale, differences in understory response between alternative A and the action alternatives seems minimal in subunit 4-5 but represents 2- to 3-fold improvement. Alternative D again produces the lowest response of the action alternatives.

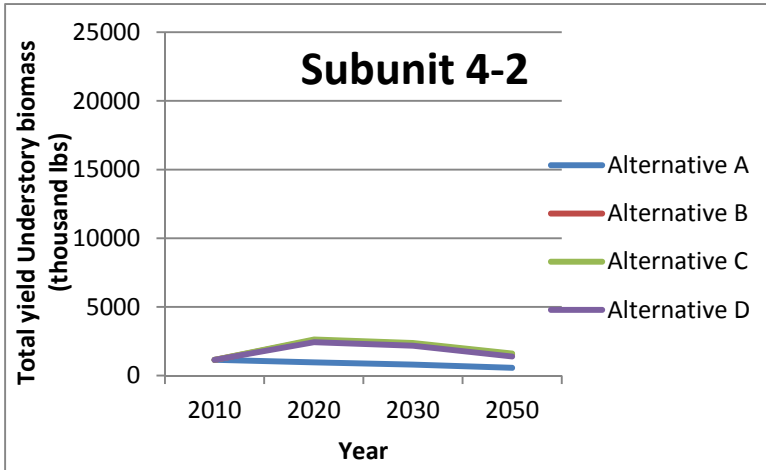


Figure 75. Total biomass yield (pounds) in Subunit 4-2, based on modeled changes in basal area

Table 24. Subunit 4-2 (10,231 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	1145.872	951.483	787.787	562.705
Alternative B	1145.872	2567.981	2312.206	1544.881
Alternative C	1145.872	2619.136	2363.361	1606.267
Alternative D	1145.872	2424.747	2168.972	1391.416

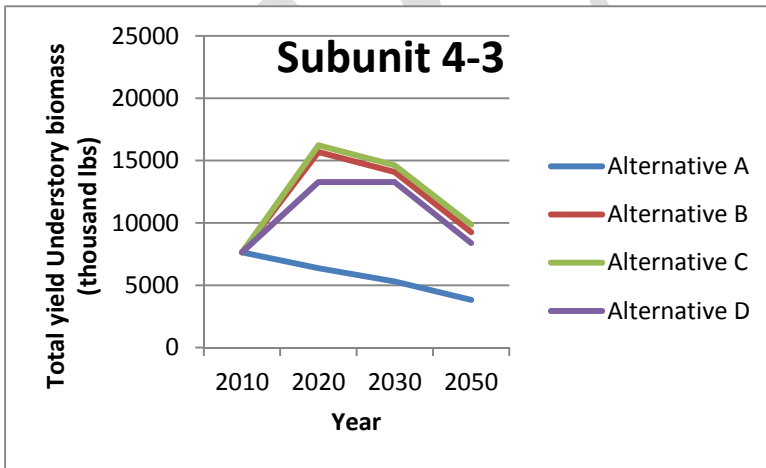


Figure 76. Total biomass yield (pounds) in Subunit 4-3, based on modeled changes in basal area

Table 25. Subunit 4-3 (67,047 acres) Total Yield (thousand pounds)

Subunit 4-3	TOTAL YIELD (Thousand pounds) (67,047 ac)			
	2010	2020	2030	2050
Alternative A	7643.358	6369.465	5296.713	3821.679
Alternative B	7643.358	15688.998	14079.87	9252.486
Alternative C	7643.358	16225.374	14616.246	9855.909
Alternative D	7643.358	13275.306	13275.306	8380.875

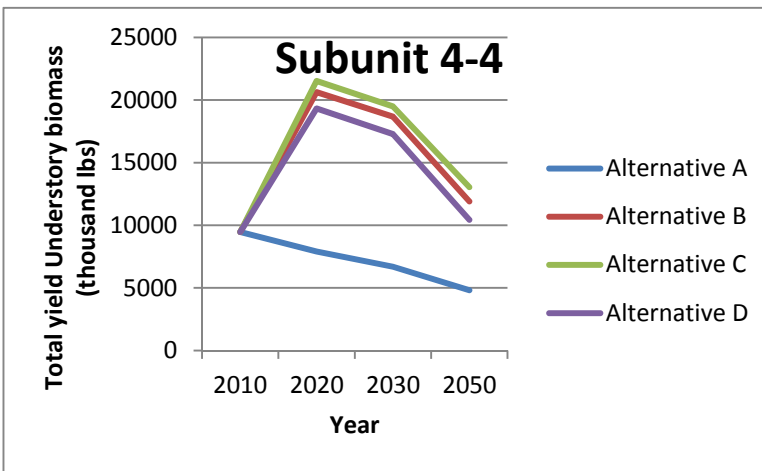


Figure 77. Total biomass yield (pounds) in Subunit 4-4, based on modeled changes in basal area

Table 26. Subunit 4-4 (81,541 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	9458.756	7909.477	6686.362	4810.919
Alternative B	9458.756	20629.873	18672.889	11904.986
Alternative C	9458.756	21526.824	19488.299	13046.56
Alternative D	9458.756	19325.217	17286.692	10437.248

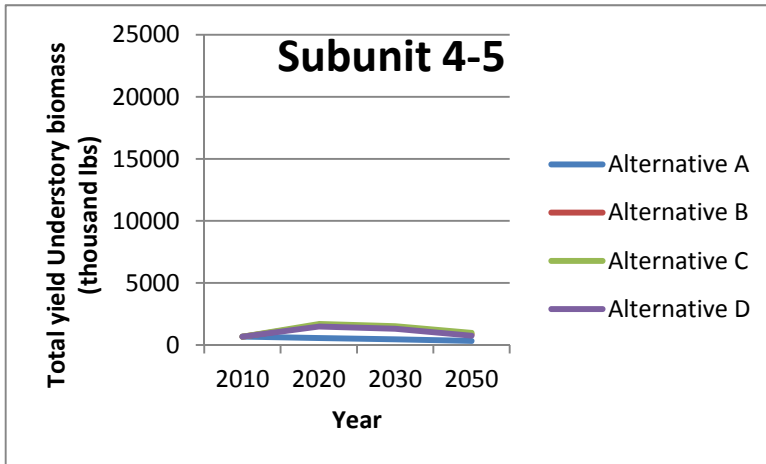


Figure 78. Total biomass yield (pounds) in Subunit 4-5, based on modeled changes in basal area

Table 27. Subunit 4-5 (6,985 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	670.56	551.815	454.025	321.31
Alternative B	670.56	1585.595	1410.97	859.155
Alternative C	670.56	1683.385	1508.76	977.9
Alternative D	670.56	1480.82	1306.195	754.38

Restoration Unit 5

Restoration Unit 5 is northeast of Flagstaff and north of I-40. Limestone is nearly absent from the Unit and subunit 5-2 has over 3,000 acres of loose cinders (the latter is not included in yield calculations). In addition, subunit 5-2 has nearly 34,000 acres of proposed burn-only treatment in each of the action alternatives. Differences in biomass response are still apparent between most alternatives in this subunit despite the acres of burn only and loose cinders, (Figure 79 through Figure 80). Alternative C includes over 1,700 acres of grassland restoration in subunit 5-2.

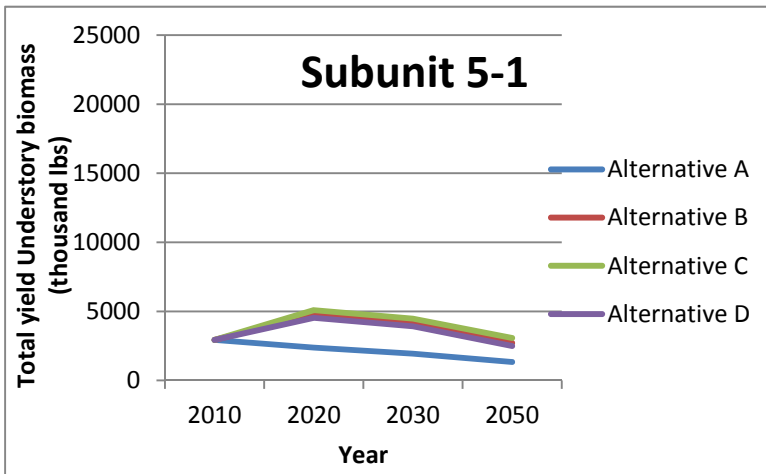


Figure 79. Total biomass yield (pounds) in Subunit 5-1 based on modeled changes in basal area

Table 28. Subunit 5-1 (24,210 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	2929.41	2372.58	1936.8	1331.55
Alternative B	2929.41	4745.16	4115.7	2711.52
Alternative C	2929.41	5084.1	4478.85	3074.67
Alternative D	2929.41	4527.27	3922.02	2493.63

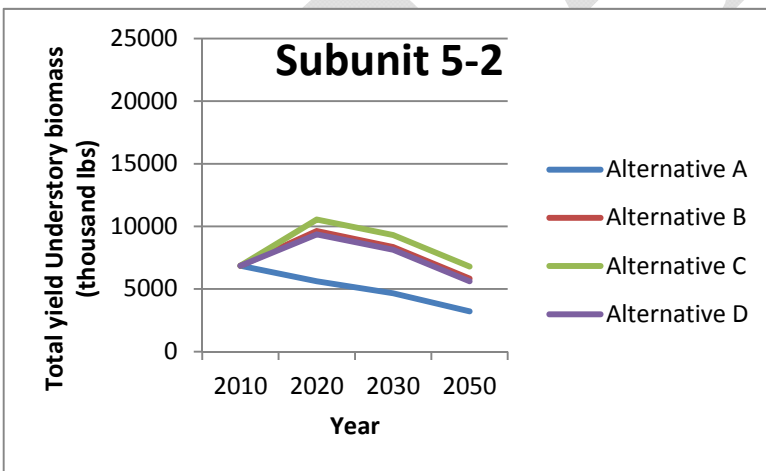


Figure 80. Total biomass yield (pounds) in Subunit 5-2, based on modeled changes in basal area

Table 29. Subunit 5-2 (53,520 acres) Total Yield (thousand pounds)

Subunit 5-2		Total Yield (Thousand pounds)			(53,520 ac)
Treatments	2010	2020	2030	2050	
Alternative A	6850.56	5619.6	4656.24	3211.2	
Alternative B	6850.56	9633.6	8349.12	5833.68	
Alternative C	6850.56	10543.44	9312.48	6797.04	
Alternative D	6850.56	9366	8135.04	5619.6	

Restoration Unit 6

Restoration Unit 6 is on the Tusayan Ranger District south of the Grand Canyon National Park. The subunits are all limestone soil and subunit 6-2 includes pine-sage treatments. The largest biomass response for this restoration unit occurs in subunit 6-3. The line for alternative B is hidden by alternative C because of nearly identical understory responses. Alternative D again has the lowest response identified for any action alternative (Figure 81 through Figure 83). Subunit 6-4 has one of the most muted responses with over 80 percent of the treatment consisting of burn-only treatments. As noted above, this analysis does not account for ecosystem contributions of prescribed fire.

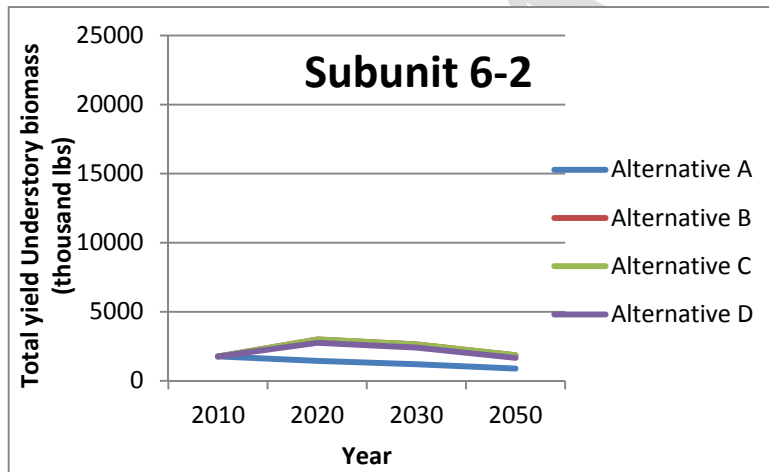


Figure 81. Total biomass yield (pounds) in Subunit 6-2, based on modeled changes in basal area

Table 30. Subunit 6-2 (5,552 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	1765.536	1443.52	1193.68	888.32
Alternative B	1765.536	2992.528	2631.648	1859.92
Alternative C	1765.536	2992.528	2631.648	1859.92
Alternative D	1765.536	2748.24	2398.464	1654.496

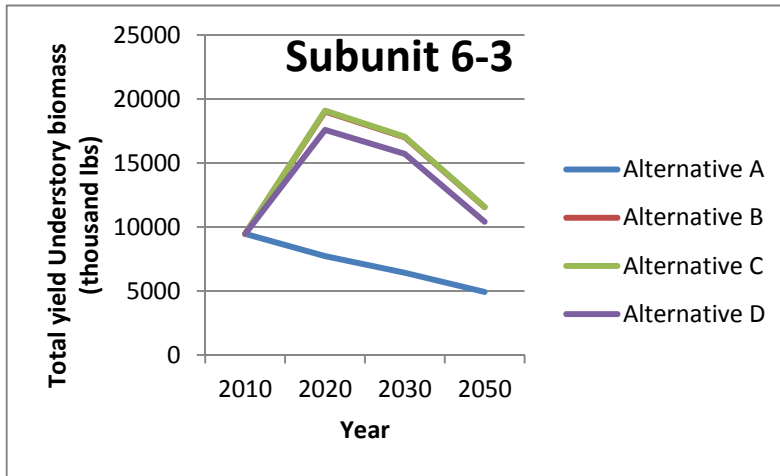


Figure 82. Total biomass yield (pounds) in Subunit 6-3, based on modeled changes in basal area

Table 31. Subunit 6-3 (34,156 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	9461.212	7719.256	6421.328	4918.464
Alternative B	9461.212	19024.892	17009.688	11544.728
Alternative C	9461.212	19093.204	17043.844	11578.884
Alternative D	9461.212	17590.34	15711.76	10417.58

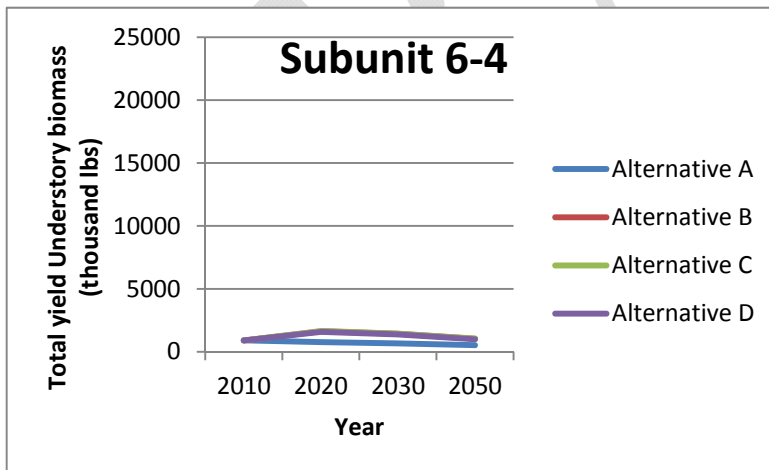


Figure 83. Total biomass yield (pounds) in Subunit 6-4, based on modeled changes in basal area

Table 32. Subunit 6-4 (3,870 acres) Total Yield (thousand pounds)

Treatments	2010	2020	2030	2050
Alternative A	901.71	762.39	654.03	522.45
Alternative B	901.71	1629.27	1420.29	1037.16
Alternative C	901.71	1644.75	1435.77	1052.64
Alternative D	901.71	1575.09	1373.85	994.59

Summary and Effects to Wildlife

Understory biomass would consistently continue to decline across all subunits under alternative A. Alternative C consistently provides the greatest response in herbaceous biomass over all other alternatives. Conversely, alternative D does the least to move understory conditions back towards the historical range of variation relative to the other action alternatives. Alternative B is similar to alternative C, although with fewer acres treated. Where subunit graphs apparently display overlapping lines for two or all three action alternatives, the actual yield values in the tables can show differences of millions of pounds of forage. The equations were derived to address biomass yield, but the output represents a diversity of plants providing food and cover for a wide range of wildlife species from ground dwelling arthropods to granivorous and insectivorous avian species. The herbaceous response affects soil chemistry by altering the ratios of organic input and changes soil microflora, including mycorrhizae, and fire behavior. While alternative D frequently mirrors the other action alternatives in terms of yield through time, the associated benefits of low-intensity fire will not be realized because of the restricted broadcast burning related to this alternative. At the site or stand scale, this limit means no nutrient pulse into the soil, no decrease in litter layer, and none of the associated changes to soil chemistry and microflora. In addition, the heterogeneity in microhabitat resulting from thinning and burning will be less, limiting the important change to existing homogeneity. While alternative D improves understory conditions and greatly improves biomass response over alternative A, the improvements consistently remain below the other action alternatives.

Moore and Deiter (1992) concluded overstory density effects on understory production were most predictable for grasses, sedges, and forbs while shrubs showed only a slight response to changing overstory density. Cool-season plants showed a much stronger relationship with overstory density than did warm-season plants. As a rule, cool-season grasses, sedges, and forbs responded more predictably to changes in stand density than did warm-season vegetation regardless of the plant type (Moore and Deiter 1992). Implementation of 4FRI could potentially reverse the declining trend in C₃ plants, particularly under alternative C. Forest floor depth is estimated to have increased 73.5% increase since 1876 (Moore et al. 2004). All alternatives action would reduce litter depth across the 4FRI treatment area, but the change would be most extensive under alternative C and most restricted in alternative D.

Increasing the understory should directly benefit the arthropod community. Changes in the understory are expected to include more flowering forbs and the plants should be more widely distributed. Thinning and creating canopy gaps under currently homogeneous forest cover would contribute towards reconnecting isolated pockets of herbaceous cover, reversing the trend of increasing fragmentation of pollinator habitat. Increasing herbaceous productivity, including leaf, root, fruit, and seed development, improves bird and mammal forage directly (plants) and

indirectly (arthropods). Upper trophic-level species like raptors and terrestrial carnivores should benefit from improvements to prey species habitat.

The most abundant foods on earth are plants and insects and so it is no surprise that the most abundant small mammals are rodents (largely herbivores/granivores) and bats (largely insectivores) (Merritt 2010). Mice and mouse-like rodents have been labeled the most important small mammal in terms of their effect on the environment and as a staple food for predators (Merritt 2010). In general, small mammal communities can benefit from thinning treatments in fire-prone ecosystems, particularly when heterogeneity of forest structure is retained (Converse et al. 2006, Noss et al. 2006, Kalies et al. 2012). Kalies et al. (2012) found five of eight small mammal species responded positively in terms of occupancy to forest thinning treatments (golden-mantled ground squirrel, Mogollon vole, gray-collared chipmunk, deer mouse, rock squirrel). One of three species that responded negatively, Botta's pocket gopher, responded positively to open forest structural conditions, but negatively to treatments that reduced tree BA and density. The two remaining species, tassel-eared squirrels and Mexican woodrats, responded negatively to treatment unless specific habitat features were retained (Kalies et al. 2012). All but the latter two species had inverse relationships in terms of occupancy to pine BA and responded positively to understory cover. Kalies et al. (2012) concluded that all eight small mammal species can benefit from restoration treatments. Kalies et al. (2012) and Converse et al. (2006) concluded thinning treatments will have positive effects on small mammal biomass but Bagne and Finch (2009) found thinning did not change total small mammal abundance. Converse et al. (2006) stated response of small mammal populations to thinning would be greatest in areas where tree densities are especially high. While reestablishing the understory herbaceous layer can benefit many small mammals, small fossorial mammals can, in turn, be important agents in maintaining the ecology of grassland and savanna systems (Yoshihara et al. 2009, Ganey and Chambers 2011). Table 33 lists expected impacts to key mammal and bird species within the 4FRI treatment area.

Understory restoration is expected to enhance cover for ground-nesting birds and increase forage for insectivores, frugivores, and granivores. While studies rarely correlate avian response to understory development directly, work has been done relating thinning and burning to bird communities. In a comparison of forest structure, George et al. (2005) compared bird communities between an old-growth stand of ponderosa pine containing a relatively open canopy, large snags, and developed understory, with a dense second-growth ponderosa pine forest in California. Overall bird species composition was similar between sites; most of the species detected at only one site were rare at the site where they were detected. They found woodpeckers, bark gleaners, and flycatchers all more abundant in the old-growth forest. Foliage gleaners were more abundant in second-growth (George et al. 2005). While the connection between foliage gleaners and younger forest was not clear, mid-age pine trees tend to have more foliage volume than older trees and foliage gleaners are cup-nesters (George et al. 2005) and may prefer the denser crowns of younger trees. They also found the presence of flying arthropods greater in the old-growth and positively associated with ground vegetation, down wood, shrubs, and saplings (George et al. 2005).

Hurteau et al. (2008) looked at effects of thinning and prescribed burning treatments on birds in ponderosa pine forests on the Kaibab and Coconino National Forests. They did not find effects to species richness or evenness. Although some individual species increased (e.g., western bluebirds) and some decreased (e.g., mountain chickadees) they determined the modest effects treatments had on the avian community warranted implementing prescribed surface fire after thinning projects. Thinning and burning effects were evaluated specifically for western bluebirds

in northwestern Arizona and the authors described increased herbaceous ground cover and Gambel oak density as likely improving invertebrate assemblages and thus improving forage abundance for nesting bluebirds (Wightman and Germaine 2006). A project in the Black Hills, South Dakota, reported overall species richness was generally lower in ponderosa pine forest with overstory canopy cover greater than 40 percent compared to ponderosa pine forest with less than 40 percent canopy cover (Mills and Flake 2000). Most changes in forest structure will benefit some species and negatively impact others. Creating a mosaic of forest conditions following treatments may be the most suitable approach for a wide range of forest passerines (Hurteau et al. 2008).

Table 33 presents a list of birds and mammals identified as Threatened, Sensitive, Management Indicator Species, migratory birds, or primary prey of goshawks in the Southwest (Reynolds et al. 1992) and occurring in the 4FRI treatment area. Included in the table are expected responses to understory changes resulting from overstory treatments.

Table 33. Short-term (10 years) effects of increased understory production on selected wildlife species; see text for detail

Species Status	Species	Habitat Link(s)	Nature of Link	Species Response
Threatened and Endangered Species	Mexican Spotted Owl	Vertebrate Prey	Indirect through effects to small mammals, birds, and key arthropod species	Positive
Management Indicator Species	Abert Squirrel	Overstory Manipulation	Indirect through interruption of tree canopy; decrease in mycorrhiza fruiting bodies	Negative
Management Indicator Species	Northern Goshawk	Vertebrate Prey	Indirect through birds and small mammals	Positive
Management Indicator Species	Pygmy Nuthatch	Invertebrate Prey and Nesting and Foraging Habitat	Direct through increase in invertebrates; Indirect through promotion of large trees and snags	Positive
Management Indicator Species	Turkey	Invertebrate Prey, Hard Mast, and Cover	Direct through increase in understory and invertebrates	Positive
Management Indicator Species	Elk	Herbaceous Food and Calving Cover	Direct through understory growth	Positive
Management Indicator Species	Hairy Woodpecker	Overstory Manipulation	Indirect through promotion of large trees and snags	Positive
Management Indicator Species	Red-naped Sapsucker	Invertebrate Prey (especially ants)	Direct through increase in invertebrates; Indirect through promotion of large trees and snags	Positive

Species Status	Species	Habitat Link(s)	Nature of Link	Species Response
Management Indicator Species	Mule Deer	Herbaceous Food and Fawning Cover	Direct through understory growth	Positive
Management Indicator Species	Juniper Titmouse	Hard Mast and Cover	Indirect through promotion of large, open grown trees	Positive
Management Indicator Species	Pronghorn	Herbaceous Food and Fawning Cover	Direct through understory growth	Positive
Sensitive Species	Ferruginous Hawk	Vertebrate Prey	Indirect through increase in habitat for small mammals and birds	Positive
Sensitive Species	American Peregrine Falcon	Vertebrate Prey and open habitat	Indirect through increase in prey habitat (food and cover)	Positive
Sensitive Species	Baird's Sparrow	Herbaceous Food and Cover	Direct through increase in understory and invertebrates	Positive
Sensitive Species	Merriam's Shrew	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Dwarf Shrew	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Western Red Bat	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Spotted Bat	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Allen's Lappet-Browed Bat	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Pale Townsend's Big-Eared Bat	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Greater Western Mastiff Bat	Invertebrate Prey	Direct through increase in invertebrates	Positive
Sensitive Species	Mogollon Vole	Invertebrate Prey and Cover	Direct through increase in understory and invertebrates	Positive
Sensitive Species	Long-Tailed Vole	Invertebrate Prey and Cover	Direct through increase in understory and invertebrates	Positive
Migratory Birds	Bark Gleaners	Invertebrate Prey	Indirect through promotion of large, open grown trees	Positive
Migratory Birds	Foliage Gleaners	Decrease in Dense Mid-aged Canopy (Food & Cover?)	Indirect Through Overstory Habitat Changes	Negative
Migratory Birds	Insectivores	Invertebrate Prey	Direct through increase in invertebrates	Positive

Species Status	Species	Habitat Link(s)	Nature of Link	Species Response
Selected Goshawk Prey	American Robin	Invertebrate Prey	Direct through increase in invertebrates	Positive
Selected Goshawk Prey	Band-tailed Pidgeon	Hard and Soft Mast	Direct through increase in foraging habitat	Positive
Selected Goshawk Prey	Cottontail	Herbaceous Food and Cover	Direct through increase in understory and invertebrates	Positive
Selected Goshawk Prey	Golden-Mantled Ground Squirrel	Herbaceous Food and Cover	Direct through increase in understory and invertebrates	Positive
Selected Goshawk Prey	Mourning Dove	Forage (especiallly graminoid production) and Nest Site Structure	Direct through increase in foraging habitat; Indirect through improved nest structure	Positive
Selected Goshawk Prey	Northern Flicker	Invertebrate Prey	Direct through increase in invertebrates (especially ants)	Positive
Selected Goshawk Prey	Stellar's Jay	Invertebrate Prey and Mast Production	Direct through increase in invertebrates (especially beetles, grasshoppers, and wasps)	Positive
Selected Goshawk Prey	Williamson's Sapsucker	Forest Structure, Invertebrate Prey, and Mast Production	Indirect: Nests in aspen and dense forest. Direct: feeds on Invertebrates, sap, and mast.	Positive

Literature Cited

Appendix 9. Existing Forest Structure in Goshawk Habitat by Subunit (SU) and Restoration Unit (RU)

Table 34. Existing Forest Structure – Goshawk PFA/Nest Un-even Aged Stands

Area	Percent of Area by Vegetative Structural Stage (dbh)					
	1 – Grass/Forb/Shrub (0.0 – 0.9”)	2 – Seedling/Sapling (1.0 – 4.9”)	3 – Young Forest (5.0 – 11.9”)	4 – Mid-age Forest (12.0 – 17.9”)	5 – Mature Forest (18.0 – 23.9”)	6 – Old Forest (24.0” +)
SU 1-1	0%	0%	100%	0%	0%	0%
SU 1-2	0%	0%	38%	6%	27%	29%
SU 1-3	0%	0%	21%	71%	7%	0%
SU 1-4	0%	0%	0%	90%	0%	10%
SU 1-5	0%	0%	66%	13%	7%	14%
RU 1	0%	0%	41%	42%	9%	8%
SU 3-1	0%	0%	23%	55%	22%	0%
SU 3-2	0%	0%	8%	84%	8%	0%
SU 3-3	0%	0%	25%	44%	11%	20%
SU 3-5	0%	0%	60%	25%	15%	0%
RU 3	0%	0%	23%	56%	11%	9%
SU 4-2	0%	0%	40%	25%	22%	13%
SU 4-3	0%	2%	33%	49%	14%	2%
SU 4-4	0%	0%	18%	48%	25%	9%
SU 4-5	0%	0%	0%	34%	66%	0%
RU 4	0%	1%	28%	45%	19%	6%
SU 5-1	0%	0%	16%	54%	21%	9%
SU 5-2	0%	0%	10%	44%	25%	20%
RU 5	0%	0%	13%	49%	23%	15%

Percent of Area by Vegetative Structural Stage (dbh)						
Area	1 – Grass/ Forb/Shrub (0.0 – 0.9’’)	2 – Seedling/ Sapling (1.0 – 4.9’’)	3 – Young Forest (5.0 – 11.9’’)	4 – Mid-age Forest (12.0 – 17.9’’)	5 – Mature Forest (18.0 – 23.9’’)	6 – Old Forest (24.0’’) +)
SU 6-2	0%	1%	6%	58%	11%	24%
SU 6-3	0%	2%	61%	4%	13%	20%
RU 6	0%	2%	56%	8%	13%	20%
All	0%	1%	34%	39%	15%	11%

Table 35 PFAs: Existing Forest Structure – Goshawk PFA/Nest Even Aged Stands

Percent of Area by Vegetative Structural Stage (dbh)						
Area	1 – Grass/ Forb/Shrub (0.0 – 0.9’’)	2 – Seedling/ Sapling (1.0 – 4.9’’)	3 – Young Forest (5.0 – 11.9’’)	4 – Mid-age Forest (12.0 – 17.9’’)	5 – Mature Forest (18.0 – 23.9’’)	6 – Old Forest (24.0’’) +)
SU 1-1	-%	-%	-%	-%	-%	-%
SU 1-2	0%	0%	71%	29%	0%	0%
SU 1-3	0%	0%	30%	70%	0%	0%
SU 1-4	0%	0%	81%	19%	0%	0%
SU 1-5	0%	0%	25%	75%	0%	0%
RU 1	0%	0%	50%	50%	0%	0%
SU 3-1	2%	0%	34%	51%	13%	0%
SU 3-2	0%	0%	21%	66%	13%	0%
SU 3-3	13%	0%	34%	51%	3%	0%
SU 3-5	32%	0%	0%	68%	0%	0%
RU 3	11%	0%	28%	55%	6%	0%
SU 4-2	4%	0%	22%	36%	38%	0%

Percent of Area by Vegetative Structural Stage (dbh)						
Area	1 – Grass/ Forb/Shrub (0.0 – 0.9’’)	2 – Seedling/ Sapling (1.0 – 4.9’’)	3 – Young Forest (5.0 – 11.9’’)	4 – Mid-age Forest (12.0 – 17.9’’)	5 – Mature Forest (18.0 – 23.9’’)	6 – Old Forest (24.0’ +)
SU 4-3	1%	0%	27%	67%	4%	1%
SU 4-4	0%	0%	40%	50%	10%	0%
SU 4-5	0%	0%	34%	61%	5%	0%
RU 4	1%	0%	31%	58%	9%	1%
SU 5-1	4%	0%	60%	25%	9%	2%
SU 5-2	0%	0%	8%	68%	17%	7%
RU 5	3%	0%	42%	40%	12%	4%
SU 6-2	3%	0%	58%	0%	40%	0%
SU 6-3	8%	14%	40%	19%	14%	6%
RU 6	7%	12%	41%	18%	16%	5%
All	3%	1%	35%	52%	8%	1%

Table 36. Existing Forest Structure – Goshawk LOPFA: Even-Aged Stands

Percent of Area by Vegetative Structural Stage (dbh)						
Area	1 – Grass/ Forb/Shrub (0.0 – 0.9’’)	2 – Seedling/ Sapling (1.0 – 4.9’’)	3 – Young Forest (5.0 – 11.9’’)	4 – Mid-age Forest (12.0 – 17.9’’)	5 – Mature Forest (18.0 – 23.9’’)	6 – Old Forest (24.0’ +)
SU 1-1	1%	1%	38%	47%	2%	10%
SU 1-2	5%	0%	47%	44%	4%	0%
SU 1-3	1%	1%	48%	45%	1%	4%
SU 1-4	2%	0%	53%	43%	2%	0%
SU 1-5	1%	0%	44%	42%	9%	3%

Area	Percent of Area by Vegetative Structural Stage (dbh)					
	1 – Grass/ Forb/Shrub (0.0 – 0.9’')	2 – Seedling/ Sapling (1.0 – 4.9’')	3 – Young Forest (5.0 – 11.9’')	4 – Mid-age Forest (12.0 – 17.9’')	5 – Mature Forest (18.0 – 23.9’')	6 – Old Forest (24.0’” +)
RU 1	2%	<1%	46%	44%	5%	3%
SU 3-1	2%	1%	31%	53%	13%	0%
SU 3-2	6%	0%	14%	56%	22%	1%
SU 3-3	4%	0%	37%	50%	7%	1%
SU 3-4	0%	3%	29%	58%	8%	2%
SU 3-5	3%	1%	34%	58%	4%	0%
RU 3	4%	0%	31%	54%	10%	1%
SU 4-2	4%	0%	27%	42%	25%	2%
SU 4-3	11%	0%	32%	50%	7%	1%
SU 4-4	4%	0%	33%	54%	8%	1%
SU 4-5	12%	0%	32%	49%	7%	0%
RU 4	7%	0%	32%	52%	8%	1%
SU 5-1	36%	0%	25%	30%	8%	1%
SU 5-2	19%	0%	16%	55%	7%	3%
RU 5	26%	0%	20%	44%	7%	2%
SU 6-2	5%	4%	84%	6%	1%	0%
SU 6-3	4%	2%	78%	11%	5%	1%
SU 6-4	2%	1%	87%	10%	0%	0%
RU 6	4%	2%	79%	10%	4%	1%
All	7%	0%	36%	47%	8%	1%

Table 37. Existing Forest Structure – Goshawk LOPFA Uneven-Aged Stands

Area	Percent of Area by Vegetative Structural Stage (dbh)					
	1 – Grass/ Forb/Shrub (0.0 – 0.9”)	2 – Seedling/ Sapling (1.0 – 4.9”)	3 – Young Forest (5.0 – 11.9”)	4 – Mid-age Forest (12.0 – 17.9”)	5 – Mature Forest (18.0 – 23.9”)	6 – Old Forest (24.0” +)
SU 1-1	0%	1%	32%	54%	10%	3%
SU 1-2	0%	4%	45%	41%	8%	2%
SU 1-3	0%	4%	38%	34%	15%	9%
SU 1-4	0%	0%	62%	29%	3%	6%
SU 1-5	0%	1%	27%	52%	14%	5%
RU 1	0%	2%	37%	43%	12%	6%
SU 3-1	0%	5%	42%	36%	12%	4%
SU 3-2	0%	0%	18%	38%	23%	21%
SU 3-3	0%	2%	38%	42%	10%	8%
SU 3-4	0%	0%	17%	47%	24%	12%
SU 3-5	0%	4%	37%	42%	5%	11%
RU 3	0%	2%	32%	41%	13%	11%
SU 4-2	0%	2%	33%	42%	22%	0%
SU 4-3	0%	1%	38%	31%	16%	14%
SU 4-4	0%	1%	34%	43%	14%	8%
SU 4-5	0%	0%	34%	50%	7%	10%
RU 4	0%	1%	36%	38%	15%	10%
SU 5-1	0%	13%	15%	37%	8%	27%
SU 5-2	0%	0%	12%	8%	24%	56%
RU 5	0%	3%	13%	14%	20%	50%
SU 6-2	0%	1%	55%	18%	10%	15%

Area	Percent of Area by Vegetative Structural Stage (dbh)					
	1 – Grass/ Forb/Shrub (0.0 – 0.9”)	2 – Seedling/ Sapling (1.0 – 4.9”)	3 – Young Forest (5.0 – 11.9”)	4 – Mid-age Forest (12.0 – 17.9”)	5 – Mature Forest (18.0 – 23.9”)	6 – Old Forest (24.0” +)
SU 6-3	0%	5%	64%	18%	5%	7%
SU 6-4	0%	0%	77%	4%	3%	16%
RU 6	0%	4%	64%	16%	6%	10%
All	0%	2%	35%	32%	14%	17%

Appendix 10. Relative Changes in Vegetation Structural Stage (VSS) within Northern Goshawk (NGH) Habitat by Alternative.

Alternative A - Percent VSS in NGH Nest/PFA/dPFA Habitat by Restoration Unit

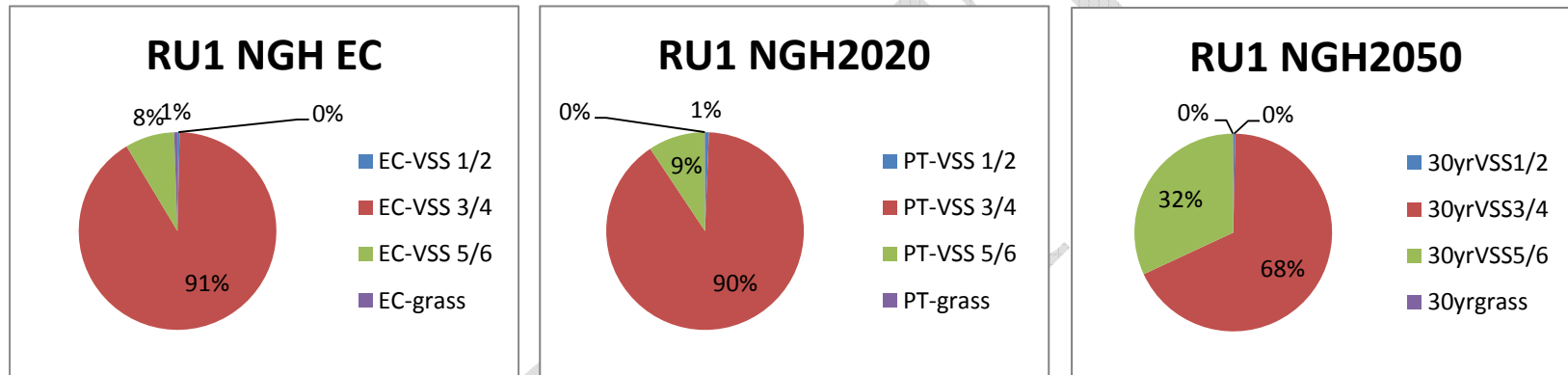


Figure 84. Alternative A Restoration Unit 1 Changes in VSS within Northern Goshawk Habitat Over Time

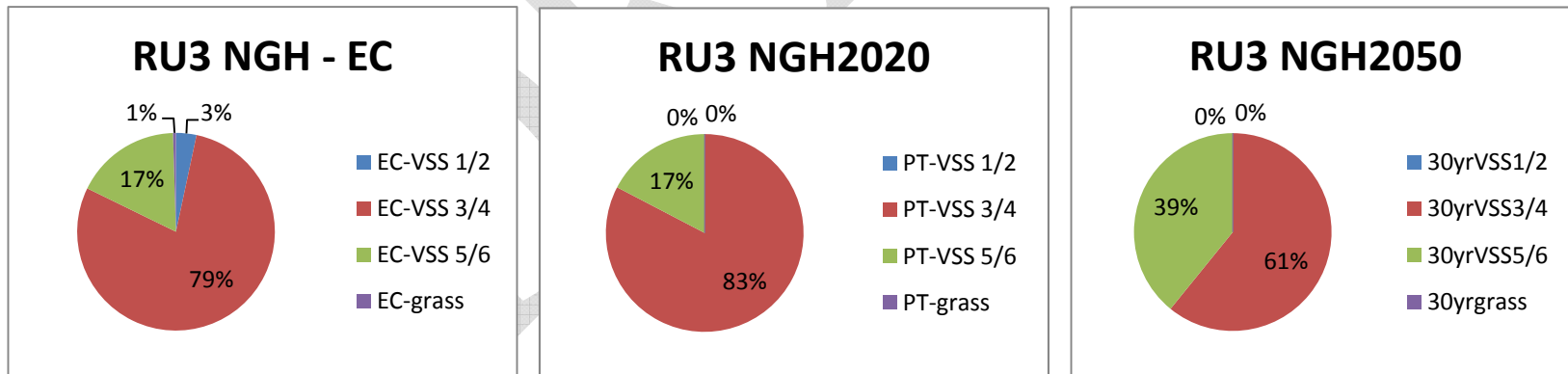


Figure 85. Alternative A Restoration Unit 3 Changes in VSS within Northern Goshawk Habitat Over Time

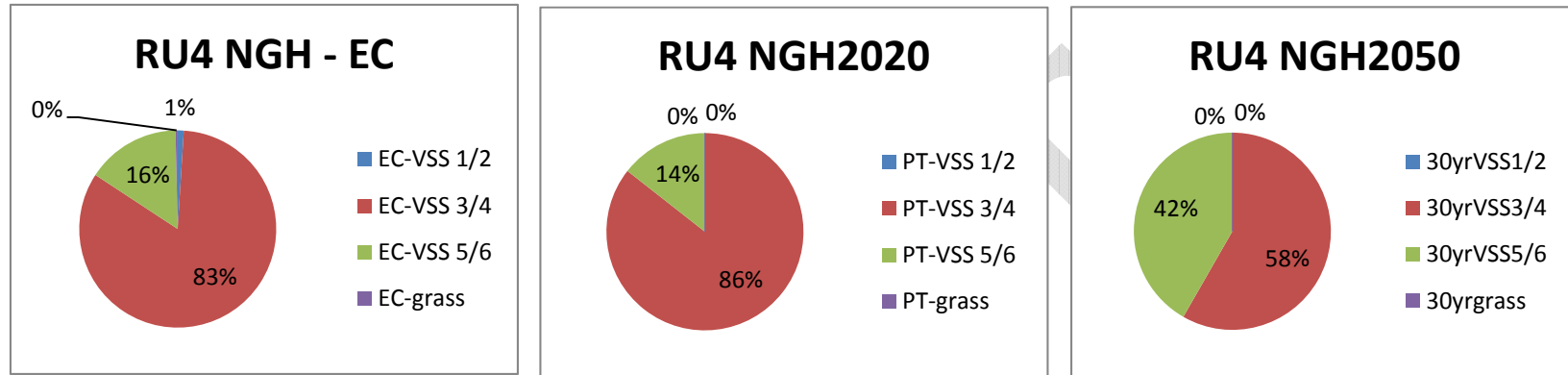


Figure 86. Alternative A Restoration Unit 4 Changes in VSS within Northern Goshawk Habitat Over Time

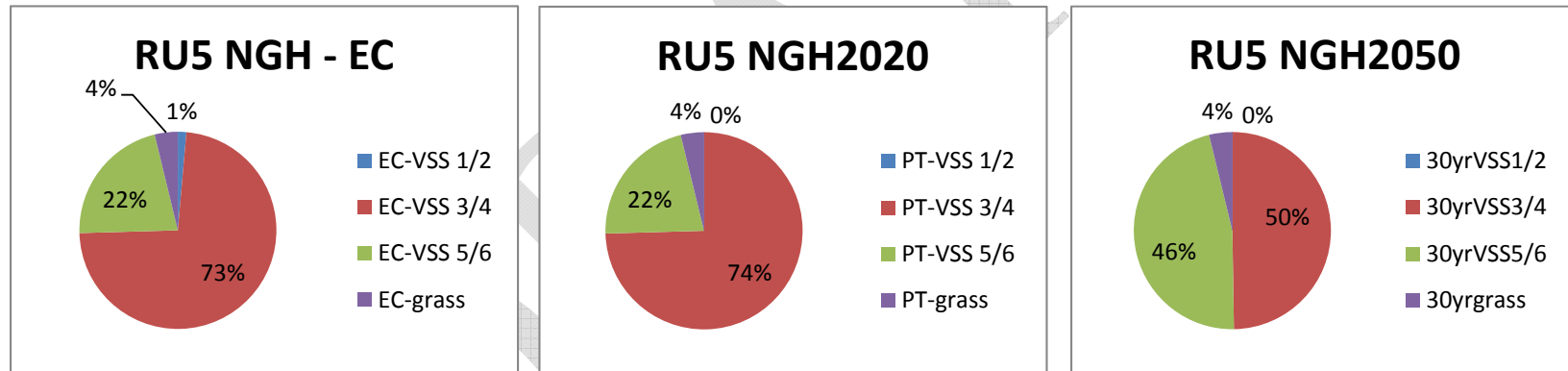


Figure 87. Alternative A Restoration Unit 5 Changes in VSS within Northern Goshawk Habitat Over Time

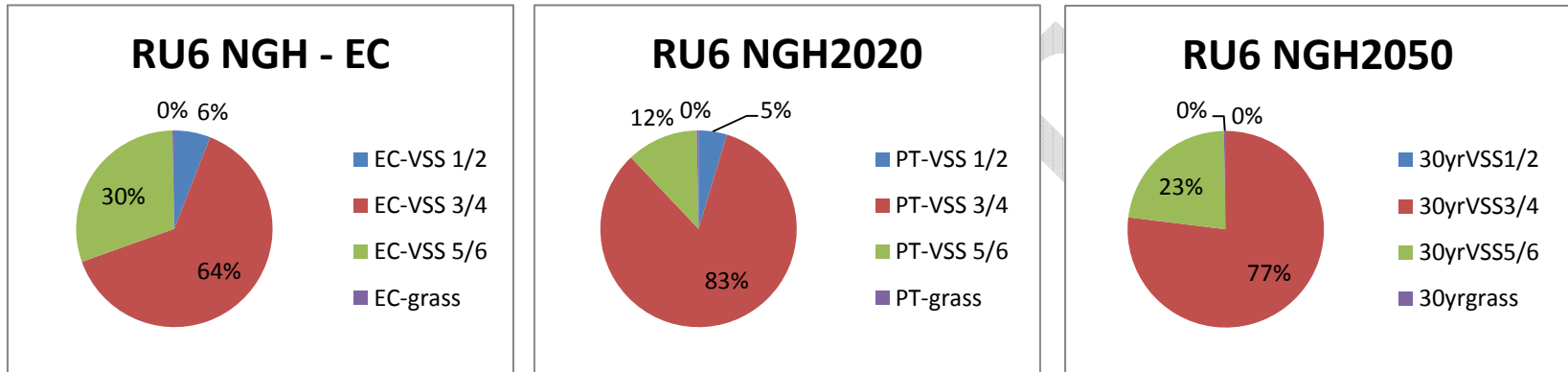


Figure 88. Alternative A Restoration Unit 6 Changes in VSS within Northern Goshawk Habitat Over Time

Alternative B and C - PercentVSS in NGH Nest/PFA/dPFA Habitat by Restoration Unit

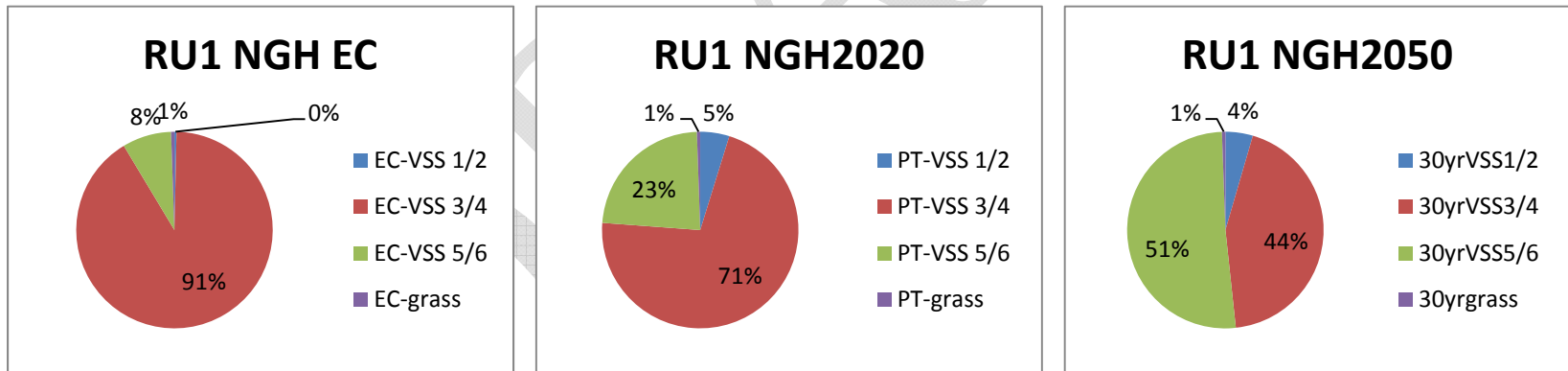


Figure 89. Alternative B and C Restoration Unit 1 Changes in VSS within Northern Goshawk Habitat Over Time

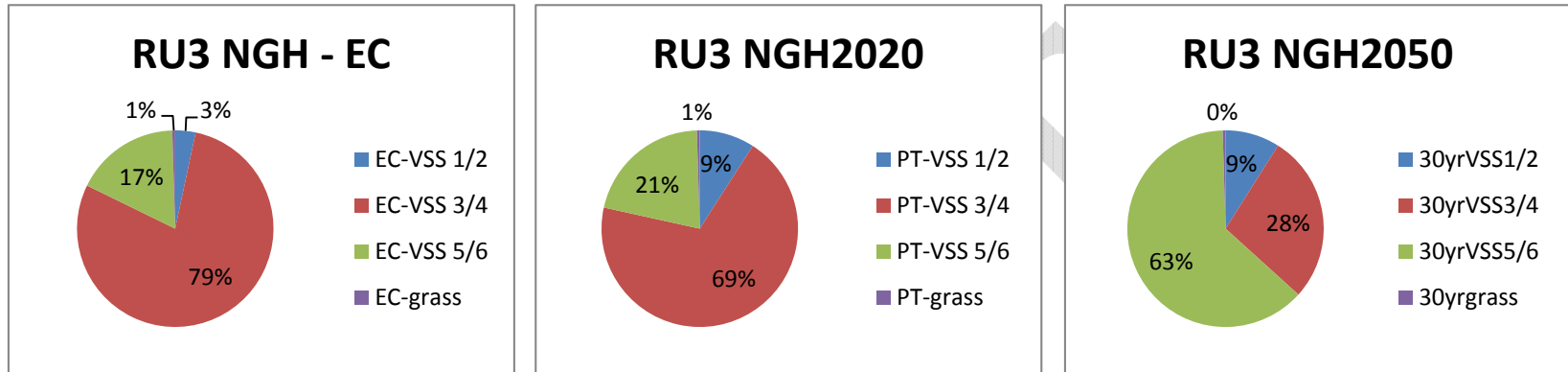


Figure 90. Alternative B and C Restoration Unit 3 Changes in VSS within Northern Goshawk Habitat Over Time

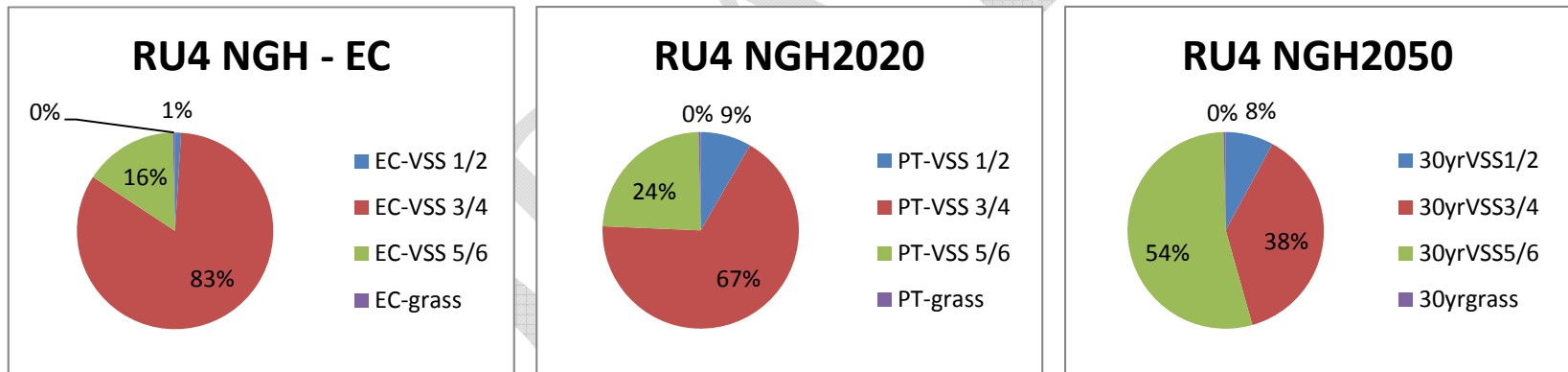


Figure 91. Alternative B and C Restoration Unit 4 Changes in VSS within Northern Goshawk Habitat Over Time

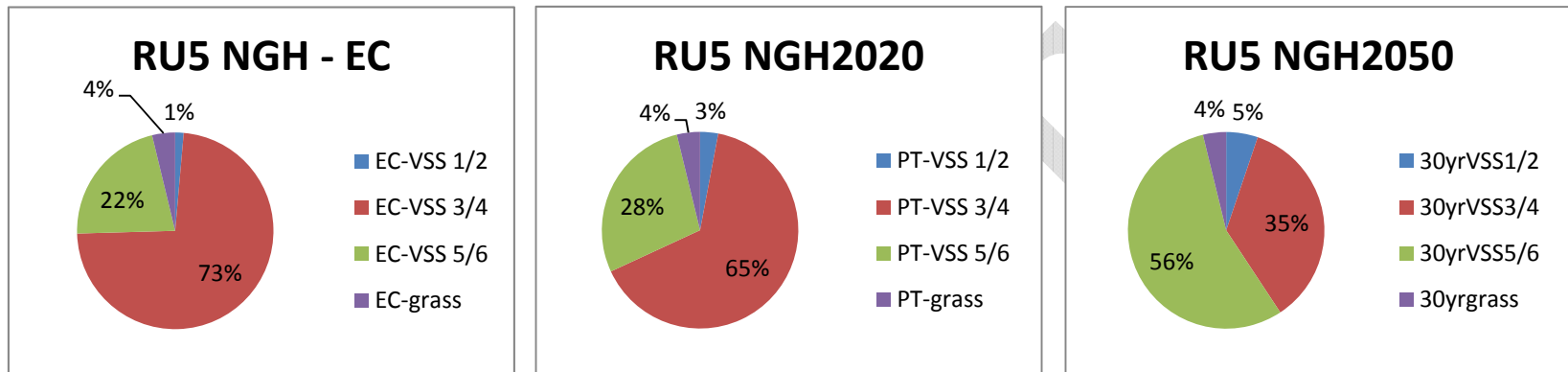


Figure 92. Alternative B and C Restoration Unit 5 Changes in VSS within Northern Goshawk Habitat Over Time

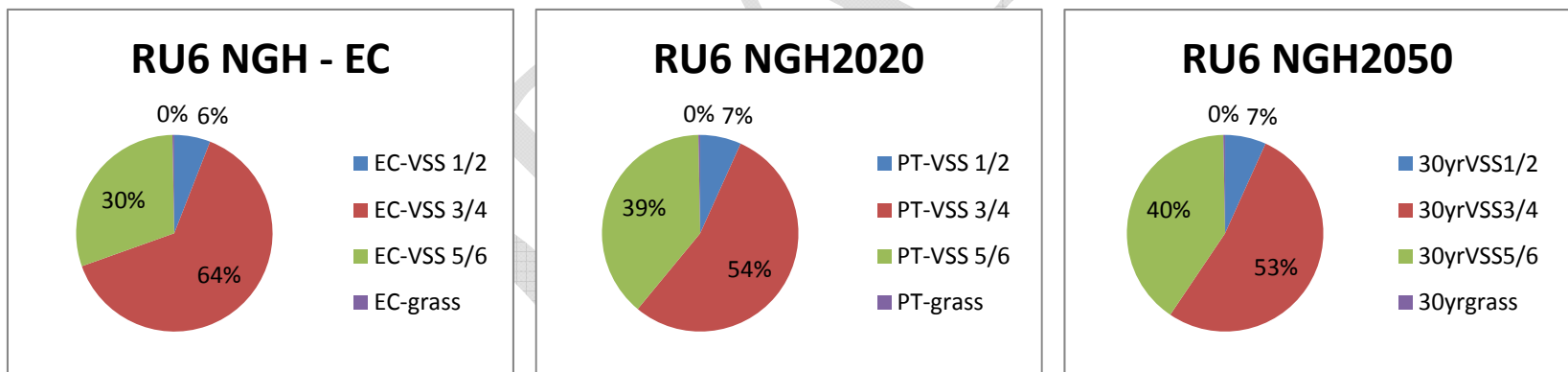


Figure 93. Alternative B and C Restoration Unit 6 Changes in VSS within Northern Goshawk Habitat Over Time

Alternative D - PercentVSS in NGH Nest/PFA/dPFA Habitat by Restoration Unit

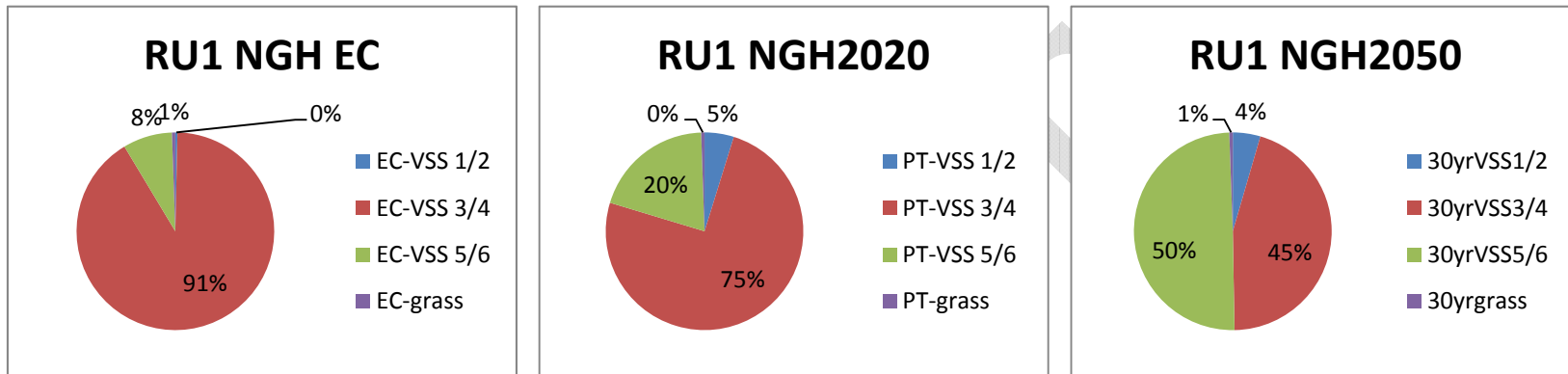


Figure 94. Alternative D Restoration Unit 1 Changes in VSS within Northern Goshawk Habitat Over Time

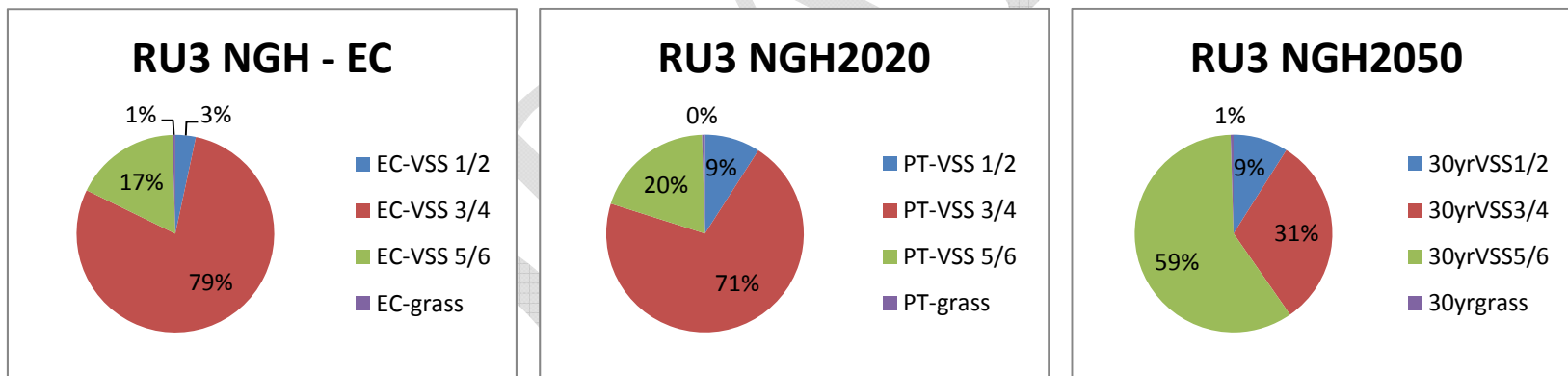


Figure 95. Alternative D Restoration Unit 3 Changes in VSS within Northern Goshawk Habitat Over Time

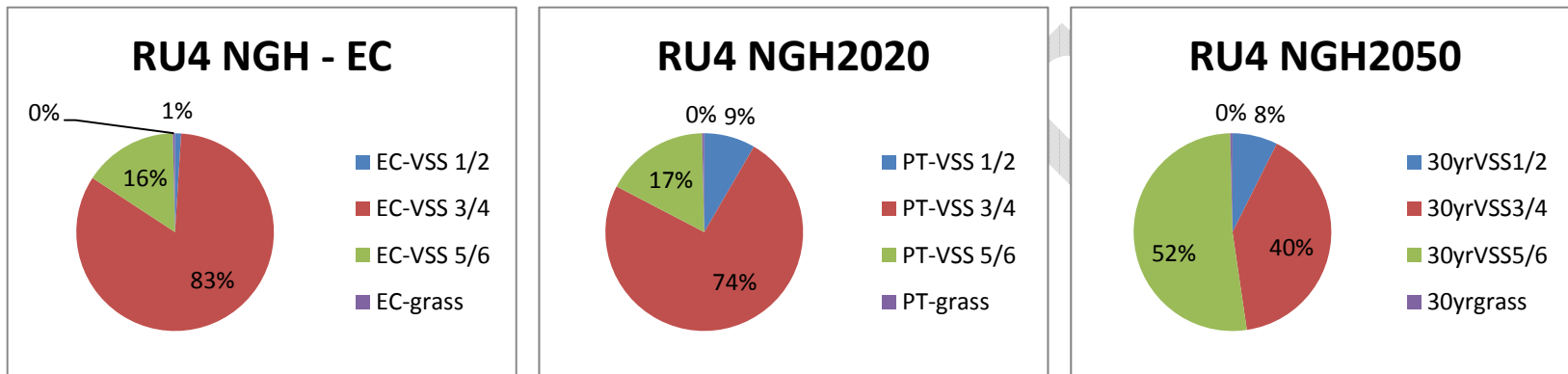


Figure 96. Alternative D Restoration Unit 4 Changes in VSS within Northern Goshawk Habitat Over Time

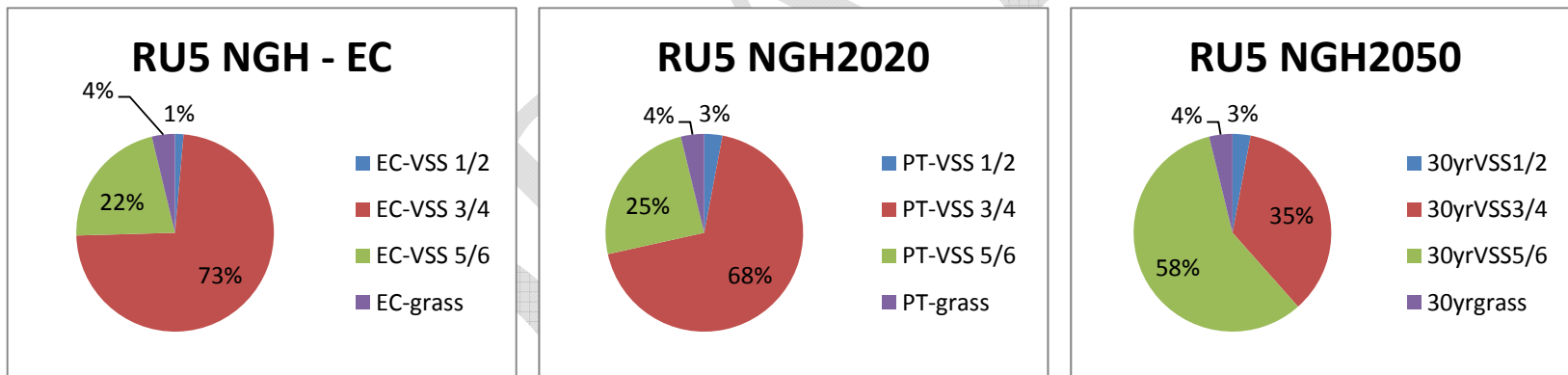


Figure 97. Alternative D Restoration Unit 5 Changes in VSS within Northern Goshawk Habitat Over Time

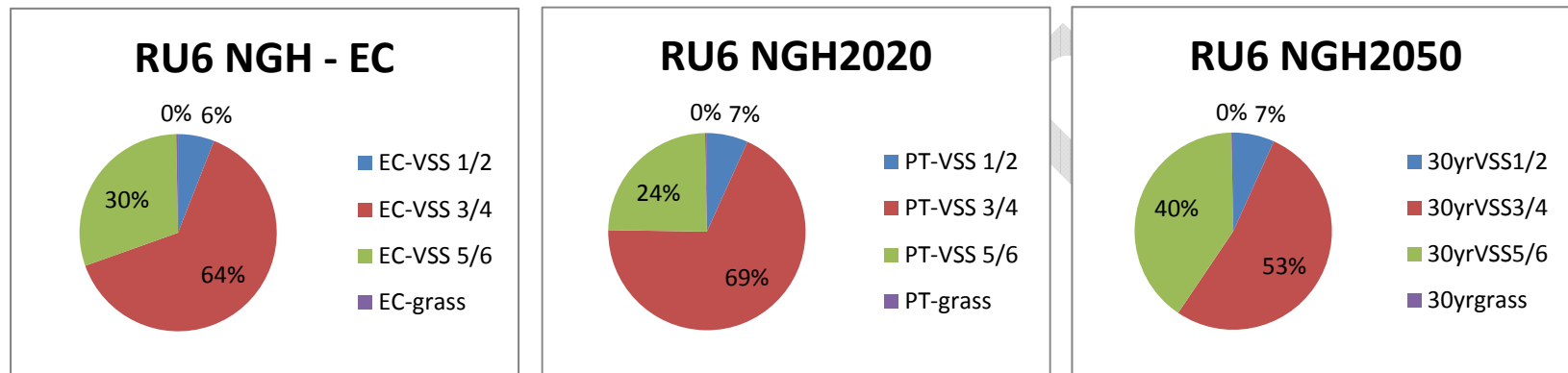


Figure 98. Alternative D Restoration Unit 6 Changes in VSS within Northern Goshawk Habitat Over Time

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Appendix 11. Forest Plan VDDT modeling:

“For the total acres of early and late seral ponderosa pine for the Coconino NF this analysis used the vegetation model (VDDT) that is being use for plan revision to determine the amount of acres currently available. See Appendix B”

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Appendix 12. Cumulative Effects

Table 38. Description of Past Projects by Ranger District (RD) on the Kaibab (K) and Coconino (C) National Forests

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
K-Williams	Williams High Risk Pre Commercial Thin	2001 (decision)	Activities database shows 756 acres thinned, machine piled and burned in 2002 to 2003	No project records could be located
K-Williams	Potato Hill Habitat Improvement	2003 (decision)	Total acres: 1,275 Mechanically remove juniper and pinyon on 1,275 acres that range up to 6" drc or 12" dbh Slash offered as firewood with only lop and scatter occurring for 300 feet along FR 144	Objective: improve wildlife habitat Categorized as past due to decision date and scope of project
K-Williams	Frenchy	2003 (decision)	Total Mechanical: 9,319 - Total Fire: 9,319 acres 6,529 acres implemented to date Total commercial treatments – 8,227 acres Commercial: Intermediate thin – 2,878 acres Croup Selection – 1,876 acres Savanna/meadow restoration – 2,125 acres Sanitation – 43 acres Individual tree selection – 53 acres Non-commercial - 1,092 acres Non Commercial: 256 acres of intermediate thin, 473 acres of savanna/meadow restoration, 405 acres of large oak/juniper/yellow pine release, 78 acres of sanitation	Objective: Restore forest health, reduce fuel accumulations, improve wildlife habitat diversity, increase large, old trees Note: Decision states: This alternative proposes over 800 additional acres of full restoration treatments between Moose Ranch and Garland Prairie. This area would be managed for an average canopy cover of less than 40 percent over time – no plan amendment was included Categorized as on-going – DN/FONSI in hard copy files has decision date of 1990 See Pomeroy and KA – on-going thin and prescribed burn – broadcast burn (6,529 acres accounts for removing KA and Pomeroy acres) categorized as ongoing due to restoration emphasis of the project

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			Broadcast burning over entire EMU over time, 12.9 miles of road obliteration, 17.3 miles of road closures, forest plan amendment (remove timber suitability), seeding of native grasses in areas where soil was disturbed and tree density is below moderate	
K- Williams	Dogtown Fuels Reduction Project	2004 (decision)	Total Acres: 8,209, implementation began in 2004 – 6,509 acres implemented with 1,700 acres left to implement in 2013 Treatments: (1) 3,105 acres – irregular/sanitation thinning (1,307 ac. Is for mistletoe), (2) 300 acres – group selection, (3) 480 acres – grassland maintenance/fuels reduction, (4) 6,085 acres – prescribed burning, (5) 3,912 – slash treatments, (6) 344 acres – deferred from treatment, (7) 18 miles – road closed	Objective: reduce hazardous fuels and associated fire risk Categorized as both past (6,509 acres implemented) and on-going due to 1,700 acres being part of shelf stock (2013)
K-Williams	Clover High Fuels Reduction	2004	385 acres implemented by 2004 -thin, machine pile, burn	No project records could be located
K-Williams	Pineaire Fuels Reduction	2004 (decision)	Total acres: 650 acres of treatments, implemented 2004 to 2009 (1) 302 acre of commercial low thinning, (2) 91 acres of non-commercial low thinning 9”dbh, (3) 56 acres low thinning, (4) 150 acres of whole tree skidding, (4) 645 acres of broadcast burn (post pile/burn), (5) 169 acres of pile/burn (0 miles of road proposed for closure or decommission)	Objective: reduce fuel hazards around communities Categorized as past due to decision
K-Williams	Williams Follow-up Mistletoe Treatment	2004 (decision)	Total Acres: 368 Non commercial mistletoe sanitation on 368 acres within 13 separate sites Slash piles burned	Objective: forest health Categorized as past due to date of decision and scope of project]

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	Project			
K-Williams	Government Mountain/Coleman Aspen Restoration	2005 (decision)	Total acres: 75 75 acres of conifer removal within aspen stands up to 16" dbh Construct wire fencing totaling 3,000 feet around 11 acres of (of 51 total acres of aspen) aspen sprouts	Encourage and promote aspen and protect from heavy browse Categorized as past due to date of decision and scope of project (75 acres)
K - Williams	Garland Prairie Grassland Restoration	2005 (decision)	Total acres: 500 Mechanical – 500 acres Lop, pile, burn – 47 acres Treatment: Cut encroaching ponderosa pine and juniper trees. Treats 500 acres of 14,000-acre total Garland Prairie. Lop and scatter fuels to address visual concerns (Overland Trail and TH, I-40, Sycamore Rim Trail)(0 miles of road proposed for closure or decommission)	Objective: improve wildlife habitat including pronghorn fawning, nursing, movement, migration, and sighting distance and elk winter and summer range Categorized as past due to date of decision and scope of project
K- Williams	City Project	2005 (decision)	Total acres: 12,400, implemented 2006 to 2010 with 600 acres left to implement in 2014 Acres of mechanical: 8667 Thinning: (1) commercial - sawtimber 9" dbh + – 4,918 acre (19,672 CCF), (2) commercial Roundwood 5-9" dbh – 1,339 acres (16,093 CCF), (3) noncommercial thinning – 2,366 acres, (4) Savanna Restoration – 41 acres, (5) Aspen Restoration – 3 acres, wood product total: 35,765 CCF (0 miles of road proposed for closure or decommission) Prescribed Burning – entire project including initial underburning with no mechanical – 2,300 acres, burning with non-commercial thin post fire – 963 acres Slash piling and burning – 3,000 acres	Objective: Reduce tree densities and hazardous fuels to improve forest health and sustainability, reduce potential for high intensity fire into the City of Williams and its watershed, provide for public and firefighter safety Addresses 12,400 acres of high priority treatment area identified in the Greater Williams CWPP Categorized as past as DN/FONSI does not reference maintenance burning and ongoing as 600 mechanical acres (= 600 acres of prescribed fire) planned to be implemented in 2014

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			(= 9,400 acres of prescribed fire, and 3,000 acres of pile/burning)	
K-Williams	Kendrick Prescribed Burning	2005-2006 (implemented)	Total Acres: Unknown – need data from Kaibab	
K – Williams	Flag Tank Aspen Restoration	2007 (decision)	Total acres: 36 22 acres – mechanical 36 acres - prescribed fire Treatments: Cut conifers up to 20” dbh and fence three aspen stands on approximately 22 acres: (1) no yellow pines cut, (2) all trees cut by hand, no commercial sales	Objective: prevent further loss of aspen Categorized as past given date of decision and total acres to be treated
K-Williams	Ida Grassland Maintenance Project	2008 (decision)	Total Acres: 1,800 Treatments: (1) Thin juniper and ponderosa pine less than 12” dbh on encroached grasslands with agra-axe and chainsaws, (2) Pile and burn residual slash within 3 years of treatment (0 miles of road proposed for closure or decommission)	Categorized as past – Kaibab web information states project was implemented in 2010 GIS for 4 FRI depicts project boundary
K-Williams	Bill Williams Cap Fuels Reduction	2009 (decision)	Total acres: 10 Thinning trees up to 12” dbh and removal of 17 to 25 trees > 10” dbh near structures: remove approx. 175 trees per acre < 5” dbh and 20 trees/acre between 5 and 12” dbh, predominantly douglas and white fir – thin to overall basal area of 170 to 140 sq. ft per acre Hand piling/burning of 80% of slash, prescribed fire in northern portion of project area, and maintenance burns (0 miles of road proposed for closure or decommission)	Objective: Reduce hazardous fuels on 10 acres at the top of Bill Williams Mountain to protect electronic site Implemented in 2010 Categorized as both past and on-going due to maintenance burns
K-Williams	Community Tank Grassland	2011 (decision)	Acres implemented: 185 thinning/burning Treatments: Restore grassland condition in meadow	Part of shelf stock – 865 acres left to implement in 2013 – 185 acres categorized as past

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	Restoration Project		and ponderosa pine savanna – 1,050 acres, Prescribed Burn 1,400 acres with re-entry burns over 20 year period, Remove 1 miles of fence (pronghorn), Obliterate 2.2 miles of road	Retains all yellow pines, uses evidence-based approach for old trees Categorized as on-going/current project due to maintenance burns
K-Tusayan	Ten X and Red Horse Mudersbach Timber Sale	1998 (decision)	Total Mechanical Treatment Acres: 324 acres Total Prescribed Fire: 3,500 acres Treatments: 41 acres of natural reforestation to increase age class distribution 10 miles of road obliterated for watershed conditions Guzzler construction (9,000 gal tank) – improve distribution of reliable water 85 acres of pinyon juniper thinned – improve cliffrose understory to increase browse 198 acres of thinning to remove encroaching pinyon juniper from ponderosa pine to improve growth 3,500 acres of prescribed burn – reduce haz fuels, improve forage and plant vigor	Objective: forest health (vigor, distribution, understory and forage), reduce hazardous fuels, improve water sources and watershed No information available via hard copy or electronic project records – gathered information from PALS and GIS shape files Categorized as past due to date and decision does not mention maintenance burns
K-Tusayan – outside project area	Upper Basin Project	2000 (decision)	Total acres: 1,884 1,884 acres of sagebrush and grassland prescribed burning	Objective: Improve and maintain grassland and winter range habitat Categorized as past due to decision date and no mention of maintenance burning
K-Tusayan	Tusayan West	1998-2001	850 acres total: (1) 549 acres of thinning, (2) 850 acres of prescribed burning, (3) 75 miles of road obliteration	No project record located – found in airport fuels cum effects
K-Tusayan	Tusayan South/Boggy Tank	2000-2002	Tusayan South – 1,100 acres of fuel reduction, Boggy Tank – 1,848 acres of fuels reduction 2000 – 2,948 acres completed in 2000 and 2012 is ongoing (2,948) no information could be located in terms of road decommission or road closure	No project record – found in airport fuels cum effects categorized as on-going in Airport Fuels cum effects

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
K-Tusayan	Anita project	2002	100 miles of road obliteration	No project record located – found in airport fuels cum effects
K-Tusayan	Ten X Pre-Commercial Thinning Project	2004 (decision)	Total Acres implemented 2,761 acres Total Treatment Acres: 2,761 Mechanical = 1,780 acres 909 acres – thin ponderosa pine that has dense stocking up to 9” dbh with 60 to 70 residual trees/acre of which there are 20 to 35 larger trees, fuels lopped and scattered 871 acres – thinning of ponderosa pine that has extreme stocking up to 9” dbh with 60 to 70 residual trees/acre of which there are 20 to 35 larger trees, fuels lopped and scattered 700 acres of underburning only, 1,700 acres of thinning and burning and 250 acres of burn-thin-burn, maintenance burns to occur several years after initial burning (0 miles of road proposed for closure or decommission)	Objective: improve forest health, stand and tree resilience and vigor, improve understory diversity 2,761 acres Categorized as past due to decision date and 700 acres categorized as ongoing due to maintenance burns
K-Tusayan	Topeka Fuels Reduction Project	2004 (decision)	Total acres: 1,100 Non-commercial mechanical thinning and prescribed burning on 1,100 acres with fuelwood collection and slash treatments: (1) Burn Only – 702 acres in low to moderately dense pinyon-juniper woodland with some ponderosa pine, (2) Thin and burn to 75 to 100 trees/acre – 1,095 acres in pinyon pine and juniper (9 to 12” dbh), ponderosa pine (9” dbh and less) and Gambel oak, Slash lopped and scattered and slash piles burned (0 miles of road proposed for closure or decommission)	Objective: Reduce fuels within the urban interface areas around Tusayan and adjacent to the Grand Canyon NP Categorized as past due to date of decision and scope of project
K-Tusayan	Moqui Antelope Habitat Improvement	2006 (decision)	Total Acres: 1,300 Moqui, 1,690 Red Butte 2,990 total thin/burn Remove encroaching trees on 2,990 acres of grassland/woodland	Objective: antelope habitat and watershed improvement Categorized as past project due to date of decision, scope of project, and estimated date for implementation (08/2006)

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	Project			
K-Tusayan	Scott	2001-2007 (implementation)	From 2002 to 2004 – 421 acres of pre-commercial thin and 300 acres machine piled and burned 2002 to 2007 – 9,434 acres broadcast burned	No project records could be found other than shape files
K-Tusayan	X-Fire Hazard Tree Removal	2009 (decision)	Total acres: 140: Treatments: Remove hazard trees that have 80 percent of greater total crown damage, are tall enough to impact a road/fence, and pose a threat to falling towards a road/fence on 140 acres along FR 302, 303, 688, 835 and 2709, Charlie Trick Tank Road and ½ mile of fence south of 835 road, along 1 mile of private along 302 road	Categorized as past due to scope and date of decision
K-Tusayan	O'Connell	Pre-2009	500 acres of grassland improvement, sagebrush mowing	No project record found in airport fuels cum effects
K-Tusayan	Tusayan Wildlife Waters Project	2008 (decision) 2008-2010 Implemented	24 water developments constructed Sites include 255-259, 372-373, 391, 972, 1019, 3 waters along old Highway 64 (ADOT assist), and 1186 (see GIS) Four waters developed in the Triangle (see GIS data) 6 of 24 had new pipeline constructed Data per Colby Walton, ADGF Wildlife Manager and John DeLuca Note: More waters developed than displayed on map	Digitized points Objective: provide for water needs for wildlife, reduce hauling costs, improve elk habitat use patterns to reduce impacts to vegetation and soil resources around existing water developmetns Relevant to this project in terms of ungulate dispersal per Bill
C-Flagstaff	Arboretum WUI	2000	602 acres total: 62 acres – UEA 38 acres – 9” dbh and less 100 acres of hand felling, bunchers, or machines 612 acres of prescribed burning	Objective: reduce fuel loading, fuel ladders, and overall fire hazards within the WUI and reduce fire potential to The Arboretum and Dry Lake Caldera Cateogirzed as both past (602 acres of thin/burn) and ongoing (602 acres of burn)

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			602 acres of thin/burn – past and 602 acres of maintenance burn – ongoing	
C-Mogollon Rim – Peaks RD	Fort Valley	2000	1,700 acres of thinning less than 16” dbh Road closures Trail relocation Retore meadow and riparian habitat EA and DN so convoluted that it is impossible to figure out how many miles of road were proposed for closure	Categorized as past due to volume and year’ There have been numerous Fort Valley projects from 1999 to present
C-Flagstaff	A-1 MultiProduct Timber Sale (in PALS) East M-P, A-1 West, A-1 East	2000-2002	Three projects totaling 14,155 acres of which 8,274 acres is broadcast burn, 364 acres is pile burn and 5,517 acres is thinning (no details available) Insufficient details to provide information on road decommission or closures	13,463 acre-boundary found in GIS, acreage is from GFFP 2010 data summary Assume 14,155 acres implemented (past) and 8,274 acres is ongoing maintenance burning
C-Flagstaff	Rocky Park Fuels Reduction	2001	Total acres thinned: 5,651 acres Total acres prescribed burned – 8,000 acres 2,196 acres – thin up to 12” dbh ponderosa pine 800 acres – thin up to 12” dbh with openings averaging 1 acre in size – turkey and eagle 700 acres – thin up to 12” dbh –yellow pine competition reduction 700 acres – thin up to 12” dbh with openings averaging 1 acre – for turkey winter habitat 700 acres- thin up to 12”dbh with openings between 2-5 acres for turkey summer habitat 225 acres – thin up to 9” dbh – MSO protected 330 acres- thin up to 12” dbh - MSO restricted 8,000 acres- burn only	Objective: reduce fire potential Categorized as past as no mention of maintenance burns

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			200 acres- meadow restoration Noxious weeds No roads proposed for closure or decommission	
C-Flagstaff	Lake Mary Fuels Reduction (PALS : Lake Mary Meadows Tow Fuel Reduction)	2005	2 projects including 3,245 acres of prescribed burning and 1,845 acres of thinning: 1,616 acres of broadcast burning, 1,824 acres of thinning (no details) and 1,629 acres of broadcast burning – No information on whether road closure or decommission was part of the decision	Only shape files could be retrieved from corporate data, numbers are from GFFP data PALS project description: Meadow restoration and fuels reduction to be accomplished by removing pine encroachment on grassland soils.
C-Flagstaff	APS Hazard Tree Removal	2003	315 acres broadcast burn	Data from GFFP data - past
C-Flagstaff	APS Powerline	2007 (decision)	Flagstaff to Happy Jack - construction of 46 miles of 12kV distribution powerline including vegetation clearing on 167 acres (30 feet in width) Past: 46 miles of construction/167 acres of clearing Ongoing: 167 acres of vegetation clearing maintenance	See project details - assume construction and vegetation clearing is complete due to date of decision and that maintenance on 167 acres is ongoing – part of forest-wide acre summary (ongoing)
C-Mogollon Rim	Blue Ridge 69 Kv Transmission Line	2005 (decision)	11 miles of powerline with 2-acre substation 50 acres of tree removal and 1,300 acres of prescribed burn and maintenance burning every 5 to 7 years Past: 50 acres thin and 1,300 acres burn Ongoing: 1,300 acres maintenance burning	See spatial data Categorized as on-going due to powerline maintenance and maintenance burns in DN/FONSI – part of forest-wide acre summary (ongoing)
C-Flagstaff	Doney Park	2007 decision	1.75 miles of 69 kV line from US Highway 89 to existing 69 Kv line - 8.48 acres Past – 8.48 acres vegetation clearing Ongoing – maintenance (8.48 acre)	Categorized as both past and ongoing due to maintenance (8.48 acre) – part of forest-wide acre summary (ongoing)

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
C-Flagstaff	Kachina Village	2003	Thin 4,800 acres (3,801 acres implemented) broadcast and maintenance burn 6,229 acres (2,147 acres of burning implemented) No road closure or decommission included	Implementation acres data from GFFP report – project objective: improve declining forest health and reduce wildfire potential
C-Mogollon Rim	Apache Maid Grass CE	2004	54,528 acres of hand cutting (lop and scatter) invasive pine and juniper trees within pastures of the Apache Maid Allotment No road closure or road decommission included	Objective: grassland maintenance
C-Flagstaff	Woody Ridge Forest Restoration Project	2004	Total acres of maintenance prescribed (broadcast) burning: 11,184 acres. Mechanical RX: 7,987 ac. (completed) Fire RX: 11,184 acres (completed) 1,286 –thin/burn for antelope 2,945 – burn only MSO PAC thin/burn – 71 acres PFA thin/burn – 228 acres MSO target thin/burn – 252 acres Turkey thin/burn – 660 acres Fire Risk Reduction thin/burn – 3,494 Wildlife movement thin/burn – 89 UEA thin/burn – 2,519 No road closure or decommission included 14.5 miles of new non-motorized trail constructed and 3 miles of social trail obliterated	Objective: reduce fire risk and improve forest health, restore travelways for antelope and bear Maintenance burning every 3 to 10 years Categorized as both past (7,897 ac. thin and 11,184 burn) and ongoing due to maintenance burns (11,184 ac)
C-Flagstaff	Mormon Lake Fuels Reduction	2005	2,388 acres thinned and prescribed (broadcast) burned – confusing description of acres to be treated Past: 2,388 acres thin/burn Ongoing: 2,388 acres burn	Objective: fuels reduction Categorized as both past and ongoing due to maintenance burns

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			No road closure or decommission included but system and non-system road segments converted to non-motorized trails	
C-Flagstaff	Skunk Canyon Prescribed Burn Fuel Reduction	2005 decision	831 acres of low intensity groundfire in 50 to 200 acre blocks – maintain with burning every 5 to 9 years in up to 400-acre blocks Past: 831 acres burn Ongoing: 831 acres maintenance burn No road closure or decommission included	Objective: Reduce fuel loading and fire hazard within WUI Categorized as past and ongoing due to maintenance burning
Coconino/GFFP	Elden	2006	193 acres of fuels reduction – cooperatively thinned Categorized as past due to small volume No road closure or decommission included	No project record located – project referenced in Eastside Fuels DN
Coconino/Flagstaff (GFFP)	Eastside Fuels Reduction and Forest Health	2006	Total thin/burn acres: 7,819 acres thin and 20,197 acre burn: 3,819 acres of UEA, 3,404 acres up to 12” dbh, 377 acres fuelbreaks, 220 acres of grassland restoration, 20,197 acres of prescribed burning, some grassland and aspen restoration Past: 7,819 acres thin and 20,197 acres burn Ongoing: 20,197 acres of maintenance burning No road closure or decommission included	Objective: fuels reduction (WUI) with some restoration Categorize as past and ongoing due to maintenance burns
C-Mogollon Rim	East Clear Creek Watershed Health Improvement	2006	Total project acres: 16,228: 1,645 acres of thinning less than 9” dbh 83 acres of thinning less than 16 inch dbh- implemented 14,500 acres of prescribed and maintenance burning – implemented and ongoing Decommission 30 miles of road and 14 miles of previously closed road – implemented	Objective: restore understory and overstory health and diversity, reduce potential for stand-replacing fire and road impacts on watershed and riparian habitat Categorized as both past and ongoing due to maintenance burns 83 acres thinned, 14,500 burned Ongoing: 1,562 thin, 4,700 burn

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			Past:83 acres thin, 14,500 burn 4,700 acres planned for thin (1,562) and burn (4,700) in 2013	
C-Flagstaff	Elk Park Fuels Reduction and Forest Health	2007	4,700 acres of UEA in ponderosa pine 6,400 acres of prescribed burning Hoxworth Spring crossing improvement and 0.80 mile of road construction/relocation out of meadow Past: 1,800 ac. thinning completed and 3,500 ac. burning Ongoing: 2,900 acres planned (2012) thin and burn	No mention of maintenance burning in DN/FONSI
C-Flagstaff	Little Draw Aspen	2009	53 aspen exclosures on 107 acres w/fencing No road closure or decommission included	Implemented 2010
C-Flagstaff	Munds Park Fuels Reduction	2009 (decision)	Thin 990 acres of ponderosa pine - complete 2,950 acres of initial and maintenance prescribed burns – initial burn complete No road closure or decommission included	Reduce fire risk Categorized as both past and ongoing due to maintenance burns
C-Flagstaff	Munds Park CE	2007 (decision)	Thin 990 acres Initial and maintenance burns on 2,950 acres No road closure or decommission included	Objective: reduce fire hazard rating in WUI
C-Flagstaff	Slate Mountain Pronghorn Habitat Restoration Phase III	2010	2,250 acres of grassland restoration – hand cut encroaching ponderosa pine and juniper No road closure or decommission included	Categorized as past due to date of decision
C-Flagstaff	Shultz Fire BAER	2010-2011	150 snags removed within 100 feet of road on 17.5 miles of road - Waterline Road 22 snags removed in Weatherford PAC 29 snags removed in Pipeline PAC	Categorized as past

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			2 acres of disturbance within MSO habitat – reconstruction activities – 0.525 acres lost in Pipeline PAC and 0.435 acres lost in Weatherford PAC, 0.75 acres lost in restricted habitat	

Table 39. Description of Past Projects by Other Agencies or Private Lands

Agency/ Owner	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
Department of Defense	Camp Navajo	2003-2010	1,636 acres of broadcast burning	Camp Navajo Data, no data available prior to 2003
Department of Defense	Camp Navajo Westside Buffer Thinning and Prescribed Fire Project	2006-2011	1,045 acres of mechanical thin and broadcast burn	retain trees > 18" dbh, removed excess density of trees between 5" to 18" dbh to an average stand basal area of 50
Department of Defense	Camp Navajo Tornado Fuels Reduction Project	2012	854 acres – removed storm damaged trees	Data from Camp Navajo
GFFP/State Forestry	AZ State Forestry	2000 to 2010	1,310 acres of private land thinned through State Forestry grants Past due to need to implement during funding window	Data from AZ State Forestry

Table 40. Wildfires

Forest	Year	Fire Class/Name	Acres
Coconino NF	2001-2010	Various Class C Fires (10 – 99.9 acres)	2,205
Coconino NF	2009	Class D/Cinder Hills-256	256
Coconino NF	2000	Class D/Clover-111	111
Coconino NF	2003	Class D/Fry-179	179
Coconino NF	2004	Class D/Good-119	119
Coconino NF	2008	Class D/Late-140	140
Coconino NF	2008	Class D/OH -196	196
Coconino NF	2009	Class D/Reservoi-170	170
Coconino NF	2006	Class D/Sawmill-244	244
Coconino NF	2005	Class D/Tater-166	166
Coconino NF	2006	Class D/Towel-279	279
Coconino NF	2002	Class D/Tram-197	197
Coconino NF	2006	Class D/Woody-107	107
Coconino NF	2000-2009	Total Class D Fire Acres	2,164
Coconino NF	2010	Class E/89 Mesa - 523	523
Coconino NF	2009	Class E/Bear – 272	272
Coconino NF	2005	Class E/Bull Run -884	884
Coconino NF	2002	Class E/Five Mile -379	379
Coconino NF	2006	Class E/Knife-589	589
Coconino NF	2006	Class E/La Barranca -836	836
Coconino NF	2000	Class E/Pipe -634	634
Coconino NF	2002	Class E/Springer-882	882
Coconino NF	2010	Class E/Tuba -300	300

Coconino NF	2000-2010	Total Class E Fire Acres (300 – 999 acres)	5,299
Coconino NF	2006	Class F/Brins -4,317	4,317
Coconino NF	2000	Class F/Golf-1,470	1,470
Coconino NF	2010	Class F/Hardy-281	281
Coconino NF	2001	Class F/Leroux-1,113	1,113
Coconino NF	2003	Class F/Mormon-2,712	2,712
Coconino NF	2002	Class F/Packrat-3,006	3,006
Coconino NF	2000	Class F/Power-1,527	1,527
Coconino NF	2009	Class F/Taylor-3,538	3,538
Coconino NF	2004	Class F/Webber-1,411	1,411
Coconino NF	2000	Class F/Willow - 1,488	1,488
Coconino NF	2000-2010	Total Class F Fire Acres (1,000 – 4,999 acres)	20,863
Coconino NF	2007	Class G/Birdie-5,018	5,018
Coconino NF	2004	Class G/Jacket-17,218	17,218
Coconino NF	2003	Class G/Lizard-5,220	5,220
Coconino NF	2010	Class G/Schultz-15,065	15,065
Coconino NF	2000	Glass G/Pumpkin*	7,020
Coconino NF	2003-2010	Total Class G Fire Acres (≥ 5,000 acres)	59,541
Kaibab NF	2009	Class E/Indian	107
Kaibab NF	2009	Class E/Twin	1,617
Kaibab NF	2010	Class E/Juniper	470
Kaibab NF	2010	Class E/Scott	492
Kaibab NF	2000-20010	Total Class E Fire Acres (300-999 acres)	2,686
Kaibab NF	2008	Class F/X	2,060
Kaibab NF	2009	Class F/Ruby	4,671
Kaibab NF	2009	Class F/Rae	1,392

Kaibab NF	2009	Class F/Miller	3,160
Kaibab NF	2009	Class F/Anderson	1,238
Kaibab NF	2010	Class F/Hobble	2,227
Kaibab NF	2000-2010	Total Class F Fire Acres (1,000-4,999 acres)	14,748
Kaibab NF	2000	Pumpkin*	8,759
Kaibab NF	2002	Trick	5,572
Kaibab NF	2009	Wildhorse	7,450
Kaibab NF	2000-2010	Total Class G Fire Acres (≥ 5,000 acres)	21,781
*Coconino and Kaibab NFs	2000	Class G/Pumpkin	15,779 total (8,759 acres on Kaibab NF, 7,020 acres on the Coconino NF)

Table 41. Descriptions of Current/Ongoing Projects by Ranger District (RD) on the Kaibab (K) and Coconino (C) National Forests

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
K-Williams	Pomeroy – part of Frenchy (2003)	2012	1,740 acres to be implemented - mechanical and prescribed fire	Part of shelf stock -
K-Williams	KA – part of Frenchy (2003)	2012	1,050 acres to be implemented – mechanical and prescribe fire	Part of shelf stock
K-Tusayan	Russell Vegetation Management Project	2011 (decision)	Planned Treatments: 5,000 acres non-commercial thinning (less than 9” dbh) and 8,000 acres of prescribed fire	Objective: vegetation improvement, fuels Categorized as ongoing/current project due to 4th quarter 2011 decision date
K-Williams	Community Tank Grassland Restoration	2011 (decision)	Treatments: Restore grassland condition in meadow and ponderosa pine savanna – 1,050 acres, Prescribe Burn 1,400 acres with re-entry burns over 20 year period, Remove 1 miles of fence (pronghorn),	Part of shelf stock – 865 acres left to implement in 2013 – 185 acres categorized as past Retains all yellow pines,

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	Project		Obliterate 2.2 miles of road	uses evidence-based approach for old trees Categorized as on-going/current project due to maintenance burns
K-Williams	Bill Williams Cap Fuels Reduction	2009 (decision)	Total Acres: 10 Thinning trees up to 12" dbh and removal of 17 to 25 trees > 10" dbh near structures: remove approx. 175 trees per acre < 5" dbh and 20 trees/acre between 5 and 12" dbh, predominantly douglas and white fir – thin to overall basal area of 170 to 140 sq. ft per acre Hand piling/burning of 80% of slash, prescribed fire in northern portion of project area, and maintenance burns	Objective: Reduce hazardous fuels on 10 acres at the top of Bill Williams Mountain to protect electronic site Vegetation and fire implemented in 2010 Categorized as both past and on-going due to maintenance burns
K-Tusayan	Ten X Pre-Commercial Thinning Project	2004 (decision)	Ongoing Acres: 700 acres of burn	Objective: improve forest health, stand and tree resilience and vigor, improve understory diversity Categorized as past (2,761 acres of mechanical and burning) and ongoing due to maintenance burns (700 acres)
K- Tusayan	Airport Fuels Reduction Project	01/2009 (decision)	Total mechanical is 2,961 Total Burn: 2,961 Thin from below 2,225 acres of pinyon-juniper and retain large, older trees, Slash disposal – lopped, scattered, piled/burned, prescribe fire with first and second entry 602 acres of ponderosa pine: prescribe burn, thin from below, prescribe burn with a third burn being a broadcast and jackpot ignition 134 acres of sagebrush-grassland: thin, regain all pre-settlement trees using evidence-based approach, jackpot burning to create small openings In all project area, managing for less than 5 percent mortality in pipo and large diameter oak Maintenance burns scheduled on a 5 to 15-year cycle	Objective: pinon/juniper: recreate stand conditions created by mixed fire severity to create contiguous patches alternating between stand replacement and no fire effects Categorized as on-going due to maintenance burns

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
K-Williams	South Williams Prescribed Burn #51	2005 (decision)	Prescribed burning within grassland openings on 290 acres to remove small diameter ponderosa pine and pinyon/juniper tree encroachment with small dozer line constructed along the west and east boundaries of the Coleman Lake Site and on a portion of the Whiting site boundary. First burn occurring in 2006 and maintenance burns would occur every 5 to 10 years	Objective: Improve and maintain grassland species, stimulate decadent grass, forbs and browse plants, restore periodic burning into the ecosystem Categorized as on-going due to use of fire to maintain grassland openings
K-Tusayan	Long Jim Fuels Reduction	2005 (decision)	Past 913 acres mechanical Past Burn: 1,175 acres Ongoing: 1,175 acres burning Total acres: 1,300 Burn Only – 462 acres –light stocking of small diameter pinyon, juniper and pockets of ponderosa pine Mechanically thin up to 12” dbh and burn – 713 acres in ponderosa pine, pinyon pine, juniper and Gambel oak Agra-axe or Agra-mow trees up to 12” dbh and burn – 200 acres – scattered ponderosa pine, pinyon pine, juniper, and Gambel oak and sagebrush openings on flatter terrain Post mechanical treatment broadcast burn with maintenance burning occurring Mechanical – 713,200 = 913 acres Burn: 462, 713 – 1,175 acres	Objective – improve ecosystem health and sustainability and reduce risk of intense stand replacement fire to private property, Tusayan and Grand Canyon NP, addresses priority in Tusayan CWPP Categorized as on-going due to inclusion of maintenance burning in CE
K- Williams	Dogtown Fuels Reduction Project	2004 (decision)	Total Acres: 8,209, implementation began in 2004 – 6,509 acres implemented with 1,700 acres left to implement in 2013 Treatments: (1) 3,105 acres – irregular/sanitation thinning (1,307 ac. Is for mistletoe), (2) 300 acres – group selection, (3) 480 acres – grassland	Objective: reduce hazardous fuels and associated fire risk Categorized as both past (6,509 acres implemented) and on-going due to 1,700 acres being part of shelf stock (2013)

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			maintenance/fuels reduction, (4) 6,085 acres – prescribed burning, (5) 3,912 – slash treatments, (6) 344 acres – deferred from treatment, (7) 18 miles – road closed	
K-Williams	Twin	2005 (decision)	Total acres: 1,400 acres Treatments: 1,400 acres of prescribed burning to reduce fire risk in the Greater Williams Area CWPP: (1) Thin, Prune, Pile Burn Firelines, Reburn areas previously treated up to 2001, mortality in yellow pipo not to exceed 5 percent of the project area, mortality of black-bark pipo greater than 12” dbh not to exceed 10 percent, gambel oak mortality greater than 5” drc not to exceed 15 percent – part of the Hat Allotment Mtn Plan EA?? Per information in Twin project record (project description is not consistent with files on hand at the district that are dated in the 1990s)	Objectives: firefighter and public safety; reduce the potential for wildland fire to enter private property from the forest; reduce the risk for uncharacteristically intense stand-replacement wildland fires by creating openings in the forest canopy, reducing forest fuel loads (dead and down woody debris), reducing ladder fuels (includes increasing the distance from the ground to lower live tree branches), and lowering tree densities; protect watershed condition and soil productivity; and prevent the spread of high-intensity wildland fire into the City of Williams watershed. DN-FONSI not specific on whether maintenance burns would occur Categorized as on-going due to assumption that maintenance burns within a CWPP would be needed
K- KNF	Treatment of Noxious Weeds – 3 forests	2004 (decision)	Incorporated into forest plan direction	NEPA Completed in 2004 Categorized as on-going
K-Williams	Frenchy	2003 (decision)	Total Mechanical: 9,319 - Total Fire: 9,319 acres 6,529 acres implemented to date Total commercial treatments – 8,227 acres Non-commercial - 1,092 acres Commercial: Intermediate thin – 2,878 acres Croup Selection – 1,876 acres	Objective: Restore forest health, reduce fuel accumulations, improve wildlife habitat diversity, increase large, old trees Note: Decision states: This alternative proposes over 800 additional acres of full restoration treatments between Moose Ranch and Garland Prairie. This area would be managed for an average canopy cover of less than 40 percent over time – no plan amendment was included

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			<p>Savanna/Meadow restoration – 2,125 acres Sanitation – 43 acres Individual tree selection – 53 acres Non Commercial: 256 acres of intermediate thin, 473 acres of savanna/meadow restoration, 405 acres of large oak/juniper/yellow pine release, 78 acres of sanitation Broadcast burning over entire EMU over time, 12.9 miles of road obliteration, 17.3 miles of road closures, forest plan amendment (remove timber suitability), seeding of native grasses in areas where soil was disturbed and tree density is below moderate</p>	<p>Categorized as on-going – DN/FONSI in hard copy files has decision date of 1990 See Pomeroy and KA – on-going thin and prescribed burn – broadcast burn (6,529 acres accounts for removing KA and Pomeroy acres) categorized as ongoing due to restoration emphasis of the project</p>
	Williams and Tusayan fuelwood policy	2011 (current)	<p>Cross-country motorized use not permitted Dead limbs may not be removed from live trees Ponderosa Pine – Only dead, standing trees less than 12 inches in diameter (38 inches in circumference) or less than 15 feet in height may be removed Pinyon Pine – Only dead, standing trees less than 10 inches in diameter (32 inches in circumference) or less than 12 feet in height may be removed. Gambel Oak – Only dead, standing trees less than 8 inches in diameter (25 inches in circumference) or less than 12 feet in height may be removed. In addition, dead, standing oak may only be removed between June 1 and September 30. Juniper – Only dead, standing trees less than 20 inches in diameter (68½ inches in circumference) or less than 15 feet in height may be removed. Aspen – Only dead, standing trees less than 12 inches in diameter (38 inches in circumference) or less than 12</p>	

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			feet in height may be removed. In addition, dead, standing aspen may only be removed between June 1 and September 30. Green Juniper – diameter size limits apply by specific area	
K-Tusayan	Tusayan Travel Management	2011 (decision)	566 miles of open road: Changes: (1) 143 miles of open road become admin, (2) 15 miles of spur roads added, (3) game retrieval within one mile of all designated roads,	Relevant to this project
K-Williams	Williams Travel Management	2011 (decision)	Close 380 miles of open road, add 16 miles of spur roads that includes 8 miles of closed road and unauthorized user created routes, add 18 miles of spur roads, allow big game retrieval within 1 mile of open roads	Categorized as current/ongoing due to decision date
K-Williams	Radio Hill Road Obliteration	2005 (decision)	Close 50 miles of road, decommission or obliterate 67.3 miles of road	Objective: Improve wildlife habitat, protect heritage resources, maintain serviceable road system Categorized as on-going due to miles of road and date of decision
C-Flagstaff	A-1 East M-P, A-1 West, A-1 East	2000-2002	Three projects totaling 14,155 acres of which 8,274 acres is broadcast burn, 364 acres is pile burn and 5,517 acres is thinning (no details available) Past mechanical: 14,155 acres Past burning: 8,636 acres (broadcast burn, pile burn) Ongoing: 8,274 acres maintenance burn	13,463 acre-boundary found in GIS, acreage is from GFFP 2010 data summary Assume 14,155 acres implemented (past) and 8,274 acres is ongoing maintenance burning
K-Tusayan	Tusayan South/Boggy Tank	2000-2002	Tusayan South – 1,100 acres of fuel reduction, Boggy Tank – 1,848 acres of fuels reduction 2000 – 2,948 acres completed in 2000 and 2012 is ongoing (2,948 acres)	No project record – found in airport fuels cum effects categorized as on-going in Airport Fuels cum effects 2,948 acres completed in 2000 and 2012 is ongoing (2,948 acres)

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
K-Tusayan	Tusayan East	2002	2,600 acres of fuels reduction	No project record – shape files in O drive – found in airport fuels cum effects categorized as on-going in Airport Fuels cum effects
K-Forest-wide	Grazing Allotments	Current	28 grazing allotments authorizing 340,394 acres of livestock (cattle, sheep, horse) grazing within project area – see spatial data for allotment location. Allotments managed for 30 to 40 percent maximum forage utilization Grazing systems range from rest rotation to deferred rotation Forest-wide there are 38 grazing allotments covering 1,414,000 or 92 percent of the forest.	Anita, Bellemont, Big Springs, Cameron, Chalender, Crova, Cowboy Tank, Davenport Lake, Elk Springs, Government Mtn, Government Prairie, Hat, Homestead, Juan Tank, Kendrick Mountain, Mooney Mtn, Mortiz Lake, Pine Creek, Pomeroy, Rain Tank, Seven C Bar, Sitgreaves, Smoot Lake, Spitz Hill, Squaw Mtn, Tule, Twin Tanks, Garland Prairie
Coconino/GFFP	Arboretum Fuels Reduction	2000	602 acres cooperatively thinned and prescribed burned: 62 acres UEA, 38 acres 9” dbh and less, hand felling, bunchers, tractor systems – 100 acres, 602 acres prescribed burning Categorize as 602 acres past thin/burn and 602 acres of ongoing maintenance burns	Objective: reduce fuel loading, fuel ladders, and overall fire hazards within the WUI and reduce fire potential to The Arboretum and Dry Lake Caldera – GFFP data shows 61 acres of thin and 763 acres of broadcast burn implemented
C-Flagstaff	Woody Ridge Forest Restoration Project	2004	Total acres of maintenance prescribed (broadcast) burning: 8,599 1,286 –thin/burn for antelope 2,945 – burn only MSO PAC thin/burn – 71 acres PFA thin/burn – 228 acres MSO target thin/burn – 252 acres Turkey thin/burn – 660 acres Fire Risk Reduction thin/burn – 3,494 Wildlife movement thin/burn – 89 UEA thin/burn – 2,519	Objective: reduce fire risk and improve forest health, restore travelways for antelope and bear Maintenance burning every 3 to 10 years Categorized as both past and ongoing

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
C-Flagstaff and Mogollon RD	Post-Tornado Resource Protection and Recovery Project	Current (2011 decision)	Remove downed material from the tornado corridor on approximately 3,990 acres and treat within stands with evidence of bark beetle infestation on a maximum of approximately 14,766 acres adjacent to the tornado corridor on the Flagstaff and Mogollon Rim Ranger Districts. Total maximum acreage for treatment is 18,756 acres; however treatment in the buffer will only occur in areas showing signs of bark beetle infestation and therefore, the area treated may be much smaller.	Treatments could occur for approximately five years (see DN/FONSI) post-decision (2011 to 2016) dependent on bark beetle activity
C - Flagstaff	Hart Prairie Fuels Reduction	2010 (decision)	9,815 acres thin/burn total 3,790 acres – ponderosa pine restoration – 2-40 trees/group, 0.7 acres in size, BA 50 sf or greater in VSS 4-6 – initial and maintenance burning 250 acres – mixed conifer restoration groups of trees up to 4 acres in size with BA of approx 50-120 sf – pile and broadcast burn 3,215 acres – aspen restoration with prescribed fire 30 acres- thin from below on steep slopes up to 9” dbh 1,515 acres – meadow restoration 965 acres – burn only 25 acres- slope stabilization 25 acres-Bebbs willow restoration Spring enclosures, water tank/catchment relocation	Objective – move towards historic natural conditions including fire regime Categorized as ongoing due to date of decision, size of project, and maintenance burning
C-Flagstaff	Munds Park Fuels Reduction	2009 (decision)	2,950 acres of maintenance prescribed burns	Reduce fire risk Categorized as both past and ongoing due to maintenance burns
Coconino	power lines, oil and gas	2012 existing permits	30,710 acres forest-wide	right-of-way vegetation clearing for maintenance purposes and to reduce fire risk (includes Flagstaff to Happy Jack

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	lines, natural gas/FERC, meter sites, gas compression and substation sites*			2007, Blue Ridge 69 kV transmission line 2005, Doney Park 2007, Sandvig Young 2011)
Kaibab NF	power lines, oil and gas lines, natural gas/FERC, meter sites, gas compression and substation sites*	2012 existing permits	1,634 acres of right- of-way vegetation clearing for maintenance purposes and to reduce fire risk	Forest-wide
C-Mogollon Rim	East Clear Creek Watershed Health Improvement	2006	Total project acres: 16,228: 1,645 acres of thinning less than 9" dbh 83 acres of thinning less than 16 inch dbh- implemented 14,500 acres of prescribed and maintenance burning – implemented and ongoing Decommission 30 miles of road and 14 miles of previously closed road – implemented Past:83 acres thin, 14,500 burn 4,700 acres planned for thin (1,562) and burn (4,700) in 2013	Objective: restore understory and overstory health and diversity, reduce potential for stand-replacing fire and road impacts on watershed and riparian habitat Categorized as both past and ongoing due to maintenance burns 83 acres thinned, 14,500 burned Ongoing: 1,562 thin, 4,700 burn
C-Flagstaff	Mormon Lake Fuels	2005	2,388 acres thinned and prescribed (broadcast) burned – confusing description of acres to be treated	Objective: fuels reduction Categorized as both past and ongoing due to maintenance

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	Reduction		Past: 2,388 acres thin/burn Ongoing: 2,388 acres burn	burns
C-Flagstaff	Skunk Canyon Prescribed Burn Fuel Reduction	2005 decision	831 acres of low intensity groundfire in 50 to 200 acre blocks – maintain with burning every 5 to 9 years in up to 400-acre blocks Past: 831 acres burn Ongoing: 831 acres maintenance burn	Objective: Reduce fuel loading and fire hazard within WUI Categorized as past and ongoing due to maintenance burning
Coconino/Flagstaff (GFFP)	Eastside Fuels Reduction and Forest Health	2006	Total thin/burn acres: 7,819 acres thin and 20,197 acre burn 3,819 acres of UEA, 3,404 acres up to 12" dbh, 377 acres fuelbreaks, 220 acres of grassland restoration, 20,197 acres of prescribed burning, some grassland and aspen restoration Past: 7,819 acres thin and 20,197 acres burn Ongoing: 20,197 acres of maintenance burning	Objective: fuels reduction (WUI) with some restoration Categorize as past and ongoing due to maintenance burns
C-Flagstaff	Munds Park Fuels Reduction	2009 (decision)	2,950 acres of maintenance prescribed burns	Reduce fire risk Categorized as both past and ongoing due to maintenance burns
CNF	Travel Management	2011 decision	Travel Management for CNF	Designates 3,136 miles as open, and provides for motorized access for game retrieval on 991,793 acres, 43,313 acres open to motorized dispersed camping
CNF	Bob's	??	2,000 acres planned for implementation in 2012	
CNF	Clark's	??	1,600 acres planned for implementation in 2012	
C-Flagstaff	Elk Park Fuels Reduction and Forest	2007	4,700 acres of UEA in ponderosa pine 6,400 acres of prescribed burning Hoxworth Spring crossing improvement and road construction/decommission	No mention of maintenance burning in DN/FONSI

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
	Health		Past: 1,800 ac. thinning completed and 3,500 ac. burning Ongoing: 2,900 acres planned (2012) thin and burn	
C-Flagstaff	Jack Smith Schultz		2,000 acres planned for implementation in 2012	Ongoing
	Weatherford		1,000 acres planned for implementation in 2013	Ongoing
	Railroad		250 acres planned for implementation in 2013	Ongoing
GFFP	GFFP	2012	100 acres of thinning and prescribed burning	100 acres of private property made up of 20 parcels within the GFFP boundary - ongoing

Table 42. Descriptions of Reasonably Foreseeable Projects by Ranger District (RD) on the Kaibab (K) and Coconino (C) National Forests

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
K- Williams	Aspen Restoration Project	2012 - NEPA in progress	Treat 402 acres of aspen within 69 stands and prescribed fire	Objective: Thin conifers, fencing, jackstrawing, prescribed fire, and cutting diseased or dying aspen within stands to encourage regeneration Categorized as reasonably foreseeable project due to NEPA status
K-Williams	McCracken Project	2012- NEPA in progress	Planned treatments: 3,597 acres – group selection, 2,049 acres – shelterwood, 17 acres – irregular thinning, 43 acres – sanitation, 87 acres – aspen release, 806 acres – meadow restoration, 3,551 acres – pine/woodland savanna, 1,053 acres – woodland thinning, 4,049 acres – pre-commercial thinning Total thinning acres: 15,262 Total prescribed fire: 17,337	Paroject Objective: move towards uneven-aged forest structure, reduce mistletoe, restore meadows, savanna, and woodlands part of shelf stock – 2014 implementation Categorized as reasonably foreseeable project due to NEPA status
K-Tusayan	Ten X-Fire Planting	2010 (scoping) – NEPA on hold	Plant 12 acres of ponderosa pine seedlings with 15 plantations that range in from 0.3 to 2.5 acres.	Objective: restore vegetation in high severity burn area Planting within X-Fire perimeter within 815 acre high

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			Construct 8' hog wire fence around plantations	severity burn Categorized as reasonably foreseeable due to project status
K-Williams	Bill Williams Mountain Restoration Project (EIS)	2012- In progress	11,650 acres of veg treatment, 15,200 acres of RX Burn: (1) 11,100 acres – treat up to 40 percent slopes, (2) treat 200 acres with specialized equipment helicopter, (3) treat 350 acres greater than 40 percent slopes, (4) 2,500 non-commercial thinning, (5) 15,200 acres of prescribed fire, (6) 23 miles of new road construction, (7) 16 miles of temporary road construction, (8) obliterate 28 miles of poorly located roads, (9) 1 mile of new trail and trailhead construction, (10) 3 plan amendments: remove 8,954 acres from timber suitability, treat greater than 40% slopes, deviate in goshawk PFA nest areas	Categorized as reasonably foreseeable due to NEPA status (underway)
KNF/CNF	Rock Pit Development : Coconino and Kaibab National Forests	2012 (foreseeable)	39 material pits to support road maintenance for all projects across the Forests	Road maintenance – see GIS spatial data
Department of Defense	Camp Navajo Westside Buffer Thinning and Prescribed Fire Project	2013	1,269 acres of mechanical thin 530 acres of broadcast burn 968 acres of mechanical thin and broadcast burn	
Department of Defense	AZARNG Thinning, Burning	2013	17,049 acres – mechanical thin, hand thin, slash treatment and prescribed fire – reduce tree density in 5” dbh to 18” dbh	Ponderosa pine, pine-oak and grasslands to mitigate fire risk, provide diversity in forest conditions, ecosystem health

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
GFFP Projects	GFFP	2013-2014	535 acres of vegetation thinning and prescribed fire on private land parcels within 180,000-acre GFFP boundary	245 acres (5 private land parcels) in 2013, 190 acres (4 to 10 parcels) in 2014, and 100 acres of prescribed burning through 2014
C-Flagstaff	Marshall Fuels Reduction	2011 (decision)	<p>Total thinning acres: 10,800 ac. Total prescribed fire acres: 6,260 ac.</p> <p>4,220 acres – ponderosa pine restoration -maintain approximately 40-50% canopy cover with groups of three to 20 trees in 0.1 to 1 acres patches and openings in between of up to one to four acres in size and retain and enhance existing groups of older, larger trees (typically 18” diameter at breast height [dbh] or greater</p> <p>3,590 acres – grassland restoation – mechanical or hand thin of conifers, prescribed burning</p> <p>2,000 acres – transition zone mehcanical and prescribed burning (pile, broadcast,maintenance burning up to 20 years)</p> <p>700 acres - MSO PAC Fuels reduction – 9” dbh</p> <p>200 acres – hand thinning up to 9” dbh – steep slopes</p> <p>90 acres – meadow restoration – thin/pile burn, maintenance burn</p> <p>350 acres – burn-only around wetlands and stands with low tree densities</p> <p>230 acres – waterfowl habiat restoration - burning</p>	<p>Project objective: reduce the risk of wildfire, improve forest health and associated habitats in the Marshall Project Area, according to Coconino National Forest Plan guidance. There is a need to move vegetation toward conditions that support natural and desirable fire behavior with healthy and sustainable forests, woodlands, meadows, and wetlands.</p> <p>Categorized as foreseeabe as appeal period is complete.</p>
C-Flagstaff	Turkey/Barn ey Pasture Forest Health Restoration	2012	<p>Thin in dwarf misteltoe</p> <p>Create Helispot</p> <p>Liberation Cut</p> <p>MSO PAC RX at least up to 9” dbh</p> <p>8 acres- hand thinning around Turkey Butte</p>	PA under development

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			260 acres- tornado salvage	
CNF	Western Area Power Administration	2012- Foreseeable	4,584 acres of vegetation thinning (equates to 9,572 total trees removed) to remove trees that may impinge on power line – of this 1,770 acres is within ponderosa pine, 8 acres of aspen, 10 acres of cottonwood/willow riparian, 25 acres of wetland cienega, 35 acres montane/subalpine grass, 175 acres semi-desert grass, 810 acres pinyon-juniper evergreen shrub, 1,280 acres p/j woodland - EA underway	See O drive spatial files Coconino\Program\1900Planning\1950EnviroPolicyProcedures\SO\lands_projects\WAPA_powerline_Veg_Clearing\GIS_data
C-MR	Upper Beaver Watershed Fuel Reduction	2010 (decision)	2,000 acres planned for 2013 Vegetation treatments by a variety of prescriptions on about 15,807 acres (about 5,897 acres are within the WUI), Prescribed burning on about 31,162 acres (about 10,870 acres are within the WUI), Maintenance burning on about 43,906 acres (about 15,024 acres are within the WUI)	reduce the areas at risk to stand-replacement wildfire that threatens people, private property and natural resource values within the WUI.
C-Flagstaff	Wing Mountain Fuels Reduction and Forest Health	2012 (under analysis)	Total acres thinning: 10,190 acres Total acres pile/burn and prescribe burn: 10,767 acres Ponderosa pine thin and pile/prescribe/maintenance burn – 7,079 acres Ponderosa pine thin and pile/prescribe/maintenance burn in goshawk PFA – 959 acres and 456 acres = 1,415 acres Aspen thin/burn – 1,422 acres Thin from below and burn – 352 acres MSO habitat thin/burn: 542 acres Grassland thin/burn: 629 acres Grassland/pine savanna thin/burn – 173 acres Prescribe-burn only – 577 acres	Restoration in ponderosa pine, mountain grassland, pine savanna, aspen and spring r(Maxwell and Big Leroux), road decommission

Forest/RD	Project	Year	Planned Treatments by Type and Size (acres)	Project Objective
			Spring restoration – Maxwell and Big Leroux (fencing)	
AZ State Lands Dept, Flagstaff	Grapevine Canyon Wind Project	2012 analysis in progress	22 miles southeast of Flagstaff, AZ - general locatiob is south of I—40 to Happy Jack – 200 ft ROW – construction on 8.5 miles of NFSL and constructin of 15-acre switchyard	

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Mexican Spotted Owls

Values for project treatments in the tables below were derived from overlaying GIS datalayers for projects and wildlife habitat. Values of 5 acres or less were assumed to be a result of spatial mapping errors and dropped from the analysis. Dates are when accomplishments were entered into FACTS, the Forest Service database of record. Projects were assessed ½ mile beyond the 4FRI project boundary.

Table 43. Past Projects and Treatment Types (Acres) Overlapping MSO Protected Habitat

Project Name and Treatments	Acres	Year(s)
City	64	
Precommercial Thin	64	2006
Kachina Village Forest Health Project	659	
Precommercial Thin	659	2005-2007
Kendrick Rx Burn	7	
Invasives - Biocontrol, Classic	7	2006
Mint Springs Analysis Area	134	
Commercial Thin	134	2007
Mormon Lake Basin Fuel Reduction Project	298	
Commercial Thin	260	2007-2008
Piling of Fuels, Hand or Machine	38	2009
Pumpkin Fire Logs	230	
Burning of Piled Material	152	2004
Invasives - Biocontrol, Classic	78	2007-2009
Ritter 10K Block	31	
Precommercial Thin	31	2007
Spring Valley Urban/Wildland Interface	10	
Site Preparation for Natural Regeneration - Other	10	2009
Twin	26	
Precommercial Thin	13	2008
Thinning for Hazardous Fuels Reduction	13	2008
Grand Total	1,458	

Table 44. Past Projects and Treatment Types (Acres) Overlapping MSO Restricted Habitat

Project Name/Activity	Acres	Year(s)
City	967	
Broadcast Burning - Covers a majority of the unit	177	2008
Piling of Fuels, Hand or Machine	281	2006-2009
Precommercial Thin	509	2005-2008

Project Name/Activity	Acres	Year(s)
Dogtown	1,495	
Broadcast Burning - Covers a majority of the unit	170	2008
Burning of Piled Material	112	2009
Piling of Fuels, Hand or Machine	438	2005-2009
Precommercial Thin	945	2005-2008
Frenchy Vegetation/Fuels Management	213	
Animal Damage Control for Reforestation	18	1998
Disease Control	23	2003
Precommercial Thin	58	2005-2009
Thinning for Hazardous Fuels Reduction	56	2003
Underburn - Low Intensity (Majority of Unit)	99	2004
Kachina Village Forest Health Project	6	
Precommercial Thin	6	2005
Mormon Lake Basin Fuel Reduction Project	547	
Commercial Thin	447	2007-2008
Piling of Fuels, Hand or Machine	42	2009
Precommercial Thin	59	2007
Twin	1,057	
Broadcast Burning - Covers a majority of the unit	1,024	2009
Precommercial Thin	12	2008
Thinning for Hazardous Fuels Reduction	12	2008
Underburn - Low Intensity (Majority of Unit)	9	1999-2004
Upper Beaver Creek	11	
Wildland Fire Use	11	2009
Grand Total	4,299	

Table 45. Current Projects and Treatment Types (Acres) Overlapping MSO Protected Habitat

Project Name	Acres	Year(s)
City	1,014	
Piling of Fuels, Hand or Machine	507	2010
Precommercial Thin	507	2010
Jack Smith/Schultz Fuel Reduction and Forest Heal*	30	
Site Preparation for Natural Regeneration - Manual	30	2011
Kendrick Rx Burn	28	
Invasives - Pesticide Application	28	2011

Project Name	Acres	Year(s)
Pumpkin Fire Logs	584	
Invasives - Pesticide Application	584	2011
Shultz BAER	12	
Site Preparation for Natural Regeneration - Manual	12	2011
Spring Valley Urban/Wildland Interface	33	
Watershed Resource Non-Structural Improvements Erosion Cont	33	2010
Woody Ridge Forest Restoration Project	30	
Broadcast Burning - Covers a majority of the unit	30	2012
Grand Total	1,730	

Table 46. Current Projects and Treatment Types (Acres) Overlapping MSO Restricted Habitat

Project Name	Acres	Year(s)
City	422	
Burning of Piled Material	111	2010-2011
Invasive Weed Control	8	2,010
Piling of Fuels, Hand or Machine	147	2010-2011
Precommercial Thin	156	2010-2011
Clover High	6	
Invasive Weed Control	6	2,010
Dogtown	362	
Broadcast Burning - Covers a majority of the unit	170	2010-2011
Burning of Piled Material	52	2010
Piling of Fuels, Hand or Machine	140	2010
Eastside Fuels Reduction and Forest Health	167	
Broadcast Burning - Covers a majority of the unit	167	2010-2011
Frenchy Vegetation/Fuels Management	453	
Broadcast Burning - Covers a majority of the unit	36	2010
Burning of Piled Material	110	2010-2011
Commercial Thin	147	2010
Group Selection Cut	67	2010
Precommercial Thin	93	2010
Kachina Village Forest Health Project	83	
Broadcast Burning - Covers a majority of the unit	83	2011
Woody Ridge Forest Restoration Project	574	
Broadcast Burning - Covers a majority of the unit	7	2012

Project Name	Acres	Year(s)
Burning of Piled Material	567	2012
Grand Total	2,067	

Table 47. Reasonably Foreseeable Projects and Treatment Types (Acres) Overlapping MSO Protected Habitat

Project Name	Total Acres
Aspen Restoration Project	8
Bill Williams Mountain Restoration	1,311
Elk Park Fuels Reduction and Forest Health Project	851
Mahan-Landmark	26
Marshall	1,451
Schultz Fire Rehabilitation	143
Turkey/Barney Pasture	2,468
Upper Beaver Creek	17
WAPA	32
Wing Mountain	650
Grand Total	6,955

Table 48. Reasonably Foreseeable Projects and Treatment Types (Acres) Overlapping MSO Restricted Habitat

Project Name	Acres
Bill Williams Mountain Restoration	1,585
Elk Park Fuels Reduction and Forest Health Project	1,793
Marshall	1,089
McCracken	8,861
Rock Pits COF	7
Rock Pits KNF	26
Turkey/Barney Pasture	9,870
Upper Beaver Creek	12
Wing Mountain	315
Grand Total	23,561

Table 49. Acres of Past and Current Treatments in Mexican Spotted Owl Habitat Summarized From the Above Tables

Activity	Protected Habitat (Acres)	Restricted Habitat (Acres)
Piling of Fuels	545	1,048
Pre-commercial Thinning	1,274	1,838
Group Selectin Harvest	0	67
Commercial Thinning	394	594
Thinning to Reduce Hazardous Fuels	13	68
Animal Control Damage	0	18
Invasive Weed Treatments	697	14
Pile Burning	152	952
Wildfire	0	11
Erosion Control	33	0
Broadcast Burnin	30	1,942

Appendix 13. Map of NLF designated occupied & critical breeding sites with ¼ mile buffer; potential breeding sites with 200' buffer

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Appendix 14. Miles of Road Maintenance, Construction, and Decommissioning by Individual PAC

Table 50. Miles of roads proposed for decommissioning within PAC habitat.

Forest	PAC_Name	Road Miles Decommissioned in PAC	Total Road Miles in PAC	Total Proposed for Decommissioning (%)
COF	Aspen Spring	0.5	0.8	60
	Bar M	0.3	4.8	6
	Bear Jaw	0.2	0.2	100
	Bear Seep	0.1	3.8	2
	Blade Tank	0.6	2.8	21
	Bonita Tank	0.0	4.3	1
	Bristow Tank/Limpios	0.8	4.3	18
	Casner	1.4	2.4	60
	Casner Cabin	0.2	0.6	41
	Clark	2.6	5.0	51
	Coyote Park	0.8	0.8	100
	Dry Lake	0.0	0.7	5
	Fain Mountain	0.7	4.0	17
	Frank	0.5	3.2	15
	Frog Tank	1.5	3.7	41
	Fry	0.6	1.0	60
	Gash Mountain	0.1	3.7	3
	Harding Point	0.8	1.1	74
	Hochderffer	1.0	2.4	40
	Holdup	1.0	2.3	41
	Howard Mountain	0.9	3.4	25
	Iowa Camp	3.8	7.0	54
	Jack Smith	2.0	4.1	49
	James Canyon	1.8	2.5	70
	Jeep	1.3	1.5	84
	Kelly	1.4	2.1	64
	Lake #1/Seruchos	1.0	3.8	25
	Little Spring	2.4	3.0	81
	Lockwood	0.2	3.2	7
	MB Smith	2.9	4.8	60
	Milos Butte	0.6	3.3	18

Forest	PAC_Name	Road Miles Decommissioned in PAC	Total Road Miles in PAC	Total Proposed for Decommissioning (%)
	Mint Spring	0.5	1.5	38
	Moore Well/Rock Dike	0.4	3.0	12
	Mormon Mountain	0.4	2.8	14
	Mt Elden	0.2	1.6	13
	Mustang	1.6	4.4	38
	Orion Spring	0.9	2.3	40
	Pierce Tank	1.4	2.2	64
	Pipeline	0.2	2.4	9
	Pumphouse Wash	1.6	1.9	86
	Racetrack Tank	1.1	2.0	54
	Red Hill	0.7	2.6	27
	Red Raspberry	1.3	6.8	19
	Rock Top	1.0	5.3	20
	Roundup	0.5	2.7	17
	Sawmill Springs	0.2	3.5	5
	Schultz Creek	0.1	0.7	20
	Snowbowl Road	0.9	3.5	25
	Sterling	0.1	1.1	10
	Stock Tank	0.2	0.2	100
	T Bird	0.4	1.9	20
	Two Holes	0.5	3.3	15
	Weatherford	0.8	4.9	16
	Weimer Springs	0.4	5.1	8
	Woods	0.8	6.4	12
	Woody Ridge	0.0	0.0	74
KNF	Sitgreaves	0.1	0.6	13
Grand Total for 56 PACs:		48.0	235.4	20.4

Table 51. Miles and percent of roads decommissioned within core areas on the Coconino NF

PAC_Name	Road Miles Decommissioned	Total Road Miles	Percent of Total Miles Decommissioned
Casner	0.68	0.68	100
Clark	0.93	0.93	100
Frog Tank	0.07	0.67	11
Holdup	0.33	0.33	100
Howard Mountain	0.23	0.84	28
Iowa Camp	0.59	0.59	100
Jeep	0.69	0.69	100
Lake #1/Seruchos	0.02	0.94	2
Little Spring	0.26	0.58	44
MB Smith	0.37	0.37	100
Mint Spring	0.01	0.08	16
Mustang	0.56	0.61	92
Orion Spring	0.01	0.41	1
Red Raspberry	0.09	0.12	71
Grand Total for 14 Core Areas:	4.86	19.67	24.7

Table 52. Road Maintenance for Hauling and Construction of Temporary Roads (Miles) in PACs

PAC Treatments	PAC Name	Road Maintenance	Temporary Road Construction	Grand Total
Mechanical	Archies	2.18		2.18
	Bar M	3.55		3.55
	Bear Seep	3.20	0.27	3.47
	Bonita Tank	2.76	1.17	3.93
	Crawdad	3.54		3.54
	Foxhole	2.21		2.21
	Frank	2.53		2.53
	Holdup	1.88		1.88
	Iris Tank	3.12		3.12
	Knob	4.20		4.20
	Lake #1/Seruchos	1.18	1.37	2.55
	Lee Butte	5.84		5.84
	Mayflower Tank	0.99		0.99

PAC Treatments	PAC Name	Road Maintenance	Temporary Road Construction	Grand Total
	Red Hill	2.21		2.21
	Red Raspberry	6.07	0.30	6.37
	Rock Top	4.28		4.28
	Sawmill Springs	1.96		1.96
	T6 Tank	5.40		5.40
Mechanical Treatment Group Total		57.10	3.12	60.22
Burn Only Treatment Group	Blade Tank	1.24		1.24
	Boondock	0.04		0.04
	Bristow Tank/Limpios	0.53		0.53
	Casner	1.53		1.53
	Casner Cabin	0.18		0.18
	Coulter Ridge	2.95	1.76	4.71
	Coyote Park	0.22	0.05	0.27
	Dairy Spring	0.01		0.01
	De Toros	0.33		0.33
	Fain Mountain	0.11		0.11
	Frog Tank	2.77		2.77
	Fry	0.32		0.32
	Gash Mountain	0.90		0.90
	Girdner	1.69		1.69
	Harding Point	0.82		0.82
	Howard Mountain	2.51		2.51
	Iowa Camp	2.26		2.26
	James Canyon	0.00		0.00
	Jeep	0.60	0.22	0.83
	Kelly	0.59		0.59
	Kendrick	0.20		0.20
	Lockwood	0.00	0.00	0.01
	Meadow Tank	0.22		0.22
	Milos Butte	0.46		0.46
	Mint Spring	0.56		0.56
	Moore Well/Rock	0.55	0.26	0.82

PAC Treatments	PAC Name	Road Maintenance	Temporary Road Construction	Grand Total
	Dike			
	Mormon Mountain North	0.63		0.63
	Mt Elden	1.42	0.20	1.62
	Mustang	0.65		0.65
	Nestor	0.00		0.00
	Orion Spring	0.01		0.01
	Pierce Tank	1.48		1.48
	Pumphouse Wash	0.27		0.27
	Racetrack Tank	0.32	0.02	0.34
	Rattlesnake	0.00		0.00
	Schultz Creek	0.20	0.33	0.53
	Spruce Tank	0.23		0.23
	Sterling	0.15		0.15
	Stock Tank	0.17		0.17
	T Bird	1.03		1.03
	Two Holes	2.64		2.64
	Upper West Fork	0.37	0.01	0.38
	Volunteer	0.21	0.07	0.28
	Weatherford	1.41		1.41
	Weimer Springs	2.04		2.04
	Woods	1.09		1.09
Burn Only Treatment Group Total		35.94	2.92	38.86
Grand Total		93.04	6.04	99.08

Appendix 15. Summary of Treatments in MSO Habitats by Alternative

Table 53. Comparison of PAC treatments among alternatives

Treatments	Alternative A	Alternative B	Alternative C	Alternative D
Mechanically Thin	No Action	Up to 16" dbh in 18 PACs	Up to 18" dbh in 18 PACs	Up to 16" dbh in 18 PACs
Prescribed Burn	No Action	Prescribe burn 72 PACs (no nest cores)	Prescribe burn 72 PACs including 56 nest cores	No prescribe burning would occur in PACs

Table 54. Summary of treatments (acres) by alternative in MSO Habitat

MSO Habitat	Total Acres	Alternative B		Alternative C		Alternative D	
		Mechanical	Prescribed Burning	Mechanical	Prescribed Burning	Mechanical	Prescribed Burning
PAC Outside Core Area	30,716	10,741	30,716	10,741	30,716	10,741	0
Core Area	4,850	0	0	0	4,850	0	0
Protected Other	889	0	889	0	889	0	889
Protected Total	36,455	10,741	31,605	10,741	36,455	10,741	889
Target & Threshold	8,713	8,412	8,713	8,410	8,713	8,412	301
Restricted Other	67,378	65,024	67,378	63,191	67,378	65,024	2,354
Restricted Total	76,091	73,436	76,091	71,601	76,091	73,436	2,655
Grand Total	112,546	84,177	107,696	82,342	112,546	84,177	3,543

Table 55. Alternative B: Summary of Treatments in MSO Habitats by Subunit.

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
1-1	PAC Core Area						192	192
	PAC Outside Core Area	112					786	898
	Protected Outside PAC						222	222
	Restricted		1,193				1,434	2,627
	Target/Threshold			105			153	257

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
1-1 Total		112	1,193	105			2,787	4,196
1-2	Restricted		588					588
1-2 Total			588					588
1-3	PAC Core Area						1,020	1,020
	PAC Outside Core Area	2,388				2,527	1,333	6,248
	Protected Outside PAC	92					30	122
	Restricted		7,799				3,474	11,272
	Target/Threshold			1,988	414		544	2,946
1-3 Total		2,480	7,799	1,988	414	2,527	6,400	21,608
1-4	PAC Core Area						301	301
	PAC Outside Core Area	1,781				515		2,297
	Restricted		883					883
	Target/Threshold			118				118
1-4 Total		1,781	883	118		515	301	3,598
1-5	PAC Core Area						3,136	3,136
	PAC Outside Core Area	10,944				7,027	163	18,133
	Protected Outside PAC	555						555
	Restricted		15,958				1,617	17,575
	Target/Threshold			1,729	459		213	2,401
1-5 Total		11,499	15,958	1,729	459	7,027	5,129	41,801
3-1	PAC Outside Core Area						112	112
	Restricted	20	7,269				15,105	22,394
	Target/Threshold			0	311		1,228	1,539
3-1 Total		20	7,269	0	311		16,445	24,045
3-2	Restricted	159	4,666				5,287	10,111
	Target/Threshold	74		631	215		941	1,861

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
3-2 Total		233	4,666	631	215		6,227	11,972
3-3	PAC Core Area						254	254
	PAC Outside Core Area	366				647	182	1,195
	Protected Outside PAC	45						45
	Restricted	1,736	10,927				3,867	16,529
	Target/Threshold	227		1,068	355		520	2,170
3-3 Total		2,375	10,927	1,068	355	647	4,823	20,193
3-4	PAC Core Area						265	265
	PAC Outside Core Area	1,546					763	2,309
	Protected Outside PAC	146					6	153
	Restricted		2,447				620	3,067
	Target/Threshold			318			338	656
3-4 Total		1,692	2,447	318			1,992	6,449
3-5	PAC Core Area						141	141
	PAC Outside Core Area	1,127				26	2,527	3,679
	Protected Outside PAC	47					38	86
	Restricted	410	11,115				10,408	21,933
	Target/Threshold			561	139		1,759	2,459
3-5 Total		1,584	11,115	561	139	26	14,874	28,298
4-3	PAC Core Area						212	212
	PAC Outside Core Area	186					947	1,133
	Protected Outside PAC						27	27
	Restricted	29	87					116
4-3 Total		214	87				1,186	1,488
4-4	PAC Core Area						195	195

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
	PAC Outside Core Area	257					878	1,136
	Protected Outside PAC	3					133	135
	Restricted		1,271				5	1,277
	Target/Threshold						28	28
4-4 Total		260	1,271				1,239	2,770
4-5	Restricted		188				15	204
4-5 Total			188				15	204
5-1	PAC Core Area						267	267
	PAC Outside Core Area	808					1,832	2,640
	Restricted		234				526	760
	Target/Threshold						9	9
5-1 Total		808	234				2,634	3,676
5-2	PAC Outside Core Area	461					2,143	2,605
	Restricted		399				129	528
	Target/Threshold						263	263
5-2 Total		461	399				2,535	3,396
Grand Total		23,519	65,024	6,518	1,894	10,741	66,587	174,283

Table 56. Alternative C: Summary of Treatments in MSO Habitats by Subunit.

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
1-1	PAC Core Area	25					166	192
	PAC Outside Core Area	112					786	898
	Protected Outside PAC						222	222
	Restricted		1,193				1,434	2,627
	Target/Threshold			105			153	257

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
1-1 Total		137	1,193	105			2,761	4,196
1-2	Restricted		588					588
1-2 Total			588					588
1-3	PAC Core Area	749					271	1,020
	PAC Outside Core Area	2,388				2,527	1,333	6,248
	Protected Outside PAC	92					30	122
	Restricted	594	7,205				3,474	11,272
	Target/Threshold			1,988	414		544	2,946
1-3 Total		3,823	7,205	1,988	414	2,527	5,652	21,608
1-4	PAC Core Area	301						301
	PAC Outside Core Area	1,781				515		2,297
	Restricted		883					883
	Target/Threshold			118				118
1-4 Total		2,082	883	118		515		3,598
1-5	PAC Core Area	2,981					155	3,136
	PAC Outside Core Area	10,944				7,027	163	18,133
	Protected Outside PAC	555						555
	Restricted	6	15,952				1,617	17,575
	Target/Threshold			1,729	459		213	2,401
1-5 Total		14,486	15,952	1,729	459	7,027	2,148	41,801
3-1	PAC Outside Core Area						112	112
	Restricted	20	7,269				15,105	22,394
	Target/Threshold			0	311		1,228	1,539
3-1 Total		20	7,269	0	311		16,445	24,045
3-2	Restricted	625	4,200				5,287	10,111
	Target/Threshold	76		629	215		941	1,861

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
3-2 Total		701	4,200	629	215		6,227	11,972
3-3	PAC Core Area	254						254
	PAC Outside Core Area	366				647	182	1,195
	Protected Outside PAC	45						45
	Restricted	2,036	10,627				3,867	16,529
	Target/Threshold	227		1,068	355		520	2,170
3-3 Total		2,929	10,627	1,068	355	647	4,568	20,193
3-4	PAC Core Area	265						265
	PAC Outside Core Area	1,546					763	2,309
	Protected Outside PAC	146					6	153
	Restricted		2,447				620	3,067
	Target/Threshold			318			338	656
3-4 Total		1,957	2,447	318			1,727	6,449
3-5	PAC Core Area	39					102	141
	PAC Outside Core Area	1,127				26	2,527	3,679
	Protected Outside PAC	47					38	86
	Restricted	877	10,648				10,408	21,933
	Target/Threshold	0		560	139		1,759	2,459
3-5 Total		2,090	10,648	560	139	26	14,835	28,298
4-3	PAC Core Area	91					121	212
	PAC Outside Core Area	186					947	1,133
	Protected Outside PAC						27	27
	Restricted	29	87					116
4-3 Total		305	87				1,095	1,488
4-4	PAC Core Area	22					173	195

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
	PAC Outside Core Area	257					878	1,136
	Protected Outside PAC	3					133	135
	Restricted		1,271				5	1,277
	Target/Threshold						28	28
4-4 Total		281	1,271				1,217	2,770
4-5	Restricted		188				15	204
4-5 Total			188				15	204
5-1	PAC Core Area	124					143	267
	PAC Outside Core Area	808					1,832	2,640
	Restricted		234				526	760
	Target/Threshold						9	9
5-1 Total		931	234				2,510	3,676
5-2	PAC Outside Core Area	461					2,143	2,605
	Restricted		399				129	528
	Target/Threshold						263	263
5-2 Total		461	399				2,535	3,396
Grand Total		30,204	63,191	6,516	1,894	10,741	61,737	174,283

Table 57. Alternative D: Summary of Treatments in MSO Habitats by Subunit.

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
1-1	PAC Core Area						192	192
	PAC Outside Core Area						898	898
	Protected Outside PAC						222	222
	Restricted		1,193				1,434	2,627
	Target/Threshold			105			153	257

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
1-1 Total			1,193	105			2,898	4,196
1-2	Restricted		588					588
1-2 Total			588					588
1-3	PAC Core Area						1,020	1,020
	PAC Outside Core Area					2,527	3,721	6,248
	Protected Outside PAC	92					30	122
	Restricted		7,799				3,474	11,272
	Target/Threshold			1,988	414		544	2,946
1-3 Total		92	7,799	1,988	414	2,527	8,788	21,608
1-4	PAC Core Area						301	301
	PAC Outside Core Area					515	1,781	2,297
	Restricted		883					883
	Target/Threshold			118				118
1-4 Total			883	118		515	2,082	3,598
1-5	PAC Core Area						3,136	3,136
	PAC Outside Core Area					7,027	11,106	18,133
	Protected Outside PAC	555						555
	Restricted		15,958				1,617	17,575
	Target/Threshold			1,729	459		213	2,401
1-5 Total		555	15,958	1,729	459	7,027	16,073	41,801
3-1	PAC Outside Core Area						112	112
	Restricted	20	7,269				15,105	22,394
	Target/Threshold			0	311		1,228	1,539
3-1 Total		20	7,269	0	311		16,445	24,045
3-2	Restricted	159	4,666				5,287	10,111
	Target/Threshold	74		631	215		941	1,861

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
3-2 Total		233	4,666	631	215		6,227	11,972
3-3	PAC Core Area						254	254
	PAC Outside Core Area					647	548	1,195
	Protected Outside PAC	45						45
	Restricted	1,736	10,927				3,867	16,529
	Target/Threshold	227		1,068	355		520	2,170
3-3 Total		2,008	10,927	1,068	355	647	5,189	20,193
3-4	PAC Core Area						265	265
	PAC Outside Core Area						2,309	2,309
	Protected Outside PAC	146					6	153
	Restricted		2,447				620	3,067
	Target/Threshold			318			338	656
3-4 Total		146	2,447	318			3,538	6,449
3-5	PAC Core Area						141	141
	PAC Outside Core Area					26	3,654	3,679
	Protected Outside PAC	47					38	86
	Restricted	410	11,115				10,408	21,933
	Target/Threshold			561	139		1,759	2,459
3-5 Total		458	11,115	561	139	26	16,001	28,298
4-3	PAC Core Area						212	212
	PAC Outside Core Area						1,133	1,133
	Protected Outside PAC						27	27
	Restricted	29	87					116
4-3 Total		29	87				1,372	1,488
4-4	PAC Core Area						195	195

SU	MSO Habitat	Burn Only	MSO Restricted Treatment	MSO Target Treatment	MSO Threshold Treatment	PAC Treatment	No Treatment	Grand Total
	PAC Outside Core Area						1,136	1,136
	Protected Outside PAC	3					133	135
	Restricted		1,271				5	1,277
	Target/Threshold						28	28
4-4 Total		3	1,271				1,496	2,770
4-5	Restricted		188				15	204
4-5 Total			188				15	204
5-1	PAC Core Area						267	267
	PAC Outside Core Area						2,640	2,640
	Restricted		234				526	760
	Target/Threshold						9	9
5-1 Total			234				3,442	3,676
5-2	PAC Outside Core Area						2,605	2,605
	Restricted		399				129	528
	Target/Threshold						263	263
5-2 Total			399				2,997	3,396
Grand Total		3,543	65,024	6,518	1,894	10,741	86,562	174,283

Appendix 16. Summary of Habitat Changes by Alternative in MSO Protected Habitat

Table 58. Changes in MSO Habitat Components by Individual PAC

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Archies												
%SDI VSS4	32%	32%	30%	32%	34%	31%	32%	35%	30%	32%	34%	31%
%SDI VSS5	13%	15%	26%	13%	18%	31%	13%	19%	32%	13%	18%	30%
%SDI VSS6	7%	7%	10%	7%	8%	12%	7%	8%	12%	7%	8%	11%
TPA>18"	11	14	26	11	14	27	11	14	27	11	14	27
Snags/Ac >12"	1.40	1.89	4.50	1.40	2.60	4.06	1.40	2.81	4.07	1.40	1.74	3.84
PP BA	101	109	125	101	97	113	101	94	110	101	100	117
GO BA	15	17	22	15	16	22	15	16	22	15	16	21
Logs/Ac	0.49	0.85	2.57	0.49	0.64	2.44	0.49	0.61	2.49	0.49	0.88	2.41
CWD>3"	3.48	4.11	6.54	3.48	1.95	4.28	3.48	1.61	4.01	3.48	4.28	6.11
Understory Index	68.09	54.87	34.33	68.09	65.30	41.97	68.09	68.48	57.14	68.09	61.14	38.98
Avg % CC	64	66	71	64	64	69	64	63	68	64	65	69
Bar M												
%SDI VSS4	24%	24%	23%	24%	27%	22%	24%	28%	21%	24%	27%	23%
%SDI VSS5	14%	16%	21%	14%	20%	25%	14%	21%	26%	14%	20%	25%
%SDI VSS6	8%	9%	12%	8%	10%	14%	8%	11%	15%	8%	10%	14%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
TPA>18"	17	19	26	17	20	28	17	20	28	17	20	27
Snags/Ac >12"	4.98	5.09	7.75	4.98	5.28	6.35	4.98	5.49	6.00	4.98	4.64	6.43
PP BA	141	142	137	141	116	119	141	110	114	141	119	121
GO BA	22	24	34	22	24	32	22	24	34	22	24	32
Logs/Ac	2.40	3.99	8.56	2.40	3.04	7.61	2.40	2.62	7.16	2.40	4.04	8.24
CWD>3"	6.22	8.61	13.81	6.22	5.09	9.41	6.22	3.68	7.82	6.22	9.09	12.83
Understory Index	31.40	29.14	25.35	31.40	43.51	33.94	31.40	48.07	42.18	31.40	40.81	32.32
Avg % CC	72	73	74	72	69	71	72	67	70	72	69	71
Bear Seep												
%SDI VSS4	22%	20%	19%	22%	23%	22%	22%	23%	22%	22%	23%	23%
%SDI VSS5	20%	21%	23%	20%	26%	28%	20%	26%	28%	20%	25%	28%
%SDI VSS6	24%	24%	28%	24%	28%	34%	24%	29%	35%	24%	28%	33%
TPA>18"	24	26	32	24	26	31	24	26	32	24	26	31
Snags/Ac >12"	2.19	2.41	4.08	2.19	2.93	4.18	2.19	2.87	4.14	2.19	2.22	4.32
PP BA	126	133	147	126	121	132	126	120	130	126	124	134
GO BA	9	11	15	9	10	12	9	10	12	9	10	12
Logs/Ac	1.85	2.84	5.32	1.85	1.78	4.45	1.85	1.79	4.45	1.85	2.78	5.10
CWD>3"	4.29	5.29	7.91	4.29	1.94	4.68	4.29	1.93	4.60	4.29	5.27	7.34
Understory Index	43.63	37.09	25.87	43.63	45.85	35.19	43.63	46.98	41.77	43.63	43.82	33.95
Avg % CC	68	69	73	68	67	70	68	67	70	68	68	70

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Blade Tank												
%SDI VSS4	34%	34%	28%	34%	34%	28%	34%	34%	28%	34%	34%	28%
%SDI VSS5	13%	15%	23%	13%	16%	24%	13%	16%	24%	13%	15%	23%
%SDI VSS6	7%	7%	10%	7%	7%	11%	7%	7%	11%	7%	7%	10%
TPA>18"	15	18	30	15	18	30	15	18	30	15	18	30
Snags/Ac>12"	4.07	5.06	8.76	4.07	6.32	8.35	4.07	6.66	8.25	4.07	5.06	8.76
PP BA	123	127	129	123	123	127	123	122	126	123	127	129
GO BA	22	24	27	22	24	28	22	24	28	22	24	27
Logs/Ac	2.64	3.82	8.44	2.64	2.63	7.57	2.64	2.42	7.42	2.64	3.82	8.44
CWD>3"	6.16	8.06	13.20	6.16	4.27	9.82	6.16	3.29	8.90	6.16	8.06	13.20
Understory Index	29.44	24.71	17.99	29.44	26.62	18.47	29.44	27.12	23.01	29.44	24.71	17.99
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Bonita Tank												
%SDI VSS4	33%	33%	27%	33%	34%	23%	33%	33%	21%	33%	34%	23%
%SDI VSS5	17%	19%	27%	17%	23%	32%	17%	25%	33%	17%	23%	31%
%SDI VSS6	6%	7%	11%	6%	8%	13%	6%	9%	14%	6%	8%	13%
TPA>18"	19	22	34	19	23	37	19	23	37	19	23	37
Snags/Ac >12"	3.92	5.42	9.66	3.92	5.64	7.65	3.92	5.39	7.05	3.92	4.34	7.94
PP BA	128	133	136	128	113	122	128	104	115	128	116	125
GO BA	30	30	32	30	30	32	30	31	33	30	30	32
Logs/Ac	2.06	3.47	8.53	2.06	3.07	7.69	2.06	2.27	6.80	2.06	3.49	7.64
CWD>3"	5.55	7.75	13.49	5.55	4.97	9.87	5.55	3.10	7.74	5.55	8.00	12.20

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	28.62	23.61	17.68	28.62	35.73	23.37	28.62	42.12	34.29	28.62	33.37	22.10
Avg % CC	72	74	76	72	71	74	72	69	73	72	71	75
Boondock												
%SDI VSS4	27%	29%	30%	27%	29%	30%	27%	29%	30%	27%	29%	30%
%SDI VSS5	10%	12%	17%	10%	12%	17%	10%	12%	17%	10%	12%	17%
%SDI VSS6	6%	6%	8%	6%	6%	8%	6%	6%	8%	6%	6%	8%
TPA>18"	12	15	23	12	15	23	12	15	23	12	15	23
Snags/Ac >12"	2.84	3.70	7.54	2.84	4.76	7.24	2.84	5.17	7.13	2.84	3.70	7.54
PP BA	125	129	131	125	124	129	125	122	128	125	129	131
GO BA	32	33	37	32	34	38	32	34	39	32	33	37
Logs/Ac	1.72	2.56	5.82	1.72	1.81	5.29	1.72	1.64	5.20	1.72	2.56	5.82
CWD>3"	5.78	7.61	12.41	5.78	4.21	9.20	5.78	3.15	8.16	5.78	7.61	12.41
Understory Index	24.70	20.89	15.76	24.70	22.93	16.13	24.70	23.42	19.78	24.70	20.89	15.76
Avg % CC	74	75	77	74	74	77	74	74	77	74	75	77
Bristow Tank/ Limpio												
%SDI VSS4	26%	26%	25%	26%	26%	25%	26%	26%	25%	26%	26%	25%
%SDI VSS5	12%	14%	18%	12%	14%	18%	12%	14%	18%	12%	14%	18%
%SDI VSS6	9%	9%	12%	9%	10%	12%	9%	10%	12%	9%	9%	12%
TPA>18"	13	15	23	13	15	23	13	15	23	13	15	23

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Snags/Ac >12"	3.05	3.56	6.53	3.05	4.39	6.30	3.05	4.65	6.22	3.05	3.56	6.53
PP BA	104	109	113	104	105	110	104	104	109	104	109	113
GO BA	24	26	31	24	26	32	24	26	32	24	26	31
Logs/Ac	2.99	3.86	7.08	2.99	2.58	6.10	2.99	2.39	5.96	2.99	3.86	7.08
CWD>3"	5.51	6.99	11.04	5.51	3.73	8.14	5.51	2.89	7.35	5.51	6.99	11.04
Understory Index	53.09	41.99	25.54	53.09	45.50	26.74	53.09	45.85	37.24	53.09	41.99	25.54
Avg % CC	68	70	74	68	70	74	68	69	74	68	70	74
Casner												
%SDI VSS4	30%	31%	29%	30%	31%	28%	30%	31%	28%	30%	31%	29%
%SDI VSS5	13%	15%	21%	13%	16%	22%	13%	16%	22%	13%	15%	21%
%SDI VSS6	6%	7%	10%	6%	7%	10%	6%	7%	11%	6%	7%	10%
TPA>18"	15	18	27	15	18	27	15	18	28	15	18	27
Snags/Ac >12"	3.25	4.27	7.94	3.25	5.52	7.56	3.25	5.70	7.51	3.25	4.27	7.94
PP BA	118	123	126	118	118	123	118	117	123	118	123	126
GO BA	23	25	29	23	25	29	23	25	30	23	25	29
Logs/Ac	2.81	3.77	7.73	2.81	2.51	6.79	2.81	2.35	6.68	2.81	3.77	7.73
CWD>3"	5.94	7.63	12.35	5.94	3.73	8.80	5.94	3.14	8.26	5.94	7.63	12.35
Understory Index	35.42	29.26	19.94	35.42	31.81	20.66	35.42	32.09	26.77	35.42	29.26	19.94
Avg % CC	71	73	76	71	72	75	71	72	75	71	73	76
Casner Cabin												

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS4	28%	28%	24%	28%	28%	23%	28%	28%	23%	28%	28%	24%
%SDI VSS5	15%	16%	21%	15%	16%	21%	15%	16%	21%	15%	16%	21%
%SDI VSS6	13%	14%	17%	13%	14%	17%	13%	14%	17%	13%	14%	17%
TPA>18"	16	19	27	16	19	27	16	19	27	16	19	27
Snags/Ac >12"	3.34	3.95	6.78	3.34	5.09	6.42	3.34	5.09	6.42	3.34	3.95	6.78
PP BA	103	107	110	103	102	107	103	102	107	103	107	110
GO BA	17	18	21	17	19	22	17	19	22	17	18	21
Logs/Ac	6.85	7.67	11.22	6.85	4.58	8.83	6.85	4.58	8.83	6.85	7.67	11.22
CWD>3"	7.01	8.34	12.23	7.01	3.57	8.09	7.01	3.57	8.09	7.01	8.34	12.23
Understory Index	159.13	140.66	110.21	159.13	145.85	111.58	159.13	145.85	130.80	159.13	140.66	110.21
Avg % CC	68	70	73	68	69	73	68	69	73	68	70	73
Cave Springs												
%SDI VSS4	33%	33%	26%	33%	33%	26%	33%	33%	26%	33%	33%	26%
%SDI VSS5	22%	25%	29%	22%	25%	30%	22%	25%	30%	22%	25%	29%
%SDI VSS6	5%	7%	14%	5%	7%	14%	5%	7%	14%	5%	7%	14%
TPA>18"	23	26	36	23	26	37	23	26	37	23	26	36
Snags/Ac >12"	3.64	5.54	9.13	3.64	6.97	8.58	3.64	6.97	8.58	3.64	5.54	9.13
PP BA	130	134	137	130	129	135	130	129	135	130	134	137
GO BA	17	18	21	17	18	21	17	18	21	17	18	21
Logs/Ac	4.90	6.00	11.07	4.90	3.67	9.12	4.90	3.67	9.12	4.90	6.00	11.07
CWD>3"	6.68	8.31	13.33	6.68	3.50	9.03	6.68	3.50	9.03	6.68	8.31	13.33

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	101.14	89.99	72.73	101.14	94.31	74.12	101.14	94.31	85.05	101.14	89.99	72.73
Avg % CC	72	73	76	72	73	76	72	73	76	72	73	76
Coulter Ridge												
%SDI VSS4	34%	34%	30%	34%	34%	30%	34%	34%	30%	34%	34%	30%
%SDI VSS5	12%	15%	22%	12%	15%	23%	12%	15%	23%	12%	15%	22%
%SDI VSS6	6%	6%	9%	6%	6%	10%	6%	6%	10%	6%	6%	9%
TPA>18"	13	16	27	13	16	27	13	16	27	13	16	27
Snags/Ac >12"	3.60	4.40	7.82	3.60	5.59	7.47	3.60	5.97	7.35	3.60	4.40	7.82
PP BA	118	124	128	118	119	126	118	118	125	118	124	128
GO BA	21	22	26	21	23	27	21	23	27	21	22	26
Logs/Ac	1.92	2.93	6.84	1.92	2.19	6.34	1.92	1.88	6.12	1.92	2.93	6.84
CWD>3"	5.56	7.23	11.79	5.56	3.97	8.84	5.56	2.93	7.93	5.56	7.23	11.79
Understory Index	37.48	30.82	20.55	37.48	33.28	21.23	37.48	33.86	28.13	37.48	30.82	20.55
Avg % CC	70	72	75	70	71	75	70	71	75	70	72	75
Coyote Park												
%SDI VSS4	28%	28%	26%	28%	28%	26%	28%	28%	26%	28%	28%	26%
%SDI VSS5	12%	14%	20%	12%	15%	20%	12%	15%	20%	12%	14%	20%
%SDI VSS6	8%	8%	11%	8%	8%	11%	8%	8%	11%	8%	8%	11%
TPA>18"	15	19	27	15	19	27	15	19	27	15	19	27
Snags/Ac >12"	3.78	4.62	8.11	3.78	5.73	7.77	3.78	5.96	7.71	3.78	4.62	8.11

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	126	130	129	126	124	127	126	123	126	126	130	129
GO BA	29	31	34	29	31	35	29	31	36	29	31	34
Logs/Ac	1.89	3.04	7.24	1.89	2.16	6.58	1.89	1.96	6.43	1.89	3.04	7.24
CWD>3"	5.83	7.81	12.94	5.83	4.04	9.42	5.83	3.19	8.63	5.83	7.81	12.94
Understory Index	24.71	20.91	15.90	24.71	22.90	16.28	24.71	23.23	19.80	24.71	20.91	15.90
Avg % CC	73	75	77	73	74	77	73	74	77	73	75	77
Crater Spring Tank												
%SDI VSS4	41%	41%	33%	41%	41%	33%	41%	41%	33%	41%	41%	33%
%SDI VSS5	12%	15%	26%	12%	15%	27%	12%	15%	27%	12%	15%	26%
%SDI VSS6	4%	4%	7%	4%	5%	7%	4%	5%	7%	4%	4%	7%
TPA>18"	14	18	33	14	18	33	14	18	33	14	18	33
Snags/Ac >12"	4.99	6.21	10.00	4.99	8.39	9.22	4.99	8.39	9.22	4.99	6.21	10.00
PP BA	144	148	151	144	142	148	144	142	148	144	148	151
GO BA	23	24	26	23	24	26	23	24	26	23	24	26
Logs/Ac	1.67	3.00	8.00	1.67	2.00	7.33	1.67	2.00	7.33	1.67	3.00	8.00
CWD>3"	6.38	8.55	14.14	6.38	3.51	9.57	6.38	3.51	9.57	6.38	8.55	14.14
Understory Index	21.50	18.57	14.23	21.50	20.75	14.64	21.50	20.75	17.79	21.50	18.57	14.23
Avg % CC	75	76	78	75	75	77	75	75	77	75	76	78
Crawdads												
%SDI VSS4	37%	39%	37%	37%	41%	36%	37%	41%	33%	37%	41%	37%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS5	10%	12%	22%	10%	14%	26%	10%	15%	29%	10%	14%	25%
%SDI VSS6	6%	6%	7%	6%	7%	8%	6%	7%	9%	6%	6%	8%
TPA>18"	11	14	25	11	14	28	11	14	29	11	14	27
Snags/Ac >12"	2.59	2.75	5.01	2.59	4.01	4.20	2.59	3.77	3.50	2.59	2.30	4.46
PP BA	123	131	145	123	114	132	123	104	123	123	119	137
GO BA	22	24	31	22	24	31	22	24	32	22	24	31
Logs/Ac	0.55	1.27	3.49	0.55	0.97	3.23	0.55	0.98	3.18	0.55	1.31	3.22
CWD>3"	4.28	5.43	8.27	4.28	2.45	5.16	4.28	2.14	4.56	4.28	5.61	7.67
Understory Index	47.21	37.41	22.61	47.21	47.51	28.15	47.21	55.79	44.64	47.21	43.40	26.42
Avg % CC	69	71	75	69	68	73	69	66	72	69	69	73
Dairy Spring												
%SDI VSS4	32%	31%	25%	32%	31%	25%	32%	31%	25%	32%	31%	25%
%SDI VSS5	14%	16%	23%	14%	17%	23%	14%	17%	23%	14%	16%	23%
%SDI VSS6	8%	9%	13%	8%	9%	13%	8%	9%	13%	8%	9%	13%
TPA>18"	15	18	28	15	18	29	15	18	29	15	18	28
Snags/Ac >12"	3.42	4.29	8.03	3.42	5.56	7.68	3.42	5.56	7.68	3.42	4.29	8.03
PP BA	104	108	110	104	103	107	104	103	107	104	108	110
GO BA	19	20	25	19	20	26	19	20	26	19	20	25
Logs/Ac	3.64	4.71	9.17	3.64	2.89	7.81	3.64	2.89	7.81	3.64	4.71	9.17
CWD>3"	6.02	7.65	12.37	6.02	3.11	8.37	6.02	3.11	8.37	6.02	7.65	12.37

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	42.49	34.97	24.03	42.49	37.68	24.90	42.49	37.68	31.76	42.49	34.97	24.03
Avg % CC	69	71	74	69	70	74	69	70	74	69	71	74
De Toros												
%SDI VSS4	35%	34%	27%	35%	34%	27%	35%	34%	27%	35%	34%	27%
%SDI VSS5	14%	17%	25%	14%	18%	25%	14%	18%	25%	14%	17%	25%
%SDI VSS6	8%	8%	11%	8%	8%	11%	8%	8%	11%	8%	8%	11%
TPA>18"	18	22	34	18	22	34	18	22	34	18	22	34
Snags/Ac >12"	5.11	6.17	9.61	5.11	7.86	9.04	5.11	7.86	9.04	5.11	6.17	9.61
PP BA	139	142	142	139	137	139	139	137	139	139	142	142
GO BA	23	24	26	23	24	27	23	24	27	23	24	26
Logs/Ac	2.39	3.85	9.25	2.39	2.48	8.22	2.39	2.48	8.22	2.39	3.85	9.25
CWD>3"	6.49	8.69	14.41	6.49	3.53	9.72	6.49	3.53	9.72	6.49	8.69	14.41
Understory Index	20.75	17.94	13.91	20.75	19.88	14.28	20.75	19.88	17.13	20.75	17.94	13.91
Avg % CC	75	76	78	75	75	78	75	75	78	75	76	78
Fain Mountain												
%SDI VSS4	36%	36%	28%	36%	36%	28%	36%	36%	28%	36%	36%	28%
%SDI VSS5	14%	17%	25%	14%	17%	25%	14%	17%	26%	14%	17%	25%
%SDI VSS6	7%	8%	12%	7%	8%	13%	7%	8%	13%	7%	8%	12%
TPA>18"	14	17	29	14	17	30	14	17	30	14	17	29
Snags/Ac >12"	3.63	4.49	8.16	3.63	5.33	7.91	3.63	5.93	7.73	3.63	4.49	8.16

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	104	109	113	104	106	111	104	104	110	104	109	113
GO BA	15	16	21	15	16	21	15	16	21	15	16	21
Logs/Ac	3.55	4.62	9.11	3.55	3.68	8.42	3.55	2.84	7.81	3.55	4.62	9.11
CWD>3"	5.98	7.54	12.12	5.98	4.87	9.79	5.98	3.05	8.25	5.98	7.54	12.12
Understory Index	43.70	35.76	23.66	43.70	37.75	24.33	43.70	38.72	32.32	43.70	35.76	23.66
Avg % CC	68	70	74	68	70	73	68	69	73	68	70	74
Fisher Point												
%SDI VSS4	15%	14%	11%	15%	14%	11%	15%	14%	11%	15%	14%	11%
%SDI VSS5	14%	12%	12%	14%	12%	12%	14%	12%	12%	14%	12%	12%
%SDI VSS6	30%	31%	30%	30%	32%	30%	30%	32%	30%	30%	31%	30%
TPA>18"	17	18	21	17	18	21	17	18	21	17	18	21
Snags/Ac >12"	3.60	3.44	4.74	3.60	3.75	4.51	3.60	3.75	4.51	3.60	3.44	4.74
PP BA	69	72	70	69	69	69	69	69	69	69	72	70
GO BA	11	12	14	11	12	14	11	12	14	11	12	14
Logs/Ac	18.27	18.64	20.85	18.27	10.88	14.55	18.27	10.88	14.55	18.27	18.64	20.85
CWD>3"	10.94	11.66	14.14	10.94	5.40	8.94	10.94	5.40	8.94	10.94	11.66	14.14
Understory Index	12.52	10.70	7.57	210.84	184.76	127.93	210.84	184.76	161.42	210.84	180.28	127.46
Avg % CC	63	65	71	63	65	71	63	65	71	63	65	71
Foxhole												
%SDI VSS4	26%	28%	30%	26%	29%	28%	26%	29%	26%	26%	29%	29%
%SDI VSS5	8%	10%	14%	8%	13%	17%	8%	14%	19%	8%	12%	16%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS6	8%	8%	9%	8%	10%	10%	8%	11%	11%	8%	9%	10%
TPA>18"	11	14	19	11	14	21	11	14	22	11	14	20
Snags/Ac >12"	3.60	4.31	6.20	3.60	4.59	4.31	3.60	4.74	4.15	3.60	3.37	4.30
PP BA	139	140	142	139	115	125	139	104	115	139	120	131
GO BA	19	20	26	19	20	25	19	20	26	19	20	24
Logs/Ac	1.66	2.54	5.11	1.66	1.92	4.31	1.66	1.78	4.23	1.66	2.65	4.59
CWD>3"	5.76	7.80	11.90	5.76	4.11	7.27	5.76	3.29	6.35	5.76	8.14	10.49
Understory Index	27.83	25.23	21.06	27.83	41.73	28.44	27.83	50.58	42.29	27.83	37.57	25.70
Avg % CC	73	74	75	73	69	73	73	68	72	73	70	74
Frank												
%SDI VSS4	31%	33%	26%	31%	36%	28%	31%	36%	27%	31%	36%	29%
%SDI VSS5	13%	15%	24%	13%	18%	29%	13%	18%	31%	13%	17%	28%
%SDI VSS6	12%	12%	14%	12%	14%	17%	12%	15%	18%	12%	14%	17%
TPA>18"	15	17	26	15	18	27	15	18	28	15	18	27
Snags/Ac >12"	4.19	5.36	8.81	4.19	5.92	8.14	4.19	6.05	7.86	4.19	4.96	8.34
PP BA	123	126	124	123	114	115	123	109	110	123	117	117
GO BA	18	20	29	18	19	24	18	19	24	18	19	23
Logs/Ac	0.88	2.00	6.46	0.88	1.63	6.13	0.88	1.43	5.94	0.88	2.03	6.23
CWD>3"	4.47	6.09	10.63	4.47	3.23	7.54	4.47	2.48	6.71	4.47	6.21	10.05
Understory Index	44.38	40.54	35.36	44.38	48.87	47.11	44.38	53.35	50.52	44.38	46.27	45.07

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Avg % CC	68	69	70	68	67	67	68	66	67	68	67	68
Frog Tank												
%SDI VSS4	30%	30%	27%	30%	30%	27%	30%	30%	27%	30%	30%	27%
%SDI VSS5	15%	17%	22%	15%	18%	22%	15%	18%	23%	15%	17%	22%
%SDI VSS6	7%	8%	12%	7%	8%	12%	7%	8%	12%	7%	8%	12%
TPA>18"	16	19	27	16	19	27	16	19	27	16	19	27
Snags/Ac >12"	2.88	3.83	7.03	2.88	4.79	6.75	2.88	5.19	6.63	2.88	3.83	7.03
PP BA	116	121	127	116	117	125	116	116	124	116	121	127
GO BA	23	24	28	23	24	28	23	24	28	23	24	28
Logs/Ac	1.89	2.81	6.51	1.89	2.07	5.99	1.89	1.79	5.82	1.89	2.81	6.51
CWD>3"	5.09	6.61	10.86	5.09	3.79	8.31	5.09	2.68	7.33	5.09	6.61	10.86
Understory Index	39.57	32.57	22.33	39.57	34.39	22.90	39.57	35.11	29.46	39.57	32.57	22.33
Avg % CC	70	72	75	70	71	74	70	71	74	70	72	75
Fry												
%SDI VSS4	31%	31%	27%	31%	31%	27%	31%	31%	27%	31%	31%	27%
%SDI VSS5	13%	15%	22%	13%	16%	22%	13%	16%	22%	13%	15%	22%
%SDI VSS6	7%	8%	10%	7%	8%	11%	7%	8%	11%	7%	8%	10%
TPA>18"	15	19	28	15	19	29	15	19	29	15	19	28
Snags/Ac >12"	4.13	4.94	8.24	4.13	6.40	7.79	4.13	6.40	7.79	4.13	4.94	8.24
PP BA	125	130	131	125	124	128	125	124	128	125	130	131
GO BA	24	26	29	24	26	30	24	26	30	24	26	29

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Logs/Ac	1.84	3.03	7.39	1.84	1.97	6.61	1.84	1.97	6.61	1.84	3.03	7.39
CWD>3"	5.76	7.66	12.66	5.76	3.11	8.50	5.76	3.11	8.50	5.76	7.66	12.66
Understory Index	102.04	90.69	73.66	102.04	96.30	75.14	102.04	96.30	86.50	102.04	90.69	73.66
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Gash Mountain												
%SDI VSS4	34%	35%	30%	34%	35%	30%	34%	35%	30%	34%	35%	30%
%SDI VSS5	15%	17%	25%	15%	18%	25%	15%	18%	25%	15%	17%	25%
%SDI VSS6	5%	6%	9%	5%	6%	9%	5%	6%	9%	5%	6%	9%
TPA>18"	17	20	31	17	20	31	17	20	31	17	20	31
Snags/Ac >12"	3.73	5.08	8.73	3.73	6.25	8.35	3.73	6.81	8.13	3.73	5.08	8.73
PP BA	134	139	143	134	135	141	134	133	140	134	139	143
GO BA	24	25	27	24	25	28	24	25	28	24	25	27
Logs/Ac	2.45	3.52	7.86	2.45	2.68	7.26	2.45	2.24	6.90	2.45	3.52	7.86
CWD>3"	6.07	7.90	12.91	6.07	4.76	10.03	6.07	3.28	8.67	6.07	7.90	12.91
Understory Index	28.27	24.09	17.72	28.27	26.14	18.21	28.27	26.48	22.50	28.27	24.09	17.72
Avg % CC	73	74	77	73	74	76	73	74	76	73	74	77
Girdner												
%SDI VSS4	32%	33%	29%	32%	33%	29%	32%	33%	29%	32%	33%	29%
%SDI VSS5	12%	15%	22%	12%	15%	22%	12%	15%	22%	12%	15%	22%
%SDI VSS6	8%	8%	11%	8%	8%	11%	8%	8%	12%	8%	8%	11%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
TPA>18"	14	17	27	14	17	28	14	17	28	14	17	27
Snags/Ac >12"	3.47	4.43	7.93	3.47	5.64	7.58	3.47	5.94	7.49	3.47	4.43	7.93
PP BA	116	121	125	116	116	122	116	115	121	116	121	125
GO BA	20	22	26	20	22	26	20	22	26	20	22	26
Logs/Ac	3.14	4.14	8.19	3.14	2.88	7.30	3.14	2.57	7.08	3.14	4.14	8.19
CWD>3"	5.94	7.62	12.28	5.94	4.04	9.10	5.94	3.14	8.30	5.94	7.62	12.28
Understory Index	36.21	29.96	20.46	36.21	32.21	21.11	36.21	32.78	27.44	36.21	29.96	20.46
Avg % CC	70	72	75	70	71	75	70	71	75	70	72	75
Harding Point												
%SDI VSS4	26%	25%	22%	26%	25%	22%	26%	25%	22%	26%	25%	22%
%SDI VSS5	24%	25%	26%	24%	26%	27%	24%	26%	27%	24%	25%	26%
%SDI VSS6	8%	10%	16%	8%	11%	16%	8%	11%	16%	8%	10%	16%
TPA>18"	27	30	36	27	30	36	27	30	36	27	30	36
Snags/Ac >12"	3.71	5.63	8.56	3.71	6.70	8.07	3.71	6.70	8.07	3.71	5.63	8.56
PP BA	137	140	141	137	135	139	137	135	139	137	140	141
GO BA	21	22	23	21	22	24	21	22	24	21	22	23
Logs/Ac	6.77	7.82	12.59	6.77	4.73	9.90	6.77	4.73	9.90	6.77	7.82	12.59
CWD>3"	7.37	9.00	13.91	7.37	3.90	9.25	7.37	3.90	9.25	7.37	9.00	13.91
Understory Index	17.13	15.88	13.73	110.08	105.94	88.94	110.08	105.94	98.06	110.08	102.07	88.28
Avg % CC	74	75	77	74	74	77	74	74	77	74	75	77

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Holdup												
%SDI VSS4	26%	28%	31%	26%	30%	30%	26%	31%	29%	26%	29%	30%
%SDI VSS5	12%	12%	18%	12%	14%	20%	12%	15%	21%	12%	13%	20%
%SDI VSS6	11%	12%	13%	11%	13%	15%	11%	14%	16%	11%	13%	15%
TPA>18"	12	14	21	12	14	22	12	14	22	12	14	22
Snags/Ac >12"	1.55	1.95	5.57	1.55	2.60	4.98	1.55	2.99	4.83	1.55	1.81	5.21
PP BA	123	132	146	123	114	130	123	107	122	123	118	133
GO BA	8	9	12	8	9	13	8	9	13	8	9	12
Logs/Ac	0.66	1.20	3.61	0.66	0.94	3.56	0.66	0.89	3.66	0.66	1.28	3.66
CWD>3"	3.70	4.34	6.89	3.70	2.49	5.08	3.70	1.74	4.45	3.70	4.64	6.77
Understory Index	53.98	44.05	33.55	53.98	62.81	47.19	53.98	70.08	60.66	53.98	58.48	44.59
Avg % CC	67	69	72	67	66	69	67	64	68	67	66	70
Howard Mountain												
%SDI VSS4	33%	32%	27%	33%	32%	27%	33%	32%	27%	33%	32%	27%
%SDI VSS5	13%	16%	23%	13%	16%	23%	13%	17%	23%	13%	16%	23%
%SDI VSS6	8%	8%	12%	8%	8%	12%	8%	8%	12%	8%	8%	12%
TPA>18"	16	19	30	16	19	30	16	19	30	16	19	30
Snags/Ac >12"	3.99	4.95	8.62	3.99	5.90	8.33	3.99	6.44	8.17	3.99	4.95	8.62
PP BA	122	126	127	122	122	125	122	120	124	122	126	127
GO BA	22	23	26	22	23	27	22	24	27	22	23	26

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Logs/Ac	3.04	4.21	8.89	3.04	3.07	8.04	3.04	2.63	7.72	3.04	4.21	8.89
CWD>3"	6.29	8.17	13.32	6.29	5.06	10.56	6.29	3.33	8.95	6.29	8.17	13.32
Understory Index	31.78	26.57	18.95	31.78	28.21	19.44	31.78	28.97	24.50	31.78	26.57	18.95
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Iowa Camp												
%SDI VSS4	30%	31%	29%	30%	31%	29%	30%	31%	29%	30%	31%	29%
%SDI VSS5	11%	13%	20%	11%	14%	20%	11%	14%	20%	11%	13%	20%
%SDI VSS6	6%	7%	9%	6%	7%	9%	6%	7%	9%	6%	7%	9%
TPA>18"	13	16	26	13	16	26	13	16	26	13	16	26
Snags/Ac >12"	3.35	4.25	8.02	3.35	5.25	7.72	3.35	5.75	7.57	3.35	4.25	8.02
PP BA	121	125	127	121	121	125	121	119	124	121	125	127
GO BA	27	29	33	27	29	34	27	29	34	27	29	33
Logs/Ac	2.12	3.12	6.97	2.12	2.47	6.54	2.12	1.98	6.18	2.12	3.12	6.97
CWD>3"	5.85	7.68	12.56	5.85	4.76	9.82	5.85	3.16	8.38	5.85	7.68	12.56
Understory Index	30.51	25.46	18.49	30.51	27.58	18.93	30.51	28.19	23.74	30.51	25.46	18.49
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Iris Tank												
%SDI VSS4	33%	31%	25%	33%	32%	23%	33%	31%	21%	33%	32%	23%
%SDI VSS5	19%	22%	30%	19%	27%	35%	19%	28%	36%	19%	27%	34%
%SDI VSS6	9%	9%	12%	9%	11%	15%	9%	12%	15%	9%	11%	15%
TPA>18"	22	26	35	22	27	36	22	27	36	22	27	36

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Snags/Ac >12"	5.74	6.60	9.72	5.74	6.50	8.27	5.74	6.80	7.69	5.74	5.71	8.30
PP BA	146	148	146	146	130	132	146	124	127	146	132	134
GO BA	20	20	26	20	20	24	20	20	25	20	20	24
Logs/Ac	1.98	3.58	9.33	1.98	2.80	8.20	1.98	2.52	7.91	1.98	3.78	8.78
CWD>3"	5.62	7.72	13.11	5.62	4.49	9.25	5.62	3.25	7.87	5.62	8.07	12.22
Understory Index	39.37	35.27	30.81	39.37	45.84	40.49	39.37	50.21	46.11	39.37	43.53	38.46
Avg % CC	71	72	74	71	69	71	71	68	70	71	70	72
James Canyon												
%SDI VSS4	32%	32%	28%	32%	32%	28%	32%	32%	28%	32%	32%	28%
%SDI VSS5	12%	15%	22%	12%	15%	22%	12%	15%	22%	12%	15%	22%
%SDI VSS6	7%	7%	10%	7%	7%	10%	7%	7%	10%	7%	7%	10%
TPA>18"	15	18	28	15	18	29	15	18	29	15	18	28
Snags/Ac >12"	3.90	4.86	8.55	3.90	6.11	8.16	3.90	6.42	8.07	3.90	4.86	8.55
PP BA	126	130	132	126	125	129	126	124	128	126	130	132
GO BA	25	26	29	25	26	30	25	27	30	25	26	29
Logs/Ac	2.43	3.56	7.96	2.43	2.58	7.25	2.43	2.26	7.02	2.43	3.56	7.96
CWD>3"	6.14	8.07	13.21	6.14	4.22	9.66	6.14	3.30	8.85	6.14	8.07	13.21
Understory Index	102.71	93.83	80.90	102.71	98.24	81.85	102.71	98.91	90.76	102.71	93.83	80.90
Avg % CC	73	74	77	73	74	76	73	74	76	73	74	77
Jeep												

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS4	30%	33%	31%	30%	33%	31%	30%	33%	31%	30%	33%	31%
%SDI VSS5	11%	12%	19%	11%	13%	20%	11%	13%	20%	11%	12%	19%
%SDI VSS6	5%	6%	9%	5%	6%	9%	5%	6%	9%	5%	6%	9%
TPA>18"	11	13	23	11	13	23	11	13	24	11	13	23
Snags/Ac >12"	2.47	3.29	7.23	2.47	4.46	6.93	2.47	4.73	6.84	2.47	3.29	7.23
PP BA	104	109	115	104	104	112	104	104	111	104	109	115
GO BA	22	24	29	22	24	30	22	24	30	22	24	29
Logs/Ac	2.82	3.55	6.80	2.82	2.45	6.06	2.82	2.18	5.87	2.82	3.55	6.80
CWD>3"	5.69	7.15	11.39	5.69	3.67	8.23	5.69	2.94	7.60	5.69	7.15	11.39
Understory Index	47.09	38.08	24.10	47.09	41.15	25.07	47.09	41.85	34.28	47.09	38.08	24.10
Avg % CC	69	71	74	69	70	74	69	70	74	69	71	74
Kelly												
%SDI VSS4	29%	30%	28%	29%	30%	28%	29%	30%	28%	29%	30%	28%
%SDI VSS5	12%	14%	20%	12%	15%	20%	12%	15%	20%	12%	14%	20%
%SDI VSS6	7%	8%	10%	7%	8%	10%	7%	8%	10%	7%	8%	10%
TPA>18"	15	17	26	15	18	26	15	18	26	15	17	26
Snags/Ac >12"	3.27	4.13	7.60	3.27	5.37	7.24	3.27	5.58	7.18	3.27	4.13	7.60
PP BA	124	128	131	124	123	128	124	122	128	124	128	131
GO BA	27	28	31	27	28	32	27	28	32	27	28	31
Logs/Ac	2.52	3.46	7.15	2.52	2.35	6.36	2.52	2.18	6.24	2.52	3.46	7.15
CWD>3"	5.92	7.67	12.36	5.92	3.84	8.81	5.92	3.17	8.19	5.92	7.67	12.36

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	110.26	100.35	84.85	110.26	104.66	85.99	110.26	105.24	96.09	110.26	100.35	84.85
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Kendrick												
%SDI VSS4	26%	27%	32%	26%	28%	31%	26%	28%	31%	26%	27%	32%
%SDI VSS5	10%	13%	19%	10%	13%	20%	10%	13%	20%	10%	13%	19%
%SDI VSS6	13%	13%	14%	13%	13%	15%	13%	13%	15%	13%	13%	14%
TPA>18"	6	8	14	6	8	14	6	8	14	6	8	14
Snags/Ac >12"	1.62	1.90	3.26	1.62	2.57	3.05	1.62	2.57	3.05	1.62	1.90	3.26
PP BA	55	62	79	55	58	75	55	58	75	55	62	79
GO BA	5	5	6	5	5	6	5	5	6	5	5	6
Logs/Ac	0.51	0.94	2.61	0.51	0.62	2.45	0.51	0.62	2.45	0.51	0.94	2.61
CWD>3"	6.24	6.67	7.92	6.24	2.41	4.43	6.24	2.41	4.43	6.24	6.67	7.92
Understory Index	276.41	240.07	154.05	276.41	248.17	165.67	276.41	248.17	216.82	276.41	240.07	154.05
Avg % CC	35	42	54	35	41	53	35	41	53	35	42	54
Knob												
%SDI VSS4	27%	29%	30%	27%	32%	31%	27%	32%	30%	27%	32%	31%
%SDI VSS5	13%	14%	20%	13%	18%	24%	13%	19%	25%	13%	17%	24%
%SDI VSS6	6%	6%	10%	6%	8%	12%	6%	8%	13%	6%	7%	12%
TPA>18"	11	13	23	11	14	25	11	14	25	11	14	25
Snags/Ac >12"	1.14	1.42	2.95	1.14	2.36	2.14	1.14	2.36	1.87	1.14	1.11	2.37

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	110	119	141	110	102	127	110	97	123	110	106	132
GO BA	8	10	15	8	9	13	8	9	13	8	9	13
Logs/Ac	0.76	1.12	2.15	0.76	0.79	1.94	0.76	0.79	1.94	0.76	1.15	1.97
CWD>3"	3.48	4.21	6.12	3.48	1.84	3.66	3.48	1.68	3.35	3.48	4.42	5.58
Understory Index	69.74	56.00	32.24	69.74	67.22	38.77	69.74	72.29	58.57	69.74	62.22	36.17
Avg % CC	65	67	73	65	64	71	65	64	70	65	65	71
Lake #1/ Seruchos												
%SDI VSS4	30%	32%	35%	30%	35%	34%	30%	37%	34%	30%	35%	34%
%SDI VSS5	12%	13%	20%	12%	14%	23%	12%	16%	25%	12%	14%	22%
%SDI VSS6	4%	5%	6%	4%	5%	7%	4%	6%	7%	4%	5%	6%
TPA>18"	11	13	22	11	13	24	11	14	25	11	13	24
Snags/Ac >12"	1.05	1.79	4.45	1.05	2.49	3.84	1.05	2.91	3.24	1.05	1.45	3.66
PP BA	132	142	163	132	123	147	132	113	140	132	127	153
GO BA	16	17	19	16	17	19	16	17	20	16	17	19
Logs/Ac	0.19	0.53	2.10	0.19	0.42	2.08	0.19	0.44	1.97	0.19	0.56	1.94
CWD>3"	4.23	4.91	8.03	4.23	2.91	5.59	4.23	2.00	4.29	4.23	5.20	7.37
Understory Index	38.84	30.18	17.12	38.84	44.57	23.76	38.84	53.76	41.39	38.84	40.05	20.95
Avg % CC	69	72	76	69	69	74	69	67	73	69	69	75
Lee Butte												
%SDI VSS4	31%	31%	30%	31%	31%	29%	31%	31%	28%	31%	31%	29%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS5	13%	16%	23%	13%	18%	25%	13%	19%	25%	13%	18%	24%
%SDI VSS6	7%	7%	8%	7%	8%	9%	7%	8%	10%	7%	7%	8%
TPA>18"	12	15	24	12	16	25	12	16	25	12	16	25
Snags/Ac >12"	2.93	3.97	7.44	2.93	4.61	6.74	2.93	4.73	6.15	2.93	3.56	6.95
PP BA	106	113	123	106	100	112	106	93	106	106	104	115
GO BA	23	25	30	23	25	30	23	25	31	23	25	29
Logs/Ac	0.67	1.72	6.11	0.67	1.41	5.68	0.67	1.27	5.48	0.67	1.80	5.89
CWD>3"	4.12	5.32	9.42	4.12	2.80	6.70	4.12	2.19	5.94	4.12	5.51	8.96
Understory Index	55.36	43.80	28.40	55.36	54.29	33.74	55.36	60.64	49.17	55.36	50.23	31.79
Avg % CC	66	69	73	66	66	71	66	65	70	66	67	72
Lockwood												
%SDI VSS4	25%	27%	28%	25%	27%	28%	25%	27%	28%	25%	27%	28%
%SDI VSS5	10%	12%	17%	10%	12%	17%	10%	12%	17%	10%	12%	17%
%SDI VSS6	6%	7%	8%	6%	7%	9%	6%	7%	9%	6%	7%	8%
TPA>18"	13	15	22	13	15	23	13	15	23	13	15	22
Snags/Ac >12"	2.84	3.66	7.40	2.84	5.03	7.02	2.84	5.03	7.02	2.84	3.66	7.40
PP BA	122	127	128	122	120	125	122	120	125	122	127	128
GO BA	32	34	38	32	34	40	32	34	40	32	34	38
Logs/Ac	1.61	2.48	5.75	1.61	1.60	5.15	1.61	1.60	5.15	1.61	2.48	5.75
CWD>3"	5.64	7.46	12.23	5.64	3.08	8.06	5.64	3.08	8.06	5.64	7.46	12.23

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	25.04	21.15	15.90	25.04	23.77	16.36	25.04	23.77	20.02	25.04	21.15	15.90
Avg % CC	73	74	77	73	74	76	73	74	76	73	74	77
Mayflower Tank												
%SDI VSS4	28%	27%	22%	28%	27%	22%	28%	26%	20%	28%	28%	22%
%SDI VSS5	13%	16%	20%	13%	17%	20%	13%	18%	21%	13%	17%	20%
%SDI VSS6	4%	5%	7%	4%	5%	7%	4%	5%	8%	4%	5%	7%
TPA>18"	12	16	23	12	16	23	12	17	23	12	16	23
Snags/Ac >12"	3.67	4.65	7.49	3.67	5.16	5.98	3.67	4.72	5.55	3.67	3.93	6.47
PP BA	91	94	94	91	86	89	91	80	84	91	89	92
GO BA	48	52	63	48	53	67	48	53	68	48	53	65
Logs/Ac	0.83	1.80	5.61	0.83	1.22	4.55	0.83	1.26	4.43	0.83	1.78	4.88
CWD>3"	4.00	5.75	10.49	4.00	2.25	6.22	4.00	2.25	5.92	4.00	5.65	9.18
Understory Index	55.20	46.32	27.85	55.20	52.51	29.24	55.20	57.57	46.08	55.20	49.74	28.29
Avg % CC	68	70	74	68	69	74	68	68	73	68	69	74
MB Smith												
%SDI VSS4	30%	31%	28%	30%	31%	28%	30%	31%	28%	30%	31%	28%
%SDI VSS5	14%	16%	22%	14%	16%	22%	14%	16%	22%	14%	16%	22%
%SDI VSS6	7%	8%	11%	7%	8%	11%	7%	8%	11%	7%	8%	11%
TPA>18"	15	18	28	15	18	28	15	18	28	15	18	28
Snags/Ac >12"	3.55	4.53	7.95	3.55	5.61	7.60	3.55	5.96	7.48	3.55	4.53	7.95

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	120	125	127	120	120	125	120	119	124	120	125	127
GO BA	23	24	28	23	24	28	23	24	28	23	24	28
Logs/Ac	3.65	4.63	8.60	3.65	3.41	7.66	3.65	2.86	7.24	3.65	4.63	8.60
CWD>3"	6.29	7.98	12.64	6.29	4.55	9.53	6.29	3.33	8.43	6.29	7.98	12.64
Understory Index	34.83	28.79	19.57	34.83	30.93	20.11	34.83	31.49	26.29	34.83	28.79	19.57
Avg % CC	71	73	76	71	72	75	71	72	75	71	73	76
Meadow Tank												
%SDI VSS4	24%	22%	19%	24%	22%	19%	24%	22%	20%	24%	22%	19%
%SDI VSS5	37%	38%	34%	37%	38%	34%	37%	39%	35%	37%	38%	34%
%SDI VSS6	7%	11%	20%	7%	11%	20%	7%	11%	20%	7%	11%	20%
TPA>18"	36	39	42	36	39	42	36	39	42	36	39	42
Snags/Ac >12"	2.59	5.17	7.68	2.59	5.43	7.66	2.59	5.99	7.28	2.59	5.17	7.68
PP BA	142	145	150	142	145	150	142	142	149	142	145	150
GO BA	16	16	17	16	16	17	16	16	17	16	16	17
Logs/Ac	5.31	6.27	11.21	5.31	6.15	11.19	5.31	3.81	8.95	5.31	6.27	11.21
CWD>3"	5.81	7.02	11.29	5.81	6.34	10.79	5.81	3.00	7.66	5.81	7.02	11.29
Understory Index	46.08	39.89	28.63	46.08	40.88	29.43	46.08	41.43	35.94	46.08	39.89	28.63
Avg % CC	72	73	75	72	73	75	72	72	75	72	73	75
Milos Butte												
%SDI VSS4	32%	32%	29%	32%	32%	29%	32%	32%	28%	32%	32%	29%
%SDI VSS5	12%	15%	21%	12%	15%	22%	12%	15%	22%	12%	15%	21%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS6	6%	7%	9%	6%	7%	10%	6%	7%	10%	6%	7%	9%
TPA>18"	15	18	29	15	18	29	15	18	29	15	18	29
Snags/Ac >12"	4.08	5.06	8.70	4.08	6.17	8.35	4.08	6.68	8.18	4.08	5.06	8.70
PP BA	133	137	138	133	132	136	133	130	135	133	137	138
GO BA	27	28	31	27	29	32	27	29	32	27	28	31
Logs/Ac	2.02	3.19	7.60	2.02	2.40	7.03	2.02	2.06	6.79	2.02	3.19	7.60
CWD>3"	6.14	8.17	13.47	6.14	4.84	10.38	6.14	3.35	9.00	6.14	8.17	13.47
Understory Index	22.30	19.09	14.61	22.30	20.63	14.90	22.30	21.29	18.15	22.30	19.09	14.61
Avg % CC	74	75	77	74	75	77	74	75	77	74	75	77
Mint Spring												
%SDI VSS4	33%	33%	29%	33%	33%	29%	33%	33%	29%	33%	33%	29%
%SDI VSS5	14%	16%	23%	14%	17%	24%	14%	17%	24%	14%	16%	23%
%SDI VSS6	6%	6%	10%	6%	7%	10%	6%	7%	10%	6%	6%	10%
TPA>18"	16	19	29	16	19	30	16	19	30	16	19	29
Snags/Ac >12"	3.94	4.98	8.40	3.94	6.24	7.98	3.94	6.56	7.88	3.94	4.98	8.40
PP BA	128	133	136	128	128	134	128	127	133	128	133	136
GO BA	23	24	27	23	24	28	23	24	28	23	24	27
Logs/Ac	2.23	3.35	7.64	2.23	2.34	6.88	2.23	2.14	6.74	2.23	3.35	7.64
CWD>3"	5.91	7.73	12.64	5.91	4.07	9.32	5.91	3.17	8.49	5.91	7.73	12.64
Understory Index	33.34	27.58	18.72	33.34	29.70	19.28	33.34	30.39	25.33	33.34	27.58	18.72

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Moore Well/Rock Dike												
%SDI VSS4	31%	31%	25%	31%	31%	25%	31%	31%	25%	31%	31%	25%
%SDI VSS5	13%	16%	22%	13%	17%	22%	13%	17%	23%	13%	16%	22%
%SDI VSS6	12%	13%	16%	12%	13%	17%	12%	13%	17%	12%	13%	16%
TPA>18"	18	22	31	18	22	31	18	22	31	18	22	31
Snags/Ac >12"	3.94	5.30	8.58	3.94	6.50	8.22	3.94	6.78	8.14	3.94	5.30	8.58
PP BA	126	129	129	126	125	127	126	124	126	126	129	129
GO BA	19	19	22	19	20	23	19	20	23	19	19	22
Logs/Ac	5.24	6.42	11.28	5.24	4.28	9.73	5.24	3.91	9.45	5.24	6.42	11.28
CWD>3"	6.69	8.56	13.73	6.69	4.61	10.30	6.69	3.63	9.43	6.69	8.56	13.73
Understory Index	28.52	24.29	17.73	28.52	26.22	18.32	28.52	26.48	22.65	28.52	24.29	17.73
Avg % CC	73	74	76	73	73	76	73	73	76	73	74	76
Mormon Mountain North												
%SDI VSS4	31%	33%	31%	31%	33%	31%	31%	33%	31%	31%	33%	31%
%SDI VSS5	10%	12%	20%	10%	13%	20%	10%	13%	20%	10%	12%	20%
%SDI VSS6	5%	5%	7%	5%	5%	7%	5%	5%	7%	5%	5%	7%
TPA>18"	12	15	25	12	15	26	12	15	26	12	15	25

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Snags/Ac >12"	3.43	4.40	8.25	3.43	5.97	7.75	3.43	6.13	7.71	3.43	4.40	8.25
PP BA	130	134	137	130	129	134	130	128	134	130	134	137
GO BA	29	31	34	29	31	35	29	31	36	29	31	34
Logs/Ac	1.49	2.46	6.14	1.49	1.73	5.68	1.49	1.62	5.59	1.49	2.46	6.14
CWD>3"	5.85	7.77	12.75	5.85	3.81	9.04	5.85	3.21	8.48	5.85	7.77	12.75
Understory Index	24.53	20.82	15.67	24.53	22.98	16.06	24.53	23.39	19.78	24.53	20.82	15.67
Avg % CC	74	75	77	74	74	77	74	74	77	74	75	77
Mt Elden												
%SDI VSS4	33%	34%	29%	33%	34%	29%	33%	34%	29%	33%	34%	29%
%SDI VSS5	12%	14%	22%	12%	14%	22%	12%	14%	22%	12%	14%	22%
%SDI VSS6	7%	8%	11%	7%	8%	11%	7%	8%	11%	7%	8%	11%
TPA>18"	13	16	27	13	16	28	13	16	28	13	16	27
Snags/Ac >12"	3.64	4.53	8.17	3.64	5.65	7.82	3.64	6.11	7.66	3.64	4.53	8.17
PP BA	116	121	124	116	117	122	116	115	121	116	121	124
GO BA	21	22	26	21	23	26	21	23	27	21	22	26
Logs/Ac	4.37	5.32	9.31	4.37	4.30	8.58	4.37	3.26	7.77	4.37	5.32	9.31
CWD>3"	6.70	8.39	13.07	6.70	5.24	10.26	6.70	3.51	8.72	6.70	8.39	13.07
Understory Index	36.39	30.14	20.56	36.39	32.02	21.06	36.39	32.71	27.38	36.39	30.14	20.56
Avg % CC	71	72	75	71	72	75	71	72	75	71	72	75
Mustang												

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS4	32%	32%	27%	32%	32%	27%	32%	32%	27%	32%	32%	27%
%SDI VSS5	13%	15%	21%	13%	15%	22%	13%	15%	22%	13%	15%	21%
%SDI VSS6	7%	7%	11%	7%	7%	11%	7%	7%	12%	7%	7%	11%
TPA>18"	12	15	25	12	15	25	12	15	25	12	15	25
Snags/Ac >12"	2.61	3.46	7.03	2.61	4.23	6.82	2.61	4.80	6.64	2.61	3.46	7.03
PP BA	97	103	110	97	100	107	97	98	106	97	103	110
GO BA	19	21	26	19	21	27	19	21	27	19	21	26
Logs/Ac	2.90	3.74	7.36	2.90	2.89	6.78	2.90	2.30	6.36	2.90	3.74	7.36
CWD>3"	5.33	6.70	10.82	5.33	4.34	8.76	5.33	2.73	7.36	5.33	6.70	10.82
Understory Index	48.45	39.15	25.80	48.45	41.35	26.63	48.45	42.23	35.10	48.45	39.15	25.80
Avg % CC	67	69	73	67	69	73	67	69	73	67	69	73
Nestor												
%SDI VSS4	34%	33%	28%	34%	33%	27%	34%	33%	27%	34%	33%	28%
%SDI VSS5	13%	16%	24%	13%	17%	24%	13%	17%	24%	13%	16%	24%
%SDI VSS6	7%	8%	11%	7%	8%	11%	7%	8%	11%	7%	8%	11%
TPA>18"	16	20	31	16	20	31	16	20	31	16	20	31
Snags/Ac >12"	4.47	5.40	8.84	4.47	6.46	8.50	4.47	6.99	8.33	4.47	5.40	8.84
PP BA	129	133	134	129	129	132	129	127	131	129	133	134
GO BA	23	24	27	23	24	28	23	24	28	23	24	27
Logs/Ac	2.25	3.53	8.33	2.25	2.64	7.66	2.25	2.27	7.39	2.25	3.53	8.33
CWD>3"	6.10	8.09	13.34	6.10	4.83	10.41	6.10	3.28	8.99	6.10	8.09	13.34

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	26.51	22.37	16.42	26.51	24.12	16.84	26.51	24.63	20.94	26.51	22.37	16.42
Avg % CC	73	74	77	73	74	76	73	73	76	73	74	77
O'Leary Peak												
%SDI VSS4	31%	32%	28%	31%	33%	28%	31%	33%	28%	31%	32%	28%
%SDI VSS5	14%	15%	21%	14%	16%	22%	14%	16%	22%	14%	15%	21%
%SDI VSS6	7%	8%	12%	7%	8%	13%	7%	8%	13%	7%	8%	12%
TPA>18"	10	12	22	10	12	22	10	12	22	10	12	22
Snags/Ac >12"	2.33	2.63	5.72	2.33	3.67	5.50	2.33	3.67	5.50	2.33	2.63	5.72
PP BA	77	84	94	77	80	90	77	80	90	77	84	94
GO BA	10	12	20	10	12	20	10	12	20	10	12	20
Logs/Ac	2.83	3.52	6.45	2.83	2.12	5.48	2.83	2.12	5.48	2.83	3.52	6.45
CWD>3"	4.68	5.59	8.71	4.68	2.21	5.94	4.68	2.21	5.94	4.68	5.59	8.71
Understory Index	72.85	58.09	35.08	72.85	62.63	36.90	72.85	62.63	51.25	72.85	58.09	35.08
Avg % CC	62	65	70	62	64	70	62	64	70	62	65	70
Orion Spring												
%SDI VSS4	31%	31%	30%	31%	32%	29%	31%	32%	29%	31%	31%	30%
%SDI VSS5	13%	15%	20%	13%	15%	21%	13%	15%	21%	13%	15%	20%
%SDI VSS6	6%	6%	10%	6%	7%	10%	6%	7%	10%	6%	6%	10%
TPA>18"	11	14	23	11	14	23	11	14	23	11	14	23
Snags/Ac >12"	3.14	3.39	6.04	3.14	4.60	5.73	3.14	4.60	5.73	3.14	3.39	6.04

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	100	107	116	100	101	112	100	101	112	100	107	116
GO BA	16	18	24	16	18	24	16	18	24	16	18	24
Logs/Ac	1.14	1.98	4.96	1.14	1.29	4.51	1.14	1.29	4.51	1.14	1.98	4.96
CWD>3"	4.50	5.74	9.24	4.50	2.26	6.23	4.50	2.26	6.23	4.50	5.74	9.24
Understory Index	64.38	50.83	29.10	64.38	55.82	30.89	64.38	55.82	44.86	64.38	50.83	29.10
Avg % CC	65	68	73	65	67	72	65	67	72	65	68	73
Pierce Tank												
%SDI VSS4	35%	35%	30%	35%	35%	30%	35%	35%	30%	35%	35%	30%
%SDI VSS5	13%	16%	23%	13%	16%	24%	13%	16%	24%	13%	16%	23%
%SDI VSS6	5%	6%	9%	5%	6%	9%	5%	6%	9%	5%	6%	9%
TPA>18"	15	18	30	15	18	30	15	18	30	15	18	30
Snags/Ac >12"	3.97	5.13	8.64	3.97	6.67	8.11	3.97	6.88	8.03	3.97	5.13	8.64
PP BA	130	134	139	130	129	136	130	128	136	130	134	139
GO BA	24	25	28	24	25	29	24	25	29	24	25	28
Logs/Ac	2.11	3.24	7.61	2.11	2.18	6.86	2.11	2.09	6.79	2.11	3.24	7.61
CWD>3"	5.94	7.81	12.86	5.94	3.70	9.12	5.94	3.22	8.68	5.94	7.81	12.86
Understory Index	31.41	25.55	17.47	31.41	27.92	18.17	31.41	28.10	23.34	31.41	25.55	17.47
Avg % CC	73	74	77	73	73	76	73	73	76	73	74	77
Powerline Tank												
%SDI VSS4	27%	29%	30%	27%	29%	30%	27%	29%	30%	27%	29%	30%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS5	10%	12%	17%	10%	12%	18%	10%	12%	18%	10%	12%	17%
%SDI VSS6	6%	6%	8%	6%	6%	8%	6%	6%	8%	6%	6%	8%
TPA>18"	12	14	22	12	14	22	12	14	22	12	14	22
Snags/Ac >12"	2.76	3.44	6.97	2.76	4.40	6.72	2.76	4.84	6.60	2.76	3.44	6.97
PP BA	117	122	127	117	118	124	117	116	123	117	122	127
GO BA	28	29	33	28	29	34	28	30	35	28	29	33
Logs/Ac	1.58	2.37	5.40	1.58	1.78	5.01	1.58	1.52	4.84	1.58	2.37	5.40
CWD>3"	5.42	7.04	11.40	5.42	4.13	8.70	5.42	2.89	7.52	5.42	7.04	11.40
Understory Index	38.54	31.33	20.28	38.54	34.52	21.15	38.54	34.90	28.51	38.54	31.33	20.28
Avg % CC	71	73	76	71	72	75	71	72	75	71	73	76
Pumphouse Wash												
%SDI VSS4	33%	34%	29%	33%	34%	29%	33%	34%	29%	33%	34%	29%
%SDI VSS5	13%	16%	23%	13%	16%	23%	13%	17%	24%	13%	16%	23%
%SDI VSS6	9%	9%	12%	9%	9%	13%	9%	10%	13%	9%	9%	12%
TPA>18"	18	21	31	18	21	32	18	21	32	18	21	31
Snags/Ac >12"	4.02	5.59	9.01	4.02	6.71	8.63	4.02	7.36	8.41	4.02	5.59	9.01
PP BA	140	143	145	140	139	143	140	137	142	140	143	145
GO BA	22	23	25	22	23	25	22	23	26	22	23	25
Logs/Ac	4.16	5.31	9.96	4.16	4.03	9.03	4.16	3.29	8.48	4.16	5.31	9.96
CWD>3"	6.63	8.58	13.87	6.63	5.42	11.03	6.63	3.66	9.45	6.63	8.58	13.87

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	74.85	69.59	60.99	74.85	72.31	61.64	74.85	73.54	67.95	74.85	69.59	60.99
Avg % CC	74	75	77	74	75	77	74	74	77	74	75	77
Racetrack Tank												
%SDI VSS4	28%	28%	27%	28%	28%	27%	28%	28%	27%	28%	28%	27%
%SDI VSS5	13%	14%	19%	13%	15%	19%	13%	15%	20%	13%	14%	19%
%SDI VSS6	7%	7%	10%	7%	7%	10%	7%	7%	10%	7%	7%	10%
TPA>18"	14	16	25	14	17	25	14	17	25	14	16	25
Snags/Ac >12"	2.97	3.86	7.35	2.97	4.62	7.14	2.97	5.18	6.95	2.97	3.86	7.35
PP BA	116	120	124	116	117	122	116	114	120	116	120	124
GO BA	27	28	33	27	29	33	27	29	34	27	28	33
Logs/Ac	2.20	3.12	6.70	2.20	2.38	6.17	2.20	1.97	5.87	2.20	3.12	6.70
CWD>3"	5.55	7.22	11.79	5.55	4.68	9.48	5.55	2.97	7.87	5.55	7.22	11.79
Understory Index	35.08	28.51	19.46	35.08	30.32	19.92	35.08	31.40	26.04	35.08	28.51	19.46
Avg % CC	71	73	76	71	72	75	71	72	75	71	73	76
Rattlesnake												
%SDI VSS4	37%	37%	27%	37%	37%	27%	37%	37%	27%	37%	37%	27%
%SDI VSS5	14%	17%	26%	14%	18%	27%	14%	18%	27%	14%	17%	26%
%SDI VSS6	8%	8%	13%	8%	9%	14%	8%	9%	14%	8%	8%	13%
TPA>18"	14	18	30	14	18	31	14	18	31	14	18	30
Snags/Ac > 12"	3.57	4.55	8.46	3.57	5.79	8.08	3.57	6.00	8.03	3.57	4.55	8.46

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	101	105	109	101	102	107	101	101	106	101	105	109
GO BA	14	15	20	14	15	20	14	15	20	14	15	20
Logs/Ac	4.23	5.31	10.05	4.23	3.65	8.83	4.23	3.23	8.53	4.23	5.31	10.05
CWD>3"	6.25	7.81	12.51	6.25	3.91	9.14	6.25	3.18	8.54	6.25	7.81	12.51
Understory Index	48.01	39.39	26.50	48.01	41.60	27.27	48.01	42.17	35.50	48.01	39.39	26.50
Avg % CC	68	70	73	68	69	73	68	69	73	68	70	73
Red Hill												
%SDI VSS4	34%	35%	30%	34%	36%	26%	34%	36%	23%	34%	36%	26%
%SDI VSS5	16%	17%	24%	16%	21%	28%	16%	22%	30%	16%	20%	27%
%SDI VSS6	4%	4%	9%	4%	5%	10%	4%	5%	11%	4%	5%	10%
TPA>18"	18	20	31	18	20	35	18	21	36	18	20	34
Snags/Ac >12"	2.78	5.08	9.95	2.78	5.56	7.31	2.78	5.52	6.81	2.78	4.23	7.62
PP BA	146	150	149	146	125	134	146	115	125	146	129	137
GO BA	14	15	15	14	15	15	14	15	16	14	15	15
Logs/Ac	2.47	3.25	7.73	2.47	2.21	6.31	2.47	2.19	6.18	2.47	3.36	6.93
CWD>3"	6.12	7.70	13.77	6.12	4.13	9.06	6.12	3.34	7.93	6.12	8.20	12.41
Understory Index	42.74	39.67	34.83	42.74	51.80	38.91	42.74	59.28	51.38	42.74	49.08	37.47
Avg % CC	72	74	76	72	70	74	72	68	73	72	71	75
Red Raspberry												
%SDI VSS4	25%	25%	21%	25%	25%	20%	25%	25%	20%	25%	26%	20%
%SDI VSS5	14%	16%	21%	14%	17%	22%	14%	18%	23%	14%	17%	22%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS6	10%	11%	14%	10%	12%	15%	10%	12%	15%	10%	11%	14%
TPA>18"	16	20	28	16	20	30	16	20	30	16	20	29
Snags/Ac >12"	4.80	5.63	6.85	4.80	5.66	6.11	4.80	5.60	5.67	4.80	4.61	6.23
PP BA	96	99	105	96	91	98	96	87	95	96	94	101
GO BA	34	33	36	34	34	35	34	34	36	34	33	35
Logs/Ac	4.59	6.39	10.84	4.59	3.85	8.05	4.59	3.87	7.96	4.59	6.14	9.73
CWD>3"	6.94	9.65	14.37	6.94	3.76	8.33	6.94	3.75	8.08	6.94	9.20	12.97
Understory Index	46.12	40.03	27.78	46.12	49.90	36.21	46.12	53.27	46.50	46.12	46.50	33.65
Avg % CC	70	71	75	70	70	74	70	69	73	70	70	74
Rock Top												
%SDI VSS4	31%	32%	27%	31%	32%	26%	31%	32%	23%	31%	32%	26%
%SDI VSS5	15%	17%	24%	15%	19%	26%	15%	20%	27%	15%	18%	26%
%SDI VSS6	7%	7%	9%	7%	8%	10%	7%	8%	11%	7%	8%	10%
TPA>18"	14	16	25	14	16	26	14	16	26	14	16	26
Snags/Ac >12"	3.16	3.72	6.15	3.16	4.42	5.44	3.16	4.27	4.92	3.16	3.20	5.59
PP BA	108	114	121	108	101	111	108	95	106	108	105	114
GO BA	18	20	26	18	20	26	18	20	27	18	20	25
Logs/Ac	2.09	2.97	6.05	2.09	2.03	5.22	2.09	1.96	5.01	2.09	3.02	5.78
CWD>3"	4.96	6.35	9.89	4.96	3.20	6.70	4.96	2.60	5.82	4.96	6.49	9.39
Understory Index	58.63	49.08	32.83	58.63	59.80	39.64	58.63	64.14	53.89	58.63	55.70	37.02

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Avg % CC	66	68	72	66	66	70	66	65	70	66	67	71
Roundup												
%SDI VSS4	33%	34%	30%	33%	34%	30%	33%	34%	29%	33%	34%	30%
%SDI VSS5	13%	16%	23%	13%	16%	23%	13%	16%	24%	13%	16%	23%
%SDI VSS6	6%	7%	11%	6%	7%	11%	6%	7%	11%	6%	7%	11%
TPA>18"	14	17	28	14	17	28	14	17	28	14	17	28
Snags/Ac >12"	3.21	4.16	7.83	3.21	5.08	7.57	3.21	5.72	7.38	3.21	4.16	7.83
PP BA	116	121	126	116	118	124	116	116	123	116	121	126
GO BA	21	22	26	21	22	26	21	22	26	21	22	26
Logs/Ac	2.47	3.42	7.42	2.47	2.67	6.91	2.47	2.15	6.55	2.47	3.42	7.42
CWD>3"	5.67	7.29	11.84	5.67	4.68	9.52	5.67	2.97	7.98	5.67	7.29	11.84
Understory Index	32.80	27.54	19.64	32.80	28.85	20.00	32.80	30.03	25.42	32.80	27.54	19.64
Avg % CC	70	72	75	70	71	75	70	71	74	70	72	75
Sawmill Springs												
%SDI VSS4	29%	30%	28%	29%	34%	31%	29%	35%	31%	29%	34%	32%
%SDI VSS5	18%	20%	23%	18%	21%	25%	18%	22%	26%	18%	20%	25%
%SDI VSS6	6%	6%	11%	6%	7%	13%	6%	7%	13%	6%	7%	12%
TPA>18"	17	19	27	17	19	28	17	19	28	17	19	28
Snags/Ac >12"	3.32	3.68	6.74	3.32	4.04	5.02	3.32	4.39	4.60	3.32	3.01	5.13
PP BA	120	127	139	120	117	134	120	112	130	120	121	138

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
GO BA	21	23	32	21	22	28	21	22	29	21	22	28
Logs/Ac	1.22	2.34	6.01	1.22	1.70	4.81	1.22	1.50	4.60	1.22	2.22	5.03
CWD>3"	4.56	5.90	9.61	4.56	3.21	6.33	4.56	2.26	5.30	4.56	5.88	8.39
Understory Index	46.44	38.22	24.58	46.44	47.19	29.82	46.44	51.33	41.70	46.44	43.50	27.91
Avg % CC	69	70	74	69	68	72	69	67	72	69	69	73
Schultz Creek												
%SDI VSS4	23%	21%	21%	23%	21%	21%	23%	21%	21%	23%	21%	21%
%SDI VSS5	22%	23%	21%	22%	24%	22%	22%	24%	22%	22%	23%	21%
%SDI VSS6	7%	9%	14%	7%	9%	14%	7%	9%	14%	7%	9%	14%
TPA>18"	22	24	28	22	24	28	22	24	28	22	24	28
Snags/Ac >12"	2.32	3.87	6.43	2.32	4.74	6.04	2.32	4.74	6.04	2.32	3.87	6.43
PP BA	114	118	126	114	113	122	114	113	122	114	118	126
GO BA	25	28	31	25	28	32	25	28	32	25	28	31
Logs/Ac	3.11	3.97	7.61	3.11	2.46	6.28	3.11	2.46	6.28	3.11	3.97	7.61
CWD>3"	4.95	6.26	10.33	4.95	2.64	7.04	4.95	2.64	7.04	4.95	6.26	10.33
Understory Index	50.08	37.69	21.83	50.08	40.70	23.31	50.08	40.70	32.41	50.08	37.69	21.83
Avg % CC	69	71	75	69	70	75	69	70	75	69	71	75
Spruce Tank												
%SDI VSS4	33%	34%	31%	33%	34%	30%	33%	34%	30%	33%	34%	31%
%SDI VSS5	12%	14%	22%	12%	15%	22%	12%	15%	22%	12%	14%	22%
%SDI VSS6	6%	6%	9%	6%	6%	9%	6%	6%	9%	6%	6%	9%

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
TPA>18"	12	15	25	12	15	26	12	15	26	12	15	25
Snags/Ac >12"	3.33	3.99	7.33	3.33	5.29	6.94	3.33	5.47	6.90	3.33	3.99	7.33
PP BA	111	116	123	111	112	120	111	111	119	111	116	123
GO BA	20	21	26	20	21	26	20	21	26	20	21	26
Logs/Ac	1.94	2.86	6.43	1.94	1.89	5.76	1.94	1.82	5.72	1.94	2.86	6.43
CWD>3"	5.36	6.88	11.11	5.36	3.25	7.90	5.36	2.78	7.47	5.36	6.88	11.11
Understory Index	45.02	36.41	22.98	45.02	39.07	23.80	45.02	40.03	32.81	45.02	36.41	22.98
Avg % CC	69	71	74	69	70	74	69	70	74	69	71	74
Sterling												
%SDI VSS4	24%	25%	25%	24%	25%	25%	24%	25%	25%	24%	25%	25%
%SDI VSS5	10%	11%	15%	10%	11%	15%	10%	11%	15%	10%	11%	15%
%SDI VSS6	19%	19%	20%	19%	20%	21%	19%	20%	21%	19%	19%	20%
TPA>18"	18	20	25	18	20	25	18	20	25	18	20	25
Snags/Ac >12"	2.88	4.67	7.29	2.88	6.14	6.83	2.88	6.14	6.83	2.88	4.67	7.29
PP BA	134	135	136	134	130	132	134	130	132	134	135	136
GO BA	21	23	25	21	23	26	21	23	26	21	23	25
Logs/Ac	8.50	9.31	12.80	8.50	5.56	10.10	8.50	5.56	10.10	8.50	9.31	12.80
CWD>3"	7.27	8.98	13.61	7.27	4.13	9.42	7.27	4.13	9.42	7.27	8.98	13.61
Understory Index	55.25	49.37	38.53	55.25	52.35	39.41	55.25	52.35	46.63	55.25	49.37	38.53
Avg % CC	73	74	76	73	73	76	73	73	76	73	74	76

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Stock Tank												
%SDI VSS4	26%	28%	32%	26%	29%	31%	26%	29%	31%	26%	28%	32%
%SDI VSS5	14%	16%	21%	14%	16%	21%	14%	16%	21%	14%	16%	21%
%SDI VSS6	7%	7%	10%	7%	7%	10%	7%	7%	10%	7%	7%	10%
TPA>18"	8	10	17	8	10	17	8	10	17	8	10	17
Snags/Ac >12"	1.86	2.09	4.10	1.86	2.37	4.06	1.86	2.94	3.90	1.86	2.09	4.10
PP BA	70	77	91	70	75	89	70	72	87	70	77	91
GO BA	10	10	14	10	11	14	10	11	14	10	10	14
Logs/Ac	0.55	1.08	3.06	0.55	0.97	3.03	0.55	0.71	2.90	0.55	1.08	3.06
CWD>3"	4.84	5.51	7.49	4.84	4.31	6.54	4.84	2.08	4.68	4.84	5.51	7.49
Understory Index	180.41	152.53	94.89	180.41	157.80	99.97	180.41	160.05	136.82	180.41	152.53	94.89
Avg % CC	46	51	61	46	50	60	46	50	60	46	51	61
T Bird												
%SDI VSS4	33%	34%	32%	33%	34%	32%	33%	34%	32%	33%	34%	32%
%SDI VSS5	10%	12%	20%	10%	13%	21%	10%	13%	21%	10%	12%	20%
%SDI VSS6	4%	5%	7%	4%	5%	7%	4%	5%	7%	4%	5%	7%
TPA>18"	12	15	26	12	15	26	12	15	26	12	15	26
Snags/Ac >12"	3.52	4.54	8.46	3.52	5.79	8.06	3.52	6.36	7.88	3.52	4.54	8.46
PP BA	133	137	141	133	133	138	133	130	137	133	137	141
GO BA	29	30	33	29	30	34	29	30	34	29	30	33
Logs/Ac	1.63	2.60	6.35	1.63	1.94	5.92	1.63	1.70	5.78	1.63	2.60	6.35

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
CWD>3"	6.02	7.95	13.00	6.02	4.68	9.95	6.02	3.29	8.64	6.02	7.95	13.00
Understory Index	23.05	19.68	14.84	23.05	21.27	15.13	23.05	22.22	18.74	23.05	19.68	14.84
Avg % CC	74	75	77	74	75	77	74	74	77	74	75	77
T6 Tank												
%SDI VSS4	27%	28%	25%	27%	30%	26%	27%	30%	24%	27%	30%	26%
%SDI VSS5	13%	15%	21%	13%	18%	27%	13%	20%	28%	13%	18%	26%
%SDI VSS6	11%	11%	14%	11%	14%	17%	11%	15%	18%	11%	13%	16%
TPA>18"	14	17	25	14	18	27	14	18	27	14	18	27
Snags/Ac >12"	2.22	2.73	6.47	2.22	3.44	5.54	2.22	3.42	4.88	2.22	2.46	5.60
PP BA	117	126	138	117	107	122	117	100	117	117	112	127
GO BA	18	20	26	18	19	23	18	19	24	18	19	23
Logs/Ac	0.95	1.71	4.67	0.95	1.21	4.34	0.95	1.22	4.30	0.95	1.78	4.64
CWD>3"	3.90	4.95	8.15	3.90	2.26	5.40	3.90	1.97	4.92	3.90	5.19	7.75
Understory Index	57.01	46.66	34.60	57.01	63.28	49.38	57.01	69.95	60.42	57.01	58.65	46.09
Avg % CC	67	69	72	67	66	69	67	64	68	67	67	70
Two Holes												
%SDI VSS4	32%	31%	27%	32%	32%	27%	32%	32%	26%	32%	31%	27%
%SDI VSS5	13%	16%	22%	13%	16%	23%	13%	16%	23%	13%	16%	22%
%SDI VSS6	7%	8%	11%	7%	8%	11%	7%	8%	11%	7%	8%	11%
TPA>18"	15	19	29	15	19	29	15	19	29	15	19	29

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Snags/Ac >12"	4.12	5.00	8.33	4.12	6.16	7.95	4.12	6.48	7.85	4.12	5.00	8.33
PP BA	124	128	130	124	124	128	124	122	127	124	128	130
GO BA	24	25	29	24	26	30	24	26	30	24	25	29
Logs/Ac	2.04	3.25	7.74	2.04	2.35	7.08	2.04	2.10	6.89	2.04	3.25	7.74
CWD>3"	5.80	7.70	12.73	5.80	4.16	9.54	5.80	3.13	8.59	5.80	7.70	12.73
Understory Index	32.59	26.62	18.22	32.59	28.78	18.86	32.59	29.28	24.41	32.59	26.62	18.22
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Upper West Fork												
%SDI VSS4	33%	33%	27%	33%	33%	27%	33%	33%	27%	33%	33%	27%
%SDI VSS5	12%	15%	22%	12%	15%	23%	12%	15%	23%	12%	15%	22%
%SDI VSS6	13%	13%	16%	13%	14%	16%	13%	14%	16%	13%	13%	16%
TPA>18"	19	22	32	19	22	32	19	22	32	19	22	32
Snags/Ac >12"	4.50	5.99	8.97	4.50	7.55	8.44	4.50	7.73	8.37	4.50	5.99	8.97
PP BA	140	143	143	140	138	140	140	137	140	140	143	143
GO BA	20	20	22	20	20	22	20	20	23	20	20	22
Logs/Ac	5.98	7.20	12.02	5.98	4.48	10.02	5.98	4.40	9.96	5.98	7.20	12.02
CWD>3"	7.24	9.24	14.55	7.24	4.43	10.35	7.24	4.01	9.97	7.24	9.24	14.55
Understory Index	90.18	84.32	74.29	90.18	88.14	75.29	90.18	88.37	82.28	90.18	84.32	74.29
Avg % CC	74	75	77	74	75	77	74	74	77	74	75	77
Volunteer												

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS4	31%	31%	25%	31%	31%	25%	31%	31%	25%	31%	31%	25%
%SDI VSS5	19%	21%	26%	19%	21%	26%	19%	22%	26%	19%	21%	26%
%SDI VSS6	8%	9%	14%	8%	9%	14%	8%	9%	14%	8%	9%	14%
TPA>18"	21	24	33	21	24	33	21	24	33	21	24	33
Snags/Ac >12"	3.90	5.24	8.49	3.90	6.34	8.10	3.90	6.60	8.01	3.90	5.24	8.49
PP BA	127	131	133	127	127	131	127	126	131	127	131	133
GO BA	20	21	23	20	21	23	20	21	23	20	21	23
Logs/Ac	4.49	5.62	10.36	4.49	4.01	9.05	4.49	3.45	8.61	4.49	5.62	10.36
CWD>3"	6.58	8.29	13.19	6.58	4.48	9.75	6.58	3.46	8.86	6.58	8.29	13.19
Understory Index	113.76	103.05	85.48	113.76	106.31	86.52	113.76	107.14	97.75	113.76	103.05	85.48
Avg % CC	72	73	76	72	73	76	72	73	76	72	73	76
Walnut 33												
%SDI VSS4	23%	23%	25%	23%	24%	25%	23%	24%	25%	23%	23%	25%
%SDI VSS5	11%	12%	16%	11%	13%	16%	11%	13%	17%	11%	12%	16%
%SDI VSS6	8%	8%	10%	8%	8%	10%	8%	9%	10%	8%	8%	10%
TPA>18"	13	16	22	13	16	22	13	16	22	13	16	22
Snags/Ac >12"	2.85	3.54	7.05	2.85	4.09	6.90	2.85	4.64	6.75	2.85	3.54	7.05
PP BA	116	120	120	116	117	118	116	113	116	116	120	120
GO BA	33	35	41	33	36	42	33	36	43	33	35	41
Logs/Ac	1.33	2.27	5.58	1.33	1.88	5.29	1.33	1.48	5.00	1.33	2.27	5.58
CWD>3"	5.25	7.06	11.74	5.25	4.98	9.76	5.25	2.90	7.77	5.25	7.06	11.74

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	68.85	62.40	54.08	120.22	112.67	95.15	120.22	115.45	105.71	120.22	108.96	94.43
Avg % CC	72	73	76	72	73	76	72	73	76	72	73	76
Weimer Springs												
%SDI VSS4	31%	32%	28%	31%	32%	28%	31%	32%	28%	31%	32%	28%
%SDI VSS5	12%	14%	21%	12%	14%	22%	12%	14%	22%	12%	14%	21%
%SDI VSS6	6%	7%	9%	6%	7%	9%	6%	7%	9%	6%	7%	9%
TPA>18"	13	17	27	13	17	27	13	17	27	13	17	27
Snags/Ac >12"	3.70	4.63	8.31	3.70	5.96	7.89	3.70	6.18	7.81	3.70	4.63	8.31
PP BA	123	128	129	123	122	126	123	122	126	123	128	129
GO BA	26	28	33	26	28	34	26	28	34	26	28	33
Logs/Ac	1.86	2.95	7.05	1.86	2.01	6.38	1.86	1.91	6.31	1.86	2.95	7.05
CWD>3"	5.79	7.69	12.69	5.79	3.66	8.97	5.79	3.15	8.51	5.79	7.69	12.69
Understory Index	28.84	24.18	17.81	28.84	26.66	18.33	28.84	26.78	22.70	28.84	24.18	17.81
Avg % CC	72	74	76	72	73	76	72	73	76	72	74	76
Weir												
%SDI VSS4	31%	32%	27%	31%	32%	27%	31%	32%	27%	31%	32%	27%
%SDI VSS5	13%	15%	22%	13%	15%	22%	13%	15%	22%	13%	15%	22%
%SDI VSS6	7%	8%	12%	7%	8%	12%	7%	8%	12%	7%	8%	12%
TPA>18"	13	16	26	13	16	26	13	16	26	13	16	26
Snags/Ac >12"	3.01	3.80	7.54	3.01	4.93	7.23	3.01	5.11	7.18	3.01	3.80	7.54

PAC	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
PP BA	101	106	110	101	101	107	101	101	106	101	106	110
GO BA	19	21	26	19	21	27	19	21	27	19	21	26
Logs/Ac	3.21	4.13	8.03	3.21	2.79	7.07	3.21	2.53	6.88	3.21	4.13	8.03
CWD>3"	5.73	7.23	11.61	5.73	3.60	8.42	5.73	2.94	7.84	5.73	7.23	11.61
Understory Index	45.15	36.92	24.71	45.15	39.59	25.56	45.15	40.03	33.42	45.15	36.92	24.71
Avg % CC	68	70	73	68	69	73	68	69	73	68	70	73
Woods												
%SDI VSS4	29%	30%	28%	29%	30%	28%	29%	30%	28%	29%	30%	28%
%SDI VSS5	13%	15%	20%	13%	15%	20%	13%	15%	20%	13%	15%	20%
%SDI VSS6	8%	8%	11%	8%	9%	11%	8%	9%	11%	8%	8%	11%
TPA>18"	14	17	25	14	17	25	14	17	25	14	17	25
Snags/Ac >12"	2.94	3.67	6.95	2.94	4.50	6.72	2.94	5.01	6.57	2.94	3.67	6.95
PP BA	113	118	123	113	114	120	113	113	119	113	118	123
GO BA	23	25	28	23	25	29	23	25	29	23	25	28
Logs/Ac	2.78	3.63	7.01	2.78	2.59	6.27	2.78	2.25	6.04	2.78	3.63	7.01
CWD>3"	5.61	7.13	11.32	5.61	4.39	8.85	5.61	2.94	7.53	5.61	7.13	11.32
Understory Index	38.48	31.98	21.80	38.48	34.11	22.38	38.48	34.72	29.05	38.48	31.98	21.80
Avg % CC	70	71	75	70	71	74	70	71	74	70	71	75

Table 59. Changes in MSO Habitat Componentes: Protected Habitat by Individual Subunit

Subunit	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
1-3												
%SDI VSS4	30%	31%	29%	30%	31%	29%	30%	31%	29%	30%	31%	29%
%SDI VSS5	11%	13%	20%	11%	14%	21%	11%	14%	21%	11%	14%	21%
%SDI VSS6	6%	6%	9%	6%	7%	9%	6%	7%	9%	6%	7%	9%
TPA>18"	14	17	27	14	17	27	14	17	27	14	17	27
Snags/Ac >12"	3.67	4.62	8.33	3.67	6.21	7.83	3.67	6.21	7.83	3.67	6.21	7.83
PP BA	130	134	136	130	127	132	130	127	132	130	127	132
GO BA	29	30	33	29	30	35	29	30	35	29	30	35
Logs/Ac	1.79	2.85	6.84	1.79	1.85	6.14	1.79	1.85	6.14	1.79	1.85	6.14
CWD>3"	5.96	7.92	13.03	5.96	3.26	8.67	5.96	3.26	8.67	5.96	3.26	8.67
Understory Index	23.67	20.12	15.28	23.67	22.49	15.71	23.67	22.49	19.09	23.67	22.49	15.71
Avg % CC	74	75	77	74	74	77	74	74	77	74	74	77
1-5												
%SDI VSS4	30%	30%	28%	30%	30%	27%	30%	30%	27%	30%	30%	27%
%SDI VSS5	12%	14%	20%	12%	15%	21%	12%	15%	21%	12%	15%	21%
%SDI VSS6	7%	7%	10%	7%	8%	10%	7%	8%	10%	7%	8%	10%
TPA>18"	14	17	26	14	17	27	14	17	27	14	17	27
Snags/Ac >12"	3.48	4.37	8.06	3.48	5.80	7.63	3.48	5.80	7.63	3.48	5.80	7.63
PP BA	120	125	126	120	118	123	120	118	123	120	118	123

Subunit	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
GO BA	26	28	32	26	28	33	26	28	33	26	28	33
Logs/Ac	2.25	3.30	7.32	2.25	2.09	6.46	2.25	2.09	6.46	2.25	2.09	6.46
CWD>3"	5.88	7.72	12.65	5.88	3.16	8.46	5.88	3.16	8.46	5.88	3.16	8.46
Understory Index	28.83	24.15	17.77	28.83	26.69	18.31	28.83	26.69	22.60	28.83	26.69	18.31
Avg % CC	72	74	76	72	73	76	72	73	76	72	73	76
3-3												
%SDI VSS4	23%	24%	23%	23%	24%	23%	23%	24%	23%	23%	24%	23%
%SDI VSS5	10%	13%	17%	10%	13%	17%	10%	13%	17%	10%	13%	17%
%SDI VSS6	20%	20%	22%	20%	21%	23%	20%	21%	23%	20%	21%	23%
TPA>18"	12	14	20	12	14	20	12	14	20	12	14	20
Snags/Ac >12"	2.18	2.32	3.13	2.18	3.21	2.86	2.18	3.21	2.86	2.18	3.21	2.86
PP BA	84	91	105	84	87	102	84	87	102	84	87	102
GO BA	7	7	8	7	7	8	7	7	8	7	7	8
Logs/Ac	0.80	1.43	3.52	0.80	0.93	3.23	0.80	0.93	3.23	0.80	0.93	3.23
CWD>3"	5.88	6.69	8.67	5.88	2.31	5.09	5.88	2.31	5.09	5.88	2.31	5.09
Understory Index	122.94	101.86	59.37	122.94	106.15	62.14	122.94	106.15	88.51	122.94	106.15	62.14
Avg % CC	58	61	67	58	60	67	58	60	67	58	60	67
3-4												
%SDI VSS4	35%	36%	31%	35%	36%	31%	35%	36%	31%	35%	36%	31%

Subunit	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
%SDI VSS5	11%	14%	23%	11%	15%	23%	11%	15%	23%	11%	15%	23%
%SDI VSS6	5%	5%	8%	5%	6%	8%	5%	6%	8%	5%	6%	8%
TPA>18"	14	17	29	14	17	30	14	17	30	14	17	30
Snags/Ac >12"	4.21	5.28	9.06	4.21	7.15	8.45	4.21	7.15	8.45	4.21	7.15	8.45
PP BA	137	141	144	137	135	140	137	135	140	137	135	140
GO BA	26	27	30	26	27	31	26	27	31	26	27	31
Logs/Ac	1.87	3.03	7.45	1.87	1.98	6.73	1.87	1.98	6.73	1.87	1.98	6.73
CWD>3"	6.24	8.29	13.63	6.24	3.41	9.12	6.24	3.41	9.12	6.24	3.41	9.12
Understory Index	64.61	59.63	52.47	64.61	63.03	53.14	64.61	63.03	58.14	64.61	63.03	53.14
Avg % CC	74	76	78	74	75	77	74	75	77	74	75	77
3-5												
%SDI VSS4	33%	34%	31%	33%	34%	31%	33%	34%	31%	33%	34%	31%
%SDI VSS5	11%	14%	21%	11%	14%	22%	11%	14%	22%	11%	14%	22%
%SDI VSS6	5%	6%	8%	5%	6%	8%	5%	6%	8%	5%	6%	8%
TPA>18"	14	17	28	14	17	29	14	17	29	14	17	29
Snags/Ac >12"	3.94	4.97	8.75	3.94	6.74	8.19	3.94	6.74	8.19	3.94	6.74	8.19
PP BA	135	139	141	135	132	138	135	132	138	135	132	138
GO BA	27	28	31	27	29	32	27	29	32	27	29	32
Logs/Ac	1.94	3.04	7.26	1.94	1.97	6.53	1.94	1.97	6.53	1.94	1.97	6.53
CWD>3"	6.20	8.21	13.45	6.20	3.38	8.97	6.20	3.38	8.97	6.20	3.38	8.97

Subunit	Alternative A			Alternative B			Alternative C			Alternative D		
	2010	2020	2050	2010	2020	2050	2010	2020	2050	2010	2020	2050
Understory Index	21.91	18.81	14.35	21.91	21.10	14.77	21.91	21.10	17.94	21.91	21.10	14.77
Avg % CC	74	76	78	74	75	77	74	75	77	74	75	77
4-4												
%SDI VSS4	33%	36%	57%	33%	37%	55%	33%	37%	55%	33%	37%	55%
%SDI VSS5	0%	9%	24%	0%	9%	25%	0%	9%	25%	0%	9%	25%
%SDI VSS6	0%	0%	2%	0%	0%	2%	0%	0%	2%	0%	0%	2%
TPA>18"	0	1	6	0	1	5	0	1	5	0	1	5
Snags/Ac >12"	0.62	0.90	2.23	0.62	1.08	2.16	0.62	1.08	2.16	0.62	1.08	2.16
PP BA	13	20	44	13	19	40	13	19	40	13	19	40
GO BA	0	0	0	0	0	0	0	0	0	0	0	0
Logs/Ac	0.00	0.09	0.88	0.00	0.09	0.91	0.00	0.09	0.91	0.00	0.09	0.91
CWD>3"	6.59	6.29	6.02	6.59	2.24	2.75	6.59	2.24	2.75	6.59	2.24	2.75
Understory Index	436.79	382.12	247.96	436.79	393.82	267.73	436.79	393.82	346.62	436.79	393.82	267.73
Avg % CC	8	19	39	8	17	36	8	17	36	8	17	36

Appendix 17. Summary of Treatments in MSO Critical Habitat by Alternative

This site is still under construction

DRAFT

Appendix 18. Fire Behavior Modeled for Existing Conditions and by Alternative (2020) in MSO Habitat

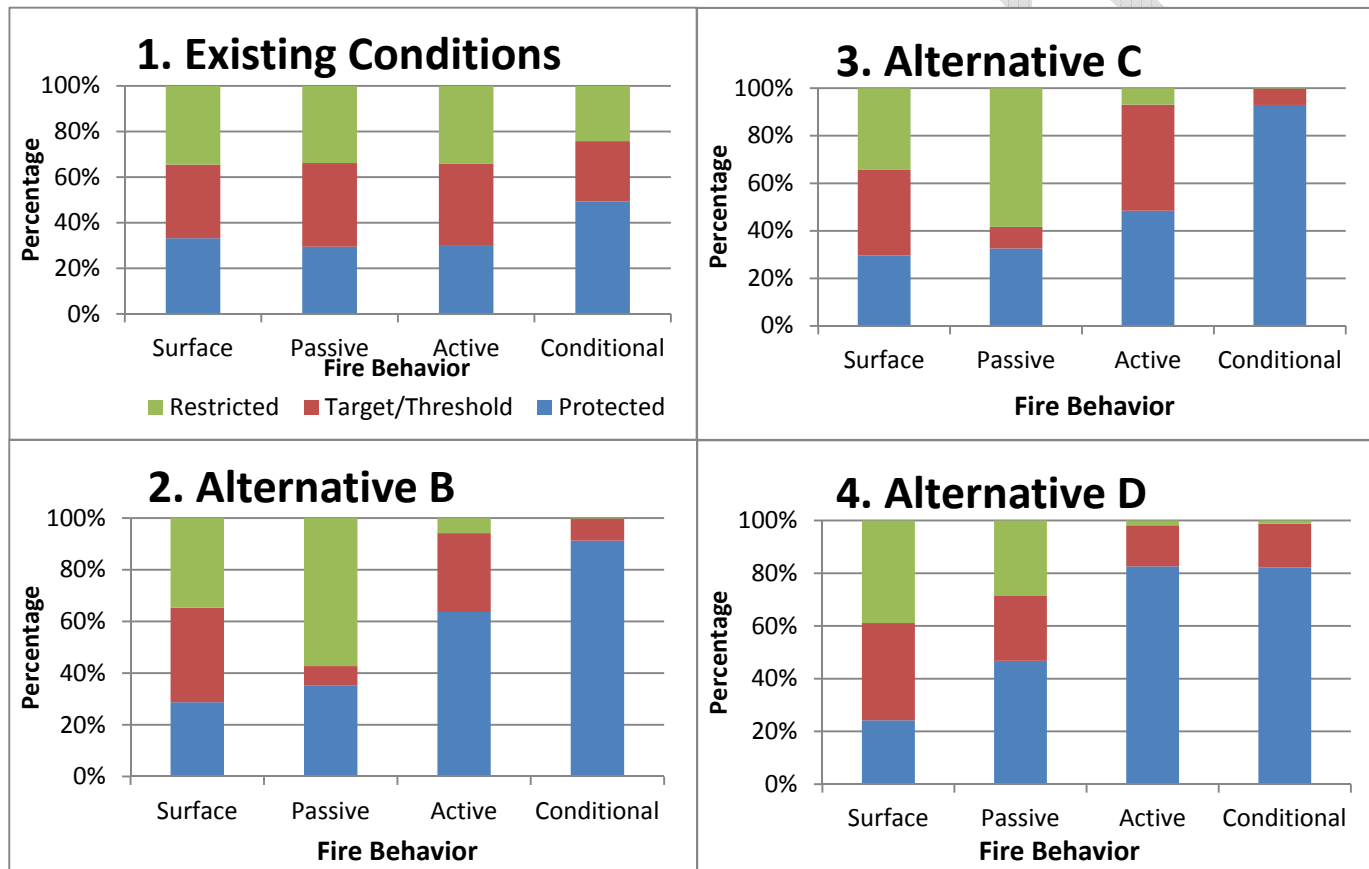


Figure 99. Percent area of MSO Habitat by fire type. Crown fire is divided into passive, active, and conditional (see text for definitions).

Appendix 19. Mechanical treatments likely added to the accumulation of down wood while burning decreased available wood. The changes were somewhat variable by individual subunit

Refer to DEIS for:

1. OTRS
2. Forest Plan amendments
3. LTRS

See Appendix A. Changes in forest structure and prey habitat between Alternatives use these in text and make this the subunit display (Excel = “Large MSO Habitat tables)

Table 60. Changes in Forest Structure Attributes Within MSO PACs By Alternative. Values Shown Are Model Results For For the Year 2050

Forest Attribute	Alternative A ¹	Alternative B ²	Alternative C ³	Alternative D ⁴
PACs With Thinning Outside Core Areas; Prescribed Burning Varies by Alternative (n = 18)				
12 – 18” dbh (%)	28	27	26	27
18 – 23.9” dbh (%)	22	26	27	25
≥ 24” dbh (%)	11	13	14	13
TPA ≥ 18” dbh	26	28	28	28
Snags/ Ac ≥ 12” dbh	6.7	5.6	5.2	5.7
Ponderosa Pine BA	134	122	116	126
Gambel Oak BA	27	26	27	26
Canopy Cover	73	71	71	72
PACs With No Thinning; Prescribed Burning Varies by Alternative (n = 54)				
12 – 18” dbh (%)	27	27	27	27

Forest Attribute	Alternative A ¹	Alternative B ²	Alternative C ³	Alternative D ⁴
18 – 23.9” dbh (%)	22	22	22	22
≥ 24” dbh (%)	12	12	12	12
TPA ≥ 18” dbh	27	28	28	27
Snags/ Ac ≥ 12” dbh	7.7	7.4	7.3	7.7
Ponderosa Pine BA	125	123	122	125
Gambel Oak BA	27	27	28	27
Canopy Cover	75	75	74	75

¹ = No Action Alternative

² = No Treatments Within Core Areas

³ = No Mechanical Treatments Within Core Areas; 56 Core Areas Prescribed Burned

⁴ = No Burning Within PAC Habitat

Appendix 20. Livestock Allotments Across the 4FRI Landscape

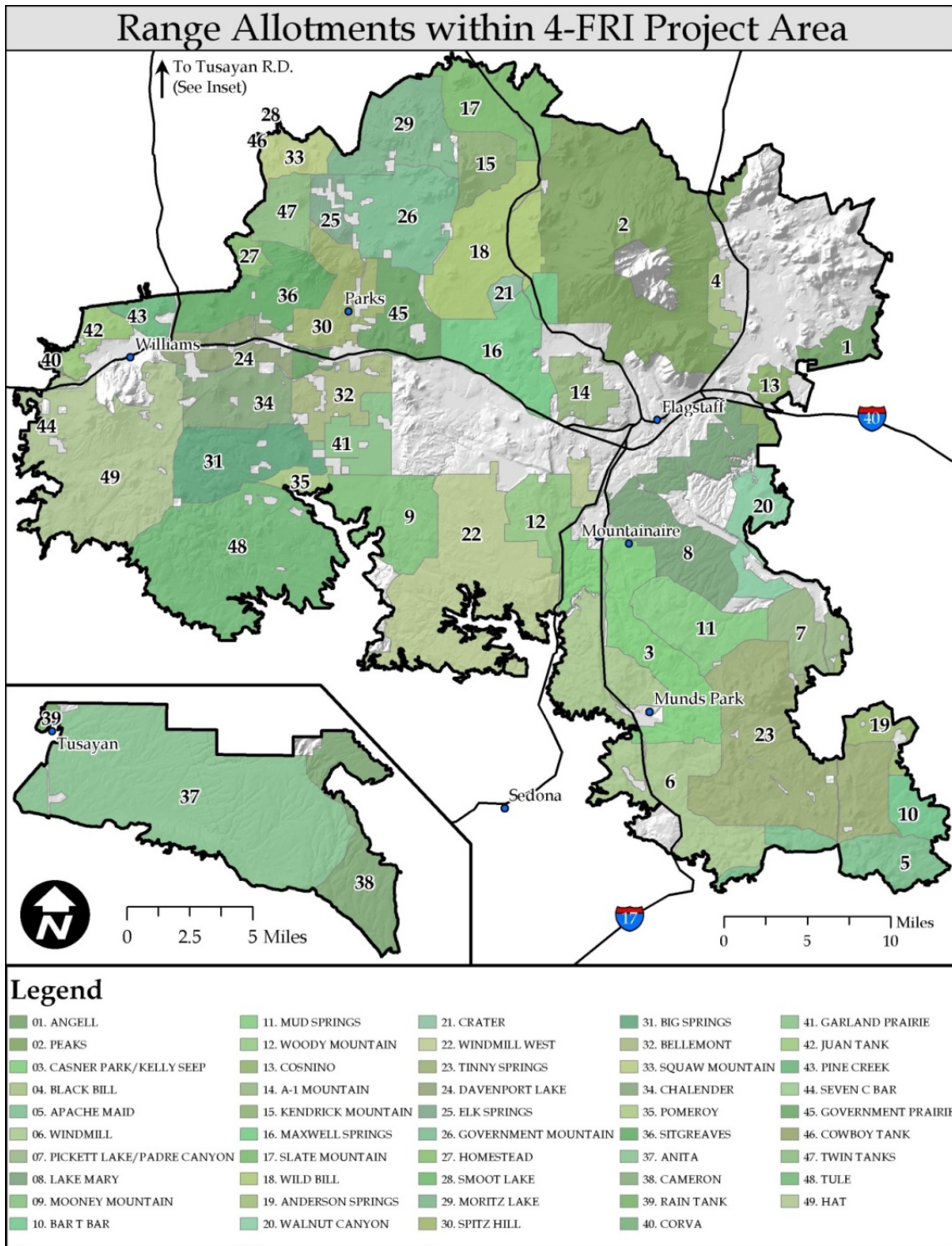


Figure 100. Map of Range Allotments in the 4FRI Project Area