United States
Department of
Agriculture

Forest
Service

**Southwestern Region**

# Forest Health Specialist Report

## Apache-Sitgreaves National Forests

## Forest Plan Revision EIS

**Submitted by:** __/s/ _ Monica Boehning ________

**Monica Boehning**
Forest Silviculturist
Apache-Sitgreaves National Forests
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## Contents

# Forest Health Specialist Report

## Introduction

This report evaluates and discloses the potential environmental consequences of tree-dependent insects and diseases with respect to forest health, which may result with the adoption of a revised land management plan. It examines, in detail, four different alternatives for revising the 1987 Apache-Sitgreaves NFs land management plan (1987 forest plan).

For the purposes of this analysis, the large numbers of forest health concerns are grouped into these five general categories: bark beetles, defoliators, aspen decline, persistent diseases, and new invasive (exotic) species. This analysis relies heavily on a consolidated report prepared by Lynch et al., 2010, covering the ponderosa pine, dry and wet mixed conifer, and spruce-fir forested and piñon-juniper woodland potential natural vegetation types (PNVTs).

## Relevant Laws, Regulations, and Policy that Apply

The authority for maintaining and/or restoring forestland and woodland health is derived from many laws enacted by Congress and Executive Orders, as well as Federal Directives and Forest Service Policy. The laws include:

- Anderson-Mansfield Reforestation and Revegetation Act of October 11, 1949
- Bankhead-Jones Farm Tenant Act of July 22, 1937
- Clarke-McNary Act of June 7, 1924
- Federal Insecticide, Rodenticide, and Fungicide Act of October 21, 1972
- Federal Land Policy and Management Act of October 21, 1976
- Forest and Rangeland Renewable Resources Planning Act of August 17, 1974
- Healthy Forests Restoration Act of 2003 (H.R. 1904)
- Knutson-Vandenberg Act of June 9, 1930
- Multiple-Use Sustained-Yield Act of June 12, 1960
- National Environmental Policy Act of January 1, 1970
- National Forest Management Act of October 22, 1976
- Organic Administration Act of June 4, 1897
- Stewardship End Result Contracting Projects
- Supplemental National Forest Reforestation Fund Act of September 18, 1972
- Sustained Yield Forest Management Act of March 29, 1944
- Tribal Forest Protection Act of 2004

Executive Orders include:

- Executive Order 11514 : Protection and enhancement of environmental quality (35 FR 4247, March 7, 1970, as amended by E.O. 11991 issued May 24, 1977).
- Executive Order 13112 : Invasive Species. (64 FR 6183, February 8, 1999).

Federal Regulations include:

- 1982 Planning Rule Provisions

- 36 CFR 221 Timber Management Planning

Forest Service Directives include:

**FSM 2000** National Forest Resource Management

- **FSM 2020** Ecological Restoration and Resilience, ID_2020-2010-1

**FSM 2400** Timber Management, Southwestern Region and Apache-Sitgreaves NFs supplements

- **FSM 2470** Silvicultural Practices

**FSM 3400** Forest Health Protection

### Programmatic Agreements

Memorandum of Understanding among the Arizona Game and Fish Department, New Mexico Game and Fish Department, U.S.D.A. Animal and Plant Health Inspection Service/Wildlife Services, U.S.D.A Forest Service, U.S. Fish and Wildlife Service, White Mountain Apache Tribe, Arizona Counties of Graham, Greenlee, and Navajo, New Mexico Counties of Catron and Sierra, and the New Mexico Department of Agriculture

Also see Appendix D of the Plan**.**

## Methodology and Analysis Process

Beyond this section, brief disclosure of analysis data and methodology are also provided where appropriate in the affected environment and environmental consequences sections, to assist the reader with concepts and conclusions discussed therein. Several appendices were created to help describe and demonstrate methods of analysis. Due to the size and nature of the appendices to this report, they are all available in the Plan set of documents as separate electronic files. They are listed at the end of this report as an index, and are referenced throughout this report when needed.

Bark beetle, defoliator and aspen condition maps and related data are collected annually during USFS Forest Health Protection aerial detection surveys. Ground data are collected during site visits to project areas, and permanent monitoring plots established across the Apache-Sitgreaves NFs. Persistent pathogen data were collected on the ground by roadside surveys across each ranger district, and provided by the USFS Forest Health Protection Arizona Zone Pathologist Fairweather, 2010a, and March 2010b. Additional personal knowledge of these diseases was added, based on 31 years of field work across much of the Apache NF, and discussions/field trips with Foresters and Silviculturists on the Sitgreaves NF. For more information on data sources and methods of collection, see Appendix A of this report.

Portions of this analysis rely heavily on the Vegetation Dynamic Development Tool (VDDT) model. The VDDT model only addresses vegetation development (structural) states for each PNVT based on various combinations of three structural attributes: predominant tree bole diameter range (seedling/sapling, small, medium, very large); canopy closure (open, closed); and number of canopy layers (single-storied, multi-storied). See Appendix B3 to this report, and the Vegetation Specialist Report for detailed explanation of the VDDT model, most of its limitations, and methodology for its use in forest planning analysis.

Report Appendices B1 through B5, E1, and E2 demonstrate how the VDDT model was calibrated by Region-3 and used by the Apache-Sitgreaves NFs to simulate the different mixtures of prescribed tree cutting, tree planting, and prescribed burning treatments designed to reflect the emphasis of each Apache-Sitgreaves (ASNFs) planning alternative for comparative analysis.

While the three structural attributes listed above are very important for forest health, restoration involves more than just forest or woodland physical structure. Many forest insects and diseases are specific to certain host tree species.

For prescribed cutting, burning, and planting activities input into the VDDT model, the state transition changes that result do not reflect changes in tree species composition, or in disease infection levels. It may appear that restoration of a PNVT would occur, based on shifts in those 3 structural attributes toward desired conditions as tracked by VDDT. However, without also correcting tree species composition (Fulé et al., 2009), and taking measures to address undesired levels of disease-infected trees, true restoration of that PNVT has not really occurred (Evans et al., 2011). Thus, additional silvicultural knowledge was used to analyze the cutting methods and burn severities that were modeled in VDDT, and what results their implementation on the ground may produce. See report Appendices B1, G, and H.

Additionally, using region-wide Forest Inventory Analysis (FIA) plot data for each PNVT and structural state, USFS Region-3 Forest Vegetation Simulator (FVS) model runs were used to help calibrate VDDT state transitions based on management-induced changes to those 3 structural attributes (Weisz et al., 2012; report Appendix B4). FVS is a model that can track changes in tree species as a result of management actions. Therefore, pre-treatment species composition compared to post-treatment species composition in the Region-3 FVS model tables was also consulted to validate silvicultural expectations of the various treatment methods that were input in the VDDT model by PNVT, and used as assumptions outlined in that section below.

In an attempt to move acres of vegetation structural states toward desired structural conditions for each PNVT, all cutting methods were examined with respect to how well they can reduce percentages of the landscape currently in surplus of the desired amount for that state. Similarly, how well each cutting method can create extra acres of those desired structural states currently in deficit from the desired percentages was examined (see report Appendix B3 for examples). Regionally-derived state transitions from the FVS model provide this information by percentages (see Appendices B1 and B4 of this report). Each alternative model run in VDDT then uses a different mix of those cutting methods by PNVT to simulate the alternative's different management emphasis (see report Appendices B2 and B5).

FVS gives per-acre averages, while VDDT can handle as many acres as the analysis area contains in any given PNVT. A major limitation of the FVS and VDDT models is that neither one is a spatial model. Both are dynamic, density- and time-dependent, and each reacts in its own way to changes in existing condition parameters as a result of natural growth and disturbances, including management actions.

VDDT simulations were run out for 50 years. In the case of this analysis, neither model was used to simulate changes in methods of cut from one treatment entry to the next on the same acre. Treatments can be turned off in VDDT, using the "time-since-disturbance" feature, as was done for single-entry clearcuts done on grasslands and cuts implemented in Alternative D. But in cases where several cutting entries are expected on the same land, like on forested acres in Alternatives

A, B, and C, the exact same prescribed cutting method (or prescribed burn severity) input into VDDT to implement for year 1 is repeatedly implemented again every time the same acre is due for another treatment some number of years later.

So a logical sequence of different silvicultural treatments that would normally be prescribed for any piece of ground over time was not modeled in our use of VDDT. For example, if an intermediate thinning cut was input for a certain number of acres in Entry1, that same thinning method and target basal area was replicated in VDDT for those same acres again in each subsequent entry. No future regeneration cut or conversion to the group selection cutting method was possible for those acres.

Within the first 15 years, another example of a logical sequence not simulated in VDDT: Burn-only Entry #1 = prescribed moderate or high-severity fire to break up the main canopy and consume ground fuels; followed by Burn-only Entry #2 = prescribed low-severity fire to maintain desired conditions thereafter. A more intensive VDDT modeling effort was undertaken only in Alternative B after year 15, to address the need to make this management change after the planning period (see the Forest Products Specialist Report).

Therefore given this limitation of our VDDT modeling, the results are less reliable when enough decades have passed to expect the next entry on the same acres. That timeframe varies by alternative, but generally occurs after the planning period. Thus, beyond year 15, the VDDT model's reliability is considered to be questionable with respect to precisely measured outputs for insect and disease analysis. However, reliable model outcomes of general vegetation structural trends beyond this timeframe are still assumed.

## Assumptions

In the analysis for this resource, the following assumptions have been made:

- For estimating the consequences of alternatives at the programmatic forest plan level, it is assumed the kinds of resource management activities allowed under the prescriptions will in fact occur to the extent necessary to achieve the goals and objectives of each alternative toward reaching the desired conditions. However, the actual locations, design, and extent of such activities are generally not known at this time. That will be a site-specific (project-by-project) decision. It is also unsure if the budgets needed to implement the specific activities will be forthcoming. Thus, the discussions here refer to the potential for consequences to occur, realizing that in many cases, these are only estimates. This programmatic analysis is useful in comparing and evaluating alternatives on a forest-wide basis, but is not to be applied to specific locations on the forest.

- The percentages of affected lands stated in Lynch et.al. (2010) which include both Apache-Sitgreaves NFs and Fort Apache Tribal Reservation lands across east-central Arizona collectively, are valid for application to the Apache-Sitgreaves alone.

- The ongoing levels of regional average annual tree growth, non-fire mortality, insect and disease influences, and wildfires used in FVS and VDDT modeling are reflective of the rates generally occurring currently (in 2011-2014) on the Apache-Sitgreaves NFs, and would continue at about the same rates for at least the next 15 year life of the proposed plan. Thus, current insect and disease trends are assumed to be indicative of short-term future trends.

- Weather extremes and climate change are assumed to be equivalent for all alternatives. Only improvements to forest/woodland conditions are compared between alternatives with respect to managed resiliency to weather and climate changes.

- When the structure and tree species compositions for all vegetation developmental states are in the desired condition proportions for each PNVT, native insects and diseases function more in their natural ecosystem roles. All alternatives are designed to manage toward the same desired conditions.

- The VDDT model results are assumed to be reliable for the existing conditions and resulting conditions at year 15 to represent reasonable estimates for comparison of alternatives for this planning period. Longer-term VDDT results may not be as reliable, due to numerous model limitations.

- Movement toward desired conditions is assumed to generally correspond with a reduction in risks to abnormal insect and disease outbreaks. (McMillin and Hanavan in report Appendices C and D; Fairweather, March 2010b).

- Prescribed fire (planned ignition) as a silvicultural tool would only be used in accordance with carefully prepared burn prescriptions designed to meet plan desired conditions, as developed by regionally-certified silviculturists working closely with qualified fuels specialists (Bartuska and Croft, 2001; Rasure and Harbor, 2011). Specialists like entomologists/pathologists may also be consulted.

- Based on professional experience it is assumed that tree mortality resulting directly from burning treatments or indirectly from post-fire beetle attacks, if salvaged, may not be salvaged fast enough to remove bark beetle host material before beetles complete at least one life cycle (usually within the first 1-2 years after fire, Furniss and Carolin, 1977).

- It is assumed that diameter-limit cuts (caps) would not enable total removal of undesired off-site tree species for full restoration, because such trees over the capped diameter would remain as seed-producers to perpetuate that encroached species where it does not belong (Triepke et al., 2011; report Appendix G).

- It is assumed that the types of tree thinning most effective at reducing dwarf mistletoe infections are: seed cuts, clear-cuts, free thinning, and a portion of group selection cuts. A diameter limit cut is assumed not to be effective at reducing dwarf mistletoe present in the overstory. All of these cuts were included in the Apache-Sitrgreaves NFs VDDT modeling for plan revision. This assumption is based on silvicultural concepts, field observations, and an understanding of forest biometrics and dwarf mistletoe behavior. Additionally the assumption is based on examination of Regional FVS model results of different cutting methods applied to each PNVT and structural state (see Appendices B1, B4, E2, and H of this report; and Weisz et al., 2012).

Because no new post-Wallow wildfire insect-disease surveys have yet been conducted, the additional assumptions were made in this analysis:

- Pre-Wallow wildfire existing insect-disease activity described in Lynch et.al. (2010) is assumed to still be representative for all forested and woodland acres not burned by high or moderate severity wildfire, at the same percentages as stated in that paper.

- Some portions of existing insect and disease populations were reduced directly in the fire, or indirectly by the fire's reduction of their obligate host tree species and forest structure.

- All localized populations of insect and disease species were temporarily eliminated from areas that are now deforested (approximately 21.5% of all forest PNVT acres).

- Dwarf-mistletoe infection levels in trees which survived the Wallow fire on moderate or low severity burned acres may be reduced due to scorched lower limbs (Conklin and Geils, 2008).

- Some insects, like bark beetles, will thrive as they take advantage of fire-killed and/or fire-stressed trees. The resulting insect population irruptions could threaten more live trees within and adjacent to burned areas (Furniss and Carolin, 1977; Parker et al., 2006; McMillin and Allen, 2003). Beetle outbreaks can increase fuel loadings and fire behavior on-site (Jenkins et al., 2014), and hazard trees in recreation areas (McMillin, 2010).

- Existing insect and disease species and their hosts remain nearby the severely burned areas, such that re-establishment of infestation/infection will occur in burned areas as the host trees and conditions again become suitable for them.

- Natural predators (birds, wasps, beetles, etc.) of insect pest species generally would not prevent bark beetle or defoliator populations from reaching epidemic numbers. They may only shorten the length of an outbreak after it has begun (McMillin, 2012; Munson, 2005).

## Revision Topics Addressed in this Analysis

**Revision Topic 1: Maintenance and Improvement of Ecosystem Health**

**Issue: Vegetation Conditions**
Analysis Topic:

A. For insects and diseases important to forested and/or woodland PNVTs, including native and invasive pest species, on <u>treated</u> acres the indicators are

   Bark Beetles:

   - *Annual treatment rates of each alternative, by forested and woodland PNVT*
   - *Bark beetle risk rating, based on basal area categories of percent of forestedPNVT structural states at year 15 from VDDT model results*
   - *Relative amount of moderate and/or high severity fire treatments by alternative*

   Defoliators:

   - *Percent of forested PNVTs by number of closed canopy levels at year15 from VDDT model results*

- *Ability of treatment methods emphasized in alternatives to improve species composition and vertical or horizontal spacing*
- *Relative amounts of artificial tree planting by alternative*

Aspen Decline:

- *Ability of treatment methods emphasized in alternatives (cutting and fire) to remove conifer competition without harming aspen above ground and aspen root systems below ground*
- *Plan components designed to improve conditions for aspen management*

Persistent Diseases:

- *Ability of treatment methods emphasized in alternatives to improve species composition and vertical or horizontal spacing*

Non-native and Invasive New Pests:

- *Relative movement by alternative toward desired conditions for each forested and woodland PNVT by year 15*

B. For insects and diseases important to forested and/or woodland PNVTs, including native and invasive pest species, on <u>untreated</u> acres the indicator is

All Pest/Forest Health categories:

- *Annual treatment rates for each alternative, and relative amounts of acres left untreated by year 15.*

## Summary of Alternatives

A summary of alternatives, including the key differences among alternatives, is outlined in the Environmental Impact Statement, Chapter 2. Proportions of treatment methods modeled according to the emphasis and management approach of each alternative are shown in this report's Appendices B2, B5, and E1, E2.

## Description of Affected Environment (Existing Condition)

Approximately 22 percent of all forested PNVT acres are currently deforested as a result of severe wildfire and other uncharacteristic disturbances (see the Forest Products Report for more information). The following affected environment descriptions are for those 78 percent of forested PNVT acres that still support tree cover, ranging from early developmental to mature structural states.

### Insects and Diseases

Insects and diseases are natural disturbance agents in forested ecosystems. Activity by these agents is always expected, although extent and severity of damage can vary spatially and temporally. Due to the episodic nature of insect outbreaks, damage is evaluated over an extended period before designating any shorter period as "unusual." As documented by Lynch et al. (2010), a century-long record of insect and disease activity across the Apache-Sitgreaves NFs and the adjacent Fort Apache Indian Reservation gives some information on which species impact forests in east-central Arizona, how often outbreaks of insects and transitory pathogens might occur, and how much damage may be expected from insects and diseases.

All native insects and diseases play a natural role in the forest ecosystem with which they have evolved. Interactions can be very complex between them and their host tree species, the environment, and other disturbance agents. When forest conditions are within their natural range of variability, native insects and diseases generally survive at endemic levels, and thus generally are not considered pests because they act as natural thinning agents by killing individual trees or small to large tree groups.

Insect and disease activity that might be considered normal in forests of east-central Arizona, include:

- Bark beetle damage associated with localized tree disturbances (e.g., road building, harvesting, wind events, snow breakage, fire) in piñon-juniper woodland and ponderosa pine, mixed-conifer, and spruce-fir forests.
- Periodic localized outbreaks of *Dendroctonus* bark beetles, particularly western and roundheaded pine beetles, in large-diameter ponderosa pine.
- Increased bark beetle activity during droughts in piñon-juniper and ponderosa pine, and to a lesser extent mixed-conifer, where the timing and severity damage is dependent upon host species, insect species, drought severity, length of drought conditions, and coincidence with other disturbance agents.
- Persistence of dwarf mistletoe infestations, including spread and intensification.
- Defoliation by native defoliating agents (e.g., western tent caterpillar, black leaf spot on aspen) and several defoliators in mixed-conifer. Typically, except in aspen, damage from these agents is localized rather than widespread.

When forest conditions are departed from their natural range of variability, native insects and diseases can take advantage of resulting opportunities to increase their population levels and expand into new territory. If this continues, epidemic population levels can be reached. In such cases, they inflict greater damage or damage at a faster rate than their normal role in the ecosystem. They are considered pests whenever tree mortality exceeds stated management objectives. Likewise, non-native insects or diseases can find opportunities to move into areas of weakened forest conditions and become newly established in the absence of natural controls that would resist or restrain them.

Insect activity in east-central Arizona’s forests has increased in the last couple of decades. In most vegetation types, the acreage affected is greater than what was damaged during the 1950s drought period (Lynch et al.,2010). Insect and disease populations have responded to changing forest character (especially forest structure and tree species composition) and variability in climate.

Contemporary patterns of insect and disease activity in east-central Arizona appear to have changed from pre-1950s regimes. These changes include:

- In ponderosa pine, *Ips* genus bark beetle species (pine engraver beetle and Arizona fivespined *ips*, which typically attack 3 to 12 inch diameter trees) became more prevalent and damaging than the drought responsive *Dendroctonus* genus bark beetle species (western pine beetle and roundheaded pine beetle, which typically attack 12 inch or greater diameter trees). The reverse was the case at the beginning of the 20th century.

- Damage to white fir by bark beetles and defoliators has increased in all PNVTs where it occurs. The fir engraver beetle was not a significant damaging agent until the 1980s.
- Damage in the spruce-fir PNVT is unprecedented in the historic record, both in terms of the severity of damage and the identity and variety of insects causing damage. Engelmann spruce has especially suffered unprecedented damage from several insects including: native (and previously innocuous) defoliators called loopers, an aggressive bark beetle outbreak, and an invasive (exotic) foliar aphid . These species' populations may be influenced by warm temperatures.
- Over the past decade, widespread mortality of mature aspen occurred due to a combination of drought, frost, and defoliation events, in conjunction with conifer competition and failure of aspen regeneration to recruit to larger sizes because of herbivory and damage caused by domestic and wild ungulates like mule deer and non-native Rocky Mountain elk (St. Clair et al., 2013; Eisenberg et al., 2013; Boehning, 1982-2014). Physical barriers against browsing (e.g. minimum 7-foot tall fences) have been found necessary to protect aspen regeneration and root systems from mortality.
- For piñon-juniper woodlands in east-central Arizona, the size and severity of drought and *Ips*-related piñon mortality in the early 2000s was unprecedented. It was six times as large as the 1990 outbreak, which was the first notable outbreak recorded for this area, although significant piñon mortality likely occurred during the 1950's drought.
- Extensive areas of damaged piñon-juniper are becoming juniper woodlands or grasslands.
- In areas not recently burned, dwarf mistletoe occurrence and severity of infection have increased in ponderosa pine, Douglas-fir, and spruce, due to altered disturbance regimes, and loss of forest openings and canopy gaps, resulting in more continuous forest canopy.
- Root/butt/stem decay diseases have become a problem in developed recreation areas like Hannagan, KP Cienega, Gabaldon, and Winn Campgrounds, due to tree over-maturity and stress from soil compaction. These diseases exist across all forested PNVT acres at varying levels, but have only been surveyed and well-documented in developed recreation sites where they are of greatest concern as contributing factors to hazard trees.

Several of these changes in disturbance regimes appear to be responses to changes in forest structure and composition that resulted from fire exclusion and past management practices: *Ips* bark beetles have responded to an abundance of dense, small-diameter ponderosa pine; western spruce budworms have responded to a proliferation of shade-tolerant host species in multi-storied canopies; fir engravers have responded to a proliferation of white fir in ponderosa pine and mixed-conifer forests where white fir used to be less well represented (Fulé et. al., 1997; Lynch et. al., 2010); and, to some extent, piñon *ips* beetles have responded to increased extent and density of piñon pine.

Lack of regular forest thinning by characteristic fire and/or cutting activities has caused increased forest density and continuity, which have facilitated more dwarf mistletoe tree infection and spread. Drought is also a factor in modifying disturbance regimes. Warming climate has been a factor in spruce-fir; however, its role in the other vegetation types is not known.

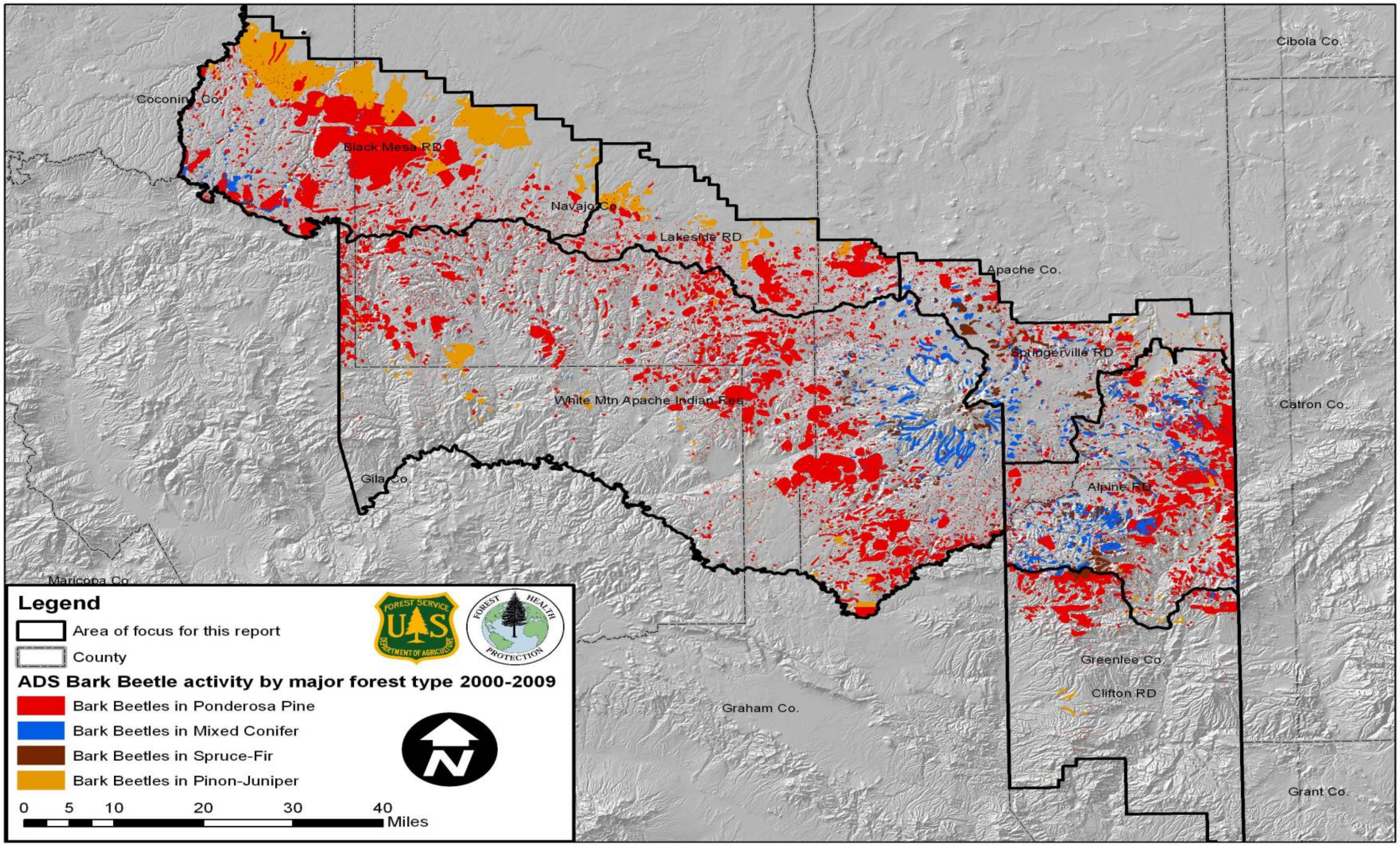
A vegetation shift is occurring in piñon-juniper woodlands because of the extent and severity of tree mortality; higher levels of mortality in the larger, reproductive trees; and preferential mortality of piñon versus juniper. The result is that piñon-juniper woodlands are becoming dominated by juniper, a species typical of lower elevation and more arid conditions.

All forested and woodland tree insects and diseases tend to capitalize on changes in stand conditions that stress trees and make them more vulnerable. Changes in stand conditions may be caused by environmental factors (e.g., lightning, wildfire) and human actions (e.g., logging, fire damage). In addition, infestation by one insect or disease may predispose trees to attack by other damaging agents. For example, heavy dwarf mistletoe infection of ponderosa pine increases their susceptibility to attack by *Ips* beetles during drought (Kenaley et al., 2008); and heavy dwarf mistletoe infection of large Douglas-fir increases their susceptibility to attack by Douglas-fir bark beetles, especially in dense and/or fire-stressed stands (McMillin, 2010; Anhold, 2012; McMillin and Anhold, 2013).

### *Bark Beetles*

The most destructive forest insects in western coniferous forests are bark beetles (Furniss and Carolin, 1977). Map 1 shows a compilation of bark beetle activity, evident as beetle-damaged/killed trees visibly mapped during annual aerial detection surveys from 2000 to 2009.

**Map 1. Bark beetle activity in east-central Arizona by major forested and woodland types from 2000-2009**



During the past decade, a widespread bark beetle outbreak in ponderosa pine impacted more than 200,000 acres across east-central Arizona (map 1). Pine mortality averaged approximately 9.6 percent by basal area, and approached 100 percent in some stands. Douglas-fir beetle and fir engraver affected about 2,000 to 8,000 acres of mixed conifer annually, causing the mortality of entire groups of Douglas-fir and white fir (potential increases might be expected based on records of historical outbreaks). Nearly 40,000 acres of spruce have been impacted by spruce beetle, with related tree mortality in the past decade. Piñon ips activity occurred on more than 150,000 acres in the same timeframe, where tree mortality reduced piñon stand density by approximately 60 percent.

Numerous bark beetle species exist across the Apache-Sitgreaves NFs' forested and woodland ecosystems which can inflict serious attacks upon nearly all native conifer trees and some hardwood trees. Beetle populations and corresponding tree mortality generally increase above endemic levels under the following conditions: drought; overstocked tree densities; stress caused by dwarf mistletoe, root decay fungi, or defoliating insects; and buildup of fresh, dead green wood as brood material across large areas. Brood material may result from logging/thinning slash left untreated on-site in consecutive years or from windthrow, fire, or other damaging agents that weaken and/or kill host trees.

Douglas-fir and spruce beetles are were expected to increase attacks on large trees (12 inch or greater diameter) within and near the Wallow Fire burned area (Anhold, 2011), and indeed now are approaching outbreak levels (McMillin and Anhold, 2013; Gaylord et al., 2014). Likewise, mountain pine beetle is also increasing attacks on southwestern white pines that survived Wallow (McMillin and Anhold, 2013; Gaylord et al., 2014). These recent developments are a key concern for surviving patches of old growth, Mexican spotted owl habitat, and developed recreation sites in the mixed conifer and lower elevation mixed spruce-fir PNVTs.

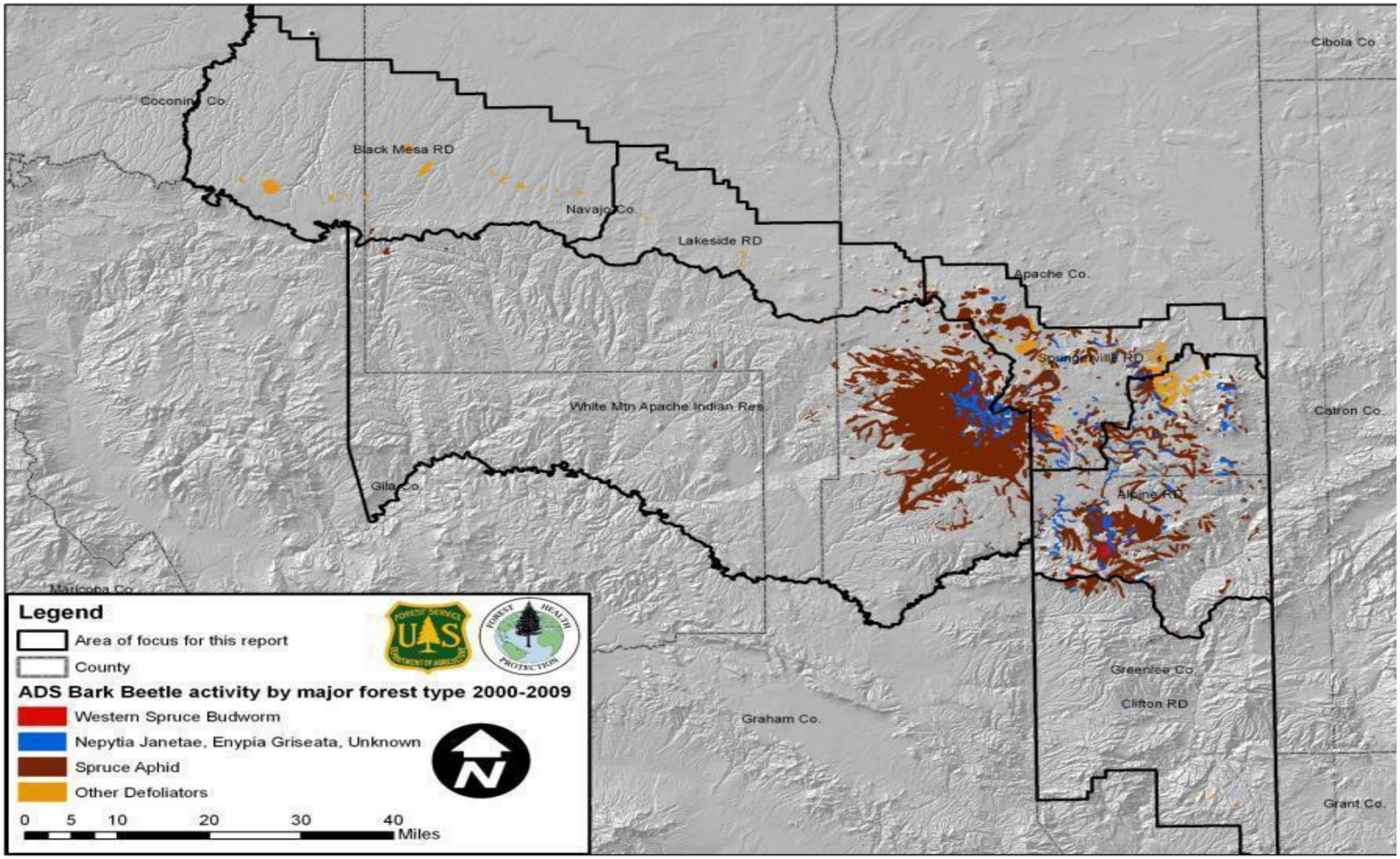
### *Defoliators*

Defoliators weaken and sometimes kill trees by consuming the green needles or leaves, thereby reducing photosynthetic capacity. During the past decade, various defoliators have seriously impacted over 300,000 acres across east-central Arizona (map 2). Damage by native defoliators is typically localized rather than widespread, and recently it is most notable in the mixed conifer and spruce-fir types across the Alpine and Springerville Ranger Districts. It is especially damaging on Mount Baldy, visible to the naked eye from miles away as a wide gray band of dead trees.

Key defoliators include the exotic spruce aphid, native loopers (Janet's looper and mountain girdle), western spruce budworm, western tent caterpillar, and the larvae of other moths and sawflies, black leaf spot, tip moths, and shoot borers. Defoliators contribute to tree stress and decline, predisposing trees to mortality by other agents like bark beetles. They generally do not kill trees outright unless outbreaks are intense and persist under the right conditions. Conditions which can lead to the most damaging outbreaks include: warmer and drier weather patterns and/or climate shifts; abundance of host tree species; uninterrupted multi-storied or uneven-aged stand structure that occurs across large acreages; host species encroachment into off-site vegetation types where they normally would not be found when natural processes are functioning correctly; and dwarf mistletoe infection (see report Appendix D). Past outbreaks of Janet's looper and spruce aphid have resulted in up to 70% tree mortality in stands severely infected with dwarf mistletoe.

Cumulatively, the Mount Baldy Wilderness is the most prevalent area on the Apache-Sitgreaves NFs most affected by recent outbreaks of several major defoliators. The high number of resulting dead trees has greatly increased the fire hazard in the wilderness (map 2). Portions of the other two wilderness areas are also affected but to a lesser extent. Mount Baldy Wilderness was the only wilderness area not burned by the Wallow Fire.

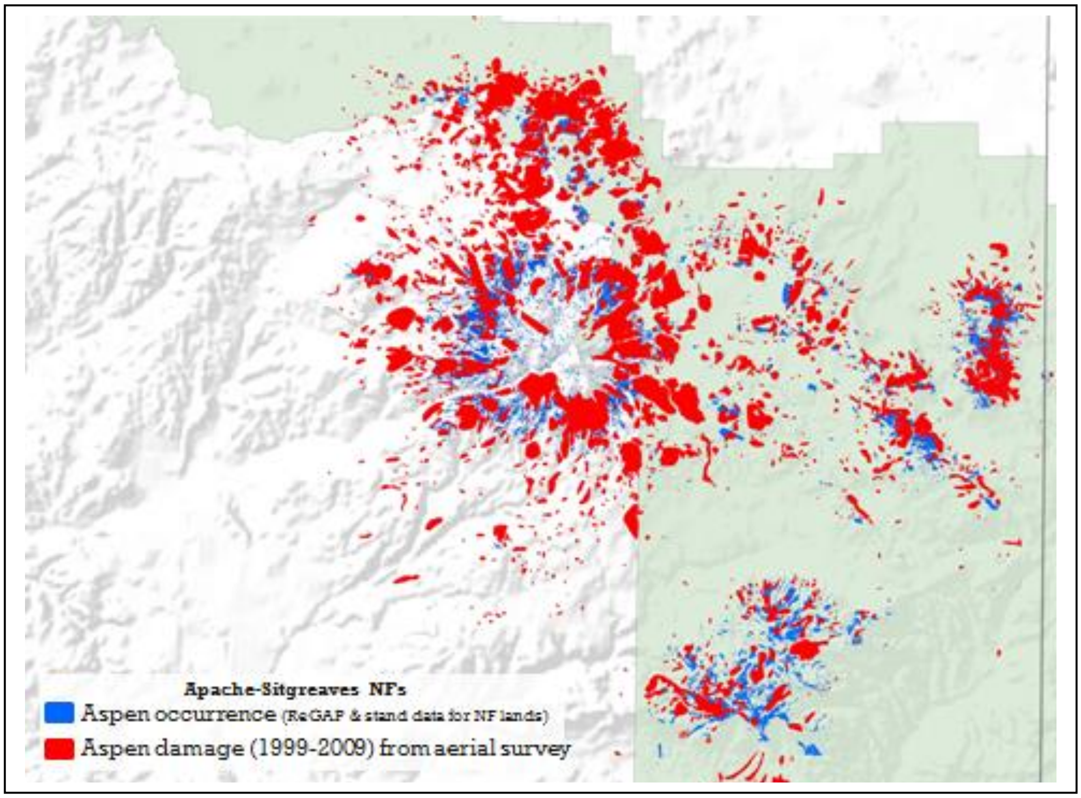
**Map 2. Major defoliator activity compliled from aerial detection surveys mapped annually in east-central Arizona for 2000-2009**



## *Aspen Decline and Mortality*

Numerous damaging factors have been documented as contributing to aspen decline (Rogers, 2008; Worrall, 2013; and Appendix A of this report). Map 3 illustrates non-wildfire-caused aspen damage mapped by annual USFS aerial detection surveys from 1999-2009. Damage is shown in context of aspen occurrence mapped across the area. Prior to 2008 aspen mortality acres were included as aspen "damage" areas.

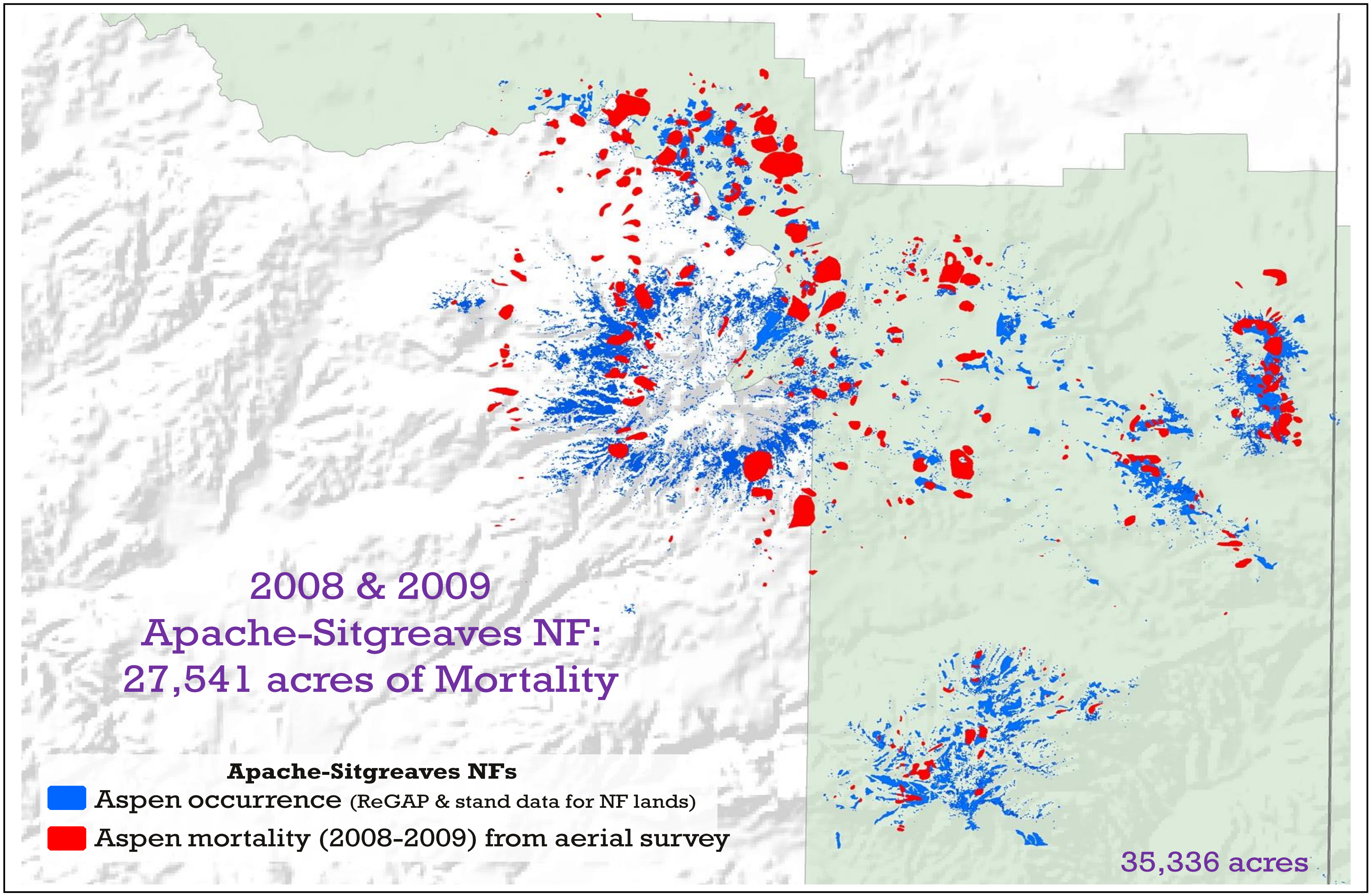
**Map 3. Forestwide aspen damage in east-central Arizona 1999-2009**




Recent aspen mortality has become so visible, that beginning in 2008, mortality is now mapped separately from aspen damage. Damage mapped in prior years may be detected in subsequent years as mortality (Fitzgibbon, 2009).

Map 4 illustrates non-wildfire-caused aspen mortality from 2008 to 2009. Mortality is shown in context of aspen occurrence mapped across the area. In those two years, the Apache-Sitgreaves NFs lost a total of 27,541 acres of aspen due to factors other than tree cutting or wildfire (27 percent of the existing 102,000 forest acres dominated and co-dominated by aspen at that time). Much of this mortality was mapped in previous years as aspen damage, indicative of aspen decline.

**Map 4. Forestwide aspen mortality in east-central Arizona 2008-2009**



Although aspen trees typically mature after about age 80, they can persist for more than 200 years in the West (DeByle and Winokur, 1985). Root systems can persist much longer, although no good method has been developed to determine the age of aspen roots. Pure aspen forests do not burn readily, however aspen trees above ground can be easily killed by fire of even the lightest intensity due to their extremely thin bark (Debyle and Winokur, 1985: pgs. 79-80).  Brown and DeByle (1987) found that minimal flame heights required to kill aspen with 90% probability ranged from only 10 cm (about 4 inches tall flame) for a 10-cm diameter tree to 60 cm (about 24 inches tall flame) for a 25-cm (about a10 inch) diameter tree.

This species is adapted to fire because its extensive root system has the ability to survive ground surface heat and, afterward, produce root sprouts (known as suckers) to begin a new, young aspen stand. Occasionally, mature aspen can produce seed transported by wind to germinate new seedlings in post-fire bare soil (Fairweather et al., 2014). Therefore, a single fire event or treatment can be an excellent means to replace old trees with young aspen regeneration, provided all other conditions are ideal for long-term survival of the resulting new trees. Once successély established, young and immature aspen clones benefit from a lack of fire until they reach maturity and are then ready to repeat the renewal process.

### *Persistent Diseases*

Persistent pathogens (diseases like dwarf mistletoes, root/butt/stem decay fungi, and white pine blister rust) often cause substantial tree stress and growth losses over time, and they diminish mature trees' ability to produce viable seed (Hawksworth and Weins, 1996; Hagle et.al., 2003). They also hasten large tree mortality and threaten the ability of young trees to successfully reach maturity (Hawksworth and Geils, 1990; Mathiasen, 1986; Hart and Hawksworth, 1989). Stands severely infected with dwarf mistletoe tend to have higher fuels loadings and may be more prone to fire laddering into the canopy (Hoffman et al., 2007). Persistent diseases tend to intensify and/or spread infection beyond desired levels under the following conditions: overstocked forest densities, decline in site quality during drought; uniformity of host tree species; multi-storied or uneven-aged stand structure uninterrupted across large acreages; host species encroachment into off-site vegetation types, including grasslands and riparian forested PNVTs.

It can be inferred that dwarf mistletoe abundance was likely lower historically based on the present understanding of mistletoe ecology, increases in host abundance and canopy continuity over the past 150 years, and decreases in fire frequency. The table below shows known information about infections of major diseases on the Apache-Sitgreaves NFs by ranger district.

**Table 1. Estimated percent of tree species infected with major diseases by ranger district (RD)[1]**

| Dwarf Mistletoe, by Tree Host Species | Black Mesa RD | Lakeside RD | Springerville RD[2] | Alpine RD[2] | Clifton RD[3] | Estimated Forestwide Average |
|---|---|---|---|---|---|---|
| Ponderosa pine | 54-61% | 39% | 67% | 51% | NA | 52% |
| Douglas-fir | Present | NA | Present | Present | NA | Approx. 50% |
| Spruce | NA | NA | Present | Present | NA | Approx. 60% |
| SW White pine | Present | NA | Present, possibly 20-30+% | Present, possibly 30+% | NA | % unknown |
| **White Pine Blister Rust Known Infection Centers** | surveys in progress | Present, more surveys in progress | Present, more surveys in progress | Present, more surveys in progress | surveys in progress | % unknown |
| **Root/Butt/Stem Decay Fungi Infections** | Present | Present | Present | Present | Present | % unknown[4] |

[1]NA = detailed information not available or not applicable. Air detection surveys are not designed to inventory or monitor these diseases. Ground visits, permanent monitoring plots, and reported district observations are used instead.
[2]Data represents conditions prior to the 2011 Wallow Fire. Post-fire changed conditions have not yet been assessed.
[3] Persistent pathogenic disease levels are not well documented for the Clifton Ranger District due to a lack of road access for ground surveys, and limited commercially suitable acres. This category is not easily mapped from air detection surveys.
[4]Levels of root/butt/stem disease infections are often missed during surveys because they are difficult to detect and mortality is often associated with bark beetles and/or dwarf mistletoe, so impacts on forest ecosystems may be underestimated.

Root rots can increase and spread to additional host trees when woody food sources are created and left on-site in the form of stumps and dead trees, such that thinning for bark beetle control or other objectives can exacerbate root disease problems. Larger trees declining from root pathogens are often attacked and killed by bark beetles (Hagle, 2004). Fires which do not create intense heat below the soil surface generally do not kill root diseases. Root diseases tend to be a particular problem when they persist in developed recreation sites and other areas of human use, which makes it more critical for comprehensive, long-term vegetation management plans to be completed under site-specific (project-level) NEPA analysis.

### *Recent Arrivals of Invasive or New Pests*

Establishment of new invasive (exotic) insects and pathogens is a growing threat. Fairly recent arrivals of several non-native pest species are of particular concern because natural resistance and control organisms for them may not exist or they are currently unknown in these ecosystems, thus making them potentially quite destructive (Moser et al., 2009). White pine blister rust, a non-native disease, now infects southwestern white pine. Numerous aeras within the Apache-Sitgreaves NFs provide suitable conditions for blister rust to persist and spread. This is due to the prevalence of its required alternate host, *Ribes* (gooseberry and currant). *Ribes* bushes are common across the widespread area where white pines also occur. This disease is mostly found attacking host trees in very wet drainage bottoms in close proximity to permanent waters, but increasing presence on upper slopes is also documented. Some infected trees identified within the Wallow Fire, as well as many *Ribes* bushes near them, are known to have been killed by the burn.

Spruce aphid is a non-native insect that now infests Engelmann spruce, and to a lesser extent, Colorado blue spruce (Lynch, 2004).

Several other new issues are also likely to develop with native insects and diseases. If warmer, drier climate trends continue as predicted, some insect and disease agents may become more prevalent and impact larger areas. Some localities may become more suitable for additional damaging insect and pathogen species. Insects and pathogens may expand their range into new territory or exhibit enhanced population dynamics under these new conditions due to factors such as increased growth rates or increased survival. Previously innocuous native insects and diseases that become serious problems are known as emerging pests. Recent examples of emerging pests are the loopers known as Janet's looper and mountain girdle. These previously innocuous defoliators have severely damaged spruce-fir and mixed-conifer forests across east-central Arizona. Prior to these events, Janet's looper was known only from its taxonomic description, and neither had been recorded as causing any damage in the Southwest. These outbreaks may be associated with warm climate trends or altered forest character. Janet's looper is well distributed throughout the Southwest and California, including northern Arizona, so an outbreak is quite possible. Outbreaks by other previously innocuous species are also likely in northern and east-central Arizona.

Mountain pine beetle was not previously known to occur locally until its first discovery above the Mogollon Rim on the Alpine Ranger District in 2008. Its arrival was documented in association with fresh attacks on several southwestern white pines that had survived the 2007 Chitty Fire. In 2012 it was also found on the Springerville District, and now it is widely active across the Wallow fire area (McMillin and Fitzgibbon, 2008; McMillin, 2009; Anhold, 2012; McMillin and Anhold, 2013). Another example is southern pine beetle, which along with the Mexican pine beetle, damaged almost 12,000 acres of Chihuahua and Apache pine in the Chiricahua Mountains of southern Arizona in 2000. This was the first record of a southern pine beetle outbreak in Arizona, though the species has been known to occur in the State. Southern pine beetle is part of the complex of pine bark beetles in north-central Arizona. Chihuahua pine is regenerating naturally and successfully on harsh sites deforested by the 2002 Rodeo-Chediski Fire. The roles of southern pine and mountain pine beetles in future outbreaks are not yet clear.

Likewise, some native insects appear to be emerging pests by expanding their local activity into additional host tree species. For example, Arizona five-spined ips is usually known to have outbreaks in ponderosa pine stands occurring at low elevations. No prior records of this insect attacking southwestern white pine on the ASNFs were documented before 2012 beetle monitoring visits found this activity inside the Wallow Fire (Anhold, 2012).

### Future Trends

Prevalent pest problems are expected to change as forest structure and species composition and environmental conditions change. These changes may occur naturally and/or as a result of treatments. Many insects and diseases attack specific tree species and sizes or particular parts of trees. If small diameter ponderosa pine continues to be abundant, especially in dense stands, *Ips* outbreaks will especially continue during extended drought periods. If shade-tolerant, fire-intolerant tree species continue to proliferate, so would their pests such as fir engraver, western spruce budworm, and root disease.

Mortality would be elevated during droughts, perhaps dramatically. Based on observations of the recent severe drought, ponderosa pine and piñon mortality during future drought episodes should be greatest at mid- to low-elevations, in areas of poor site quality (e.g., shallow soils, southern aspects) and in high density stands. However, it should be noted that mortality on some of the high risk sites approached 100 percent in the recent outbreaks; therefore, those sites cannot experience the same severity of mortality until tree densities increase to pre-drought levels. During non-drought periods, ponderosa pine and piñon mortality should be higher in stands with high stand density indices and greater dwarf mistletoe infection.

If ponderosa pine forests continue to be dominated by smaller diameter size classes, *Ips* species would probably continue to be of more significance as primary attackers than *Dendroctonus* species. This could be the case on new acres of pine sapling structural states resulting from wildfires. Conversely, recent fuel reduction treatments, large tree retention strategies, aging stands, and proposed burns reduce smaller size classes will shift more average forest size to larger diameter classes, and therefore favor *Dendroctonus* beetle species.

Future regeneration of ponderosa pine in areas burned by large fires and in areas that have incurred substantial bark beetle-related mortality may be subject to tip moth damage, which could be worse than in the past if warming temperature regimes result in a greater number of insect generations occurring per year.

If trends continue toward warmer climate and increasing fire-damage, tree stress will also intensify (Vose et al., 2012; Williams et al., 2012; Seagar et al., 2007). Tip moth and shoot borer prevalence and damage may also increase, particularly in large post-fire tree planting projects. Increases in defoliator populations that favor mild winters may reduce viable cone and seed crops. Drought-related reduced production of cone crops with viable seed is possible, as are more insect attacks to cones and seed. These could cause indirect problems for reforestation potential and wildlife food supplies.

Equally important to wildlife, watershed stability, visual quality, and ecosystem diversity, are healthy aspen clones and aspen communities. All aspen roots depend on plentiful green leaves above ground to produce good food supply for storage as root reserves. Aspen seedling roots do not develop a more stable network until their second year after germination. Newly formed aspen suckers depend on the parent root for nutrients and water (DeByle and Winokur, 1985). When mature aspen trees are replaced by suckers or new seedlings, the root system becomes most vulnerable to mortality by ungulate browsing and other defoliators. An increasing trend of widespread intense sucker browsing has been well documented as killing persistent aspen root systems in about 3 years or less after fire or coppice/clearcutting (Fairweather, 2008 and 2011; Shepperd and Fairweather, 1994; Rolf, 2001).

Aspen are known to readily re-sprout across the Apache-Sitgreaves NFs, both without and with disturbance such as fire and tree cutting. Healthy aspen roots moderately wounded by mechanical injury (either cutting or scraping) can promote this sprout suckering (Fraser et. al., 2004; DeByle and Winokur, 1985-Regeneration chapter). Aspen regenerated prolifically after the 1951 Escudilla Fire and persisted on-site, growing into larger trees until 2011. However, the trend in survival of aspen suckers has been limited across the Apache-Sitgreaves NFs the later portion of the 20th century, as evidenced by a widespread lack of the sucker/sapling and small tree sizes (generally under 8 inches diameter) outside the Wallow Fire burned area. Informal monitoring across the Apache-Sitgreaves NFs the last 15 years has found substantial ungulate browsing of aspen suckers and barking (teething) of aspen trees' photosynthetic bark during winter and spring, when herbaceous forage is unavailable or in a dormant (non-nutritious) state. This occurs when livestock are not on high elevation aspen and conifer forest sites. Given reduced snowfall over the last two decades, wild ungulates such as elk and deer, have been observed remaining on these high elevation sites during winter and spring for many of the last 20 years.

Across the Apache-Sitgreaves and other northern Arizona forests, where ungulates are fenced from aspen or where aspen occurs in very steep or rocky areas, its regeneration is persisting and thriving (Beschta and Ripple, 2010; Rolf, 2001; Shepperd and Fairweather, 1994; Rogers, 2008, 2009, 2011; Stritar et al., 2010). The sucker/sapling age class is re-emerging on many acres post-Wallow Fire, and immediate wild ungulate damage has already been photo-documented in many locations (Rogers, 2011). One factor for aspen decline may be that the primary wild ungulate on the Apache-Sitgreaves NFs today, Rocky Mountain elk, occurs in numbers far greater than the elk once native to the Southwestern USA, Merriam's elk which became extinct by the first half of the 20$^{th}$ century (Thomas and Toweill, 1982). A recent study further links climate to aspen decline (Worrall et al., 2013). Research also indicates that on microsites which burn hot enough to expose and burn aspen roots those sites may be unable to regenerate aspen vegetatively post-fire (Margolis and Farris, 2014).

Sudden aspen decline (SAD) has become a prevalent trend across the Southwest, including on the Apache-Sitgreaves NFs. This phenomenon is more than aspen trees above ground dying in unprecedented numbers; it also includes mortality occurring below-ground of the clonal root system, and insufficient regeneration to replace the overstory losses (Rogers, 2008, 2009, 2011; Zegler et al., 2012). Aspen trees above ground are very easily killed by fire of any intensity. However, this species is adapted to fire because its extensive root system generally has the ability to survive surface heat and, afterward, produce root sprouts (known as suckers) to begin a new, young aspen stand. Documented observations on the Apache-Sitgreaves NFs following wildfires and prescribed burning include: "intensive sucker browsing, sapling girdling and toppling, and mature tree girdling" (Rogers, 2011); residual aspen stands needing to be "protected from further damage from slash pile and prescribed burning since excessive browsing by ungulates, particularly elk, is limiting successful regeneration of aspen" (Fairweather, 2008); and pre-existing clonal roots that were in decline before a wildfire are not producing suckers after the burn (professional observation by Boehning, 2009, page 13). Thus, aspen decline may be contributing to the inability of vulnerable clones to recover from fire with successful aspen recruitment that will survive to reach maturity.

This decline in clonal root system vigor is expected to continue as: conifers on unburned acres continue to dominate aspen clones and weaken them by outcompeting for limited soil moisture in a drying climate; insects, diseases, and localized weather extremes (like unseasonable frost events) cause damage; lack of characteristic fire and/or occurrence of uncharacteristic fire continue; and elk/deer browsing and bark gnawing damage persist on the majority of acres accessible to these ungulates (Rogers, 2008; Beschta and Ripple, 2010;). After visiting several large wildfire areas, including the Wallow Fire, Rogers (2011) states "… conditions that exist today in Northern Arizona's forests, in my professional opinion, constitute the most extreme regional-level denudation of aspen ecosystems anywhere in the West. …These signs indicate a pattern of unsustainable life patterns for whole aspen communities (i.e., not just trees, but dependent flora/fauna.) Without pointed attention, recent opportunities may transgress toward great tragedies for these montane forests."

Large mixed conifer and spruce-fir forest acreages burned across the Alpine and Springerville Ranger Districts in 2003-2007 which had aspen as a major component (Thomas, Steeple, KP, Three-Forks and Chitty wildfires). Most acres of these burns are indicative of moderate severity burns typical in Fire Regime III (see Fire Specialist Report). Field crews working in the KP Fire also reported seeing new aspen seedlings not originating from pre-existing clonal roots, which must have propagated from aspen seed transported in by wind. These are normal aspen regeneration responses desired after burns.

However, approximately 52 acres of new aspen suckers on the 2007 Chitty Fire (Alpine RD) were documented in 2008 and 2009 as being severely browsed by elk and deer. Additionally, a 17-acre portion of an aspen clone in decline before the 2007 Chitty Fire was noted in 2009 as failing to produce any suckers after the burn (on-site professional observations by the USFS Zone Forest Health specialist and District Silviculturist). Prescribed slash pile burning and broadcast fire in heavy fuels loadings on the Springerville ranger district (Hall Ranch WUI analysis) were found to have killed approximately 150 acres of aspen trees, followed by uncontrolled elk browsing of new suckers for 4 consecutive years hence, that apparently resulted in permanent loss of the aspen root system (Fairweather, 2008). These observations are consistent with the findings of Margolis and Farris (2014), who studied post-prescribed-fire aspen regeneration on sites somewhat similar to several very small aspen sites (under 1.25 acres each) scattered across the ASNFs. Their study revealed that the effects of prescribed fire on aspen can be highly variable, and when coupled with varying fire severity and biotic factors like competing vegetation and ungulate browsing, fire may either benefit or hasten the decline of small-sized aspen clones.

Prolific post-Wallow Fire aspen suckering response in 2011-2014 has already been observed receiving wild ungulate browse damage in several areas, especially near permanent waters. Where post-fire aspen suckers have responded in areas too steep, or too choked with logs for elk to reach the new sprouts, these young aspen are expected to have better survival chances. How large an aspen regeneration area must be to survive wild ungulate herd pressures remains as a monitoring need across the Wallow Fire. Installation of permanent monitoring plots is urgently needed, because ungulates browse away the evidence of small aspen sucker/seedling mortality that they cause (Zegler et al., 2012; Fairweather et al., 2014).

Dwarf mistletoe populations would continue to spread and intensify in ponderosa pine and Douglas-fir, further affecting stand character, fire behavior, forest character, and bark beetle vulnerability. Increases in dwarf mistletoe infection would occur where understory trees are exposed to infected overstory trees. Decreases in infection levels would occur in areas exposed to fire, which tends to burn the lower, usually more heavily infected limbs.

Invasive species and emerging pests would continue to present problems, and additional species would establish and become problematic. White pine blister rust would continue to expand into uninfected stands with topkill, branch dieback, and mortality of larger Southwestern white pine on high hazard sites. Continued spruce aphid outbreaks would lead to diminished representation of Engelmann spruce.

## Environmental Consequences of Alternatives

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Because the land management plan does not authorize or mandate any site-specific projects or activities (including ground-disturbing actions) there can be no direct effects. However, there may be implications, or longer term environmental consequences, of managing the forests under this programmatic framework.

Not all conditions that influence insects and diseases can be controlled by treatment actions. Yet even with uncertainty regarding future climate and insect and pathogen activity, general management recommendations for reducing susceptibility and vulnerability to insects and diseases remain the same. These recommendations are namely to improve tree vigor and promote forest health by maintaining natural species, size, age class distributions, and stocking densities. Proposed treatments are intended to restore forest health by incorporating these general management recommendations.

Under **any alternative**, thinning and burning treatments combined would not be implemented on enough acres annually in the first 15 years to improve forest health trends forest-wide. On the acres of ponderosa pine, dry and wet mixed conifer, and spruce-fir PNVTs, an average of 1.7 percent each would be treated annually by **alternative A**, while **alternative B** would treat an annual average of 2.2 percent in each forested PNVT, **alternative C** would treat 3.3 percent in each, and **alternative D** would treat 3.2 percent annually of each type. At year 15, a total average of about 24 percent of each forested PNVT would be treated by **alternative A**, roughly 33 percent treated by **alternative B**, about 49 percent by **alternative C**, and approximately 47 percent by **alternative D**.

In the piñon-juniper PNVT, total thinning and burning treatments would average from just 0.5 percent annually in **alternative A** (under 8 percent total by year 15), to 1.1 percent annually in **alternative B** (under 17 percent by year 15), 1.4 percent annually in **alternative C** (about 21 percent by year 15), and 2.0 percent annually in **alternative D** (about 30 percent by year 15).

All remaining forest and piñon-juniper acreages would be left untreated each year, with generally about a third of each of these PNVTs benefitting from treatments by year 15, **regardless of the alternative**. Thus nature would continue to manage more acres than humans could in this planning period.

Across **all alternatives** and PNVTs, relatively higher than endemic levels of bark beetle and root/butt disease activity and related tree mortality can be expected in the short-term (first cutting and/or burning entry). Even though high stand densities would be reduced and forest structure would move somewhat toward desired conditions, activity-created logging/thinning slash and stumps, prescribed fire-killed snags, and trees stressed by fire treatments would provide temporary increases in food and breeding conditions that could favor more localized bark beetle outbreaks and root rot infection spread. In the long-term (after desired conditions are reached), the rate and severity of bark beetle and root/butt disease attacks would be expected to return to levels within the natural range of variability.

Defoliating insects and dwarf mistletoes could benefit from the conversion from single-storied to multi-storied conditions in the short-term, but if canopies are broken up horizontally with enough openings and interspaces are maintained between tree groups or patches, the effects of defoliating insects and dwarf mistletoe should be minimized in the long-term. Acres impacted by conifer-defoliating insects would be reduced as shade tolerant trees species like white fir and spruce are removed from the dry mixed conifer type. However, defoliators would likely continue their normal pattern of infrequent cyclical population irruptions and crashes in the wet mixed conifer and spruce-fir types. Dwarf mistletoes would persist as long as their host tree species remain, but a lower rate of spread might be possible with appropriate management. Short-term use of even-aged treatments designed to control the spread of dwarf mistletoe on moderately to severely infected acres would temporarily delay attainment of the desired conditions, but may be a necessary first step to ultimately achieve long-term sustainability.

Improved tree vigor on treated acres would generally help trees survive native insect and disease attacks (Reynolds et al., 2013; Evans et al., 2011). If future climatic conditions differ from historic conditions, the long-term restored ecosystem should have greater resiliency to tolerate and/or adapt to such changes (provided enough acres can be restored before uncharacteristic disturbances alter site potential). Under **alternatives D and C**, more forested and woodland acres would be treated (first entry cut or an initial prescribed burn) leading to more vigorous trees than under **alternatives A or B**. In the meantime, current insect and disease trends are expected to continue on the vast majority of acres left untreated each year, and in each cutting cycle, until fully restored to the desired conditions.

## Future Trends for Treated Acres

The following discussions pertain to factors that can be influenced by treatment actions and resulting consequences.

### *Bark Beetles*

Risk of tree mortality due to bark beetles is most highly associated with four forested and woodland conditions that can be controlled by management activities: (1) high stand/forest density causing reduced vigor from intense tree competition; (2) activity-created slash and/or windthrown trees left untreated on-site (Hayes et.al., 2008; DeGomez et.al., 2008) ; (3) high dwarf mistletoe infections; and (4) trees stressed by fire damage (Parker et al., 2006; Fettig et al., 2007; Breece et al., 2008; Kenaly et al., 2008; Youngblood et al., 2009; McMillin and Allen, 2003). Reducing dwarf mistletoe infection and controlling root disease can also reduce tree susceptibility to bark beetles (Hagle, 2004).

High stand densities are correlated with higher beetle activity. Generally a change from higher density to lower density would reduce tree competition and improve tree resistance to bark beetle attack. Threshold basal areas are used in determining bark beetle risk rating, along with amount of host tree species present, and bole diameters most used by certain beetle species. For beetles in dry/warm forested PNVTs like ponderosa pine and dry mixed conifer, the thresholds are lower than for the cold/moist forested PNVTs like wet mixed conifer and spruce-fir, because of differences in tree species shade tolerance.

The following table shows general thresholds for the ASNFs 4 forested PNVTs (McMillin, Appendix C; Munson, 2005.).

**Table 2. Threshold basal areas for bark beetle risk ratings, in square feet per acre**

| Basal Area Density Classes | Ponderosa Pine and Dry Mixed Conifer | Wet Mixed Conifer and Spruce-Fir |
|---|---|---|
| **Low Risk** | <80 | <100 |
| **Moderate Risk** | 80-120 | 100-150 |
| **High Risk** | >120 | >150 |

The USFS Southwestern Region used regional and local Forest Inventory Analysis plot data in the Forest Vegetation Simulator model to compute many biometric variables (e.g. basal area and number of canopy stories) for every vegetation transition state in each forested PNVT (see report Appendix F; and Weisz et al., 2012). When the percentage of each vegetation structural state across the landscape is estimated by the VDDT model for each alternative at a point in time, like at year 15, the percentages of resulting basal area ranges can be tabulated. Using this approach, the following comparisons are made in table 3.

**Table 3. Percent of forested PNVT by bark beetle risk and alternative at the end of the planning period (year 15) compared to existing conditions**

| Forested PNVT | Beetle Risk Rating[2] | Existing Percent[1] | Year 15 Alternative A | Year 15 Alternative B | Year 15 Alternative C | Year 15 Alternative D |
|---|---|---|---|---|---|---|
| Ponderosa Pine[3] | Low | 26 | 20 | 21 | 23 | 19 |
| | Moderate | 20 | 28 | 28 | 32 | 25 |
| | High | 51 | 45 | 43 | 37 | 48 |
| Dry Mixed Conifer[3] | Low | 36 | 15 | 16 | 17 | 18 |
| | Moderate | 2 | 9 | 10 | 11 | 6 |
| | High | 61 | 56 | 44 | 55 | 56 |
| Wet Mixed Conifer[4] | Low | 36 | 5 | 5 | 6 | 7 |
| | Moderate | 10 | 14 | 9 | 9 | 10 |
| | High | 14 | 21 | 24 | 22 | 26 |
| Spruce-Fir[4] | Low | 34 | 5 | 10 | 10 | 11 |
| | Moderate | 0 | 3 | 10 | 10 | 9 |
| | High | 6 | 18 | 15 | 16 | 15 |

[1] Percentages do not add up to 100 due to rounding differences in VDDT model results, and exclusion of model structural states little used by bark beetles.

[2] The risk rating excludes structural states which are least utilized by conifer bark beetles. In the pine and mixed conifer PNVTs, the following states are excluded: seedling/sapling states B and F (<5"diameter). In the wet mixed conifer and spruce-fir states, the following states are excluded: The all size aspen state B, seedling/sapling/small states C, G, L, and P (<10" diameter).

[3] Risk rating based on basal area: low (<80), moderate (80-120), and high (>120)

[4] Risk rating based on basal area: low (<100), moderate (100-150), and high (>150)

As seen in the above table, **all alternatives** would reduce the amount of high risk acres in the ponderosa pine PNVT, with **alternative C** making the most improvement, followed by **alternatives B, A, and D**, respectively. Likewise, **all alternatives** would reduce the amount of high risk acres in the dry mixed conifer PNVT, with **alternative B** making the most improvement, followed by **alternatives C, and then A and D**, respectively. **Alternative D** would consistently retain higher density of larger diameter trees on mechanically-treated acres because of a 16 inch upper diameter cutting limit (although the total blended treatment includes much more prescribed fire on other acres so that the modeled state transitions disguise this).

In the wet mixed conifer and spruce-fir PNVTs, **all alternatives** would increase the beetle risk with higher conifer-dominated densities of trees 10 inch diameter and larger, according to vegetation structural state transitions that result from the treatments modeled. This may be related to the higher densities of larger diameter trees that were retained in modeling to represent compliance with the Mexican spotted owl recovery plan recommendations and desired conditions for protected and recovery nesting/roosting habitats (USDI-FWS, 1995 and 2012; plus see Appendix B5 of this report).

Based on treatment rates and amount of fire used, **alternative C** would have the least bark beetle risk in the short-term (next 15 years and until all acres have received their first entry) followed by **alternatives B, D, and A**, respectively. **Alternative C** could possibly reduce risk the most for all types combined because it would create the highest amount of open canopy forest/woodland using mechanical treatments without using as much fire as the other alternatives. **Alternatives B and D** would also convert many acres to open density, but both would use more fire (especially moderate and/or high severity fire during this planning period) than **alternative C**. **Alternative D** would use the most fire, thereby stressing the most trees to bark beetle susceptibility. **Alternative A** would treat the least acres and use the least fire treatments of all the alternatives.

The **action alternatives** include direction for prompt and appropriate treatment of tree cutting-created slash and the prevention of accelerated windthrow where dense stands are thinned to open the canopy. **Alternative A** provides some direction to prevent bark beetle outbreaks, but it lacks direction on prevention of accelerated windthrow caused by over-cutting.

Acres treated mechanically pose less threat than acres treated by fire because thinning operations should rarely harm residual trees left on-site and slash should be treated afterward. Table 4 shows amounts of burn treatments by fire-severity as modeled for each alternative during the planning period.

**Table 4. Annual prescribed burning average objective acres modeled by forested PNVT (suitable and not suitable timberlands) and by burn severity, for each alternative**

| Forested PNVT | Alternative A Burn Severity | | Alternative B Burn Severity | | Alternative C Burn Severity | | Alternative D Burn Severity | |
|---|---|---|---|---|---|---|---|---|
| | Low | Moderate &/or High | Low | Moderate &/or High | Low | Moderate &/or High | Low | Moderate &/or High |
| Ponderosa Pine | 2,836 | 316 | 2,205 | 4,095 | 1,965 | 3,649 | 4,438 | 8,242 |
| Dry Mixed Conifer | 720 | 80 | 396 | 1,268 | 363 | 1,162 | 805 | 2,576 |
| Wet Mixed Conifer | 855 | 1,047 | 633 | 1,268 | 575 | 1,150 | 1,273 | 2,551 |
| Spruce-Fir | 90 | 10 | 115 | 231 | 164 | 329 | 185 | 370 |
| **Subtotals :** | **4,501** | **1,453** | **3,349** | **6,862** | **3,067** | **6,290** | **6,701** | **13,739** |
| **Totals:** | 5,954 | | 10,211 | | 9,357 | | 20,440 | |

Fire tends to stress residual trees left on-site and the resulting tree mortality can become bark beetle host ("brood") material in 1 to 2 years, usually before it can be salvaged (Youngblood, 2009). Therefore, **alternative D** is expected to create and leave the most snags and untreated windthrow on-site as beetle brood material because it employs the most moderate and/or high severity fire while de-emphasizing mechanical treatments. **Alternatives C, B, and A**, in this order, could create fewer snags, and prevent or salvage more windthrow to reduce risk of activity-created bark beetle outbreaks.

**Alternative D** would also preclude appropriate control of dwarf mistletoe by restricting cutting to trees under 16 inch diameter, thereby leaving heavy infection where it occurs in large, stressed trees more susceptible to bark beetles. **Alternatives A and B** would also leave more infected trees to attract bark beetles than **alternative C**, but less than **alternative D**.

### *Defoliators*

The risk of tree mortality by defoliators is associated most highly with two forest conditions that can be controlled by management activities: (1) high stand/forest density that reduce tree vigor because of intense tree competition and (2) continuous multi-storied canopies that allow these insects free access to the most tree foliage food source at all canopy levels (report Appendix D; Lynch et al., 2010). Defoliators can use host trees of all sizes, especially when they are in very close proximity to many other host species trees, both horizontally and vertically. This means that large, contiguous acreages of high density (closed canopy) structural states which are also multi-storied (ie. uneven-aged) are at greatest risk of successful defoliator outbreaks.

The percent of each forested PNVT in closed canopy, single- or multi-storied structure as a result of proposed treatments in each alternative is displayed below (table 5). (The same methodology is used here as was used for table 3, see Appendix F of this report.)

**Table 5. Percent of forested PNVTs by number of closed canopy levels and alternative at the end of the planning period (year 15) compared to existing conditions**

| Forested PNVT | Canopy Level Class[1] | Existing Percent[2] | Year 15 Alternative A | Year 15 Alternative B | Year 15 Alternative C | Year 15 Alternative D |
|---|---|---|---|---|---|---|
| Ponderosa Pine | Single-storied | 17 | 19 | 16 | 14 | 23 |
| | Multi-storied | 55 | 43 | 44 | 40 | 39 |
| Dry Mixed Conifer | Single-storied | 17 | 13 | 12 | 12 | 18 |
| | Multi-storied | 45 | 61 | 60 | 61 | 58 |
| Wet Mixed Conifer | Single-storied | 2 | 2 | 2 | 2 | 2 |
| | Multi-storied | 50 | 66 | 67 | 67 | 68 |
| Spruce-Fir | Single-storied | 48 | 44 | 36 | 34 | 34 |
| | Multi-storied | 17 | 39 | 38 | 38 | 37 |

[1] In the ponderosa pine and dry mixed conifer PNVTs all closed canopy structural states are included: F, G, H, I, L, M. In the wet mixed conifer and spruce-fir states all closed canopy are included: B, C, D, E, F, L, M, N, O.
[2] Percentages do not add up to 100 due to rounding differences in VDDT model results, and exclusion of model states little used by defoliators.

Ponderosa pine is the only PNVT where **all alternative**s would reduce the amount of closed multi-storied canopy acres. **Alternatives D and C** would create the least closed multi-storied forest structure, with at least a 3 percent advantage over **alternatives A and B**. In both mixed conifer PNVTs and in spruce-fir, where defoliator outbreaks are presently the highest concern, **all alternatives** would increase the amount of closed multiple-storied canopy structure, partly consistent with the desired conditions for more uneven-aged forest. Defoliator risk would remain high, with none of the alternatives standing out as causing the least risk increase because they all rank within 1 to 2 percent of each other. This could be the modeling result of dense aspen regeneration acres post-Wallow Fire, leaving high forest density (150+ basal areas) on Mexican spotted owl habitat acres to represent compliance with the MSO recovery plan, and management toward desired conditions for these types in the VDDT model, without the ability to model horizontal spatial arrangement of the structural states.

Acres impacted by conifer-defoliating insects would be reduced as shade tolerant tree species like white fir and spruce are removed from the dry mixed conifer PNVT. Prescribed cutting selection to reduce off-site shade-tolerant tree species would reduce forest susceptibility to defoliator insects to a greater degree than burning treatments. **Alternative C** would have the greatest ability to remove off-site host trees, followed by **alternatives B, A, and D**, respectively. **Alternative D** would rank lowest in this case because it would restrict cutting to trees less than 16 inches diameter, thereby leaving seed cone-bearing sized, shade-tolerant, and off-site tree species to perpetuate as a food source in the understory over time (Triepke et al., 2011).

As more acres of tree planting (see Forest Products section) occurs after wildfires and/or substantial bark beetle outbreaks, the risk would increase for pine tip moth and similar foliar/bud/shoot insects to easily attack numerous seedlings. **Alternatives C, B, A, and D**, respectively, would rank from highest to lowest with this risk, ranked by fastest to slowest proposed planting rates. This risk could be mitigated for all alternatives at the project level by designing plantations which are not continuously large areas of uniformly-spaced tree species mono-cultures.

### *Aspen Decline and Mortality*

Risk of aspen mortality can be most reduced by: (1) removing conifers to reduce competition with aspen for water and sunlight and thereby improving clone health, restoring root carbohydrate reserves, and extending the lifespan of trees above ground; (2) protecting trees above ground from serious damage by fire, ungulates, and mechanized equipment (Debyle and Winokur, 1985; Fairweather, 2008; Shepperd and Fairweather, 1994; Rolf, 2001; Burns and Honkala, 1990); and (3) protecting shallow lateral root systems that produce suckers from severe heat below ground (Debyle and Winokur, 1985-Fire chapter).

Given the large existing acreages of aspen damage, mortality, and decline the risk of long-term aspen loss would be the least in alternatives which provide the best opportunity for aspen roots to stay healthy. Reducing conifer competition and minimizing pre-mature return of fire to acres already burned would be the most advantageous for long-term aspen tree and root maintenance (Fairweather, 2008; Debyle and Winokur, 1985; St. Clair et al., 2013). According to differences in cutting methods emphasized, the alternatives most able to reduce conifer competition that is overtopping and shading out aspen would be **C** followed by **B**, because these do not utilize a 16-inch diameter cutting limits (cap); then **alternatives A** and **D** would follow based on their respective use of that diameter cap[1]. Moreover under all alternatives, all sites either deferred from cutting, or treated to retain high basal area of large trees representing compliance with the Mexican spotted owl recovery plan, would not be successful in maintaining the aspen tree component on those forested acres.

Debyle and Winokur (1985-Fire chapter) state that due to the high sensitivity of this tree species to any fire intensity, especially that of young trees, repeated prescribed fires would be a viable tool for eliminating aspen from a site. St. Clair et al. (2013) stress there must be a balance between using fire often enough to reduce conifer competition, but without fire return intervals so short that young aspen cannot successfully mature. Margolis and Farris (2014) found that use of prescribed fire without post-burn ungulate protection (from mule deer in their case) can hasten the decline of very small aspen clones, under 1.25 acres in size. Loss of such clones might further lead to reduced genetic diversity of the aspen population across a landscape. Those alternatives which were modeled to use the least return of fire during the planning period at any severity level

[1] Alternative A (1987 forest plan) does not specify a 16-inch diameter cap. However, this diameter cap has been used as a treatment in recent and current vegetation management, consistent with the Community Wildfire Protection Plans developed for the ASNFs in Apache, Navajo, Coconino and Greenlee Counties (see the Forest Products Specialist Report bibliography).

across the landscape would maintain the most existing young and immature aspen above ground, ranked in this order: **alternative A**, followed by **C**, then **B**, then **D**. Where effective means of post-fire protection from ungulate damage might be employed successfully, then this order may be reversed. Where acres of mature/over-mature aspen are in need of renewal, **any of the action alternatives** would focus enough emphasis on using fire to accomplish this first restoration step in the short-term. Yet without the immediately necessary follow-up step of protecting the new aspen regeneration (from either return fire or ungulates), long-term aspen recruitment would not be successful on all acres desired.

Remaining aspen already in decline (perhaps as much as 35 percent of mature aspen acres, per surveys reported in Lynch et al., 2010) that are intentionally burned by moderate and/or high severity fire in the next 15 years may not recover long-term if the root systems are already weakened so that sucker production is inadequate and/or unable to withstand repetitive ungulate browsing (Fairweather, 2008). In this case, **alternative D** would pose the greatest threat to aspen sustainability based on the amounts of moderate and/or high severity fire treatments proposed annually, followed by **alternatives B, C, and A**.

The **action alternatives** (i.e. the revised plan) would provide the following management direction items, which are all updated improvements over the aspen direction in **alternative A:** aspen desired conditions, an objective, management approach, and at least one guideline (discouraging new surface water developments in close proximity to aspen stands). This guideline could help reduce ungulate browsing pressure on aspen. **These alternatives** also provide other guidance for aspen which could provide comparable results to the guidance in **alternative A.** Additionally, **Alternatives B, C, and D** would recommend the Corduroy Research Natural Area (3,350 acres) as a study area to test various treatment methods for aspen protection, maintenance and restoration, and elk impacts in the absence of livestock. This could add to the knowledge-base for managing aspen. **Alternative A** does not recommend this research natural area and would not provide additional information to help manage aspen.

### *Persistent Diseases*

Dwarf mistletoes and root/butt/stem decay diseases would persist under **all alternatives**. The risk of spread to more trees or acres for both types of pathogens is most highly associated with: (1) the absence of alternate non-host tree species within and around infection centers and (2) the absence of large canopy gaps/openings in the forest (Conklin and Fairweather, 2010; Hagle, 2004).

Due to the less predictable nature of fire (including prescribed fire, especially at moderate and high burn severity used during this planning period) those alternatives which would employ more tree cutting may have more control in selecting the right mix of non-host tree species and/or spacing arrangement to prevent further disease spread. **Alternative C**, followed by **alternatives B, A, and D**, respectively, would have the highest potential to minimize the spread of persistent diseases.

Dwarf mistletoe disease spread to more host trees would occur where understory trees are exposed to infected overstory trees. This condition would exist on all infected acres with a multi-storied vertical structure. **Alternative D** would restrict all cuts on all acres to stay under a 16-inch diameter limit, which would leave all infected overstory trees that would spread infection to nearby understory trees. Based on current management trends, **alternative A** would continue to use diameter limit cuts (diameter caps) on some acres to a lesser extent, even though the 1987 plan provides the most direction to control dwarf mistletoe. **Alternatives B** and **C** do not propose diameter caps, and the proposed plan (**alternative B**) has some focus on treating mistletoe. **Alternative C** would most emphasize using aggressive sanitation and/or even-aged cuts for removal of infected overstory trees where needed to maintain the un-infected small and medium size classes underneath or nearby. In this case, short-term use of even-aged treatments designed to control the spread of dwarf mistletoe on moderately to severely infected acres would temporarily delay attainment of desired conditions, yet may be a necessary first step to ultimately achieve long-term sustainability.

The potential for dwarf mistletoe to intensify infection levels within the same host trees (causing growth loss and mortality) would be reduced by removal of lower limbs (which are often the most highly infected). Mechanized tree cutting activities rarely involve pruning lower limbs because it is time consuming and expensive. Prescribed fire has shown some promise at reducing tree infection levels by killing the lower limbs (Conklin and Geils, 2008). With this consideration, alternatives which treat the most acres with fire in combination with sanitation cuts, that would remove the most infected trees of all sizes, could be most successful at overall control in this order: **alternative B,** followed by **alternatives C, A, and D**, respectively.

Those alternatives which most reduce dwarf mistletoe infection would similarly reduce susceptibility to bark beetle attack (see bark beetle sections of this report).

Root diseases could increase nearly equally in **all alternatives** because cutting, as well as burning, would be used to treat acres, leaving new stumps that could become a food source for these diseases. Low-moderate intensity burning would do little to kill root diseases. However, root disease spread could be slowed by the presence of non-host trees (Worrall et al., 2010; Hagle, 2004). In this order, **Alternatives C** and **B** are designed to use more methods of cut with control over leaving alternate non-host tree species inside root disease infection centers; and **alternatives A** and **D** would have the least control for this purpose.

White pine blister rust is now a persistent pathogen on the Apache-Sitgreaves NFs. Its control will depend most on keeping as many healthy white pines as possible across the landscape to ensure an abundance of genetically-diverse individuals and trees groups (Conklin et al., 2009). Because many local populations of southwestern white pine were killed by the Wallow Fire before seed could be collected from them, genetic diversity has already been greatly reduced. Remaining genetic diversity might still provide a blister rust-resistant seed source that could be used to replace lost trees where desired. The consequence of individual alternatives upon the rust's alternate*Ribes* host is not yet possible to predict. Alternatives that would use the most burning and diameter limit cuts could indiscriminately remove critically important healthy white pines and leave unhealthy ones. **Alternative C**, followed by **alternatives B, A, and D**, respectively, would have the greatest tree selection control to leave the healthiest remaining white pines.

### *Susceptibility to Additional Invasive Pests*

Introduced invasive (exotic) insects/diseases could have an outbreak independent of movement toward desired conditions under **any alternative.** However, forested lands and woodlands most in balance (least departed from historic reference conditions) with respect to horizontal and vertical structure, native vegetation species composition and genetic diversity, soil and watershed stability, and natural disturbance patterns should be the most vigorous and resilient to threats from new invasive species. The alternatives which would move the four forested PNVTs and the piñon-juniper PNVT closest to desired conditions in the next 15 years are expected to help minimize that threat. **Alternative C** would provide the most resilience to invasive pests, followed by **alternatives B, D, and A**, respectively.

### Future Trends for Untreated Acres

Current and future insect and disease trends described earlier are expected to continue on the vast majority of acres left untreated each year, and in each cutting cycle, until these acres are fully restored to the desired conditions. Contemporary trends underway on undisturbed acres differ enough from historic trends to permit anticipation of altered ecosystem processes where the benefits of treatment are delayed from occurring as needed. The occurrence of uncharacteristic vegetation densities, drought, and warm climate has increased the forests vulnerability to herbivorous insects, especially bark beetles. Consequently, there is potential for catastrophic insect outbreaks to continue, but it is difficult to characterize the risks in a temporal framework of 10 to 20 years per Lynch et al. (2010). There is more uncertainty regarding future insect outbreaks than the past record indicates. In the current period of ecological change, additional large-scale insect disturbances are expected, though the details of those events cannot be well predicted.

Other than the continued spread and intensification of dwarf mistletoe infestations, it is harder to predict pathogen response to climate change and altered forest composition and fire regimes than insect population responses. Additionally, there is great uncertainty regarding the potential effects of invasive insect and pathogen species (e.g., spruce aphid and white pine blister rust), and the effects of non-native invasive plants on forest disturbance regimes, including insect and pathogen outbreaks, are also unknown.

Under each alternative, the insect and disease trends described are expected to continue and possibly increase in proportion to the acres left untreated each year and decade. As stated previously, average treatment rates for **alternatives A and B** would result in the least amount of acres restored annually. Therefore, the affected environment trends and uncertainties would continue to be greatest under these two alternatives. **Alternatives C and D** would have greater potential to treat more acres annually, and thus, they would result in lower insect and disease risks. Based strictly on expected treatment rates and relative amounts of annual untreated acres, **alternative A** would have the highest potential for insect and disease outbreaks, followed by **alternatives B, D, and C** respectively in the four forested PNVTs. This same order would also represent risk in the piñon-juniper woodland PNVT, with the exception that **alternatives D** and **C** ranking would be reversed.

As more acres of natural conifer regeneration (see Forest Products Specialist Report) occur after wildfires and/or substantial bark beetle outbreaks, the risk would increase under **all alternatives** for pine tip moth and similar foliar/bud/shoot insects to easily attack numerous seedlings. Survival of young trees shorter than 6 feet tall could be jeopardized, especially during drought years.

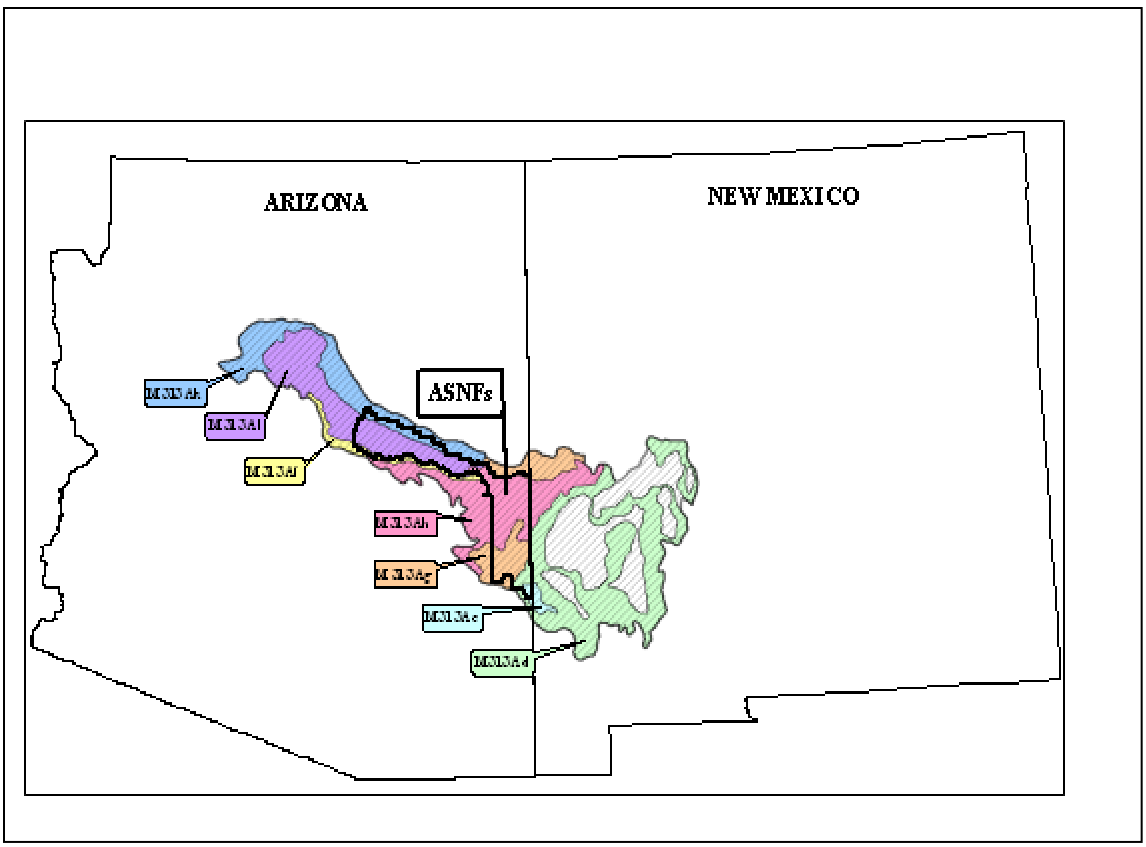
## Cumulative Environmental Consequences

The area boundary considered for this level of analysis of Forest Health is the White Mountains-San Francisco Peaks-Mogollon Rim M313A Ecoregion Section and the seven subsections on which it occurs. (Refer to the Vegetation Specialist Report for more information about this region.) The total area encompasses approximately 13,474,691acres. The ASNFs occupy 15% of that total area. This area was chosen because it surrounds the Apache-Sitgreaves on all sides with many of the same forested and woodland PNVTs that occur here. Moreover, forest health issues and insect/disease agents on all federal lands within it are familiar to the USFS Region-3 zoned Forest Health Protection entomology and pathology specialists.

Ecoregion M313A acres on adjacent National Forests include: most of the Coconino NF, portions of the Tonto NF and Prescott NF, the south Kaibab NF, all of the Gila NF and portions of the Cibola NF in New Mexico. Non-Forest Service ownerships also include BLM, AZ State, NM State, portions of the White Mountain and San Carlos Apache Reservations, other tribal lands in NM, and private lands.

Map 5 below displays the ASNFs in context to the land areas of the White Mountains-San Francisco Peaks-Mogollon Rim M313A ecoregion section (cross-hatched area) and the seven subsections in which it occurs, and the ecoregion section in context within Arizona and New Mexico. Following is the identification of the seven subsections: M313Ac = Burro Mountains Oak-Juniper Woodland; M313Ad = Mogollon Mountains Woodland; M313Af = White Mountains Scarp Woodland-Coniferous Forest; M313Ag = White Mountains Woodland; M313Ah = White Mountains Coniferous Forest; M313Ak = Coconino Plateau Woodland; and M313Al = Coconino Plateau Coniferous Forest.

**Map 5. ASNFs in context to the land areas of the White Mountains-San Francisco Peaks-Mogollon Rim M313A ecoregion**



Insect-disease conditions on the adjacent Fort Apache Indian Reservation are included in the report by Lynch et al. (2010). The annual insect/disease surveys and conditions reports provide accounts of damage that occurred each year, or since approximately the same time the previous year. They do not, however, retain much cumulative information. Maps have not been retained for Conditions Reports prior to approximately 1975. Therefore, these data cannot be used to determine how much total area was impacted during the course of an outbreak (Lynch et al., 2010).

Insect outbreaks typically start in one or more places and spread in subsequent years to additional areas. Some of the same areas are damaged repeatedly one year after another, some new areas may be damaged each year, and some areas may no longer be attacked later in the outbreak. Persistent diseases have the potential to spread to or from adjacent ownerships wherever the same host tree species are present.

Past forest and woodland management approaches (e.g., fire suppression and lack of thinning) have given rise to a surplus of trees that may continue to dominate untreated areas for many more years across the Apache-Sitgreaves NFs and adjacent lands. Recent past and present forest and woodland management actions on national forest, private, and State lands have been mostly focused on reducing immediate fire hazard, rather than complete restoration toward reference conditions. Insect and disease outbreak trends, similar to those on the Apache-Sitgreaves NFs and across the Southwest, may be found across the ecoregion.

Future forest/woodland management strategies across all other national forests within the ecoregion are expected to be similar to those proposed for the Apache-Sitgreaves NFs. They are revising their land management plans or intend to revise their plans in the near future. The other national forests and the Apache-Sitgreaves NFs would use similar desired conditions for the forested and woodland PNVTs, with uneven-aged silviculture and the return of fire and other natural disturbances to their natural roles. Similar conditions for insects and diseases could be expected to result. However, more thinning slash and fire-killed trees created concurrently by management actions on all adjacent ownerships could lead to an additive risk of larger scale bark beetle outbreaks across the ecoregion than ever seen before. Treatment timing and coordination, with proper slash management (DeGomez et al., 2008; Fettig et.al., 2006; Munson, 2005), would need to occur across all ownerships to help prevent such a result.

Due to multiple ongoing bark beetle and defoliator outbreaks, the current scale and extent of dead and dying trees on both ownerships of Mount Baldy (Fort Apache Indian Reservation and Apache-Sitgreaves NFs) predispose it to a large, stand-replacement wildfire event, particularly inside the wilderness. **None of the alternatives** proposed would likely be able to prevent such a wildfire event, given that the spruce-fir PNVT dominating the area is an infrequent-high intensity fire regime, and Mount Baldy is due for such an event. A wildfire ignited on the Fort Apache side of the mountain could easily burn onto the Forest Service side by prevailing winds. Such a fire would virtually eliminate all the insect and disease problems present, simply by removing nearly all host tree species across many acres. Widespread, even-aged forest conditions would result with subsequent artificial and/or natural reforestation expected to occur on both ownerships.

**Alternative C** would emphasize more thinning treatments in the dominant wet mixed conifer and spruce-fir PNVTs than the **other alternatives,** which could be done outside the Mount Baldy Wilderness boundary. (That green tree thinning would be analyzed under the revised forest plan.) This could break up the remaining continuous forest and fuel loadings enough that such a wildfire event may not affect the entire watershed in every direction simultaneously, and thus reburn or threaten more national forest acres not yet restored to the north, east, and northeast of Mt. Baldy.

This ecoregion has several known infection centers of white pine blister rust attacking southwestern white pines. The first located occurrences of the blister rust in Arizona were found on the Fort Apache (White Mountain) Indian Reservation in 2009, and also on the ASNFs in 2009 (personal knowledge and Fairweather, 2009). Infections were first found on the Gila NF adjacent to the AZ border in 2005. Future discovery of trees potentially resistant to white pine blister rust-resistant could contribute to tree seed tree orchards for a long-term rust resistance reforestation program; the perpetuation of this ecologically vital tree species is urgently needed (Conklin et al., 2009). On the Fort Apache Indian Reservation, the Bureau of Indian Affairs is cutting every white pine tree with observed blister rust infection (Fairweather, 2011). The 2011 Wallow wildfire also burned onto portions of both those adjacent ownerships, but its impact to southwestern white pine there is not yet known. This makes the need more critical to preserve the remaining local species population gene pool on the Apache-Sitgreaves NFs. The **action alternatives** contain direction to protect white pines for this purpose, while **alternative A** does not.

The Four Forests Restoration Initiative (refer to the Forest Products Specialist Report for further description) proposed projects on adjacent National Forest lands in Arizona are expected to produce similar results with respect to insects and diseases because they would generally treat toward similar desired conditions.

## Unavoidable Adverse Environmental Consequences

The proposed plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Therefore, decisions made in the proposed plan do not cause unavoidable adverse environmental consequences. The application of standards and guidelines during future project and activity decision-making would provide resource protection measures and would limit the extent and duration of any adverse environmental impacts.

## Irreversible and Irretrievable Commitment of Resources

Irreversible commitments of resources are those that cannot be regained, such as the extinction of a species or the removal of mined ore. Irretrievable commitments are those lost for a period, but could be regained, such as the temporary loss of timber productivity in forested areas kept clear for use as a power line rights-of-way or road.

Because the proposed plan does not directly authorize or mandate any site-specific project or activity (including ground-disturbing actions), none of the alternatives cause an irreversible or irretrievable commitment of resources. Future project-level decisions under any of the alternatives may result in potential irreversible or irretrievable commitments of resources, which would be disclosed accordingly with the project site-specific analysis.

## Adaptive Management

Desired conditions for healthy vegetation communities on the Apache-Sitgreaves NFs include resilience to dramatic changes caused by abiotic and biotic stressors and mortality agents (e.g., pine beetles), and a balanced supply of essential resources (e.g., light, moisture, nutrients, growing space). Insects and diseases typically invade in cycles followed by periods of relative inactivity. Vulnerabilities to forest threats from an environment that may be much different from the historic range of natural variability is an active area of research, and includes developing new management approaches for changing conditions. The action alternatives provide an adaptive framework to deal with impacts from climate change, by placing emphasis on managing toward resilient and redundant resource conditions to provide reasonable assurance of the ability to adapt to a changing climate.

## Other Planning Efforts

No potential conflicts are anticipated between the proposed action and the objectives of Federal, regional, State, local, or Tribal land use plans, policies, and controls for the area concerned, with respect to forest health.

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## Appendices – Forest Health

Due to the size and nature of these appendices, they are available in the Plan set of documents as separate electronic files. They are listed below as an index.

**Appendix A:** Lynch et al., Feb. (15) 2010. Forest insect and disease activity on the Apache-Sitgreaves N.F., and Fort Apache Indian Reservation, 1918-2009: Report for the Apache-Sitgreaves N.F./Regional Analysis Team. (40 page **.pdf** doc.)

***Appendix B1*****:** Surrogate Methods of Prescribed Cut and/or Burn Adopted by USFS Region-3 in the R3 FVS Process for Evaluating the Effects of Vegetation Management Activities in the Forest Plan Revision Process. By M. Boehning/Region-3, finalized Aug. 1, 2014. (11 page **.pdf** doc.) *(Identical document to Appendix B1 already on file for the Forest Products Specialist Report.)*

***Appendix B2*****:** Silvicultural Rationale for Different Timber Management Approaches and Cutting Mixes by Each ASNFs Alternative for Modeling in VDDT. By M. Boehning, March 15, 2012. (5 page **.pdf** doc.) *(Identical document to Appendix B2 already on file for the Forest Products Specialist Report.)*

***Appendix B3*****:** Sample PNVT Percentages of Surplus and Deficit Structural States on the ASNFs, Differences between Current and Desired Conditions. By M. White and USFS Region-3 (2 page **.pdf** doc/diagram, using PPF PNVT as an example.) Feb. 6, 2012. *(Identical document to Appendix B3 already on file for the Forest Products Specialist Report.)*

***Appendix B4*****:** USFS Region-3 FVS Model Prescribed Treatment Resulting State Transitions for Calibrating VDDT. By Region-3 Plan Revision Timber Working Group. Assembled for display by M. Boehning, 5/6/12. (Excel spreadsheet with a “Read-Me” tab and 5 large worksheet tables.) *(Identical document to Appendix B4 already on file for the Forest Products Specialist Report.)*

***Appendix B5*****:** Apache-Sitgreaves NFs Silviculture Tree Cutting and Planting Prescriptions to Model in VDDT – prepared by Alternative, PNVT, Suitable and Non-suitable timberlands, Hi and Low treatment objectives, by M.Boehning, completed Feb. 21, 2012. (Four **.pdf** docs of 60 total colored tables assembled and labeled by each Alternative.) *(Identical document to Appendix B5 already on file for the Forest Products Specialist Report.)*

**Appendix C**: Email correspondence between AZ Zone Entomologist and Forest Silviculturist, regarding bark beetle risk measures and indicators. By J. McMillin and M.Boehning, March 25, 2010. (2 page **.pdf** doc.)

**Appendix D:** Email correspondence between AZ Zone Entomologist and Forest Silviculturist, regarding defoliating insect measures and indicators. By R. Hanavan and M. Boehning, March 25, 2010. (2 page **.pdf** doc.)

***Appendix E1*****:** Acreages of treatment methods modeled in VDDT, by alternative. By ASNFs Plan Revision Team, M.Boehning, and M. Davalos. Updated 5/1/12. (1 large Excel spreadsheet) *(Identical document to Appendix E1 already on file for the Forest Products Specialist Report.)*

***Appendix E2*****:** Acres by treatment type used to model the low and high annual treatment objectives in VDDT. By ASNFs Plan Revision Team and M. Davalos, May 26, 2012. (4 page **.pdf** table) *(Identical document to Appendix E2 already on file for the Forest Products Specialist Report.)*

**Appendix F:** Methodology of forest basal area ranges determined for bark beetle risk analysis, and number of canopy stories determined for defoliator risk analysis. Narrative, tables and spreadsheets by M. Boehning, May 30, 2012. (23 page **.pdf** doc = 3 pages text + 14 large color tables)

***Appendix G:*** Sample USFS Region-3 FVS model results of pre-cut, harvest, and post-cut tree species composition changes for the Free Thinning, Diameter Cap, and Group Selection cutting methods used in VDDT (using the Dry Mixed Conifer PNVT, veg. structural state I as one example.) FVS Model runs done by Region-3 in 2010-2011. Results of 3 simulations assembled for display by M.Boehning in May (15), 2012. (16 page **.pdf** doc. of FVS stand output tables with color emphasis added.) *(Identical document to Appendix G already on file for the Forest Products Specialist Report.)*

**Appendix H:**.Comparison of cutting methods with respect to dwarf mistletoe control and host species retention. Includes 3 sample tables of USFS Region-3 FVS model results of FIA plot pre-cut and post-cut infection control results, using the Dwarf Mistletoe Awareness Indicator (DMAI) and related data. (Excel spreadsheet with a 1-page “Read-Me” tab; a 2-page narrative tab by D. Vandendreische dated 8/3/2010; and three 11”x17” size spreadsheet tabs of data and illustrations. Compiled by M.Boehning on 11/16/12 for display.)