# FOREST MANAGEMENT PLAN

Resilient Landscapes
Fire Adapted Communities
Safe and Effective Wildfire Response

**Original Version - September 2009**

**Updated Version – November 2024**

**Flagstaff Fire Department**
**Wildland Fire Management**
211 W. Aspen
Flagstaff AZ 86001
(928) 213-2500

***www.flagstaff.az.gov/wildlandfire***

# Contents

## INTENT

The intent of this plan is to provide generalized guidance in planning and implementing forest treatments to achieve a Desired Future Condition of our forest that is focused on enhancing community well-being by:

1. Protecting the community from undesirable wildfire by mitigating or reducing hazards.
2. Ensuring forest sustainability by improving long-term forest health, and maintaining wildlife habitat, native plant diversity, carbon storage, recreational opportunities, and other natural benefits of the forest.
3. Providing standardized resource management guidance to the customers we service.
4. Permitting consistent implementation standards for all forest management activities within the community.

## RELATED AUTHORITIES

1. As adopted by City Council:
    a. Flagstaff Wildland Urban Interface Code (WUI Code)
    b. Greater Flagstaff Area Community Wildfire Protection Plan (CWPP)
    c. Flagstaff Zoning Code
2. FFD Fire Prevention Supplementary Regulations and Procedures

## RESPONSIBILITY

Program management rests with the Flagstaff Fire Department's Wildland Fire Management Division.

## INFLUENCING FACTORS

Partnership initiatives have influenced development and use of these Guidelines:

1) Flagstaff Watershed Protection Project
2) Coconino National Forest Land and Resource Management Plan
3) National Cohesive Wildland Fire Management Strategy
4) The Ecological Restoration Institute at Northern Arizona University
5) Greater Flagstaff Forests Partnership
6) City of Flagstaff Carbon Neutrality Plan
7) National Fire Protection Association Firewise USA
8) USFS Wildfire Crisis Strategy

## BACKGROUND

Flagstaff, Arizona is surrounded by the largest continuous ponderosa pine forest in the world. It is flanked by sacred peaks and canyons. The ponderosa pine forests of northern Arizona have existed for thousands of years and evolved to benefit from frequent fires ignited by both seasonal monsoonal weather patterns and cultural burning practices. Unfortunately, more than a century of management based on excluding cultural burning and suppressing lightning-based ignitions has left the forest in an altered condition. These changes threaten Flagstaff's natural resources, economy, built environment, water resources,

municipal infrastructure, and quality of life.

Ponderosa pine forests are extremely well adapted to, and dependent upon, frequent low-intensity wildfires, but they are extremely vulnerable to high intensity fire events. Unnatural fuel accumulations, exacerbated by insect, disease, warming and drought, have resulted in an alarming increase in the frequency of undesirable wildfires.

Catastrophic wildfire is the #1 fire threat to Flagstaff. We experience 60-100 wildfires per year within the city boundaries, and another 150+ on jurisdictions immediately surrounding our community. In addition to serious ecosystem damage, a single undesirable fire moving into the city will most-assuredly affect lives and properties, and inflict serious, and long term, economic harm.

Three factors influence fire behavior: weather, topography, and fuels. Of these, only fuel can be readily manipulated: Hazard mitigation activities, undertaken in a responsible manner and throughout the general area, are vital to ecosystem health and community protection.

Such activities are not meant to eliminate wildfire from the landscape. More than a century of wildfire suppression has demonstrated conclusively the fallacy of such efforts. Frequent, low intensity fire is required for a healthy ponderosa pine ecosystem. These fires do not pose a community wide threat. Reintroduction of such fires requires the re-creation of a natural environment that will burn in a healthy, nonthreatening, manner, and a built environment that properly considers science based defensible space and home hardening strategies.

# COMMUNITY OVERVIEW

## Applicability

This plan covers all lands within the city limits of Flagstaff. This plan may be used to provide guidelines and objectives to facilitate both planning and implementation of forest treatments across jurisdictional boundaries. This plan also assists in the preparation of natural resource protection plans as required by the City of Flagstaff Zoning Code.

## General Area

Flagstaff is the largest metropolitan community within northern AZ. Located at the base of the San Francisco Peaks, a 12,633’ dormant volcano, the community is bisected by Interstate 40 and Interstate 17: Highway 180 extends to the northwest of town and highway 89 extends to the northeast, highway 89A extends south through Sedona.

## Description

1. **Acreage:** This plan covers approximately 64 square miles (42.2K acres) within City corporate boundaries. The City of Flagstaff manages 3,321 acres of designated open space.

2. **Elevation:** Elevation in Flagstaff averages 6,900 feet.

3. **Slope:** Slope gradient varies on individual properties, but generally slopes to the south away from the San Francisco Peaks.

4. **Aspect:** Aspect is generally to south facing but varies on individual properties.

5. **Physical Characteristics:** Flagstaff has a varied topography consisting of ridges,

hilltops, plateaus, and canyons. Two major washes, the Rio de Flag and Sinclair wash, run through Flagstaff and typically flow after fall monsoon rains and spring snow melt. Special features of Flagstaff include Observatory Mesa on the west side of town and Switzer Mesa and McMillan Mesa to the east.

6. **Climate:** Chilly winters with cool, mild summers are the norm. Humidity is moderate, and large daily temperature fluctuations are common. Annual precipitation is around 20 inches, half of which occurs as snow (Dec - Mar) and half as summer rains (July - Sept). May and June are usually very dry. The last killing frost of the year is usually around June 15th, with the first around Sept 1st.

7. **Forest History:** The forests around Flagstaff have been and will continue to be influenced by the interactions of humans with the land.

   Extensive railroad logging occurred in-and-around Flagstaff from 1880 - 1930. Large tree timber harvesting continued into the 1990's. Throughout the general area, it is estimated that as much as 80% of the merchantable volume was removed during these operations.

   Indicators of the decline in forest health are evident in the considerable decrease in soil moisture and nutrient availability, the decrease in over-story and under-story species diversity, an increased occurrence of damaging insect and diseases, increased large tree mortality and an increase in the size and severity of destructive wildfires.

8. **Surrounding Land-Use:** Flagstaff is predominantly surrounded by the Coconino National Forest. A checkerboard of State lands is interspersed to the southwest of town with several State parcels located directly to the east.

   Camp Navajo Army Depot (28,347 acres) is located approximately 10 miles west of Flagstaff on Interstate 40. National Park lands are located to the east (Walnut Canyon National Monument) and to the Northeast (Sunset Crater Volcano and Wupatki National Monuments).

# ECOSYSTEM DESCRIPTION

## General

Research has well established that before European settlement, southwestern ponderosa pine forests contained larger trees scattered throughout an open landscape. "Until the 1870's light surface fires every two to five years, along with grass competition and regular drought, maintained an open and park-like landscape dominated by grass, forbs, and shrubs with scattered groups of ponderosa pine" (Covington et al. 1997).

Following Euro-American settlement heavy grazing, fire suppression, cultural burning exclusion, logging and climatic events favoring regeneration of pine trees. This changed the natural park-like conditions to a more even aged, closed canopy structure and pattern. As a result of increased in-growth, ponderosa pine has increased dramatically in trees per acre (TPA) and total basal area (BA).

Top: Walker Lake 1875 taken by John Hillers

Bottom: Walker Lake 2004 taken by Neil Weintraub

The public's "forest paradigm" has undergone a major shift over the last 25 years. A growing realization that dense forests are susceptible to disease, insect, drought, and fire have resulted in widespread acceptance of well-planned and executed forest treatments designed to counter the current downward spiral.

## Current Conditions

Results from a study in the Ft. Valley area north of Flagstaff (Table 1), shows that ponderosa pine increased from 22.8 trees per acre in 1876 to 1,253.5 trees per acre in 1992 (Covington et al. 1997).

This influx of small diameter trees from several dominant cohorts produced the continuous canopy cover that we see today. In 1876, 19% of the surface area was under pine canopy, with the balance (81%) representing grassy openings. In 1992 pine canopy covered 93% of the area with only 7% left in grassy openings.

Depending upon site conditions, some areas in and around Flagstaff have seen much greater growth of small pines than depicted in this single study, greatly affecting fire behavior and under-story plant diversity.

Table 1. Data extrapolated from a study in the Ft. Valley area illustrating the change in Ponderosa pine trees per acre and basal (1876 to 1992).

| DBH class (in) | Trees per acre 1876 | Trees per acre 1992 | BA per acre 1876 | BA per acre 1992 |
|---|---|---|---|---|
| 0-4 | 0.9 | 945 | 0.0 | 20.6 |
| 4-8 | 2.6 | 243 | 0.5 | 47.7 |

| | | | | |
|---|---|---|---|---|
| **8-12** | **2.8** | **46** | **1.5** | **25.1** |
| **12-16** | **3.6** | **6.7** | **3.8** | **7.2** |
| **16-20** | **5.1** | **1.6** | **9.0** | **2.8** |
| **20-24** | **3.7** | **2.5** | **9.8** | **6.6** |
| **24-28** | **3.2** | **2.4** | **11.8** | **8.8** |
| **28-32** | **1.2** | **4.1** | **5.9** | **20.1** |
| **32-36** | **0.4** | **1.7** | **2.5** | **10.7** |
| **36-40** | **0.6** | **0.3** | **4.7** | **2.4** |
| **40-44** | **0.3** | **0.2** | **2.9** | **1.9** |
| **Total** | **24.6** | **1253.5** | **52.5** | **154.0** |

## Vegetation

The over-story of the Flagstaff's forest is predominantly Ponderosa pine (*Pinus ponderosa* P. & C. Lawson var. *scopulorum* Engelm.). Ponderosa pine is naturally found in pure, uneven aged stands or intermixed with Gambel oak (*Quercus gambelii* Nutt. Var. *gambelii*). Gambel oak is typically found in clumps within canopy openings or as a co-dominant on rocky slopes. Alligator juniper (*Juniperus deppeana* Steud.) and Rocky Mountain juniper (*Juniperus scapulorum* Sarg.) are found sporadically throughout the forest. Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco var. *glauca* (Beissn.) Franco), and quaking aspen (*Populus tremuloides* Michx.), are located in small patches mostly in and around drainages and slopes.

Many under-story plants species are found in the forest. The most dominant grass species in the area include blue grama (*Bouteloua gracilis*), bottlebush squirreltail, (*Elymus elymoides* (Raf.) Swezey), Arizona fescue, (*arizonica* Vasey), and mountain muhly (*Muhlenbergia montana* (Nutt.) A.S. Hitchc.).

Forbaceous species include broom snakeweed (*Gutierrezia sarothrae* (Pursh) Britt. & Rusby), spreading fleabane (*Erigeron divergens* Torr. & Gray), ragleaf bahia (Bahia disecta (Gray) Britt.), and silvery lupine (*Lupinus argenteus* Pursh). Common shrubs include rabbitbrush, (*Ericameria nauseosa* (Pallas ex Pursh) Nesom & Baird), New Mexico locust, (*Robinia neomexicana* Gray).

## Insect and Disease

Southwestern Ponderosa Pine Dwarf Mistletoe (DM), a native parasitic plant, and is the most widely found disease agent in southwestern ponderosa pine forests. Throughout the southwest, it is estimated that over 1/3 of the total ponderosa pine acreage is infected.

Bark beetle activity is increasing throughout the southwest. Three species are of prime concern in this particular area. They are Western Pine Beetle (WPB), Ips Engraver Beetle (IEB), and Red Turpentine Beetle (RTB). Two other species may also be evident on a periodic basis: Roundheaded Pine Beetle (RBP) and Mountain Pine Beetle (MPB).

It should be noted that dense, overcrowded stands of ponderosa pine provide ideal conditions for development of large populations of DM, WPB, IEB, RTB, RPB, and MPB.

## Soils

In general, the soils in this area are sedimentary derived or volcanic derived. Parent material may be of a basaltic origin, though limestone regions and cinder regions of restricted extent

are found. They are generally shallow, well-drained with bedrock below 18 inches of the surface. Permeability is moderate, shrink-swell potential is low - moderate, and both compaction potential and erosion hazard is low. The soil is neutral to mildly alkaline.

### Wildlife

Wildlife is a desirable and indispensable part of forest ecosystems and must be considered when managing the forests around Flagstaff (Barnes et al. 1998). Flagstaff and the surrounding area are recognized for their natural beauty and wildlife resources. Deer and antelope are common throughout the area and contribute to the local economy by attracting hunters and visitors seeking a natural wilderness experience.

Wildlife is highly dependent upon the health of the land and its presence consequently reflects forest health conditions. Biodiversity is critical to maintaining ecosystem integrity and assuring sustainability of natural resource management (Hunter 1999). Incorporating wildlife values in to forest treatments is an important consideration but should not supersede treatments necessary to the protection of life and property.

### Noxious Weeds

Exotic and invasive plant species are common throughout Flagstaff, as they are in most southwestern ponderosa pine forests. Several of the most common exotic species include wooly mullein, (Verbascum thapsus L.), Dalmatian toadflax, (Linaria dalmatica (L.) P. Mill), diffuse knapweed (Centaurea diffusa Lam.), Russian thistle (Salsola tragus L.). Exotics are a considerable threat to ecosystem health; because they often out-compete natives due to a lack of biological control such as insect predators, plant pathogens, and fungi (Friederici 2003). Once established these plants can alter rates of nutrient cycling, displace native populations of plants/animals as well as disrupt the disturbance regime including wildfire by creating continuous fuel bed which can increase expected fire frequency and behavior. Care needs to be exercised when working on sites with noxious weeds.

## WILDFIRE RISK

### General

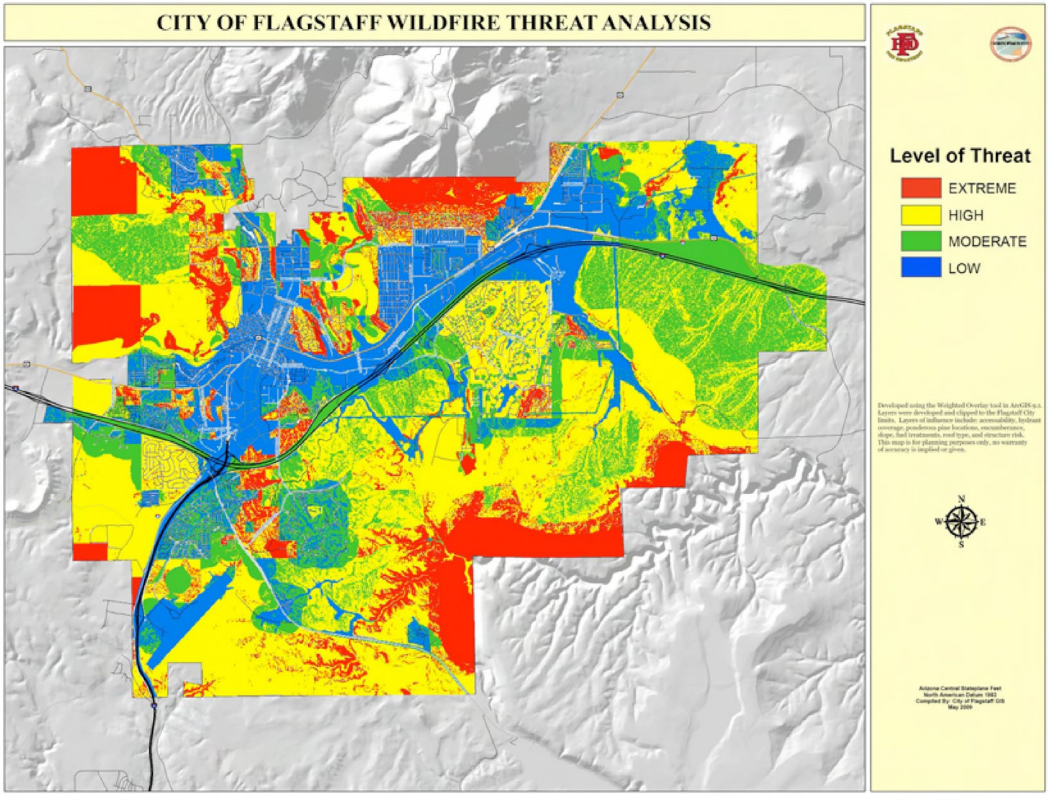
Catastrophic wildfire is a major concern in the southwest as well as in Flagstaff, AZ. During the last century forest health conditions have declined due to drought, high tree densities, grazing and fire exclusion (Fule et al., 2002). As a result, fuel loads have accumulated to an unnatural degree. Fuels include duff, leaf and needle litter, coarse woody debris, under-story and over-story vegetations. Current conditions have left ponderosa pine forests susceptible to stand replacing fires due to an increased density and fuel loads. Timber operation and pathogen outbreaks have also contributed to increased mortality in greater amounts of fuels (Fule et al., 2001). Fuel loading in many stands around Flagstaff is excessive; especially in stands of high-density pole-sized trees influenced by density dependent competition and suppression from overlapping intermediate trees. This competition for resources results in increased mortality leading to higher fuel loads. Recommended approaches to minimize fuel loads include thinning, prescribed burning and utilization of woody material.

## City

The #1 fire threat to Flagstaff is destructive wildfire. Overly dense stands of unhealthy trees have created conditions ripe for high intensity fire. Short, drought stressed trees and abundant low hanging branches provide ideal ladder fuels enabling surface fires to climb into the canopy to torch trees or produce destructive and dangerous crown fires. The result could easily be a high-intensity fire that is both difficult to control and may quickly threaten and damage/destroy property. In addition, it will create long-lasting visual scars on the property, potentially increase soil erosion, negatively impact current wildlife habitat and require significant financial expenditure to control.

A City-Wide Threat Assessment mapping project was completed in 2006, and updated in 2009, revealed that over 70% of the community was at High- Extreme risk of wildfire (Figure 1). This was determined using eight variables considered to be important influencing factors of ignition during a wildfire. These eight variables were weighted according to their significance and include: past forest treatments, vegetation, slope, roof type, construction type, hydrant distance, road condition and accessibility.

Figure 1. City of Flagstaff Wildfire Threat Analysis map




## Surrounding Area

Conditions in the forests surrounding Flagstaff pose a severe threat of large fires with broad flame fronts and long-range spotting from embers. Collaborative efforts like the Greater Flagstaff Forests Partnership (GFFP), The Flagstaff Watershed Protection Project (FWPP), and the Four Forest Restoration Initiative (4FRI) have proven successful at implementing fuel reduction treatments in priority areas around Flagstaff, although increasing the pace and

scale of these projects is still needed.

## Economic Impact

The physical and ecological effects of a severe wildfire are often immediately visible, while intangible effects may be less apparent but often quite severe. The Arizona Rural Policy Institute's 2014 FWPP Cost Avoidance Study estimated damages that the Flagstaff Watershed Protection Project hopes to mitigate. The estimates are in 2014 dollars and are divided between the two watersheds. Between the two treatment areas, potential financial damages range from $573 million to $1.2 billion.

| Source | Low ($) millions | High ($) millions |
|---|---|---|
| **Dry Lake Hills** | | |
| Response and Remediation | 43 | 43 |
| Structures and Contents | 132 | 286 |
| Property Value | 256 | 524 |
| Habitat | 0.4 | 15 |
| Communication Towers | 30 | 80 |
| BNSF Railroad Interruption | 12 | 23 |
| Retail Sales | 15 | 15 |
| **Dry Lake Hills Total** | **$489 million** | **$986 million** |
| **Mormon Mountain** | | |
| Response and Remediation | 12 | 12 |
| City Water Supply | 17 | 37 |
| Habitat | 1 | 22 |
| Communication Towers | 54 | 144 |
| **Mormon Mountain Total** | **$84 million** | **$215 million** |
| **Total, Both Areas** | **$573 million** | **$1,201 million** |

*Several of these costs show no difference between high and low estimates. For those categories, only one figure was identified.*

In 2021, ERI remeasured the full costs associated with the 2010 Schultz Fire (Colavito et al. 2021). The total cost of the Schultz Fire for the ten-year assessment period was conservatively estimated to be between $95.8 million and $100.7 million in 2021 dollars.

| | Total Costs |
|---|---|
| Government and utility expenses 2010-2019 | $72,392,991 |
| Mexican spotted owl habitat displacement | $1,080,500 (range $546,000–$1,615,000) |
| Insurance | $5,611,193 (range $4,613,866–$6,608,520) |
| Prevention and mitigation measures | $4,368,748 (range $3,437,271–$5,300,225) |
| Loss of life | $6,721,478 |
| Structural damage | $3,470,499 |
| Cleanup | $2,044,592 |
| Unpaid labor | $1,698,409 |
| Home contents | $614,158 |
| Fire evacuation costs | $250,456 |
| **Total** | **$98,253,024** (range $95,789,720–$100,716,328) |

Wildfires that have impacted the City of Flagstaff:

1. 1977 Radio Fire: 4,600 acres across Mt Elden on the Coconino National Forest; Still causing erosion and flooding concerns inside city limits.
2. 2006 Woody Fire, 120 acres inside city limits.
3. 2010 Hardy Fire, 282 acres inside city limits.
4. 2019 Newman Fire, 5,000 acres across the Coconino National Forest; This beneficial wildfire reduced wildfire risk to the Lake Mary watershed and involved significant point protection of essential water production infrastructure and equipment.
5. 2019 Museum Fire, 1961 acres across the Dry Lake Hills on the Coconino National Forest; Caused significant flooding impacts.
6. 2021 Rafael Fire, 78,065 acres across the Prescott, Kaibab, and Coconino National Forests; University Heights was put under a “Set” evacuation notice.
7. 2022 Tunnel Fire, 26,532 acres on Coconino National Forest and Sunset Crater Volcano National Monument; Response included City of Flagstaff Fire Department.
8. 2022 Pipeline Fire, 26,532 acres across the Coconino National Forest; Response included City of Flagstaff Fire Department.
9. 2024 Bravo Fire, 960 acres across Camp Navajo; Response included City of Flagstaff Fire Department.

# MANAGEMENT RECOMMENDATIONS:

## Desired Conditions at the Individual Parcel Level with Structures, Residential or Commercial:

Any construction under the jurisdiction of the City of Flagstaff must also meet the International

Wildland Urban Interface Code, and other development codes, as adopted by the City Council.

The concept of the home ignition zone (HIZ) was developed by retired USDA Forest Service fire scientist Jack Cohen in the late 1990s, following some breakthrough experimental research into how homes ignite because of radiant heat. The HIZ is divided into three zones.

**1. Immediate zone:** The home and the area 5 feet from the furthest attached exterior point of the home or building envelope; defined as a non-combustible area.

Science tells us this is the most important zone to take immediate action on as it is the most vulnerable to embers.

- Trees and vegetation shall be removed within this zone for new developments.
- Move any flammable material away from wall exteriors – mulch, flammable plants, leaves and needles, firewood piles – anything that can burn.
- Remove anything stored underneath decks or porches.
- Clean roofs and gutters of dead leaves, debris and pine needles that could catch embers.
- Fence construction should be non-combustible

**2. Intermediate zone:** 5-30 feet from the furthest exterior point of the home.

Science tells us employing careful landscaping or creating breaks that can help influence and decrease fire behavior is most important in this zone.

- Clear vegetation from under large stationary propane tanks.
- Create fuel breaks with driveways, walkways/paths, patios, and decks.
- Keep lawns and native grasses mowed to a height of four inches.
- Remove ladder fuels (vegetation under trees) so a surface fire cannot reach the crowns. Prune trees up to six to ten feet from the ground; for shorter trees do not exceed 1/3 of the overall tree height.
- Space trees to have a minimum of eighteen feet between crowns with the distance increasing with the percentage of slope.
- Tree placement should be planned to ensure the mature canopy is no closer than ten feet to the edge of the structure.
- Tree and shrubs in this zone should be limited to small clusters of a few each to break up the continuity of the vegetation across the landscape.

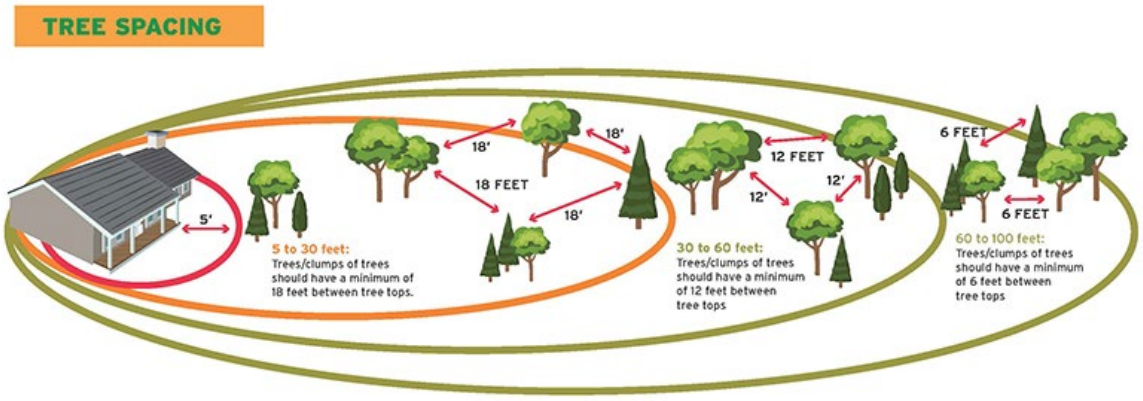
**3. Extended zone:** 30-100 feet, out to 200 feet

Science tells us the goal here should not be to eliminate fire but to interrupt fire's path and keep flames smaller and on the ground.

- Dispose of heavy accumulations of ground litter/debris.
- Remove dead plant and tree material.
- Remove small conifers growing between mature trees.
- Remove vegetation adjacent to storage sheds or other outbuildings within this area.
- Trees 30 to 60 feet from the home should have at least 12 feet between canopy tops.*
- Trees 60 to 100 feet from the home should have at least 6 feet between the canopy tops.*

- *The distances listed for crown spacing are suggested based on NFPA 1144. However, the crown spacing needed to reduce/prevent crown fire potential could be significantly greater due to slope, the species of trees involved and other site specific conditions.

In the Intermediate and Extended Zones, the retention of the largest and most fire-resistant trees on site should be prioritized.

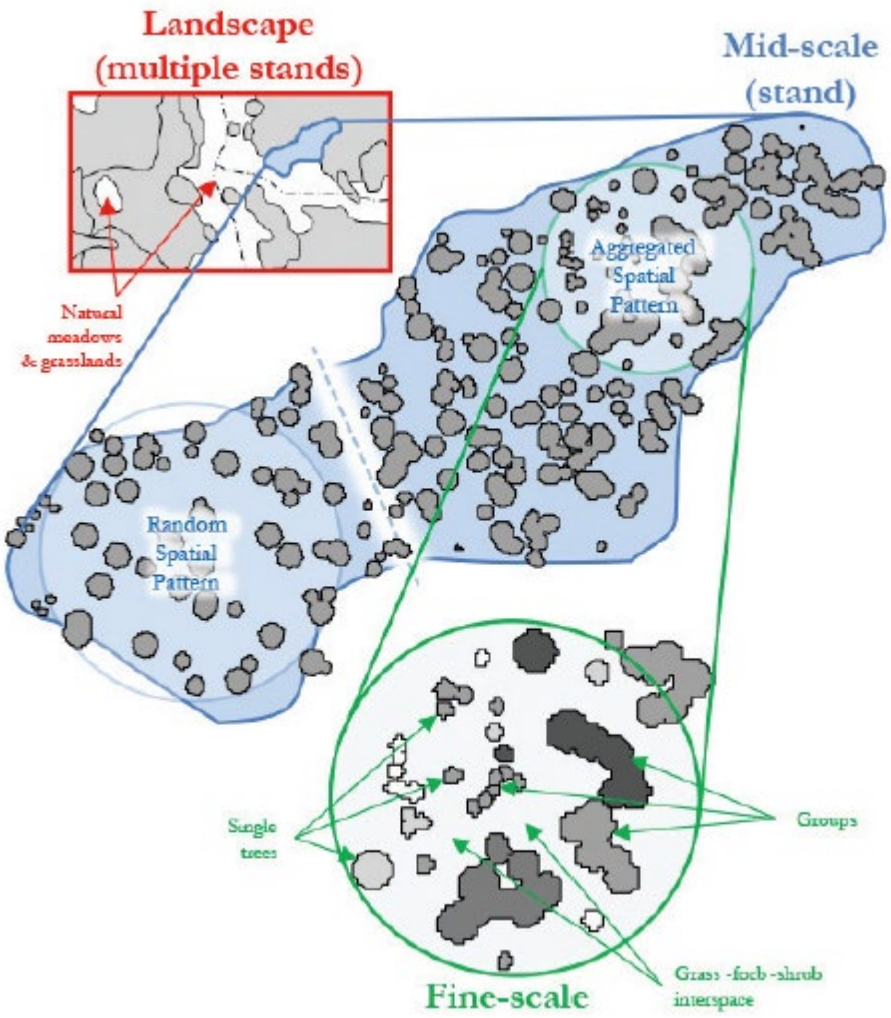



The City of Flagstaff recommends this suite of provisions be included in development codes.

## Desired Conditions at the Landscape, Mid, and Fine Scale without Structures or Development

Across all project scales, the retention of the oldest, largest, and most fire-resistant trees on site should be prioritized.

The image below (Reynolds et al. 2013) indicates landscape, mid and fine scale tree patterns.




Desired condition information is based on the Coconino National Forest Land and Resource Management Plan.

*Landscape Scale Desired Conditions (1,000-10,000+ acres)*

• Ponderosa Pine has a mosaic of trees with varying age classes and understory vegetation which provide habitat for a variety of species, and ground fuels conducive to low-severity fires.

• The composition, structure, and function of vegetation conditions are resilient to the frequency, extent, and severity of disturbances and climate variability. The landscape is a functioning ecosystem that contains its components, processes, and conditions that result from natural levels of disturbances (e.g. insects, diseases, fire, and wind), including snags, downed logs, and old trees. Grasses, forbs, shrubs, and needle cast (e.g., fine fuels), and small trees maintain the natural fire regime. Vegetative ground cover provides protection from accelerated soil erosion, promotes water infiltration, and contributes to soil nutrient cycling, plant and animal diversity, and to ecosystem function.

• Frequent, low-severity fires are characteristic in this ecological response unit, including throughout northern goshawk home ranges. Spatial heterogeneity and discontinuous crowns

(interspaces between groups and single trees) prevents fire spread. Natural and human disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

• At the landscape scale, Ponderosa Pine is composed of trees in structural stages that range from young to old and are dominated by ponderosa pine trees. Forest appearance is variable but generally uneven-aged and open; occasional areas of even-aged structure are present. Forest arrangement is in individual trees, small clumps, and groups of trees interspersed within variably sized openings of grasses, forbs, and shrubs that are similar to historic patterns. Openings typically range from 10 percent in more productive sites to 70 percent in the less productive sites. The size and shape of trees, number of trees per group, and number of groups per area are variable across the landscape. Denser tree conditions exist in some locations such as north-facing slopes and canyon bottoms.

• The ponderosa pine forest vegetation community is composed predominantly of vigorous trees, but declining trees are a component and provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris (>3 inch diameter), all well-distributed throughout the landscape. Snags, down logs and coarse woody debris are representative of the species within the vegetation community. Ponderosa pine snags are typically 18 inches or greater at DBH and average 1 to 2 snags per acre. There are varying sizes of snags greater than 18 inches DBH. In the Gambel oak subtype, large oak snags (>10 inches) are a well-distributed component. Downed logs (>12 inch diameter at mid-point, >8 feet long) average 3 logs per acre within the forested area of the landscape. Coarse woody debris, including downed logs, ranges from 3 to 10 tons per acre is sufficient to maintain or improve long-term soil productivity and provide cover and food for a variety of species.

• Old growth structure occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Consistent with vegetative characteristics of a frequent, low severity fire regime, old growth is a component of uneven-aged forests, generally comprised of groups of similarly aged trees and single trees interspersed with open grass–forb–shrub interspaces, but occasionally, it occurs in larger even-aged patches where local microsites facilitate less frequent fire regimes. Within group variability may be low but variation among groups is typically high and proportions of patches with different developmental stages may vary depending on site-specific conditions. Old growth components include old trees, dead trees (snags), and dead and downed wood (coarse woody debris including large size classes). Snags and large dead and downed fuels are irregularly distributed across the landscape and may not exist in some patches. The location of old growth components shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

• In the Gambel oak subtype, all sizes, structures (i.e., the shrub or tree forms depending on the capability of the site), and ages of oak trees are present. The Gambel oak subtype is reproducing and maintaining its presence on suitable sites across the landscape. Large to moderate sized oak snags are scattered across the landscape, as are moderate to large live oak trees with dead limbs, hollow boles, and cavities. These provide shelter and nesting habitat for a variety of wildlife species, including owls and bats.

*Mid-Scale Desired Conditions (10 to 999 acres)*

• At the mid-scale, Ponderosa Pine is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The more biologically productive sites contain more trees per group and more groups per area, resulting in less space between groups. At the mid-scale, openings typically range from 30 percent in more productive sites to 60 percent in the less productive sites, but extreme outlying sites can range from 10 percent (i.e., high elevation, mesic sites) and may be as much as 90 percent in low elevation sites on south-facing slopes or where site specific information indicates the site was historically more open. Tree density within forested areas generally ranges from 22 to 89 square feet basal area per acre (Reynolds et al. 2013) Ground cover consists primarily of perennial grasses and forbs capable of carrying surface fire, with basal vegetation values ranging between about 5 and 20% depending on the terrestrial ecological unit inventory.

• The mosaic of tree groups generally comprises an uneven-aged forest with all age classes present, including old growth. Groups of seedlings and saplings are maintained at sufficient levels to provide a reliable source of replacement as trees grow and progress into succeeding size and age classes. Infrequently patches of even-aged forest structure are present. Disturbances sustain the overall age and structural distribution.

• Diversity of understory species (e.g., grasses, forbs, and shrubs) is consistent with site potential and provides for infiltration of water and soil stability. The understory has a variety of heights of cool and warm season vegetation and produces seed heads and all age classes of vegetation food and cover for wildlife and forage for livestock. A mosaic of dense cover, high amounts of litter and bare ground provide habitat for a variety of species.

• Fires burn primarily on the forest floor and do not spread between tree groups as crown fire. Single tree torching and small group torching, however, are not uncommon, resulting in a mosaic across the landscape.

• Conditions in northern goshawk post-fledgling areas (PFAs) are similar to general forest conditions except these forests contain 10 to 20 percent higher basal area in mid-aged to old tree groups than in northern goshawk foraging areas and the general forest. Northern goshawk nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in Ponderosa Pine.

*Fine Scale Desired Conditions (less than 10 acres)*

• Trees typically occur in irregularly shaped groups and are variably spaced with some tight clumps. Crowns of trees within the mid-aged to old groups are interlocking or nearly interlocking. Interspaces surrounding tree groups are variably shaped and comprised of a grass/forb/shrub mix. Some natural openings contain individual and randomly distributed patches of trees and a diversity of grasses and forbs which provide habitat for species, including invertebrates, small mammals, migratory birds, and turkey. Trees within groups are of similar or variable ages and may contain species other than ponderosa pine. Size of tree groups typically is less than 1 acre, but they may range from a few to many trees in extent and be larger in areas managed for bald eagles and Mexican spotted owls. Old growth groups contain trees having similar age characteristics and conditions. Such groups may include fairly similar tree ages and sizes or combinations of ages and sizes, limited amounts of dead and downed material, and dead trees and spike tops (snags), but they are readily

distinguished from adjacent groups having different characteristics. Groups at the mid-aged to old stages consist of 2 to approximately 40 trees per group.

• Dwarf mistletoe is an element of the forest landscape. There is a varied level of mistletoe across the landscape, comparable with historic conditions such that it does not impede achieving and sustaining uneven-aged forest structure. Witches brooms may form on infected trees, providing habitat for wildlife species.

• Large oak trees and pine-oak groups in the Ponderosa Pine Gambel Oak subtype provide cooler, moister microsites and higher overstory diversity than found in the Ponderosa Pine Bunchgrass subtype. Gambel oak acorns provide food for wildlife species.

## Desired Tree Density

The target tree-density for any-given site, beyond the extended home ignition zone, is based on the Natural Range of Variability for Southwestern Frequent-Fire Ponderosa Pine Forests.

Narrative and Table Figure 2 from Wasserman, T.N., M.T. Stoddard, and A.E.M. Waltz. 2019. A Summary of the Natural Range of Variability for Southwestern Frequent-Fire Forests. ERI Working Paper No. 42. Ecological Restoration Institute, Northern Arizona University. 11 pp.

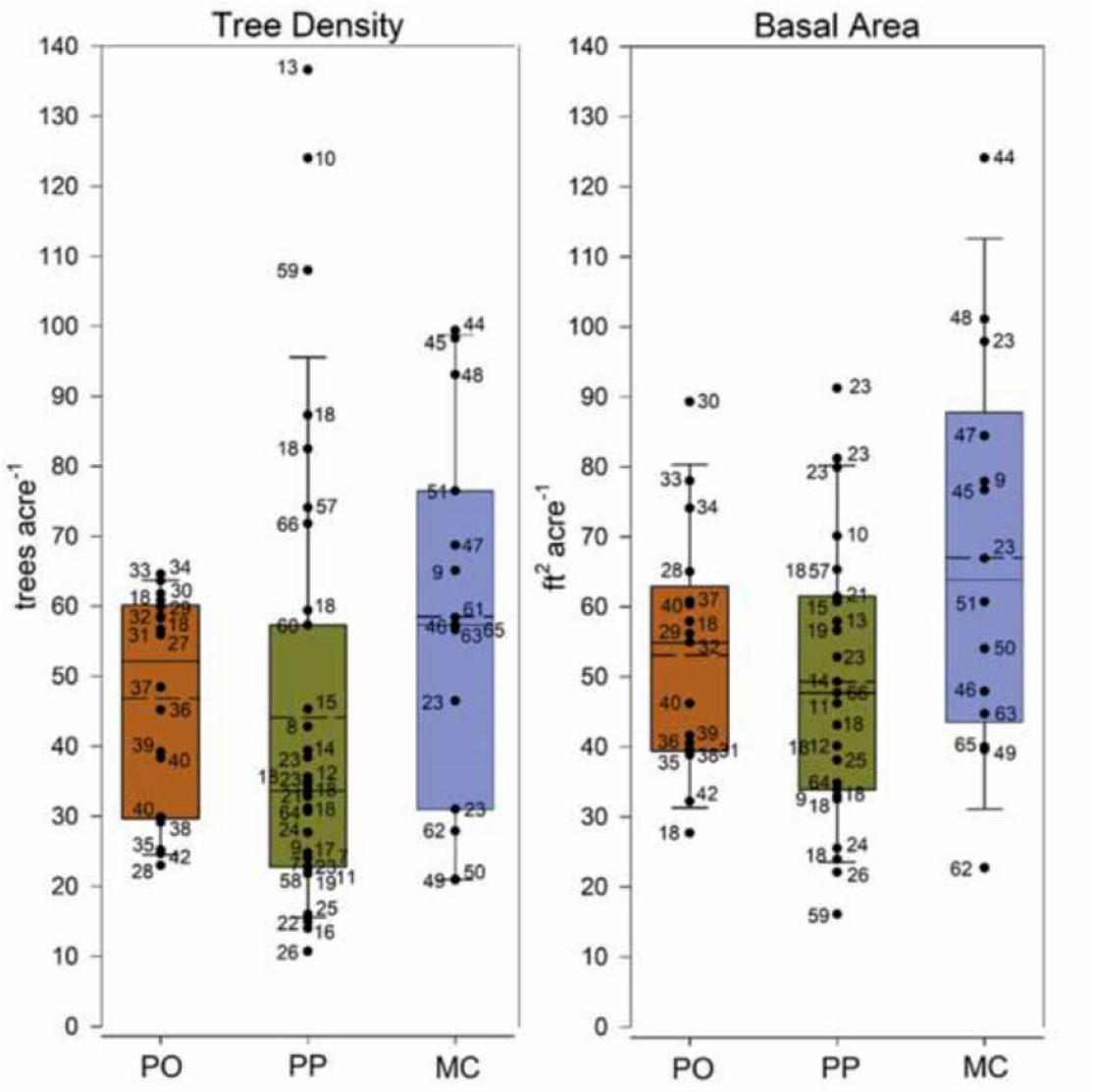



**Figure 2:** Boxplots of historical ranges in tree density and basal area group by forest type, in pine-oak (PO), ponderosa pine (PP), and mixed conifer (MC). Numbers in figures correspond to site numbers in Figure 1 and Table 1.

The table below From USDA General Technical Report 310 (Reynolds et al. 2013) also documents historic tree densities associated with a natural, fire adapted Ponderosa pine forest.

**Table 1.** Ranges of reference conditions for ponderosa pine and dry mixed-conifer forests in the Southwestern United States from studies detailed in Tables 3, 6, 7, and 9.

| | Reference conditions by forest type | |
|---|---|---|
| **Forest attribute** | **Ponderosa pine** | **Dry mixed-conifer** |
| Trees / acre | 11.7-124 | 20.9-99.4 |
| Basal area ($ft^2$ / acre) | 22.1-89.3 | 39.6-124 |
| Openness (%)[a] | 52-90 | 78.5-87.1 |
| Openness on sites with strong tree aggregation (%)[a] | 70-90 | 79-87 |
| Spatial patterns | Grouped or random | Grouped or random |
| Number of trees / group | 2-72 | Insufficient data |
| Size of groups (acres) | 0.003-0.72 | Insufficient data |
| Number of groups / acre | 6-7 | Insufficient data |
| Snags / acre | 1-10 | ≥ Ponderosa pine forests |
| Logs / acre | 2-20 | ≥ Ponderosa pine forests |

[a]Openness is the proportion of area not covered by tree crowns, estimated as the inverse of canopy cover. Openness data for dry mixed-conifer is limited; range of reference condition openness will likely change with additional studies.

# FOREST STEWARDSHIP PLANS FOR DEVELOPMENTS

The following applies to larger development parcels including subdivisions, multi-family residential, commercial, and industrial development both inside and outside the Resource Protection Overlay. It does not apply to individual hazard tree removal or individual single family residential parcels. Specific determination of need will be made by Staff.

- When a Forest Stewardship Plan is required, it must include both narrative and descriptive maps documenting how existing forest conditions will be modified to align with the desired conditions and tree density as stated above.
- The Forest Stewardship Plan is in addition to the Flagstaff Zoning Code standards.
- If a parcel falls within the Resource Protection Overlay, a Forest Stewardship Plan must be reviewed and approved prior to the submittal of the Natural Resource Protection Plan that aligns with the Resource Protection Standards **(10-50.90)**.

# SUMMARY

This plan has been prepared by City of Flagstaff to assist in general forest treatment planning and implementation. The recommendations will ensure a green, visually attractive, healthy forest for future generations and provide for community and first responder safety.

Forest treatments performed in and around Flagstaff and the use of fire adapted building materials and techniques greatly reduce the likely hood of devastating wildfire but will never fully eradicate fire from our ecosystem. Fire is integral to our environment, will continue to occur and is necessary to forest health. Fires will remain a threat to our community, but by ensuring adequate forest treatments are implemented we have a greatly reduced risk of large fires and the devastating damage that can result to individual properties and the greater Flagstaff Community.

## Literature Cited

1. Arizona Rural Policy Institute, 2014. Flagstaff Watershed Protection Project Cost Avoidance Study.

2. Barnes, B.V., D.R. Zak, S.R. Denton, and S.H. Spurr. 1998. *Forest Ecology*. New York: John Wiley & Sons, Inc.

3. Colavito, M.M., T. Combrink, E. Hjerpe, C. Edgeley, J. Burnett, and A.J. Sánchez Meador. 2021. Full-Cost Accounting Remeasurement of the 2010 Schultz Fire: Understanding the Longterm Socio-Economic Implications of High-Severity Wildfire and Post-Wildfire Flooding. ERI White Paper—Issues in Forest Restoration. Ecological Restoration Institute, Northern Arizona University. 45 p.

4. Covington, W., P.Z. Fule, M.M. Moore, S.C. Hart, T.E. Kolb, J.N. Mast, S.S. Sackett, and M.R. Wagner. 1997. Restoring Ecosystem Health in Ponderosa Pine Forests of the Southwest. *Journal of Forestry* 95: 23-29.

5. Friederici, P. (ed.). 2003. *Ecological Restoration of Southwestern Ponderosa Pine Forests*. Washington, D.C.: Island Press.

6. Fule, P. Z., A.E.M. Waltz, W.W. Covington, T.A. Heinlein. 2001. Measuring forest restoration effectiveness in hazardous fuels reduction. *Journal of Forestry*. 99 (11): 24-29.

7. Fule, P.Z., W.W. Covington, H.B. Smith, J.D. Springer, T.A. Heinlein, K.D. Huisinga, M.M. Moore. 2002. Comparing ecological restoration alternatives: Grand Canyon Arizona. *Forest Ecology and Management* 170: 19-41

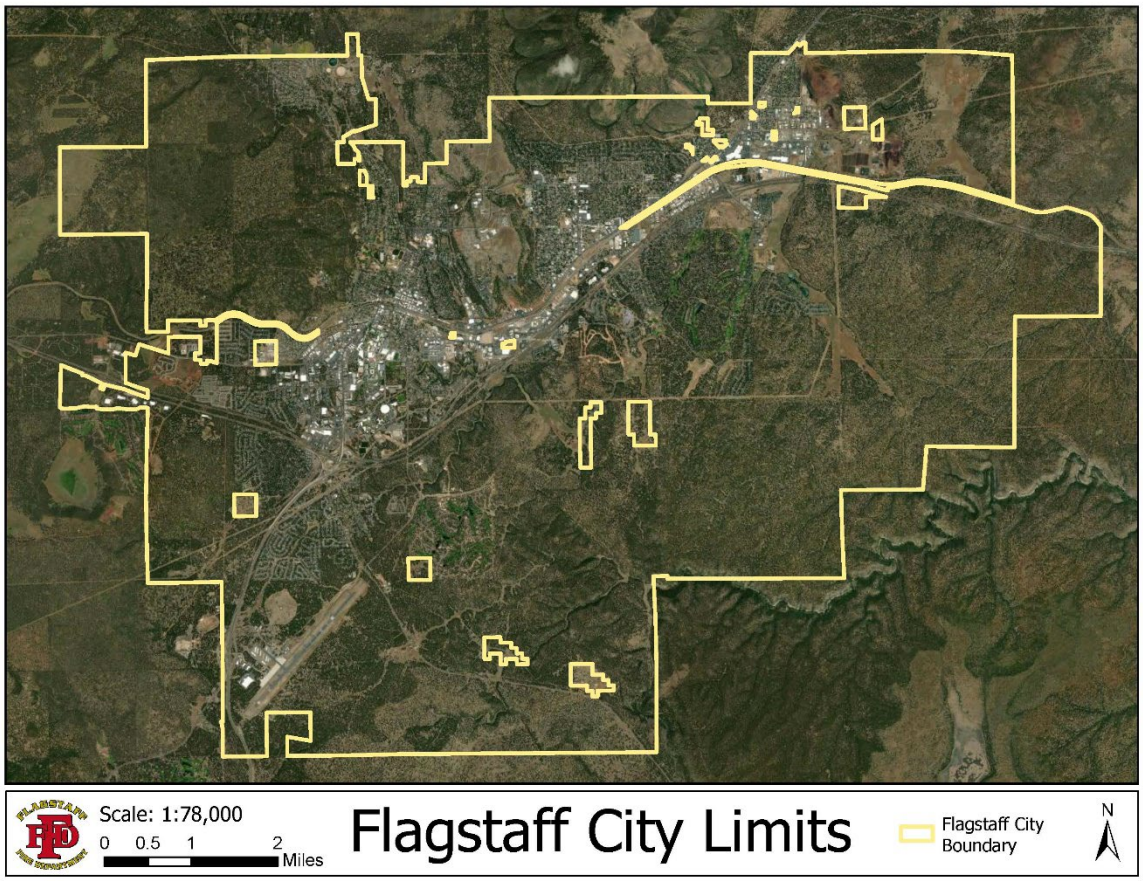
8. Hunter, M. L., 1999. *Maintaining biodiversity in forest ecosystems*. Unite Kingdom: Cambridge University Press.

9. Reynolds, Richard T.; Sánchez Meador, Andrew J.; Youtz, James A.; Nicolet, Tessa; Matonis, Megan S.; Jackson, Patrick L.; DeLorenzo, Donald G.; Graves, Andrew D. 2013. Restoring composition and structure in Southwestern frequent-fire forests: A science-based framework for improving ecosystem resiliency. Gen. Tech. Rep. RMRS-GTR-310. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

10. USDA Land and Resource Management Plan for the Coconino National Forest, March 2018

11. Wasserman, T.N., M.T. Stoddard, and A.E.M. Waltz. 2019. A Summary of the Natural Range of Variability for Southwestern Frequent-Fire Forests. ERI Working Paper No. 42. Ecological Restoration Institute, Northern Arizona University. 11 pp.

# AREA MAP


Scale: 1:78,000
0 0.5 1 2
Miles
Flagstaff City Limits
Flagstaff City Boundary
N