

The Role of Fire in Sustaining Northern Goshawk Habitat in Rocky Mountain Forests

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Abstract. The northern goshawk (*Accipiter gentilis*), is a northern latitude, forest dwelling raptor. In the Western United States, goshawks live in most forests, including those dominated by western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), lodgepole pine (*Pinus contorta* Dougl. ex. Loud.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), and western larch (*Larix occidentalis* Nutt.). It preys on a variety of small birds and mammals that require an array of forest conditions. Fire, being the primary disturbance mechanism throughout the Western United States, provided landscapes that contained and maintained goshawk populations. Goshawks and their prey adapted to forest conditions maintained by different fire regimes—nonlethal, mixed, variable, stand replacing, or rarely occurring. The goshawk recommendations by Reynolds and others (1992), coupled with knowledge of fire regimes, provide guidance for designing goshawk habitat throughout the Western United States.

Introduction

The forest conditions available to the northern goshawk (*Accipiter gentilis*) today are the result of historical disturbance and use. Throughout the Western United States fire has played an important role in the development of forests. Historical disturbances and their influence on forest development can provide an understanding of how forests change temporally and spatially. This information is useful when developing desired conditions for the goshawk and its prey.

This paper reviews the habitat needs of the goshawk based on the recommendations of Reynolds and others (1992) and the fire regimes over time that influenced the habitat. We present management options for managing goshawk habitat in the Western United States.

Goshawk

The northern goshawk, is the largest North American member of the genus (*Accipiter*), which includes both the sharp shinned hawk (*Accipiter striatus*) and the cooper's hawk (*Accipiter cooperii*) (Reynolds and Meslow 1984, Storer 1966, Wattel 1973). Goshawks are approximately the same size as a red-tailed hawk (*Buteo jamaicensis*). Because of its large body size and wing span, the goshawk seldom uses young dense forests. Rather, it lives and hunts in mature forests of the northern latitudes (Fisher 1986). In the northern portions of its range the goshawk is migratory, especially during times when prey populations are low. In other areas goshawks occasionally migrate from high elevations to lower elevations during the winter (Reynolds and others 1992). Goshawks often return to nest areas year after year to mate and raise their young (Reynolds 1983).

In North America, the goshawk is a forest generalist occurring in all major forest types (coniferous, deciduous, and mixed) (Reynolds and others 1992). Within the Western United States, it occupies a wide range of forests including those dominated by piñon pine (*Pinus* spp.), juniper (*Juniperus* spp.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), mixed-conifers, quaking aspen (*Populus tremuloides* Michx.), western hemlock (*Tsuga heterophylla* (Raf. Sarg.), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) / subalpine fir (*Abies lasiocarpa* (Hook) Nutt.), and lodgepole pine (*Pinus contorta* Dougl. ex. Loud.). In these forests, the goshawk is a top-level consumer that feeds on more than 50 species of small animals and birds such as rabbits, grouse, chipmunks, and woodpeckers (Reynolds and others 1992). A goshawk family (two adults and two fledglings) consumes 180 to 225 kg of food per year (Brown and Amadon 1968).

Goshawks hunt in a variety of forest structures and forest types. They are frequently presented with a mosaic of forest conditions in their foraging movements. They are "short sit and wait short flight" predators. They perch

briefly, if they find no prey within seconds, they fly to another perch a short distance away, sitting again for a short period (Reynolds and others 1992). The goshawk thus covers large foraging areas, 2,000 to 2,500 ha (Kennedy 1989, Reynolds 1983).

Home Range

The goshawk home range consists of: the nest area, the post fledging-family area (PFA), and the foraging area (Reynolds and others 1992) (Figure 1). Each area is unique and plays an important role in the goshawk's life history. Forest type, its current condition, and historical development will determine the size, shape, and vegetative structure for each of the three components.

The nest area, where a goshawk pair constructs the nest platform, is often used by the same pair of goshawks year after year. However, a goshawk home range can have multiple nest areas (three or more are common) within the home range (Figure 1). Multiple nests ensures that a goshawk pair will always have a nest available in case an area is damaged or lost. Each nest area has its own landform characteristics defining its size and shape. These characteristics vary depending on topography and the availability of dense patches of large trees. The nest area size ordinarily ranges from 8 to 12 ha. Nest areas are commonly on shady slopes or canyon sides are often near streams, and usually have dense canopy cover created by large trees (Bartelt 1974, Hall 1984, Kennedy 1988, Reynolds and others 1992). The dense vegetation provides mild and stable microenvironments and protection from predators (Moore and Henny 1983, Reynolds and others 1992).

The goshawk family intensively uses the PFA that surrounds the nest area (Figure 1). It varies in size from 120 to 240 ha (Kennedy 1989). The PFA is where small

birds learn to hunt and fend for themselves. It has a mosaic of vegetation structures that supply cover, protecting fledglings from predators, and providing hunting opportunities for the goshawk family. Post fledging-family areas contain relatively dense forest overstories, small openings, mid-age forests, and well-developed understories. Features that are important in PFA's include: large feeding and nesting trees for tree squirrels; large snags or trees with exposed heartwood for nest cavity excavation by woodpeckers; patches of mid-age forest with high canopy cover that provide conditions for fungi development (important for mammalian prey); small openings in the tree canopy to produce herbaceous and shrubby foods for herbivorous prey; and large downed logs and other woody debris that provide hiding, feeding, denning, and nesting sites used by goshawk prey (Reynolds and others 1992).

Surrounding the nest area and PFA is the foraging area (Figure 1), which resembles the PFA in structure but often contains more openings and less dense forests. In the Southwestern United States, the 2,200 ha foraging area provides habitat for goshawk prey and contains large trees, openings, and snags with downed logs interspersed throughout. Foraging areas consist largely of mid-age, mature, and old forests. The remaining portions are young forests, forests dominated by seedlings and saplings, and areas dominated by grasses, forbs, and shrubs (Reynolds and others 1992). The size of goshawk home ranges containing these forest structures varies depending on the forest type and historical forest development.

Given this context of the goshawk's home range, we now look at how fire regimes have influenced that home range. Within the Western United States, most forests developed in concert with one of five different fire regimes: nonlethal, mixed, variable, lethal, and where fire is rare (Arno, In prep).

Nonlethal Fire Regime

Frequent, low-intensity surface fires which characterize a nonlethal fire regime, often kill small trees but rarely kill overstory trees. Herbaceous vegetation and forest floor litter fuels these fires. Fire return intervals typical of nonlethal fire regimes are from 2 years in northern Arizona (Dieterich 1980) to 50 years in colder climates of western Montana (Arno and others 1995a). Prior to 1900, fire return intervals in most areas averaged between 5 and 30 years (Kilgore 1987, Martin 1982). Fire size depended on forest type. For example, on dry forests and adjacent grasslands in New Mexico and Arizona plateaus, fires were large. In contrast, because of rugged mountainous topography, on dry south-facing slopes in western Montana fires were small (Arno 1980).

The forests most likely to have nonlethal fire regime are dominated by ponderosa pine, Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.), or Oregon white oak (*Quercus*

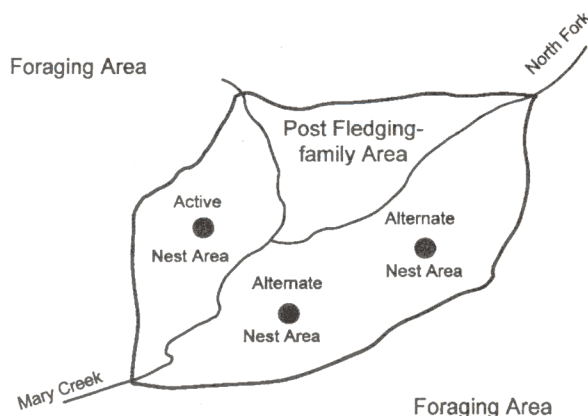


Figure 1. Goshawk home range components includes a foraging area surrounding a post fledging family area (PFA). Within the PFA, multiple nest areas usually occur (active and alternate).

garryana Dougl. ex Hook). Ponderosa pine occurs as the potential climax in forests of northern New Mexico and Arizona, while in most Northern Rocky Mountain forests, ponderosa pine occurs as a seral component.

Prior to 1900, these forests were open and park-like with sparse, shrubs, understory trees, and downed logs (Cooper 1960, Wickman 1992). Forests were uneven-aged and often contained 400- to 600-year-old trees (Arno and others 1995a). Forests with nonlethal fire regimes usually have dry fire seasons and a continuous supply of litter, all of which contribute to favorable burning conditions.

Mixed and Variable Fire Regimes

The recent description of mixed and variable fire regimes encompasses characteristics of both nonlethal to lethal fire regimes (Agee 1993, Means 1982, Morrison and Swanson 1990). The mixed fire regime has a mixture of surface fires and stand-replacement fires. These fires kill susceptible species in the overstory. In most of the understory, fire-resistant trees often survive. The result is a mosaic landscape of different fire intensities. In some burns even fire-susceptible trees survived. Fire return intervals vary from fires reburning within the same fire event to 100 years (Agee 1993, Arno, In prep).

The variable fire regime is a combination of nonlethal and stand-replacement fires. Stand-replacement fires occurred at long return intervals (150 to 400 plus years) with nonlethal surface fires occurring at short intervals (20 to 30 years) (Arno and others 1995b). The forest pattern left by this regime was complex and highly diverse.

With both the mixed and variable fire regimes, previous fires strongly influenced the temporal and spatial distribution of fuels. The mosaic of fuels ensured that future fires would burn similarly (Arno, In prep). The non-uniform burning created a mosaic of different size openings, tree spacings, and stand structures. The resulting openings provided suitable conditions for the regeneration of seral species (Graham 1990, Haig and others 1941).

These fire regimes were common prior to 1900 in Interior and Northwest coastal mountain regions in the Western United States, southern British Columbia, and Alberta (Arno, In prep). The forest types burned by mixed and variable regimes included coast Douglas-fir (*Psuedotsuga menziesii* var. *menziesii* (Mirb.) Franco), redwood (*Sequoia sempervirens* (D. Don) Endl.), red fir (*Abies magnifica* A. Murr.), Douglas-fir (*Psuedotsuga menziesii* (Mirb.) Franco), western larch (*Larix occidentalis* Nutt.), lodgepole pine, whitebark pine (*Pinus albicaulis* Engelm.), and Rocky Mountain ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engelm.).

Prior to 1900, coast Douglas-fir, Douglas-fir/hardwoods, and redwood forests were characterized by patchy, nonuniform burning, and large old, fire-resistant trees

dominated the landscape. Many large (> 2 m in diameter), old (300 to 400 years) Douglas-fir trees survived in these fire regimes. The surface and stand replacement fires, killed most fire-susceptible trees (true firs). These fires also burned understory conifers of all species, thus decreasing ladder fuels.

The red fir and Sierra lodgepole pine (*Pinus contorta* var. *murrayana* (grev. & Balf.) Engelm.) and lodgepole pine in the southern Cascades, Klamath Mountains, and Sierra Nevada developed under a mixed or variable fire regime. Within the red fir forest type, the fire frequencies ranged from 21 to 65 years (Husari and Hawk 1993, Taylor 1993). A combination of large and small stand-replacing fires and mixed intensity fires were critical in forest development (Taylor 1993). Fire frequency within the Sierra/Cascade lodgepole pine was 60 to 80 years (Agee 1993). In the Sierra/Cascade lodgepole pine forest type, the factors that influenced a mixed fire regime were pine beetle epidemics, decayed logs on the forest floor, irregular topography, and frequent rock outcrops (Parsons 1980).

In the Interior West, interior Douglas-fir, western larch, and Rocky Mountain lodgepole pine forest types developed in concert with mixed and variable fire regimes (Arno, In prep). These forests occur at mid-elevations from central British Columbia and Alberta southward to western Wyoming and western and central Montana. This fire regime left a variety of forest communities, (Arno and others 1993, Barret and others 1991, Tande 1979). These fire regimes maintained seral grasslands, shrublands, and aspen along forest boundaries. These fires kept Douglas-fir and lodgepole pine from invading these areas.

A variable fire regime created the whitebark pine forests in Southern British Columbia continuing south to western Wyoming and along the Cascades (Arno, In prep). The moist and more productive areas had stand-replacement fires. The rugged terrain, including rock outcrops and cool-moist north slopes, hampered fire spread and resulted in a variable burn pattern. In these forests, whitebark pine is seral. On all but the harshest sites, climax species (true firs) were killed in low-intensity fires while the pine survived. Bark beetle epidemics provided large amounts of fuels that caused patchy burning of crowns (Arno, In prep).

Rocky mountain ponderosa pine in the Black Hills developed under a variable fire regime (Gartner and Thompson 1973). Thickets of dense ponderosa pine regeneration were susceptible to stand replacement fires. In contrast, intervening areas that had open stands likely experienced low-severity surface fires. The rapid pine regeneration that occurred after fire contributed to a variable fire regime. Areas of the Black Hills were frequently exposed to high winds during the fire season. Steep topography and mortality caused by bark beetle epidemics also played a role in this fire regime (Arno, In prep).

Lethal Fire Regime

Lethal or stand-replacing fire regimes kill most vegetation in large crown fires. The burning pattern depends highly on topography, fuels, and burning conditions often influenced by climatic conditions (Johnson and others 1994). Fire intervals ranged from 70 years in lower-elevation Rocky Mountain lodgepole pine to 400 years in inland subalpine types to over 500 years in moist coastal forests. Shorter intervals occurred in productive areas where fuels increased over a shorter time. This fire regime formed a complex mosaic resulted from topography, microclimate, and vegetation. On sites with gentle topography, fires became more uniform. Reburns were common in forests that supported this fire regime (Arno, In prep).

The coast Douglas-fir forests at lower and middle elevations west of the Cascades developed under the lethal fire regime. Fire return interval in these forests exceeded 200 years (Agee 1993). Western hemlock is climax but seral Douglas-fir is dominant in these forests because of stand replacement fires. Other seral conifers such as western white pine (*Pinus monticola* Dougl. ex D. Don), shore pine (*Pinus contorta* var. *contorta* Dougl. ex Loud.), grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) also occur (Fonda and Bliss 1969, Franklin and Dyrness 1973, Hemstrom and Franklin 1982, Huff 1984).

Coastal true fir/mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.) in the high-elevation maritime forests along the Cascade Crest also had lethal fires. Fire return intervals averaged between 125 to 600 years (Agee 1993). Forests are dominated by Pacific silver fir (*Abies amabilis* (Dougl.) Forbes), mountain hemlock, western hemlock, and noble fir (*Abies procera* Rehd.). These species are fire sensitive and rarely survive even surface fires. Stand-replacement fires maintained early seral species such as huckleberry (*Vaccinium* spp.), and ceonothus (*Ceonothus* spp.) (Agee 1993, Franklin and Dyrness 1973), noble fir, Douglas-fir, subalpine fir, Alaska-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach), lodgepole pine, and western white pine (Arno, In prep).

Lethal fires were common in interior true fir, Douglas-fir, and western larch forest types (Arno, In prep). These forest types are at mid-elevations in the Interior West. Principal tree species are white fir and grand fir (climax), interior Douglas-fir (seral or climax), western larch, lodgepole pine, and aspen (early successional). These forests develop dense stands with ladder fuels and compact duff layers that are not favorable to surface fires. They usually occur on steep slopes that receive frequent strong winds. Fire return interval averaged between 70 and 200 years. The strong winds, dense stands, and steep slopes encouraged stand-replacing fires. Similar areas having different topography were often in the mixed and variable fire regimes (Brown and others 1994, Gruell

1983). The frequent stand-replacement fires maintained open stands of seral grasses or shrublands, favoring serviceberry (*Amelanchier* spp.), willow (*Salix* spp.), and quaking aspen (Arno, In prep).

Stand replacing fires also occurred in Rocky Mountain lodgepole pine forests at middle to high elevations within the continental mountain climate zone in the Inland West (Arno, In prep). Lodgepole pine forests burned in a mixed or variable fire regime primarily in the drier climates and with fine surface fuels. As forests aged, they became more susceptible to beetle attack and disease. Because of mortality and fuel loadings, these forests were highly susceptible to stand-replacing fires.

The relationship between forest age and fuel loadings makes this forest type unusual (Brown 1975). Young forests with large amounts of fuel regenerated after past fires or forests with beetle-killed trees have higher probabilities for stand-replacing fires than do mid-age forests containing little fuel. As these mid-age forests matured, growth and vigor decreased, bark beetles increased, and dwarf mistletoe increased — all contributing to the potential for high-intensity fires.

The western white pine, western redcedar (*Thuja plicata* Donn ex D. Don), western hemlock forests in northern Idaho, southeastern British Columbia, northeastern Washington, and northeastern Montana experienced stand-replacing fires (Krajina 1965, Shiplett and Neuenschwander 1994). Although, these forests developed primarily from a lethal fire regime, evidence shows a mixed or variable fire regime may have existed in some forest areas (valley bottoms, on gentle slopes, or on dry aspects and ridgetops) (Arno 1980, Arno and Davis 1980, Marshall 1928, Zack and Morgan 1994). These highly productive forests contain a variety of shade-tolerant species such as western hemlock and western redcedar. Consequently they rapidly acquired multiple canopies, increasing the probability for stand-replacing fires. Stand replacing fires occurred between 130 and 300 years and were primarily associated with severe drought.

Areas That Rarely Burned

Some areas within the Western United States did not burn, or burned so seldom, fires had little effect on forest development or structure. The most common forest with little evidence of fire is the Sitka spruce/western hemlock forest in the wettest areas along the western slopes of the Cascade Range, into British Columbia. In addition, while Sitka spruce forests in Alaska did not have many fires historically, wind events played an important role in forest development by creating openings.

Fire Regimes and Goshawk Habitat

Knowledge about goshawks, fire regimes, and forest conditions makes it possible to define goshawk habitat for different forest types. For example, the goshawk recommendations (Reynolds and others 1992) developed for Southwestern ponderosa pine, mixed conifer, and spruce fir forests can be useful for defining and developing desired forest conditions in other forest types. The intent of the goshawk recommendations was to maintain mosaic forest conditions that would sustain the goshawk and its suite of prey species. Those conditions include snags, downed logs, woody debris, openings, large trees, shrub and forb understories, and small trees. In the recommendations, the forest structural stages were defined as grass-forb/shrub, seedling-sapling, young forest, mid-age forest, mature forest, and old forest (Figure 2).

Forest types and their respective fire regimes provide context for developing desired conditions for sustaining northern goshawks, including home ranges for building and maintaining nests, a place for their young to learn to hunt, and an area that provides food. Because fire is the primary disturbance mechanism throughout the Western United States, it maintained landscapes for goshawk populations.

In the nonlethal fire regimes, exemplified by the ponderosa pine forests of the Southwestern United States, goshawk habitat was maintained by frequent surface fires that regenerated, cleaned, and killed forest vegetation. Goshawks and their prey species adapted to this fire regime. The uneven-age structure contained mostly large old trees. The goshawk recommendations of Reynolds and others (1992) describe the forest conditions that were maintained by the nonlethal fire regime in ponderosa pine forests. The landscape contained 10 percent grass/seedling/shrub, 10 percent sapling, 20 percent young forest, 20 percent mid-age forest, 20 percent mature forest, and 20 percent old forests in the PFA and foraging areas (total of approximately 2,400 ha) (Figure 2).

Nonlethal fires cleaned the ponderosa pine forests providing excellent foraging habitat and open canopies enabling goshawks to find prey. Also, individual trees or small groups (three to five trees) of large old trees would die from lightning, disease, or insects. These stems would provide snags and coarse woody debris. The low-intensity surface fires would gradually consume the downed logs, but not before they would contribute to wildlife habitat and provide organic matter to the forest soil. The small openings left allowed for the regeneration of new trees. Because, these are the conditions goshawks and their prey desire, the Reynolds and others (1992) recommendations are applicable for ponderosa pine and ponderosa-pine mixed conifer forests.

In forests with mixed or variable fire regimes, we suggest modifications in the recommendations. Most often forests with these fire regimes are more diverse and oc-

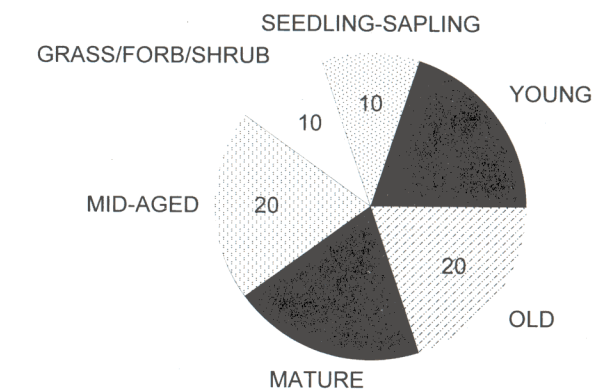


Figure 2. Proportions of a home range or landscape desirable for sustaining goshawks in forests with nonlethal fire regimes (Reynolds and others 1992).

cupy more moist sites. For example, many Douglas-fir and western larch forests have variable fire regimes. Fires in these forests created larger openings (> 2 ha), greater amounts of downed logs, and more multiple tree canopies than those with nonlethal fire regimes. The fires created openings of all sizes, leading often to patchiness or a fine-grained mosaic across the landscape.

Goshawks require areas for nests, protection for the young, and areas that provide food. In forests with variable or mixed fire regimes, multiple openings larger than 2 ha were likely at any one time. Only a portion of these areas would provide foraging habitat. Goshawks only use the edge of large openings for hunting. Also, large openings are not the preferable habitat for many goshawk prey. For example, the hairy wood pecker (*Picoides villosus*), Steller's jay (*Cyanocitta stelleri*), and red squirrel (*Tamiasciurus hudsonicus*) all prefer forests with large trees with dense canopies. The blue grouse (*Dendragapus obscurus*) and cotton tail (*Sylvilagus* spp.) do use small openings. Probably less than 4 ha along the edge of a 10 ha opening is used by goshawks. Therefore, for every 10 ha opening in a goshawk home range, an additional 6 ha of forested home range would be needed to support the goshawk family.

Larger openings are important in these forest types and fire regimes for encouraging and maintaining seral aspen, which is an important component of many goshawk home ranges.

Similar adjustments to the goshawk recommendations become apparent in lodgepole pine and white bark pine forests including adjusting patch size, tree size, and amount of downed logs. Lodgepole pine is much shorter lived with smaller tree size than ponderosa pine. Moreover, lodgepole forests are more prone to larger openings created by fire. Again, to ensure that adequate amounts of old forest are available to the goshawk and the prey, larger home ranges may be necessary.

With mixed fire regimes, the variation in crown canopy densities increases. If crown canopies are reduced in the forest, resulting conditions may not provide good habitat for squirrel, blue grouse, sapsucker (*Sphyrapicus thyroideus*), or woodpecker. Forests influenced by mixed fire regimes will have areas where crown canopy densities are low. Adjustments may be needed to provide appropriate conditions for goshawk prey, and more area would be needed to provide the necessary habitat.

In forests with variable and mixed fire regimes, a high interspersed of forest structural stages could lead to fragmentation of home ranges. To sustain goshawk habitat, adjustments may then be needed. For example, concentrating openings only in portions of a home range mimics disturbance patterns caused by fire. Temporally, these openings could move spatially covering the entire home range in 150 to 250 years depending on rate of forest development.

Forests maintained by lethal fires offer a great challenge for sustaining goshawk habitat. Opening sizes are usually large (> 10 ha) and the even-age structure of the forest occurs on a landscape level. These forest types range from Rocky Mountain lodgepole that is susceptible to stand-replacing fires at relatively frequent intervals, to western white pine and hemlock that experience stand-replacing fires at much longer intervals. Large home ranges of over 4,000 ha might be required to ensure that large amounts of old forest are available to the prey species.

Similar to forests with mixed and variable fire regimes, minimizing structural stage interspersed is important in forests with lethal fire regimes. Treatments for sustaining goshawk home ranges in these forests need to provide a range of seral to climax plant communities. Because of potential large openings, rate of forest development, and

tree longevity occurring in forests with lethal fire regimes (lodgepole to western hemlock) structural stage proportions within the home range may vary. Plans to sustain goshawks in forests with lethal fire regimes, will likely involve hundreds of years and occur within large areas.

In forest types that rarely burn, small openings created to ensure the development of regeneration and provide habitat for prey would be appropriate for sustaining goshawk home ranges. These treatments would mimic the occurrence of wind events that historically maintained these forests. Treatments could be designed to provide a wide range of structural stages on home ranges much like those described by Reynolds and others (1992) for the spruce/fir forests of the Southwestern United States. Small openings, interspersed of structural stages, and an uneven-age forest across both the PFA and the foraging area would characterize goshawk habitat in these forests.

The potential opening size generally increases as fire regimes become more lethal and crown canopy closure can decrease. Therefore, the area required to sustain a goshawk family will likely increase in the more lethal fire regimes and less interspersed of vegetative structural stages would be desired (Figure 3).

Landscape Approach

Regardless of the forest type or fire regime, a landscape approach is preferred for managing for northern goshawks or other management goals. By managing large landscapes and ensuring that their inherent structures and processes are operational and functioning will not only sustain goshawks but all forest attributes. The intent of the recommendations (Reynolds and others 1992) was to provide a framework for managing landscapes for goshawks using knowledge on forest development and disturbance.

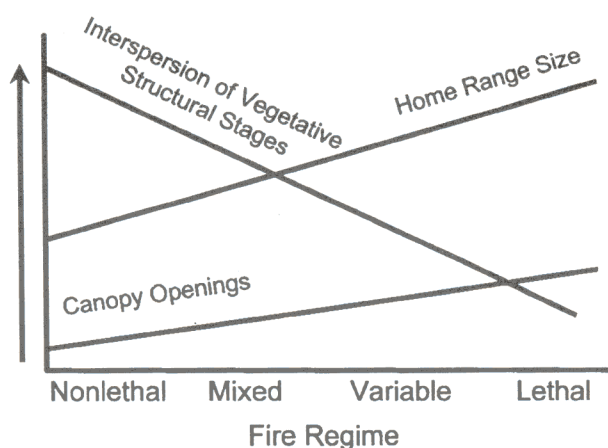


Figure 3. The relationship between fire regime and canopy openings, home range size, and interspersed of structural stages for goshawk home ranges.

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