

Comparing Recent Fire Occurrence with Historical Fire Return Intervals in Washington's National Parks

Abstract

In this study the average spatial extent of recent fires in the three National Parks in the State of Washington was quantified and compared to the average area of each park that must burn each year to maintain natural fire regimes and associated vegetation communities. Current vegetation maps and associated fire return interval data were used to calculate the aggregate annual area of fire that is necessary within each park to assure that current fire regimes and associated vegetation communities persist over time. This analysis revealed that on average, far less forest burned each year from 1986-1996 than is required over the long run to maintain natural fire regimes. In North Cascades National Park, a conservative estimated annual average of 329 hectares are expected to burn, but on average only 26 hectares per year actually burned. In Olympic National Park, a conservative estimated annual average of 654 hectares is expected to burn, compared to the annual average of only 20 hectares actually burned. In Mt. Rainier National Park, a conservative estimated annual average of 202 hectares is expected to burn, compared to the 4 hectare average that actually burned during the study period.

Introduction

National Parks in the United States were established to preserve the natural resources within their boundaries. Simultaneously, they are also managed to allow natural processes to unfold. However, these two directives can come into direct conflict when applied to fire management. For example, fire exclusion may be implemented with the goal of preserving existing vegetation communities, but fire itself is a major component of forest ecosystems and integral to allowing the natural process of a park to unfold. Maintaining natural fire regimes may be central to maintaining other elements of each park's ecosystems because many species of wildlife have co-evolved with fire (Smith 2000). Such management conflicts can be partially addressed by comparing the relative scale of the fires that are currently occurring in the parks to the scale of the fires that might be expected if the ecosystem processes, including fire, were occurring without human intervention. I used Geographic Information Systems (GIS) to compare a very brief 11 year fire history for the three national parks in Washington State to the 'average' area of land that must burn each year to maintain each park's natural fire regimes and associated vegetation communities (Figure 1).

The Pacific Northwest has a wide diversity of flammable forest ecosystems and associated fire regimes, ranging from very moist to semi arid (Agee 1993). Historically, these different types

of forests burned in different ways and at very different frequencies. Many of the changes that are occurring now in these forests are the result of a century of aggressive fire suppression, as well as logging, grazing, road building, and other human activities. In particular, because of fire suppression, we may now be experiencing fires outside the historical range of variability in both size and intensity in some forest types (Covington et al. 1994, Covington et al. 1997, Mutch et al. 1993, Weisberg and Swanson 2003, Stephens and Ruth 2005).

In most forests, management activities that reduce fuel loads can reduce the severity of those wildland fires, though the effectiveness of such treatment is questionable in the case of crown fire. (Martin et al. 1989, van Wagendonk 1996, Weatherspoon and Skinner 1996, Stephens 1998, Moore et al. 1999, Fule et al. 2001, Pollet and Omi 2002, Stephens and Ruth 2005). Along with mechanical thinning, fire is the most widely applied method for fuel removal (Mutch et al. 1993, Hann and Bunnell 2001, Graham et al. 1999, Graham, McCaffrey, and Jain 2004). However, the highly visible nature of National Parks makes extensive use of mechanical thinning or fire politically difficult.

Current federal wildland fire use policy officially condones the careful and gradual reintroduction of fire (NWCG 2001). Therefore, many land management agencies are trying to re-introduce fire, either through direct management ignition



Figure 1. Location of national parks in Washington State.

or through programs allowing lightning caused ignitions to burn in certain controlled conditions. However, these activities must be carried out at the appropriate scale and spatial arrangement or they will not have the desired effects on future wildland fires (Finney 2001). Stephens and Ruth (2005) have recently reported that in the Pacific Northwest alone there are approximately 3.6 million hectares in need of such fuel treatment. They also explain that the treatment goal for the area in 2004 was 52,000 hectares and calculated that it would take 69 years to treat all of the area once.

In this study, I use GIS to examine some of the spatial elements of these issues, specifically in North Cascades, Olympic, and Mount Rainer National Parks. The recent average yearly spatial extents of fires within the three national parks

is compared directly to the average area of land that must burn each year to maintain each park's natural fire regime.

Methods

Vegetation Classification

The vegetation data used for this study were produced for the National Park Service in the early 1990s and derived from Thematic Mapper satellite data (USDI National Park Service, 2005). These data sets mapped the lands of each of Washington's national parks into 16 categories of vegetation cover, including a category for rock and ice (Table 1). These 16 categories were overly specific for this study and presented difficulties for establishing valid "fire return interval" (FRI)

TABLE 1. Original vegetation categories and aggregated reclassification.

Original Vegetation Classification	Reclassification
Rocks, Snow, Water,	Rock
Mountain Hemlock	Alpine and Subalpine
Subalpine Fir	Alpine and Subalpine
Ak Cedar and Larch	Alpine and Subalpine
Sitka Spruce, Western Red Cedar	Coastal
Lodgepole Pine	Conifer/Deciduous Mix
Ponderosa Pine, Hardwood Mix	Conifer/Deciduous Mix
Conifer/Deciduous Mix	Conifer/Deciduous Mix
Pacific Silver Fir, Noble Fir	Mixed Conifer
Western Hemlock	Mixed Conifer
Conifer Mix	Mixed Conifer
Douglas Fir, Bigleaf Maple	Mixed Conifer
Quaking Aspen, etc	Riparian/Meadow
Meadows/Grasslands	Riparian/Meadow

values for each category. Therefore, we aggregated the categories to better reflect the range of FRI information available.

Of these 16 original categories, we eliminated both the Grand Fir, and White Fir categories, as they were absent on the landscape, and eliminated Rock and Ice as they were not relevant to our study. The remaining 13 categories were aggregated into five broader categories: alpine and subalpine forests, moist coastal forests, mixed conifer forests, conifer/deciduous mix forests, and meadows and riparian areas (Table 1).

Fire Return Interval Estimation

Two sets of FRIs were estimated for each aggregated vegetation category within each park. An FRI is defined as the average number of years between two successive fire events in a given area (Agee 1993). One set of FRI values were based on 1 km scale maps of FRIs developed for the entire conterminous US (USDA Forest Service 1999, Schmidt et al. 2002). These FRI categories were developed nationally and are most likely shorter than what occurs in Washington's national parks, which are generally wetter than the conditions for which the national categories were devised. A second more conservative set of FRI estimates were derived from values published for various vegetation types that experience climates similar to Washington's national parks. This second set of FRI values are three to five times longer

than the nationally developed coarse-scale FRI estimates. The two sets of FRI values were each used in all calculations to provide an upper and lower range of the expected annual average area of fire in the parks.

For the first FRI data set, the five vegetation categories were associated with the most appropriate FRI category used by the national level coarse-scale data set (Schmidt et al. 2002). Alpine forests and coastal forests were categorized with a 200 year FRI. Mixed conifer forests were conservatively classified with a 100 year FRI, while conifer/deciduous mix forests, and riparian areas and meadows were categorized with 35 year FRIs (Table 2).

TABLE 2. Reclassed vegetation categories with assigned national coarse-data FRI values and adjusted regional FRI values.

Vegetation Reclassification	National/ FRIs	Regional/ FRIs
Alpine and Subalpine	200	1000
Coastal	200	1000
Mix Con	100	500
Con/Dec mix	35	250
Meadow	35	250

For the second set of FRI values we examined the literature for vegetation specific and regionally specific FRI estimations. Many of the FRI values were derived from Agee (1993) (Table 2).

In forests that burn very infrequently it is rare to have fire records that are long enough or regular enough to infer cyclic patterns (Agee 1993). Therefore, in these forests the FRIs are offered more as guides to the episodic nature of these fires. Alpine and subalpine forests, which included mountain hemlock, subalpine fir, larch and Engelmann spruce vegetation communities were assigned a conservative 1000 year FRI. Lertzman and Krebs (1991) found FRIs of over 1500 years for some mountain hemlock stands (Lertzman and Krebs 1991). However, in Oregon Dickman and Cook (1989) found that over half of their 18,000 hectare study area had burned in the last 500 years (Dickman and Cook 1989). FRIs of between 109 to 275 years are reported for subalpine fir in the Pacific Northwest (Franklin et al. 1988, Agee et al. 1990). Little work has been done to determine FRIs for alpine larch and Engelmann

spruce communities, with one study indicating that larch communities rarely even burn (Arno and Habeck 1972). However larch and Engelmann spruce communities made up only about 5% of the alpine and subalpine category.

Coastal forests are very moist in this region and were also categorized with a 1000 year FRI. These forests represented the Sitka spruce and western red cedar category in the original vegetation data. Little is known about fire in these forests, but the data we have now indicates that fires were very infrequent and burned wide areas under rare conditions (Agee 1993). One study using an age-class based model indicated a 1,146 year disturbance interval in Sitka spruce in Washington (Fahnestock and Agee 1983). A similar model for Oregon forests found a 400 year disturbance interval (Andrews and Cowlin 1940). However, both these studies do not necessarily distinguish between fire and other disturbances such as wind. Other evidence of fire does also include scattered 500 year-old stands of Sitka Spruce in the western Olympics (Agee 1993).

Mixed conifer forests were assigned a conservative 500 year FRI. This broad category represented the single largest category in each of the three parks. The aggregated category included original vegetation data set categories of western hemlock, pacific silver fir and noble fir, Douglas fir and bigleaf maple, and a mixed conifer category, all of which were well represented on the landscape. A broad scale analysis of these types of forests found a regional average FRI of 230 years (Fahnestock and Agee 1983). The wet conditions of Washington's Parks do point to longer FRIs. However, the moist forests in this region tend to be first generation post-fire forest less than 750 years old, suggesting a FRI of less than 750 years (Agee 1993, p209).

Conifer/deciduous mix forests were assigned a conservative 250 year FRI. This category included original vegetation data set categories of ponderosa pine and hardwood mix, lodgepole pine, and conifer/deciduous mix. This complicated category includes some forest communities that have very short FRIs in other dryer forests. For example FRIs reported for ponderosa pine forests include 1.8 years (Dieterich 1980) 4-12 years (Weaver 1951), and FRIs closer to 20 years (Weaver 1959, Bork 1985). Lodgepole pine forests can also have short FRIs. However, only a very small portion of the

conifer/deciduous mix category is composed of these dryer forests. The FRI value of 250 years is based on moister conifer/deciduous communities that constitute most of the category. For example, Douglas-fir community types almost certainly have longer FRIs than those reported elsewhere even in the Pacific Northwest, such as the many mixed Douglas-fir/deciduous communities in other areas that have FRIs ranging from 20-80 years (Agee 1993).

Riparian areas and meadows represent a significant portion of the landscape in these parks, with meadows making up the bulk of this aggregated category. Though in many other areas of the country these sorts of meadows burn very frequently, in the case of these moist parks these areas were categorized with a 250 year FRI. This is a difficult compromise between the extensive literature that suggests short FRIs for meadows and riparian areas and other sources that indicate longer FRIs for the moist and alpine areas in these parks (Agee 1993). The situation is made more difficult by other anthropogenic considerations. For example in the Ozette Prairies of Olympic National Park indigenous groups may have burned the prairies for hunting and plant-gathering purposes (Bach and Conca 2001).

Recent Fire History

Besides the FRI data for each park, fire records were necessary to estimate the area burned in each park for each year of the record. Spatial data for forest fire occurrence from 1986-1996 were acquired from National Forest Service websites. The fire data were downloaded from the Forest Service's "Coarse-Scale Spatial Data for Wildland Fire and Fuel Management" website (<http://www.fs.fed.us/fire/fuelman>). The data were used to calculate the annual average hectares of forest burned each year between 1986 and 1996, for each of the three national parks (Table 3).

Data Analysis

Once these data sets were assembled, I multiplied the number of hectares in each vegetation category in each park by the two sets of FRI estimates. This resulted in two sets of estimates for the annual average number of hectares expected to burn in each vegetation category in each park. These areas were totaled for each park to indicate the annual average area of fire required for each park

to stay within its current range of fire regimes and associated vegetation communities.

Results and Conclusions

This analysis revealed that on average far less forest burned each year during the eleven year

TABLE 3. Hectares of fire in each of Washington's National Parks, 1986-1996

Year	NCNP	ONP	MRNP
1986	0	2.43	1.25
1987	0.04	1.09	34.6
1988	0.04	99.43	0.16
1989	0.49	3.24	0.32
1990	120.19	0.77	4.65
1991	0.97	0.93	0.45
1992	5.42	9.83	0.24
1993	0	0.32	0.04
1994	56.45	98.18	0.53
1995	103.19	6.88	0
1996	0	0.57	0
Total	286.79	223.7	42.25
Average	26.07	20.33	3.84

NCNP—North Cascades National Park

ONP—Olympic National Park

MRNP—Mount Rainier National Park

study period than is required over the long run to maintain natural fire regimes (Table 4), using either coarse-scale or more conservative estimates of FRI.

The observed annual average hectares burned in the parks ranged from about 4 ha/yr at Mount Rainier National Park to 26 ha/yr at North Cascades National Park. The calculated average expectations were several orders of magnitude higher when computed with the national coarse-data values, ranging from 1159 ha/yr at Mount Rainier to 3581 ha/yr for Olympic National Park. When average expectations were calculated using the more conservative regionally specific FRIs the results were still roughly an order of magnitude greater than the observed fire average, with values ranging from 202 ha/yr at Mount Rainier to 654 ha/yr at Olympic National Park.

Although the areas burned by wildland fires in these parks vary tremendously among years and even more as we examine fire histories over decades and centuries, the averages reported here are intended to provide a realistic yardstick with which to examine current fire policies and the spatial extent of the fires that are actually occurring. Obviously, one large fire could radically alter any park's annual average area burned. Equally

TABLE 4. Average expected hectares burned calculated with national coarse-data FRI values, adjusted regional values, and observed actual average hectares burned 1986-1996.

NCNP	Hectares	National/FRIs	Regional/FRIs	
Alpine and Subalpine	14063	70.315	14.06	
Coastal	1491	7.455	1.49	
Mix Con	71274	712.74	142.55	
Con/Dec mix	768	21.94	3.07	
Meadow	41984	1199.54	167.94	Observed
Total	129580	2011.00	329.11	26.07
ONP				
Alpine and Subalpine	55007	275.04	55.01	
Coastal	12593	62.97	12.59	
Mix Con	221221	2212.21	442.44	
Con/Dec mix	7737	221.06	30.95	
Meadow	28343	809.80	113.37	Observed
Total	324901	3581.07	654.36	20.33
MRNP				
Alpine and Subalpine	14897	74.49	14.90	
Coastal	1098	5.49	1.098	
Mix Con	58421	584.21	116.84	
Con/Dec mix	0	0	0	
Meadow	17327	495.06	69.31	Observed
Total	91743	1159.24	202.15	3.84

important, the estimates calculated in this study of yearly average hectares of fire expected without fire suppression, are meant only as broad estimates for comparison purposes only. Such overviews are further complicated by the dynamic nature of fire regimes and the likelihood that we are seeing natural departures from historical disturbance regimes.

Fires do not occur on a consistent yearly schedule. In fact, many of the forested areas in these parks are very moist and may go centuries without fire (Agee 1993). Regional fire activity also co-varies with annual climate variability (Clark 1988, Swetnam 1993). The yearly expected areas calculated here represent only the average number of hectares per year, aggregated over decades, necessary within each park to maintain natural fire regimes. These averages do not imply that these areas must burn in even yearly allotments, and they make no predictions about the consequences of forest being allowed to go unburned beyond their historical FRI. The vegetation categories used in this study represent complicated systems that will respond in complex ways to fire exclusion and changes in FRI. This research does not

quantify the range of the ecosystem changes that might accompany fire regime changes, and does not account for other long term changes that may be occurring in these forests.

The eleven-year fire record used in this study is far too short to capture the long term dynamics of the spatial patterns of fire in these parks over the long term. However, these averages do point to a situation in which large areas of these parks must eventually burn or the parks will undergo vegetation changes. Park managers must make the necessary fire management decisions with a full understanding of the large areas that have traditionally experienced fire in these parks.

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