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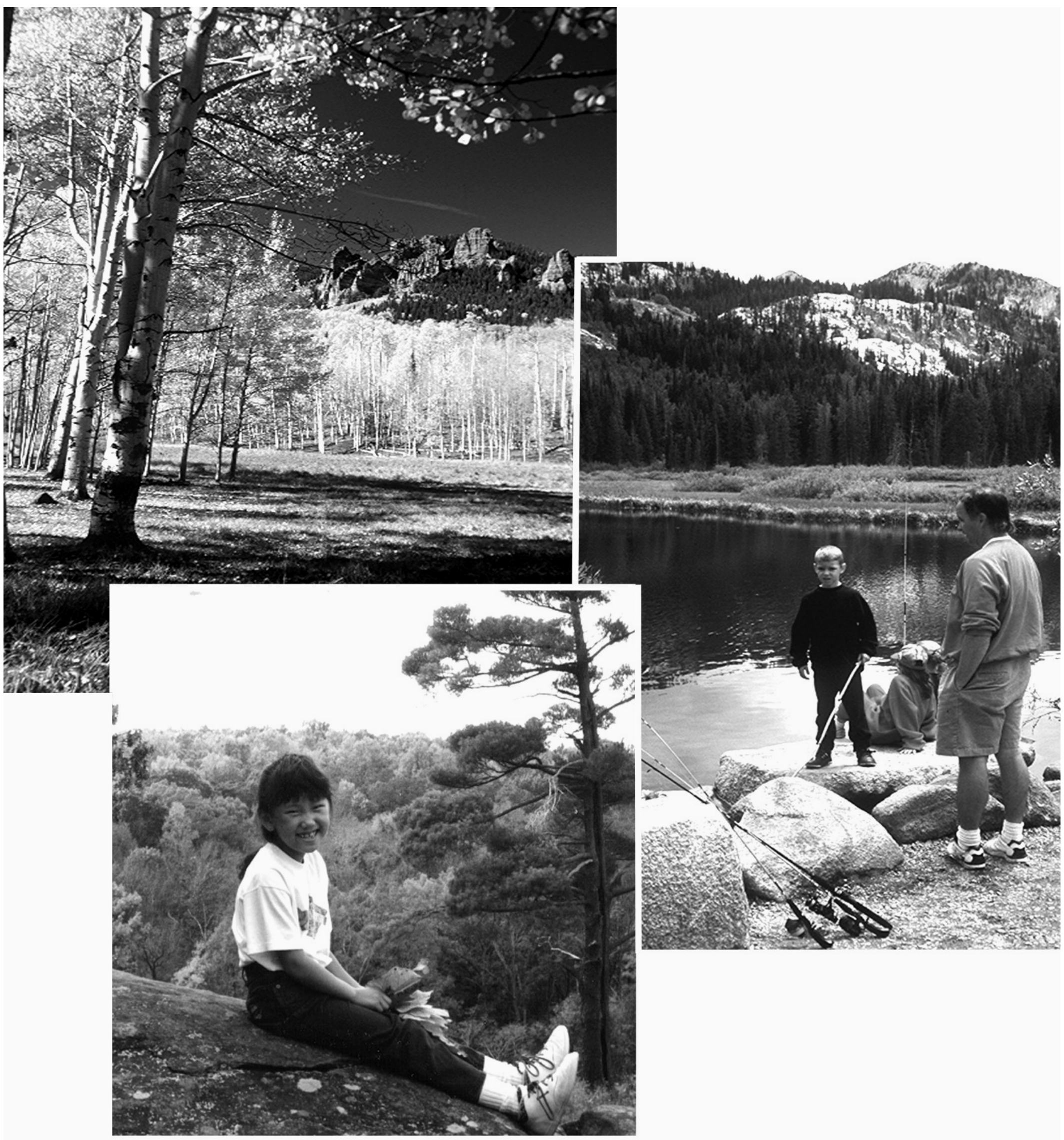
Roadless Area Conservation

Final Environmental Impact Statement

Fuel Management and Fire Suppression Specialist's Report



FUEL MANAGEMENT AND FIRE SUPPRESSION SPECIALIST'S REPORT

November 2000

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Table of Contents

Page No.

Abstract:

This report describes the source of the fire management information used in the environmental analysis of the Forest Service Roadless Area Conservation Final Environmental Impact Statement (FEIS). This report is a supplement to the data found in the FEIS and does not repeat the information found there. The specialist's report includes more detailed data and information that were used to develop the effects analysis; provides citations from a literature review used as background for the major themes, assumptions and uncertainties noted in the FEIS; lists the changes between the Draft EIS and the Final; and provides a description of problem analysis methods. The appendices include expanded data tables and background papers concerning cumulative impacts, uncertainty analyses, and condition class mapping techniques.

The analysis concluded that a direct cause-effect relationship could not be found between road access and the occurrence of large wildland fires. Within the 14 million acres of short fire return interval forests in inventoried roadless areas, 6.5 million acres could potentially be treated for fire hazard reduction purposes by prescribed fire alone; however, 7.5 million acres of forest may require some form of mechanical pretreatment before prescribed fire could be regularly applied.

The direct effect of prohibiting road construction and reconstruction in inventoried roadless areas is that the direct cost (excluding the cost of road construction) of fire hazard reduction projects could rise due to lack of access. However, the amount of high priority fuel management work occurring in roadless areas is very small as compared to areas that are essentially roaded. Some wildfires that escaped initial fire control efforts and became large could be more expensive to suppress. The negative cumulative effect of implementing this policy is low since the amount of fire hazard reduction work in roadless areas is small when compared to the amount of fuel management work found on all federal and state lands.

Changes between Draft and Final EIS:

- Expanded the discussion of fire ecology principles
- Introduced the concept of "historic range of variability"
- Replaced the term "catastrophic wildfire"
- Introduced the concept of "uncharacteristic wildfire effects"
- Prepared the background papers on the *Coarse-Scale Assessment* analysis procedures by Geospatial Service and Technical Center and Remote Sensing Applications Center in Salt Lake City, Utah
- Expanded the discussion of Fire Regime and Condition Class data and clarification of tables using this information
- Clarified the wildland urban interface demographics used by including the wildland and rural ambient population density classes
- Included strategies approved in two recent reports---*Managing the Impact of Wildfires on Communities and the Environment* and *Protecting People and*

Sustaining Resources in Fire-Adapted Ecosystems: Cohesive Strategy---which suggested that the highest priority for fire hazard reduction treatments would be hazardous fuel situations in roaded forest and rangelands adjacent to and within communities

- A section was added noting that fuel treatment costs used in the FEIS exclude the costs of constructing or reconstructing a road into an area requiring fire hazard reduction
- Expanded discussion of the environmental effects related to using timber harvest as a primary technique of fire hazard reduction and post-harvest fuel treatment
- Introduced the concepts of active and passive management and included a more thorough discussion of wildland fire for resource benefit (WFURB)
- Updated fire occurrence tables to include statistics for inventoried roadless areas and Wilderness areas. NFS lands were subdivided into areas that are classified as "essentially roadless" and those that are "essentially roaded."
- The average statistic to describe large fire size was replaced with the median statistic in Table 3-22 of the FEIS
- The average median and standard deviation statistics were calculated for large wildfires occurring in each region
- Cumulative effects were expanded to include a discussion of the Interior Columbia River Basin, the Transportation rule, the *Cohesive Strategy* and the National Fire Plan.

Affected Environment:

Initial Problem Framing Exercises

Framing the affected environment sections of the fuel management and fire suppression effects analysis within the context of a prohibition on road construction and reconstruction, and between commodity and stewardship timber harvest, was the first exercise completed before data requests were made.

In this initial problem framing exercise, telephone discussions occurred with Forest Service and National Park Service fire personnel at the national, regional, and forest levels who were experts in fire ecology, fuels management, fire suppression, fire and forest planning, air quality, fire economics, fire history analysis, fire dispatching, firefighter safety, fuels management, Wilderness fire management, and the National Environmental Policy Act. These informal telephone interviews occurred with fire management professionals in the Northeast (Region 9), South (Region 8), West (Regions 1-6), and Alaska (Region 10). Contacts were made with academics specializing in fire ecology, geography, and fire history at the University of Washington, University of Arizona, University of Wyoming, and Northern Arizona University. Researchers at the Fire Sciences Laboratory and Forestry Sciences Lab (Missoula, Montana), Pacific Northwest Research Station (Seattle, Washington) at the Laboratory of Tree-Ring Research (Tucson, Arizona), and the National Interagency Fire Center (Boise, Idaho) were contacted. Telephone interviews also occurred with the following individuals: researchers specializing in the management of Wilderness fire management programs at the Aldo Leopold Wilderness Research Institute in Missoula, Montana, private consultants specializing in wildland urban interface (The Sampson Group 2000); fire history (Barrett); fire scientists at Grand Canyon National Park responsible for implementing a ponderosa pine restoration experiment inside the Park; personnel at Ecological Restoration Institute at Northern Arizona State University; Dr. Scott Stephens, fire scientist at the University of California, Berkley; Dr.William Romme, Biology Department, Fort Lewis College, Durango, Colorado.

The following Forest Service EIS and policy documents from around the United States were reviewed:

- Herger–Feinstein Quincy Library Group Forest Recovery Act
- Final Environmental Impact Statement on Management for the Northern Spotted Owl in National Forests
- An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins
- Southern Appalachian Assessment
- Sierra Nevada Framework
- Federal Wildland Fire Policy
- National Fire Plan
- Boundary Waters Canoe Wilderness blow down draft EIS
- Northern Great Plains National Grasslands assessment

Fuels Management Data Sources

Two key sources of national fire management data and strategic direction became available in the fall of 1999. The sources allowed a more precise description of the fuel management affected environment and the cause-effect relationships for each alternative. The first data source is a set of seven geospatial layers titled *Coarse-Scale Spatial Data for Wildland Fire and Fuel Management* (Hardy and others 2000) which cover the conterminous United States. These seven layers are: (1) potential natural vegetation groups, (2) current cover types, (3) historical natural fire regimes, (4) current conditions, (5) national fire occurrence, (6) fire characteristic probabilities and (7) a population density map of the United States. A complete set of these geospatial data layers can be found at http://www.fs.fed.us/fire/fuelman.

The second source of information was a Forest Service strategy titled *Protecting People and Sustaining Resources in Fire-Adapted Ecosystems: A Cohesive Strategy* (*Cohesive Strategy*) (Laverty and Williams 2000), which outlines a fuel management implementation strategy for reducing the risk of uncharacteristic wildfire effects across National Forest systems (NFS) lands. The *Cohesive Strategy* subdivided gross acres potentially requiring fuel treatment identified in Table 3-13 of the FEIS, indicating that the fuel management emphasis should be the treatment of forest and shrub lands that have burned frequently and at low fire intensities (Fire regimes 1 and 2) and that are classified in Condition Classes 1, 2, or 3. For example, of the 14 million acres rated at moderate risk in inventoried roadless areas, approximately 7 million acres were identified for fire hazard reduction work; of the 8 million acres rated at high risk from uncharacteristic wildfire effects, approximately 4 million acres were identified for potential treatment. The complete *Cohesive Strategy* implementation schedule is found in Appendix F.

Just because an inventoried roadless area meets the classification scheme of Condition Class 1, 2 and 3, and Fire Regimes 1 and 2, it does not mean that forested areas would be automatically treated. The *Cohesive Strategy* specifically targets for fuel treatment and restoration National Forest landscapes that are "already roaded…and in close proximity to communities." The strategy also states that to "maximize effectiveness and minimize controversy, mechanical treatments will be prioritized toward wildland-urban interface areas…[and that] ecologically sensitive areas such as old growth and late successional forests should be avoided."

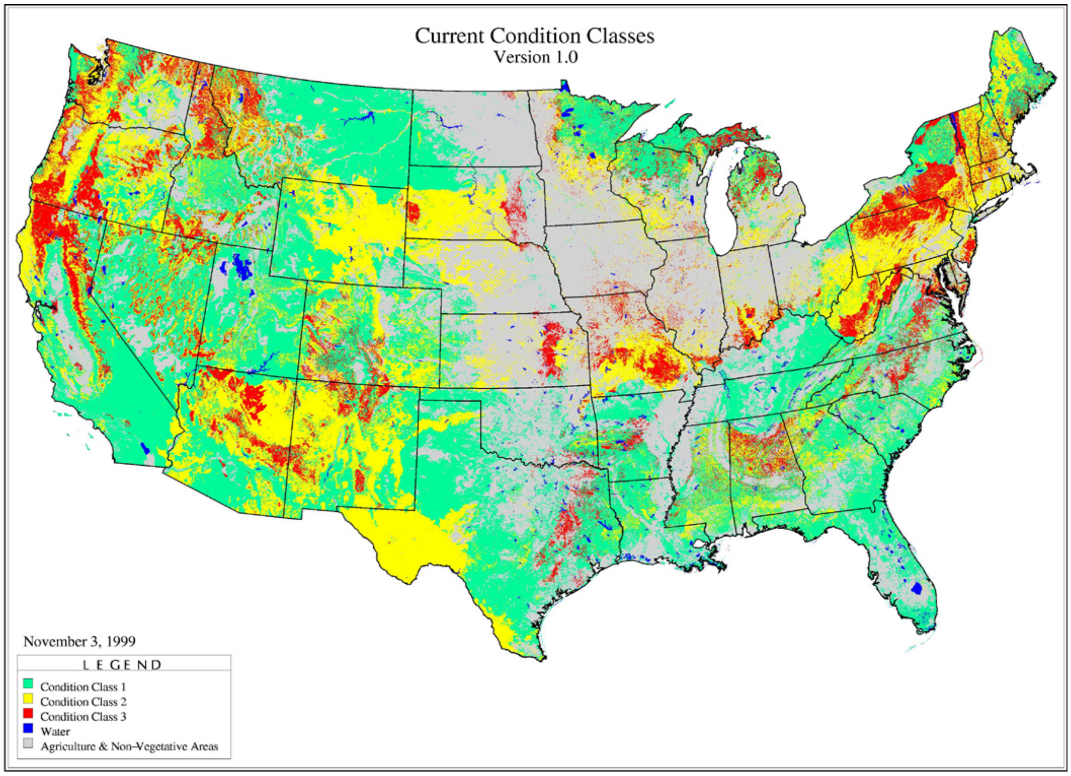
Figure 1 shows the Current Condition Class map derived from the *Coarse-Scale* data-set. This map was overlaid with GIS maps of inventoried roadless areas to produce the summary information found in Table 3-13 of the FEIS. Summary information was also obtained from data summary tables obtained by matching the current condition class map with fire regime maps (See Table 1 of Specialist Report).

Current Condition classes are defined (Hardy and others 2000) in terms "of relative risk of losing one or more key components that define an ecological system based on five ecosystem attributes." The five attributes are disturbance regimes, disturbance agents, smoke production, hydrologic function, and vegetative attributes. The ecosystem risk increases with each Condition Class, with relatively no risk at Condition Class 1 to significant risk at Condition Class 3. The public commonly uses the term "catastrophic fire" to describe fast spreading, high intensity wildfires that threatened ecosystem functioning and human communities. In the

FEIS, the phrase used to describe the detrimental effects of a wildland fire is "uncharacteristic wildfire effects." For purposes of the roadless analysis, the terms catastrophic wildfire and uncharacteristic wildfire effects are synonymous.

Figure 1: National current condition class map.

(*Source: Hardy and Others 2000 and Roadless GIS Data Team*



Uncharacteristic wildfire effects are defined as an increase in wildfire size, severity, and resistance to control, and the associated impacts to people and property. These uncharacteristic effects, caused primarily by wildfire suppression, past timber harvest practices and grazing, have resulted in dramatic changes in some areas in wildfire frequency, size and severity. Compared to less altered ecosystems, vegetative structure, density, and composition have changed causing substantial shifts in both patch size and disturbance patterns. Landscapes that retain characteristics of ecosystem composition and structure that are within the historic range of variability and that would be expected to occur under natural disturbance regimes of the current climatic period are considered characteristic. The goal of fuel management in addressing the effects of uncharacteristic wildfires would be to restore characteristic size and severity and lower the resistance to control. Uncharacteristic wildfire effect is used in the *Cohesive Strategy* and the *Interior Columbia Basin Ecosystem Management Project* (Hann and others, 1997).

It is important to note that the data in the *Coarse-Scale* spatial data set is developed for national-level fuel management planning and is only accurate to State or Forest Service regional scales (Hardy and others 2000). The first national use of this data was in the *Cohesive* Strategy and the Roadless Area Conservation FEIS. This coarse-scale information was used for purposes of strategic analysis at the national scale and not the site-specific tactical location of individual fuel management projects. Issues of scale (going from a coarse-scale to a fine-scale, for example), the proper use of coarse-scale information in environmental analysis, and the sensitivity of coarse scale condition class mapping were continuing concerns throughout the environmental analysis. A full discussion of these topics prepared by the Geospatial Service andTechnical Center, and the Remote Sensing Applications Center in Salt Lake City can be found in Appendix B ("Salmon River Fire Condition Class Comparison"), Appendix C ("A Comparative Analysis Between Inventoried Roadless Areas and Other National Forest System Lands") and Appendix D ("Propagation of Uncertainty in Map Overlay Analysis").

Table 1: Historic fire regimes by condition class (thousands of acres) for all Forest Service lands excluding Alaska and Puerto Rico.[1]

Fire Regime	Condition Class 1	Condition Class 2	Condition Class 3	Other[2]	Total
0 – 35 yrs Low Severity	17,268	26,224	23,183	3,672	70,346
0 – 35 yrs Stand Replacement	4,854	7,301	298	1,907	14,359
35-100 yrs Mixed Severity	19,088	21,036	6,847	2,755	49,726
35- 100 yrs Stand Replacement	8,043	1,812	7,283	571	17709
200+ yrs Stand Replacement	14,628	991	1,162	85	16,866
Other				1,182	1,182
Total	63,882	57,363	38,772	10,172	170,189

[1] Fire regimes are the patterns of fire occurrence, size, uniformity, and severity of wildland fires (Smith 2000).
[2]Other includes agricultural lands, barren areas, urban areas and water.
(Source: *Roadless Database 2000)*

Table 2: GIS overlay of inventoried roadless areas with fire condition classes and fire regimes I & 2 and as a percentage of total inventoried roadless area (In 1000's of acres). **(*Table 2 continues on page 9)***

			CC 1 - Low	CC 2 - Med	CC 3 - High	CC 2+3	CC 1+2+3
			Total Acres	Total Acres	Total Acres	Total Acres	Total Acres
States[a]	**National Forest System Lands Total Acres**	**Inventoried Roadless Areas Total Acres**	**(% of Inventoried Roadless Areas)**	**(% of Inventoried Roadless Areas)**	**(% of Inventoried Roadless Areas)**	**(% of Inventoried Roadless Areas)**	**(% of Inventoried Roadless Areas)**
AL	665	13	1 (5.2%)	11 (83.8%)	1 (8.3%)	12 (92.1%)	13 (97.3%)
AZ	11,255	1,174	67 (5.7%)	792 (67.4%)	108 (9.2%)	900 (76.6%)	967 (82.4%)
AR	2,586	95	71 (74.3%)	14 (14.4%)	7 (7.2%)	20 (21.5%)	91 (95.8%)
CA	20,698	4,416	484 (11.0%)	534 (12.1%)	879 (19.9%)	1,413 (32.0%)	1,897 (43.0%)
CO	14,509	4,433	34 (0.8%)	598 (13.5%)	554 (12.5%)	1,152 (26.0%)	1,186 (26.8%)
FL	1,153	50	47 (93.1%)	(0.8%)	(0.0%)	(0.8%)	47 (93.9%)
GA	865	63	29 (46.7%)	29 (46.3%)	4 (5.8%)	33 (52.1%)	62 (98.8%)
ID	20,458	9,322	291 (3.1%)	690 (7.4%)	77 (0.8%)	766 (8.2%)	1,057 (11.3%)
IL	293	11	(3.5%)	3 (31.3%)	6 (53.8%)	9 (85.1%)	10 (88.6%)
IN	196	8	(0.0%)	(0.0%)	7 (89.2%)	7 (89.2%)	7 (89.2%)
KY	694	3	1 (31.4%)	(0.0%)	(0.0%)	(0.0%)	1 (31.4%)
LA	604	7	6 (90.0%)	1 (11.7%)	(0.0%)	1 (11.7%)	7 (101.7%)
MS	1,159	3	1 (49.9%)	(16.5%)	1 (23.2%)	1 (39.6%)	3 (89.6%)
MO	1,493	25	21 (83.0%)	1 (5.6%)	2 (9.5%)	4 (15.1%)	25 (98.1%)
MT	16,893	6,397	49 (0.8%)	224 (3.5%)	90 (1.4%)	314 (4.9%)	363 (5.7%)
NE	352	7	1 (17.2%)	5 (74.8%)	(1.1%)	5 (75.9%)	7 (93.1%)
NV	5,833	3,186	551 (17.3%)	1,074 (33.7%)	483 (15.2%)	1,557 (48.9%)	2,109 (66.2%)
NM	9,327	1,597	182 (11.4%)	779 (48.8%)	358 (22.4%)	1,137 (71.2%)	1,319 (82.6%)
NC	1,244	172	105 (61.2%)	55 (32.0%)	6 (3.6%)	61 (35.6%)	167 (96.8%)
ND	1,106	266	192 (72.2%)	(0.0%)	(0.0%)	(0.0%)	192 (72.2%)
OK	397	13	2 (15.3%)	11 (85.8%)	(0.0%)	11 (85.8%)	13 (101.1%)
OR	15,658	1,965	74 (3.8%)	299 (15.2%)	428 (21.8%)	726 (37.0%)	801 (40.8%)
PA	513	25	(0.0%)	4 (17.6%)	2 (7.6%)	6 (25.2%)	6 (25.2%)
SC	613	8	5	3		3	7

States[a]	National Forest System Lands Total Acres	Inventoried Roadless Areas Total Acres	CC 1 - Low Total Acres (% of Inventoried Roadless Areas)	CC 2 - Med Total Acres (% of Inventoried Roadless Areas)	CC 3 - High Total Acres (% of Inventoried Roadless Areas)	CC 2+3 Total Acres (% of Inventoried Roadless Areas)	CC 1+2+3 Total Acres (% of Inventoried Roadless Areas)
			(59.3%)	(32.0%)	(0.0%)	(32.0%)	(91.3%)
SD	2,012	80	22 (27.5%)	53 (66.1%)	5 (6.2%)	58 (72.3%)	80 (99.8%)
TN	635	85	54 (63.1%)	18 (21.4%)	9 (10.3%)	27 (31.7%)	81 (94.8%)
TX	755	4	3 (87.3%)	(3.5%)	1 (17.4%)	1 (20.8%)	4 (108.1%)
UT	8,179	4,013	477 (11.9%)	1,119 (27.9%)	247 (6.2%)	1,366 (34.0%)	1,842 (45.9%)
VA	1,660	394	200 (50.8%)	92 (23.3%)	44 (11.2%)	136 (34.5%)	336 (85.3%)
WA	9,214	2,015	12 (0.6%)	250 (12.4%)	345 (17.1%)	595 (29.5%)	607 (30.1%)
WV	1,033	202	8 (4.2%)	46 (22.6%)	44 (22.0%)	90 (44.6%)	98 (48.7%)
WY	9,238	3,257	16 (0.5%)	115 (3.5%)	7 (0.2%)	123 (3.8%)	138 (4.2%)

[a]The following states have no data in Fire Regimes I or II for CC1, 2, or 3: CT, DE, DC, HI, KS, ME, MD, MA, MI, MN, NH, NJ, NY, OH, RI, VT, WI. (Roadless GIS Database 2000) Condition class data not calculated for Alaska or Puerto Rico. IL, IN, KY, LA, MS, NE, PA, TX and SC each have 10,000 acres or less of Condition Class 1 through 3 lands, and are shown for comparison purposes only.

Table 3-14 in the FEIS is derived from Table 2 of the Specialist's Report. It was constructed by taking the total acres in all Forest Service regions rated at low, moderate, and high risk from uncharacteristic wildfire effects within inventoried roadless areas and comparing that figure with the acres targeted for potential treatment in the *Cohesive Strategy*. For example, in Arizona, of the total inventoried roadless area of 1,174,000 acres, 67,000 is rated at low risk, 792,000 at moderate risk, and 108,000 acres is rated at high risk from uncharacteristic wildfire effects.

Wildland Fire Urban Interface Data Source

To produce the wildland urban interface data, the inventoried roadless area maps were overlaid with a geospatial map of the ambient population of the United States. The information in the ambient population map was from the LandScan Global Population Database for 1998 (Lockheed Martin Energy Research Corporation 1999). Population estimates included stationary populations, such as people dwelling in cities or rural areas, but also an ambient population estimate, which measures the diurnal movements and collective travel habits of people in and out of a particular geographic area.

Ambient populations, calculated as people per square kilometer, were subdivided into the following classes:

- **Wildland**: 0 to less than 1
- **Rural**: 1 to less than 10
- **Rural/Urban**: 10 to less than 100 people
- **Suburban**: 100 to less than 500 people
- **Urban**: 500 or more people.

In the FEIS, square kilometer area measurements were converted to square mile measurements.

For GIS mapping purposes, 1-mile and 5-mile buffer zones were created around inventoried roadless areas for each Forest Service region. Appendix A is a map of inventoried roadless areas near Tucson, Arizona, displaying the buffer zones areas. The population classes---wildland, rural, rural/urban, suburban and urban--- within each buffer zone were mapped for each region. The results of this mapping effort were total acres within each ambient population class within 1 and 5 miles of inventoried roadless area boundaries (Table 3). A state-by-state summary is in Appendix H.

The percentages found in Tables 3-16 and 3-17 of the FEIS were obtained by taking the total acreage for each ambient population class and dividing by the total acreage for all population classes in each region. This calculation produced a simple proportional statistic that allowed a comparison to be made between the five population classes for inventoried roadless area within each region, and to compare regions.

A major limitation of this data is that one cannot precisely describe where each population cell is located in relation to an inventoried roadless area boundary. As seen in Table 3, Region 1 has approximately 16,000 acres and 245,000 acres of rural/urban ambient population class located within 1 mile and 5 miles, respectively, of an inventoried roadless area boundary. It is unknown whether the acres of the rural/urban population class are located in a single geographic area or randomly mixed along all inventoried roadless area boundaries. However, confidence is high in identification of the predominant population class adjacent to all inventoried roadless area boundaries within a Forest Service region.

Table 3: Wildland urban interface ambient population data (in thousands of acres) by Forest Service Region for 1 mile and 5 mile buffer zones around inventoried roadless area boundaries. (source: Roadless Database 2000)

Region	1-Mile Buffer from Inventoried Roadless Areas					
	Wildland	Rural	Rural/Urban	Suburban	Urban	SUM
1	5,986	110	16			**6,112**
2	6,061	306	102	4		**6,474**
3	3,112	137	29	4		**3,281**
4	9,420	263	90	21	7	**9,801**
5	4,514	436	117	11	2	**5,080**
6	5,038	275	43	1		**5,357**
8	865	633	125	1	1	**1,625**
9	847	253	22	1		**1,122**
10	No Ambient Population data for Alaska					
SUM	**35,843**	**2,413**	**543**	**44**	**10**	**38,853**

Region	5-Mile Buffer from Inventoried Roadless Areas					
	Wildland	Rural	Rural/Urban	Suburban	Urban	SUM
1	15,782	552	245	25	6	**16,609**
2	14,094	869	361	58	5	**15,387**
3	10,665	571	290	61	13	**11,601**
4	21,573	1,091	569	169	90	**23,493**
5	12,534	1,667	643	172	92	**15,109**
6	14,316	1,138	262	18	4	**15,738**
8	3,042	3,246	1,351	122	4	**7,765**
9	3,476	1,551	290	8	2	**5,327**
10	No Ambient Population data for Alaska					
SUM	**95,482**	**10,685**	**4,011**	**633**	**216**	**111,028**

(Population data were not available for Alaska or Puerto Rico.)

Fire Suppression Data Sources

Fire Occurrence Data Source

Table 4 is a tabulation of fire occurrence data for all Forest Service regions except Alaska. This data is from the coarse-scale geospatial data set (Figure 2) for fire occurrence (Hardy and others 2000), and linked to regional maps of inventoried roadless areas. The fire occurrence data were classified into five categories: areas of inventoried roadless areas where roads are currently permitted; areas of inventoried roadless areas where roads are currently prohibited; Wilderness areas; all other National Forest lands; and a summary of all data. Each category was further evaluated against the following attributes: fire cause (lightning or human), fire size (more than 1000 acres or less than 1000 acres), and total acres burned. Human-caused ignitions consisted of wildland fires started by campfires, smoking, debris burning, incendiary, equipment use, railroads, and children. Fires of unknown causes are also included in the human-caused category.

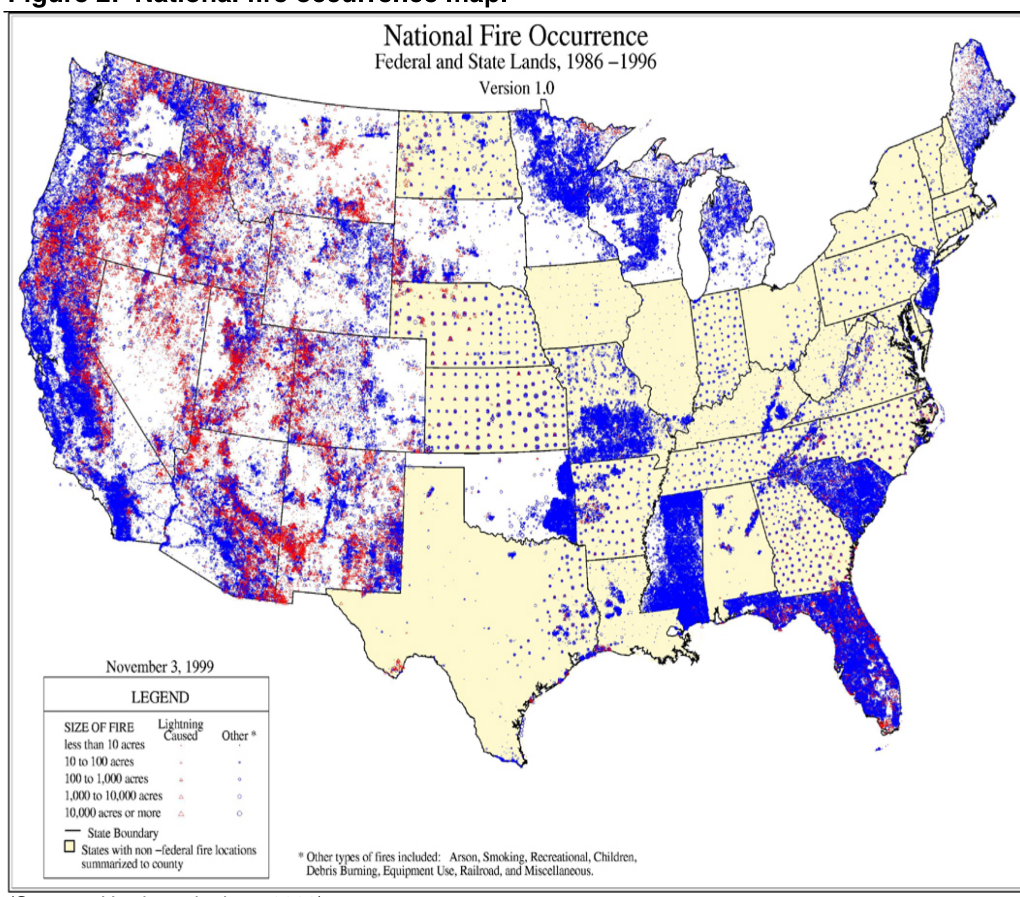
Information displayed in Tables 3-18 through 3-22 in the FEIS was calculated from the data in Table 4 in this report. Tables 3-18 through 3-21 in the FEIS with headings titled "Essentially Roadless Areas" are a summation of the data in categories titled "IRA-Roading Prohibited," "IRA-Roading Permitted," and "Wilderness" in Table 4. Tables 3-

18 through 3-21 in the FEIS with headings titled “essentially roaded” are a summation of data in the category titled “Rest of NFS.”

The starts per 10,000 and 100,000 (Table 3-21, FEIS) acres for “essentially roadless” and “essentially roaded areas” of inventoried roadless areas were derived from acreage summaries for inventoried roadless areas (Roadless GIS Database 2000) and national forest acreage figures.. This information was compared to acreage estimates in the Forest Service publication *Land Areas of the National Forest System* (USDA-Forest Service 1998).

Fire occurrence data from Alaska was manually tabulated from existing regional records (Bushnell, personal communication 2000). As indicated in Table 5, the fire occurrence in Alaska is very low (1411 total acres burned from 1986 to1996). Both the Chugach and Tongass National Forests are considered coastal rain forests. Lightning is an uncommon occurrence in these forests, and when it does occur, it is usually accompanied by rain. Because of this low fire occurrence, Alaska is not included in either the fuel management or fire suppression portions of the fire management effects analysis of the FEIS.

Figure 2: National fire occurrence map.



(Source: Hardy and others 2000)

Table 4: Total acreage (in thousands) and number of fires (<1000 acres and >1000 acres) caused by lightning or human causes stratified by IRA categories and other Forest Service land designations, listed by region. **(*Table 4 continues on page 14*)**

		< 1000 acres in size				>1000 acres in size				SUM	
		Lightening		Human		Lightening		Human			
		# starts	acres (1,000)	# starts	acres (1,000)	# starts	acres (1,000)	# starts	acres (1,000)	# starts	acres (1,000)
REGION 1	IRA-Roading Prohibited	1,116	6	152	3	7	28	3	47	1,278	84
	IRA-Roading Permitted	1,644	10	317	3	8	57	5	46	1,974	115
	Wilderness	1,633	34	179	3	43	408	10	370	1,865	815
	Rest of NFS	5,365	25	2,076	15	29	205	13	76	7,483	322
	SUM	9,758	75	2,724	24	87	698	31	539	12,600	1,336
REGION 2	IRA-Roading Prohibited	99	1	64	1			1	2	164	3
	IRA-Roading Permitted	588	2	316	4	3	8	1	1	908	16
	Wilderness	160	1	177	1	1	13			338	15
	Rest of NFS	2,649	20	1,650	17	16	76	10	42	4,325	154
	SUM	3,496	24	2,207	21	20	97	12	45	5,735	187
REGION 3	IRA-Roading Prohibited	718	10	154	1	16	74	2	40	890	125
	IRA-Roading Permitted	471	6	176	1	7	22	3	34	657	63
	Wilderness	1,793	26	275	6	38	282	2	2	2,108	316
	Rest of NFS	11,019	49	7,124	40	53	303	21	129	18,217	521
	SUM	14,001	90	7,729	49	114	681	28	206	21,872	1,025
REGION 4	IRA-Roading Prohibited	1,105	9	217	2	17	342	2	14	1,341	367
	IRA-Roading Permitted	2,872	18	796	9	31	171	10	21	3,709	219
	Wilderness	1,278	19	322	2	36	572	5	23	1,641	615
	Rest of NFS	3,921	27	1,595	16	42	510	30	597	5,588	1,150
	SUM	9,176	73	2,930	29	126	1,595	47	655	12,279	2,352
REGION 5	IRA-Roading Prohibited	790	3	429	5	9	177	4	23	1,232	208
	IRA-Roading Permitted	1,000	8	759	9	7	55	18	102	1,784	174
	Wilderness	2,128	9	657	4	18	103	5	17	2,808	133
	Rest of NFS	8,508	26	8,730	50	50	621	53	371	17,341	1,068
	SUM	12,426	45	10,575	68	84	956	80	513	23,165	1,583
REGION 6	IRA-Roading Prohibited	851	4	298	1	5	58	1	29	1,155	93
	IRA-Roading Permitted	922	5	240		25	353	2	12	1,189	370
	Wilderness	1,941	19	546	4	16	143	3	8	2,506	173
	Rest of NFS	8,968	37	4,324	28	33	285	14	111	13,339	462
	SUM	12,682	65	5,408	34	79	839	20	160	18,189	1,097
REGION 8	IRA-Roading Prohibited	33	1	79	3					112	4
	IRA-Roading Permitted	35	1	95	2	2	2	1	3	133	9
	Wilderness	62	3	180	4	3	11	4	9	249	25
	Rest of NFS	1,157	19	11,929	230	2	2	32	105	13,120	356
	SUM	1,287	24	12,283	238	7	15	37	117	13,614	394
REGION 9	IRA-Roading Prohibited			6						6	

		< 1000 acres in size				>1000 acres in size					
		Lightening		Human		Lightening		Human		SUM	
		# starts	acres (1,000)	# starts	acres (1,000)	# starts	acres (1,000)	# starts	acres (1,000)	# starts	acres (1,000)
	IRA-Roading Permitted	6		73	1					79	1
	Wilderness	101	1	105	1	5	14	1	13	212	29
	Rest of NFS	211	5	4,749	82	1	1	10	16	4,971	104
	SUM	318	6	4,933	84	6	15	11	28	5,268	134
TOTAL	IRA-Roading Prohibited	4,712	35	1,399	16	54	679	13	155	6,178	885
	IRA-Roading Permitted	7,538	49	2,772	30	83	668	40	220	10,433	966
	Wilderness	9,096	112	2,441	24	160	1,546	30	442	11,727	2,123
	Rest of NFS	41,798	206	42,177	478	226	2,005	183	1,447	84,384	4,135
	SUM	63,144	402	48,789	547	523	4,898	266	2,263	112,722	8,110

Source: Hardy and others 2000 and Roadless GIS Database 2000

Table 5: Number of wildfire ignitions and acres burned by year for Alaska's Chugach and Tongass National Forest, 1986-1996.

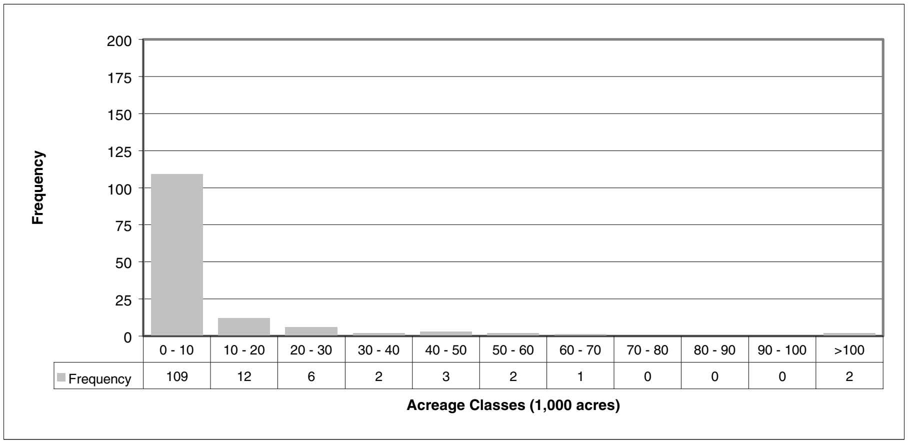
Forest		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
Chugach National Forest	No. of Fires	5	5	5	9	15	13	14	30	17	8	15	136
Tongass National Forest	No. of Fires	15	22	19	31	37	7	14	80	23	27	31	306
	Total Acres Burned	6.2	61.5	112.9	633.1	144.6	16.4	51.2	248	11.2	6.9	118.8	1410.8

[1] Of the total 442 wildland fires ignited in Alaska, only one was lightning caused
Source: Personal communication (Wayne Bushnell 2000)

Statistical Analysis of Fire Occurrence Data

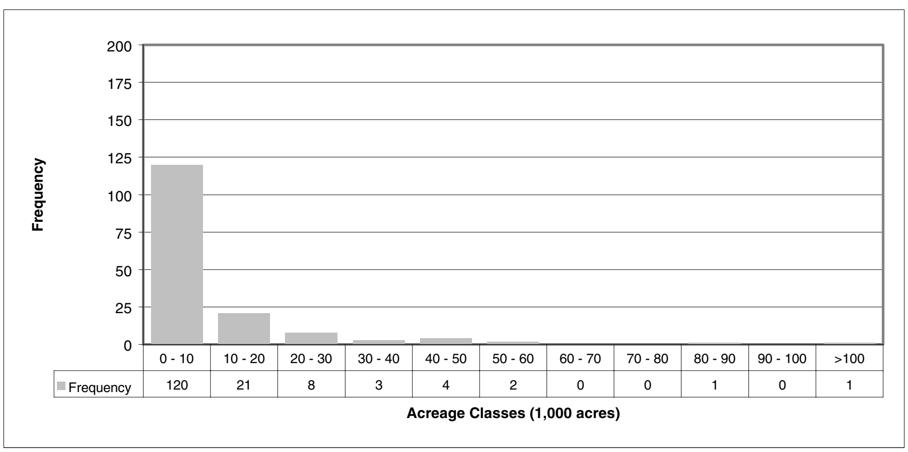
Basic statistics for the average, median, and standard deviation for large wildfires in Wilderness, inventoried roadless areas, and outside of Wilderness and inventoried roadless areas, were calculated for the fire occurrence data-set from 1986 to 1996. This data was further subdivided into the classifications wildfires ignited by lightning and "other," (meaning fires started by humans.) This statistical data was summarized on a national scale for the combination of Forest Service Regions 1-9 in Figures 3a through 3f. Appendix G summarizes the same large fire size statistics for individual Forest Service regions.

Figure 3a: Fire occurrence statistics for large wildfires ignited by lightning occurring in inventoried roadless areas in Regions 1-9, 1986-1996.



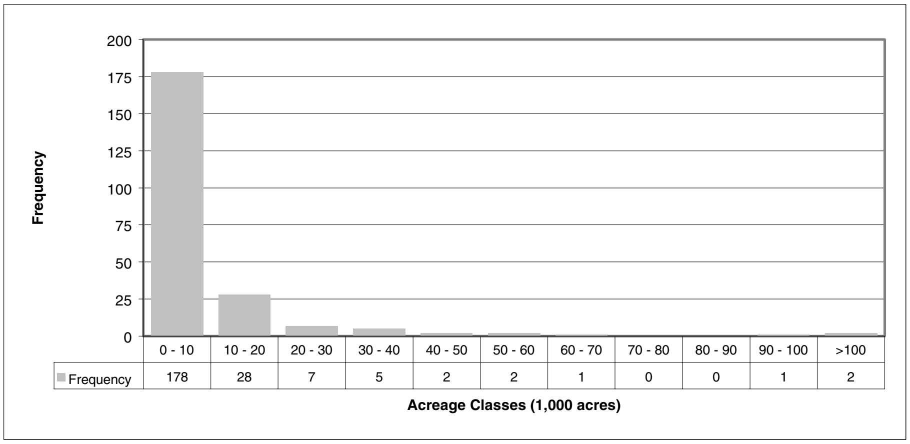
Number of Fires:	137
Avg Acreage:	9,831
Std Dev:	21,656
Median Acreage:	3,094
First Quartile:	1,749
Minimum Acreage:	1,000
Maximum Acreage:	177,544

Figure 3b: Fire occurrence statistics for large wildfires ignited by lightning occurring in Wilderness in Regions 1-9, 1986-1996.



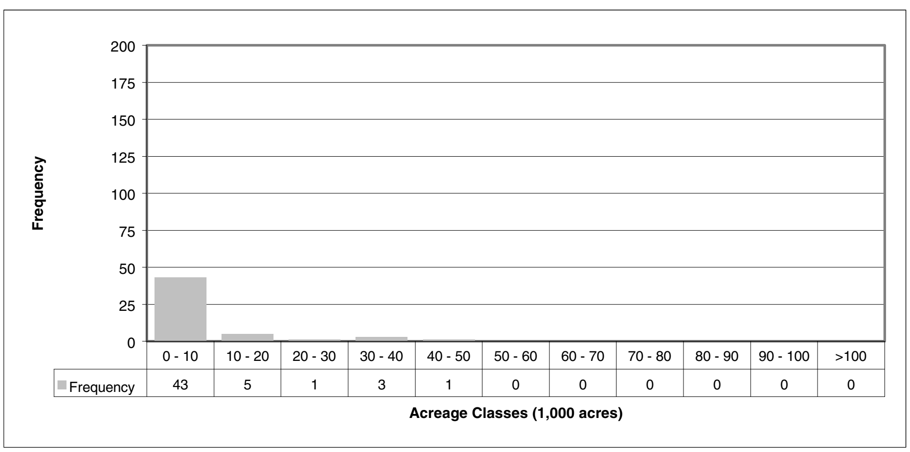
Number of Fires:	160
Avg Acreage:	9,663
Std Dev:	17,398
Median Acreage:	3,600
First Quartile:	1,798
Minimum Acreage:	1,000
Maximum Acreage:	164,560

Figure 3c: Fire occurrence statistics for large wildfires ignited by lightning occurring outside of Wilderness and inventoried roadless areas in Regions 1-9, 1986-1996.



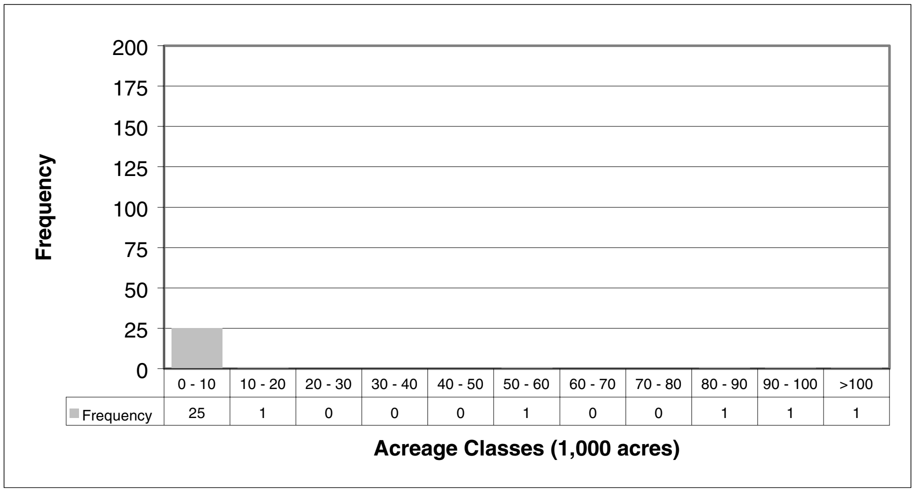
Number of Fires:	226
Avg Acreage:	8,870
Std Dev:	16,474
Median Acreage:	3,660
First Quartile:	1,600
Minimum Acreage:	1,000
Maximum Acreage:	146,400

Figure 3d: Fire occurrence statistics for large wildfires ignited by humans occurring in inventoried roadless areas in Regions 1-9, 1986-1996.



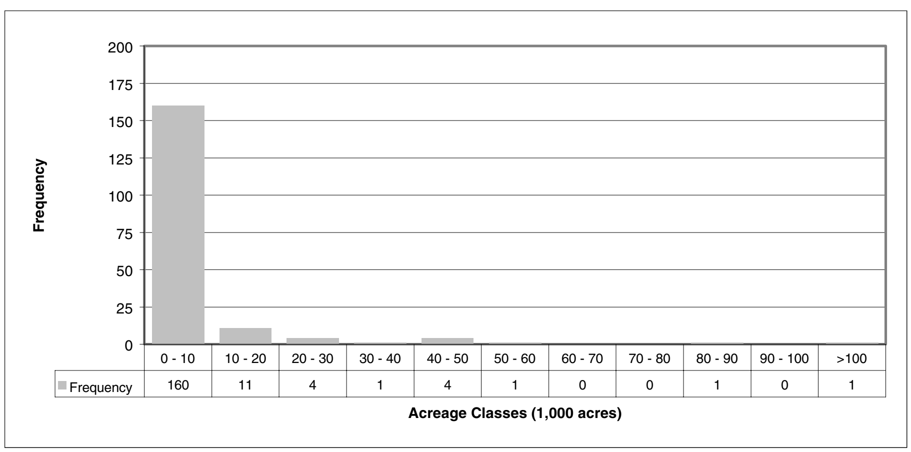
Number of Fires:	53
Avg Acreage:	7,064
Std Dev:	9,840
Median Acreage:	2,550
First Quartile:	1,500
Minimum Acreage:	1,000
Maximum Acreage:	43,201

Figure 3e: Fire occurrence statistics for large wildfires ignited by humans occurring in Wilderness in Regions 1-9, 1986-1996.



Number of Fires:	30
Avg Acreage:	14,720
Std Dev:	29,782
Median Acreage:	3,125
First Quartile:	2,109
Minimum Acreage:	1,200
Maximum Acreage:	108,942

Figure 3f: Fire occurrence statistics for large wildfires ignited by humans occurring on NFS lands outside of Wilderness and inventoried roadless areas in Regions 1-9, 1986-1996.



Number of Fires:	183
Avg Acreage:	1,049
Std Dev:	31,035
Median Acreage:	2,230
First Quartile:	1,397
Minimum Acreage:	1,000
Maximum Acreage:	400,100

Literature Review Used to Support the Major Themes, Assumptions and Uncertainties Identified in the FEIS

Assumptions and Uncertainties

A literature review continued throughout the fire effects analysis. Within the fuel management and fire suppression areas, the effect that a prohibition on road construction would have on fire hazard abatement efforts and the effectiveness of fire suppression actions was considered. Subsidiary fire management issues were the effects road access has on fire occurrence, fire cause, fire size, and fire and fuel management costs.

The assumptions used in the fuel management section were derived from expert opinion (Cleaves and Haynes 1999; Shaw 1999), fire management literature reviews and Forest Service policy statements (USDA Forest Service 1999h).

Six key assumptions (sometimes called design elements) along with the national coarse-scale assessment, fuel management strategy, fire occurrence data, and wildland-urban interface demographics were used to frame the FEIS analysis. These assumptions are listed below:

- The primary purpose of fuel management is to maintain forest and ecosystem health and reduce the occurrence of large fire (Davis and Cooper 1963; Wood 1982; Van Wagtendonk 1996).
- Unless an imminent threat to public safety, private property, water quality, or T&E species exists, inventoried roadless areas would be a low priority for fuel treatment over the next 20 years because higher priority areas are more common outside roadless areas (Laverty and Williams 2000).
- Disposing of fine fuel reduces fire hazard and can be accomplished through mechanical treatment, prescribed burning, or combinations of both (Swetnam 2000).
- Among fuel management practitioners and researchers, uncertainty exists over how to spatially locate fuel management projects (particularly at the landscape level) to prevent large fires (Deeming 1990; Turner and Romme 1994; Pollett and Omi 2000; Miller and others 2000; Johnson 1994).
- Whether timber harvesting reduces the size and intensity of a wildland fire is disputed and uncertain. Both commodity-purpose timber harvest and stewardship-timber harvest can reduce fire intensity, the resistance to control, and fire spread provided the ladder fuels and unutilized coarse and fine fuels are removed from the site. Conversely, timber harvest can sometimes elevate fire hazard by increasing dead-ground fuel, removing larger fire resistant trees, and leaving an understory of ladder fuels (Graham and others 1999; Sackett and others 1996; Barrett 1994; Feeney and others 2000; Weatherspoon 2000).

- The costs of road construction and maintenance were not factored into this analysis as they vary widely depending on terrain, road design, and associated mitigation measures. Roads used for fuel treatment are often constructed for other purposes. This analysis focused on the direct cost of fuel treatment activities (Saveland 1987), and not on the costs of building a road just for fuel management purposes.

The following literature review was accomplished for the fuel management and fire suppression sections of the FEIS.

Fuel Management and Fire Suppression Costs

Brown (1991) notes that completing fuel management work through prescribed burning in areas that are essentially roadless such as Yellowstone National Park would require substantially more funding, and that meeting the objectives of these prescribed fires could be difficult and tricky. From interviews with wildfire Incident Commanders, Schuster, Cleaves and Bell (1997) found that fire access was second only to weather conditions in importance as a driver for increasing fire suppression costs for large fires during the 1994 fire season. A staff paper on the high costs of suppressing wildland fires in the Pacific Northwest in 1999 concluded that access, vegetation, blow-down, lack of initial attack forces, availability of red-carded firefighting personnel, and shortage of Type 1 firefighting crews contributed to the high costs of suppressing wildland fires (USDA Forest Service 2000a). Kerr (1995) obtained natural fuel prescribed burning costs on the Angeles National Forest. Fire management personnel on the Clearwater and Nez Perce National Forests in Idaho use a fuel treatment allowance collection guide (USDA Forest Service 1999d) to determine the cost of completing various fuel management activities. This guide indicates that building a fireline by hand for prescribed burning in areas without roads is a higher cost than with roads. A GAO report (2000b) on reducing the wildfire threats suggests that fuel management funds should be targeted to the highest risk areas---communities, watersheds, and ecosystems and species at risk.

Summary: The literature citations listed above support the finding in the FEIS that fuel management and fire suppression costs, particularly if mechanical pre-treatment, extensive fireline construction, or staffing a large wildland fire with personnel and equipment were required, could double due to lack of road access. However, in none of the above citations did the authors calculate the cost of road construction as part of either the fuel management or fire suppression costs.

Using Prescribed Fire to Reduce the Threat of Uncharacteristic Wildfire Effects

In a study of a controlled burn [prescribed fire] in a ponderosa pine forest in east-central Arizona along the Mogollon Rim, Wagle and Eakle (1979) concluded that controlled burning “gave almost complete protection to trees from a subsequent wildfire.” Brown (2000-draft) notes that the continuity of fuel is important because it partly controls “where a fire can go and how fast it travels.” “Understory burning in southwestern ponderosa pine,” write Harrington and Sackett (1996) “can greatly, but only temporarily, reduce the fuel hazard.” They also note that a consumption of the litter fuels lessens “ignitability and rate of spread.” Fieldler and others (1995) suggest that restoring pine forests "cannot be effectively treated with fire alone…Prescribed fire is generally the most effective means of reducing high fire hazard, eliminating large numbers of understory trees…." Graham, Jain and Harvey (2000) note that low intensity fires burning "deep duff at the base of trees can damage roots systems or cambial tissues and…kill standing trees."

Summary: The scientific papers cited above note that the elimination of fine fuels can be accomplished with prescribed burning, particularly in ponderosa pine forests. However, repeated treatments using prescribed fire would be necessary.

Roads Used as Access Routes to Control Forest Fires and Complete Fuel Management Work

Major fire management bibliographies obtained from computer data bases (Greenlee and Sapsis 1996; Rocky Mountain Research Station Library 2000), current state-of-knowledge reviews (Brown 2000-draft; Smith 2000); and histories of fire management (Pyne 1997a; Pyne 1997b) were queried for scientific references describing the effects that either roading an area or not constructing a road into the same area has on fire occurrence, fire cause, fire size, firefighting effectiveness, fire suppression costs, firefighter safety and fuel management effectiveness. Few references were found specifically correlating roads and fire management issues. In a summary of scientific findings for the Interior Columbia River Basin (USDA Forest Service 1996), researchers write: "The occurrence and intensity of wildfires are correlated with lightning storm routes, fuels, local wind patterns, terrain complexity, and roads. Wildland areas with complex terrain or a moderate or high road density have moderate or higher risk of wildfires…Areas with fuels, roads, and complex terrain that are on lightning storm routes have the highest risk of wildfire." A Forest Service synthesis of scientific information on roads (USDA Forest Service 1999b) dealt primarily with biologic effects, though there is a brief discussion of fire management issues. Russian fire managers (Beisembaev 1978) suggest that, "in mountainous, wooded regions…the development of roads allow for effective protection of mountainous forests from fire." In reviewing the potential affects of prohibiting road construction in roadless areas on 8 national forests in the Western and 2 in the Eastern United States, the U. S. General Accounting Office (2000a) concluded that, "national forest managers believe the preferred alternative in the proposed roadless rule will likely have minimal impact on their ability to restore or maintain ecological sustainability."

Summary: As stated in the FEIS (3-133), there are "few peer reviewed scientific articles dealing with the consequences of building a road solely for fire suppression or fuel management purposes." This literature search supports that claim.

Logging and the Threat of Uncharacteristic Wildfire Effects

Covington (1998), in a study of ponderosa pine forests in northern Arizona, noted that these forests have become "dense with young trees and highly susceptible to catastrophic wildfire due to exclusion of the natural frequent-fire regime and the effects of livestock grazing and logging associated with Euro-American land use practices." Covington and others (1994) provide a brief history of industrial timber harvesting in the Inland West and note that fire hazard increases as roads coupled with timber harvesting changed accessible forests "from open stands of predominantly large pines, Douglas-fir, and western larch to closed stands of smaller trees, often with thickets of saplings, and a much larger component of true firs and spruce which can develop particularly dense stand conditions." In studying old growth in the Pacific Northwest, Booth (1991) noted that many fires in the 1930s in his study area occurred as the "result of logging activity, usually on areas that had been recently logged." Weatherspoon and others (1992), in a study of the California Sierran mixed conifer forests, concluded that, "Human activities since the mid-1800's---especially sheep grazing, fire suppression, and 'selective' cutting…have greatly increased the potential for stand-replacing crown fires." In a congressional report on the status of the Sierra Nevada (Wildland Resources Center 1996), the authors summarized the effects of past logging and fire hazard: "Timber harvest, through its effects on forest structure, local microclimate, and fuel accumulation, has increased fire severity more than any other recent human activity." Fire ecologists have addressed the issue of fire and roads in the Upper Columbia River Basin and for the Pacific Northwest. (Hann, personal communication 2000; Agee, personal communication 2000).

Summary: The literature cited above supports the claim made in the FEIS (3-92) that using logging as a primary mechanical fuel treatment option can be "problematic" since past harvest activities may have exacerbated fire hazard problems, and future management of the timber stand must take in the concern of post harvest fuel management.

Logging to Reduce the Risk of Uncharacteristic Wildfire Effects

Snyder (1996), in a speech to the California Biodiversity Council, quoting forest ecologist Dr. Jerry Franklin of the University of Washington, noted that the "probability of catastrophic crown fire" could be reduced by "moderate to high levels of harvest in the small and medium diameter [tree] classes." Fahnestock's (1968) study of precommercial thinning found that timber stands thinned to a 12 feet by 12 feet spacing commonly produced fuels that "rate high in rate of spread and resistance to control for at least 5 years after cutting, so that it would burn with relatively high intensity." Stephens (1998) found in studying Sierra Nevada mixed conifer forests that at a landscape scale "removing only large, standing dead trees will not reduce fire hazard." He concluded that a combination of prescribed fire and/or mechanical treatment would be needed. Hanson (2000) suggests that commercial logging causes catastrophic forest fires.

In a hearing before the U.S. House of Representatives Subcommittee on Forests and Forest Health, University of Montana forestry professor Carl Fiedler testified: ""…the opportunity to use prescribed fire as the primary means of reducing fuels or restoring sustainable conditions in today's dense forests is largely past…Mechanical treatments to reduce fuels are generally needed to allow the important use (or occurrence) of fire as an ecological process…." When precommercial thinning was used in lodgepole pine stands, Alexander and Yancik (1977) reported that a fire's rate of spread increased 3.5 times and that the fire's intensity increased 3 times. Johnson and others (1996) report that, "fuel treatments (prescribed fire or a combination of prescribed fire and timber harvest)…can significantly decrease the potential for forests to suffer severe fire."

In a newspaper article in the *Sacramento Bee,* Keye (2000) argues that logging would have helped prevent a catastrophic forest fire in the Trinity Alps Wilderness. Weatherspoon and Skinner (1995) found that the variables that most heavily influenced fire damage were "management activities" such as site preparation method. Agee (personal communication, 2000), in commenting on the notion that past timber harvesting actually raised fire hazard, wrote: "The allegations that past timber harvest has exacerbated, rather than reduced, fire severity problems is largely true. Fuels have often been 'treated' by cut and scatter techniques that only redistribute it…." Mutch (1994), noting that many forests are now excessively dense and contain many dead and dying trees, concluded that, "salvage logging may be necessary before initiating extensive prescribed burning programs." Frost (1999), in a report developed for the World Wildlife Fund, makes a case that forests at risk from catastrophic forest fires would need neither roads nor logging for restoration. Weatherspoon and Skinner (1996) write, "For the Sierra Nevada as a whole…vegetation management activities have produced considerably more new fuels than they have eliminated." The Congressional Research Service (Gorte 2000), in discussing the relationship between timber harvesting and forest fires, noted: "timber harvesting does remove fuel, but it is unclear whether this fuel removal is significant…."

Summary: The scientific papers listed above support the design element listed in the FEIS (3-90-3-91) that "uncertainty exists over how to spatially locate fuel management projects" and "whether timber harvesting reduces the size and intensity of wildland fire is disputed and uncertain."

Uncertainty about the Effectiveness of Fuel Treatment

McKenzie and others (2000), writing about the importance of how fire frequency affects vegetation composition, conclude: "Informed decisions are needed at increasingly broad spatial scales, but in most cases, detailed quantitative data are not available." Turner and Dale, writing of natural disturbances in shaping landscapes, state: "Whether large, infrequent disturbances are qualitatively different from small frequent disturbances remains an unresolved issue in ecology…." Bessie and Johnson (1995), in a study of subalpine forests in the southern Canadian Rocky Mountains, concluded that, "forest fire behavior is determined primarily by weather variation among years rather than fuel variation associated with stand age." From the perspective of climate change scientists have noted that the interaction between climate, vegetation, and fire are complex and uncertain (Ryan 2000, draft). Cooper (1960) surmises that to return a ponderosa pine forest after just 40 years of fire suppression to its original less dense condition could only be realized after timber harvest. Covington (1996) describes the debate over which ecosystem health management scenario to utilize (e.g. mechanical pretreatment methods) and he notes that, "scientific data to support such management actions [either a hand's off approach or the use of timber harvesting] are inadequate." Mimicking natural disturbance processes through legacies with such disturbances as wildfire [or prescribed fire] "is an intriguing question, the answer for which is often not as obvious as one might suppose" (Franklin and others 2000).

Kolb and others (1994) discuss the lack of a precise definition for the term "forest health." They conclude that because of this imprecise definition, management activities to improve forest health [such as fuel management] are difficult to apply in the field. Deeming (1990), responding to the economic payoffs to prescribed burning, wrote: "Prescribed burning will reduce fuel quantity and wildfire potential for a period of time….But the argument that prescribed burning is a cost-effective method of reducing the incidence and severity of wildfires is seldom supportable." Helms (1979) found a positive correlation between prescribed burning and wildfire intensities. Van Wagtendonk (1996) concluded his study of fuel treatment effectiveness stating prescribed burning appears to be the most effective treatment for reducing a fire's rate of spread, fire intensity, flame length, and heat per unit of area. Not only are surface fuels reduced by this treatment, but understory and ladder fuels are also reduced…" Wood (1982), in a study on the Lolo National Forest in western Montana, found that fuel treatment may be needed on hundreds of acres of land to save "a single acre from burning" from a wildfire. Countryman (1955) completed research on the microclimate of a forest after logging and found that "opening up" a forest through logging changed the "fire climate so that fires start more easily, spread faster, and burn hotter."

Strauss and others (1989) studied the size of forest fires and the damage they cause and mathematically determined that a "relatively small number of forest fires are responsible for a very high proportion of the total damage." Omi (1977) studied fuelbreaks in Southern California and found that their effectiveness was often substantially less than predicted. Agee (1997), speculating whether logging fuel-laden forests helps reduce fire severity, wrote: "To reduce fire damage from wildfires, future thinning operations must concentrate on small trees with operations called low thinning, removing the trees that have invaded these sites since fire exclusion began, and cleaning up the debris." Ingalsbee (1997) discusses the negative impacts of fuelbreaks in Sierra Nevada forests and suggests that understory prescribed burning is a better solution. Cumming (1964) concluded that prior fuel reduction efforts in State forests in New Jersey reduced "damage and intensity" from wildfires. Writing of social forces at work regarding forest restoration as a multiple-use management technique (Wagner and others 2000), restoration ecologists concluded that even if society could agree that "some previous condition was more desirable, there is considerable doubt that we have sufficient knowledge of how ecosystems function to get there." Veblen and others (2000) describe the uncertainties over the degree of forest management required to reduce the hazard from catastrophic wildfire, writing: "Although fuels reduction through thinning and prescribed burning clearly reduces the probability of small fires becoming wide spread in most years, it is uncertain that moderate levels of fuels management can prevent wildfires during years in which the weather is exceptionally conducive to fire spread." Global warming, by changing weather patterns, has the potential to change both fire potential and fire behavior in fire-dependent ecosystems. Gore (1993) writing of the strategic threat of global warming and climate change, notes that an "increase in heat seriously threatens the global climate equilibrium that determines the patterns of winds, rainfall and surface temperatures…."

Mast and others (1999), writing of the restoration of ponderosa pine forests, note that "restoration is neither a certain nor a static science." Swetnam and Baisan (1996) conclude: "climatic variations, specifically drought fluctuations, were important in determining temporal and spatial patterns of fire occurrence across time scales…and spatial scales. Climatic variation…is extremely complex and therefore difficult to predict." Turner and Rome (1994), in a study of landscape dynamics and crown fires, wrote that, "there may not be easy answers to questions of how large an area must be to encompass the 'natural' fire regime, or how likely extensive crown fires will be in the future."

Finney (2000), in discussing the "spatial dynamics of fuel patterns across landscapes," wrote that, the "problem of how to maintain the topology of a landscape-level effect on fire as fuel patches age across both space and time is very challenging." In a study of the Sierra Nevada ecosystem (Sapsis and others 1996), fuel management specialists found that "the only significant means by which large area mitigation of extreme fire behavior and potential for reduced resource damage lies with area [as compared to fuel breaks] based treatment methods." Swetnam, Allen and Betancourt, note the complications of using applied historical ecology: "Even when long historical time series can be assembled, selection of appropriate reference conditions may be complicated by the past influence of humans and the many potential reference conditions encompassed by nonequilibrium dynamics." Sampson (2000), in summarizing a Joint Fire Science's Project workshop, concluded: "Classifying and mapping fuel characteristics is a complex operation, since fuels present a diverse, three-dimensional continuum across the landscape that resists easy portrayal by 2-dimensional polygons on a map."

Summary: The scientific papers listed above support the design elements listed in the FEIS (3-90-3-91) that "uncertainty exists over how to spatially locate fuel management projects" and "whether timber harvesting reduces the size and intensity of wildland fire is disputed and uncertain."

Fire Regimes and Forest Health

Smith (2000) and Brown (2000) provide a comprehensive description of fire regimes for North America. Geographically, they subdivide North American plant communities, based on fire effects, into the following categories: Northern Ecosystems (Boreal And Laurentian Forests); Eastern Ecosystem and the Great Plains (Eastern Deciduous Forests, Southeastern Forests, and Prairie Grasslands); Western Forest (Rocky Mountain, Sierra and Pacific Coast Maritime Forests), Western Woodlands, Shrublands, and Grasslands (Chaparral and Western Oak Woodlands, Sagebrush and Sagebrush Grasslands and Deserts); Subtropical Ecosystems (Florida Wetlands). A Forest Service guidebook (USDA Forest Service 1996g) describes land management considerations in fire-adapted ecosystems. Clark and Sampson (1995) provide a summary of forest health in the Inland West. Bonnicksen (2000) provides a history of America's forests from the glacial ages through the age of discovery, often emphasizing the ecologic role of fire.

Summary: The literature cited above was used to establish the fire ecology background section to the fuel management analysis, and was important in delineating the geographic breakdown of the National Forests across the United States for fuel management purposes.

Methodology

The primary factors used to evaluate the effects of the alternatives were derived from internal and external scoping, literature reviews, and problem framing exercises.

Two processes were used to outline the fire management effects discussion. The first process, adapted from the books *Decision Traps* (Russo and Shoemaker 1990) and *Smart Choices: A Practical Guide to Making Better Decisions* (Hammond, Keeney and Raiffa 1999), is a generalized step-by-step decision framework that enables clarification of complex problems that do not have simple answers. The second process, called *Decision Protocol* (USDA Forest Service 1999c) is a procedure developed for internal Forest Service use to aid in the production of clearly thought-out environmental analyses. Both processes indicate that complete problem analysis are based on the following premises:

- The problem is clearly framed or defined
- Information is collected and used effectively
- Facts, myths, values, and uncertainties are clearly identified
- A clear discussion of environmental consequences exists
- A method to audit the problem solving process is developed

Five decision-making cycles developed for the Decision Protocol were used in the fuel management and fire suppression effects analysis.

1. Process
2. Problem
3. Design
4. Consequences
5. Action

The process cycle helped to delineate the overall situation for fuel management and fire suppression programs. The key issues resolved in this cycle were the scale of analysis, the availability of fire management data, and how best to use the available data within given timeframes.

- Scale of analysis was national, with geographic subdivisions used to sub-divide the National Forest of the United States. The subdivisions were the West (Regions 1-6), Alaska (Region 10), and East of the 100th meridian (Regions 8 and 9).
- Three key sources of national fire management data helped define the fire management affected environment. *Coarse-Scale Spatial Data for Wildland Fire and Fuel Management* (Hardy and others 2000); an internal Forest Service fuel management strategy titled *Protecting People and Sustaining Resources in Fire – Adapted Ecosystems: A Cohesive Strategy* (Laverty and Williams 2000), and a GAO report (U. S. Government Accounting Office 1999c) titled *Western National Forests: A Cohesive Strategy is Needed to Address Catastrophic Wildfire Threats*

- Since the time frame for the fire effects analysis was relatively short, a scientifically based “quick analysis” approach was used (Behn and Vaupel 1982).

The key fuel management and fire suppression issues raised during this early problem identification cycle were:

- Fire suppression costs
- Prescribed fire and fuel management costs
- Wildfire size
- Public safety
- Wildland urban interface
- Ability to complete fuel management tasks
- Firefighter safety
- Uncharacteristic wildfire effects
- Fire occurrence
- Fire cause (human versus lightning ignitions)
- Mechanical fuel treatment and fuel management work
- Geographic distribution of fire management activities (Alaska, the West, the South, the East)
- Severity of wildland fires
- Global warming and wildland fires

From this generalized list, the following specific components were established as criteria to evaluate the consequences of implementing each alternative to the fuel management and fire suppression programs. Table 6 displays a preliminary fire effects matrix using these components.

For fuel management, the primary components are:

- Numbers of large wildland fires
- Wildland-urban interface
- Potential treatment areas
- Fuel management costs

For fire suppression, the primary evaluation components are:

- Numbers of large wildland fires

- Wildland urban interface
- Annual acreage burned by wildland fire
- Annual expenditure for fire pre-suppression and emergency fire suppression

The last three cycles in the problem cycle---design, consequences and action---are fully developed within the main body of the FEIS.

Table 6: Preliminary fire effects matrix: key fire management components compared to primary components of each Alternative (D=decrease; N = no change from No Action Alternative; I = increase).

Issue	No Action-Baseline or Current Condition	No Roads	No Timber Harvest	Timber Harvest Allowed
Wildland Urban Interface (WUI)	Within 1 mile of IRA boundaries, there are few WUI intersections. Region 8, Region 9, and Region 3 have the largest percentage of IRA boundaries adjacent to populated areas.	D	D	I
Escaped Wildland Fires	98% of wildland fires are controlled at a small size; 2% escape and become large.	N	N	N
Severity of Wildland Fire	Key ecosystem components are at risk in forests rated as high risk to catastrophic fire	N	I	D
Acres burned by Wildland Fire	An average of 240,000 acres burn yearly; 7-23 large (1000 acres+) wildland fires occur yearly	N	N	N to I
Firefighter Safety	Firefighter safety is the primary objective of all fire operations: it should never be compromised to meet land management objectives	N	N	N
Cost of Fuel Management Work	$176-$276 per acre to both pre-treat mechanically and to prescribed burn	I	I	N
Cohesive Strategy	3 million acres nationally by 2004, with 1 million acres projected for high risk forests in the Interior West	D	D	I
Fire Suppression-Pre-suppression Costs	$304 Million yearly for emergency fire suppression; $326 million yearly for pre-suppression	N	N	N

Fuel Management Treatments Using Timber Harvest Portrayed in the Effects Analysis

Each of the alternatives under the fuel management affected environment discuss the acres of forest that could be treated through timber harvest for fire hazard reduction purposes. See pages 3-91, 3-93, and 3-95 of the FEIS for a discussion of potential fuel treatment areas by timber harvest method. The method of calculating those timber harvest acreages is described below.

Table 7 displays the amount of forest that could potentially be treated for fire hazard reduction purposes by timber harvest. These figures were calculated using the estimated timber volume offered by each region coupled with the assumption that for every 7,000 board feet of timber harvested, fire hazard would be reduced on 1 acre of land. These figures represent maximum acres potentially treated. These figures should be used only as trends, since there is generally a wide discrepancy between timber volume offered for sale and the amount of timber volume actually sold. As has been noted previously, Alaska is not included in these tables since there is little fire hazard work scheduled for that geographic area.

Table 7: Potential amount of fuel treated (in thousands of acres) by timber harvest for Alternatives 1-4 for a five-year period.

Region	Alternative 1	Alternative 2	Alternative 3	Alternative 4
R1	17,303	10,857	2,143	0
R2	5,863	1,429	571	0
R3	429	286	143	0
R4	33,414	9,429	3,571	0
R5	5,720	3,571	2,286	0
R6	14,920	8,429	4,143	0
R8	4,886	1,714	714	0
R9	11,226	2,857	857	0
National	93,761	38,572	14,428	0

(Source: Roadless GIS Data Team)

Table 8 shows that even if the maximum timber harvest occurred in each region, and that the area harvested was completely treated to reduce the risk from uncharacteristic wildfire effects, less than 1% of the area needing fuel treatment would be treated in the next 5 years. The exceptions to this are Regions 1 and 9.

Table 8: Percentage fuel reduction work accomplished through timber harvest.

Region	Moderate to High Risk From Catastrophic Fires (acres)	Alternative 1 % Treated	Alternative 2 % Treated	Alternative 3 % Treated	Alternative 4 % Treated
R1	379,000	4.6	2.9	<1	0
R2	1,370,000	<1	<1	<1	0
R3	1,980,000	<1	<1	<1	0
R4	3,616,000	<1	<1	<1	0
R5	1,368,000	<1	<1	<1	0
R6	1,142,000	<1	<1	<1	0
R8	286,000	1.7	<1	<1	0
R9	117,000	9.4	2.4	<1	0
National	10,253,000	<1	<1	<1	0

(Source: Roadless GIS Data Team)

Uncertainty Associated with Timber Harvesting Without Roads for Fuel Management Purposes

Background

Many people believe that prohibiting road construction and reconstruction in inventoried roadless areas, with the resulting decrease in timber harvest, will severely limit the ability of natural resource managers to reduce the threat from uncharacteristic wildfire effects and to accomplish forest health restoration objectives. The focus of their concern is that without roads, forest managers would be unable to mechanically pre-treat overgrown forests before the regular application of prescribed fire. Roads allow for the easy access of heavy logging equipment such as bulldozers, cable-yarders and rubber tired skidders, machinery commonly used to skid logs to a landing where the timber can be loaded on logging trucks and driven out of the forest.

Even though commodity based timber harvesting has been used as a technique to reduce high hazard fuel loadings for years, a great deal of uncertainty exists in the scientific community over whether logging standing dead and live trees is needed to pre-treat forests before prescribed burning can occur.

To test and study the effects that a road construction prohibition would have on fuel management objectives, three models or scenarios were developed. Scenario 1 depicts the "worse case" situation, and assumes that very little mechanical pre-treatment of forests at risk from uncharacteristic wildfire effects could occur. Scenario 2, the "most likely case," describes a situation where the amount of mechanical pre-treatment accomplished is divided evenly. Scenario 3, the "passive management case," describes a situation where absolutely no mechanical pre-treatment could be completed. Scenario 3 models what might occur if Alternative 4 were selected.

A standard process for creating risk-scenarios where one is uncertain of the actual outcome was used to develop the probabilities in the three scenario cases (Hammond, Keeney and Raiffa, 1999)[3].

Scenario # 1:

During the next 40 years none of the 7.5 million acres within inventoried roadless areas needing mechanical pre-treatment before prescribed burning can be regularly applied would be accomplished. This would be a "worse case" situation.

The likelihood of this scenario actually occurring in the next 40 years is rated at 60%

[3] Hammond, John S., Keeney, R. L and H. Raiffa. 1999. "Uncertainty," In: *Smart Choices: A Practical Guide to Making Better Decisions.* Harvard Business School Press, Boston, Mass. p. 109-133.

Scenario # 2:

During the next 40 years, 50% of the 7.5 million acres within inventoried roadless areas needing mechanical pre-treatment before prescribed burning can be regularly applied would be accomplished.

The likelihood of this scenario actually occurring during the next 40 years is rated at 30%

Scenario # 3:

During the next 40 years, 75% of inventoried roadless lands needing mechanical pre-treatment will be treated.

The likelihood of this scenario actually occurring in the next 40 years is rated at 10%

Assumptions:

- After an area is mechanically pre-treated, a successful prescribed burn has been applied to the whole area, with the over-all fire hazard moving from moderate and high to low.
- If a wildfire occurs on an area that was not mechanically pre-treated, the fire effects on the remaining untreated acres will be based on the following formulas: 50% lethal; 25% mixed-severity; 25% non-lethal.
- Since most fire regime 1 and 2 forests would have missed 1 to 2 fires in 40 years, it is assumed that every acre of forest that wasn't mechanically pre-treated would have been burned-over by a wildfire.
- The scenarios do not evaluate which mechanical pre-treatment might be used---traditional timber harvest with skyline-yarders or ground-based cable yarders; helicopter logging; handpiling; dozer piling; or thinning, for example.
- For purposes of this analysis, the scenarios assume that land managers would give equal priority to treating high hazard fuels within inventoried roadless areas as outside roadless areas.
- Mechanical treatment is always needed in forests typed as Fire Regimes 1 and 2 and rated at moderate (Condition Class 2) and high risk (Condition Class 3) from uncharacteristic wildfire effects.
- Of the total 22 million acres rated at moderate and high risk within inventoried roadless areas, this uncertainty analysis focuses on the 7.5 million acres found in fire regimes 1 and 2, condition Classes 2 and 3. These are the priority landscapes strategically identified for potential treatment in the agencies' *Cohesive Strategy*.
- Fire suppression would be the primary land management objective on the remaining inventoried roadless area lands classified as Condition Classes 2 and 3, Fire Regimes 3, 4, and 5.
- There is very little quantitative data that could be used to establish a production baseline for mechanically pre-treating areas without roads. The "likelihood" (chances) of each scenario occurring was derived from informal interviews with experts in fire and fuel management.

Table 9: Probability of completing mechanical fuel treatment over a 40 year period in condition class 2 and 3, fire regime 1 and 2 Forests In inventoried roadless areas.

Scenario	Chance of Scenario Occurring	Acres Treated Mechanically	Acres Untreated Mechanic-ally	Acres Remaining at Risk from Lethal Wildfires	Acres Remaining at Risk from Mixed-Severity Wildfires	Acres Remain-ing at Risk from Non-Lethal Wildfires
# 1: No Roadless mechanic-ally pre-treated	60%	0	7.5	3.8	1.9	1.9
# 2: Mechanically pre-treat 50% of inventoried roadless area needing mechanical pre-treatment	30%	3.8	3.8	1.9	0.94	0.94
# 3: Mechanically pre-treat 75% of inventoried roadless area needing mechanical pre-treatment	10%	5.6	1.9	0.94	0.23	0.23

Summary: The cumulative probability that a substantial amount of timber harvesting could occur over the next 40 years for fuel management purposes is relatively low. Even under Scenario 2, the "most likely scenario," 3.75 million acres would not have been mechanically pre-treated in 40 years.. However, only 1.9 million acres short fire-return interval forest would remain susceptible to uncharacteristic wildfire effects.

The numbers, probabilities and outcomes expressed in this model are for gaming purposes only. There display a probable outcomes and consequences, and are not to be perceived as absolute values.

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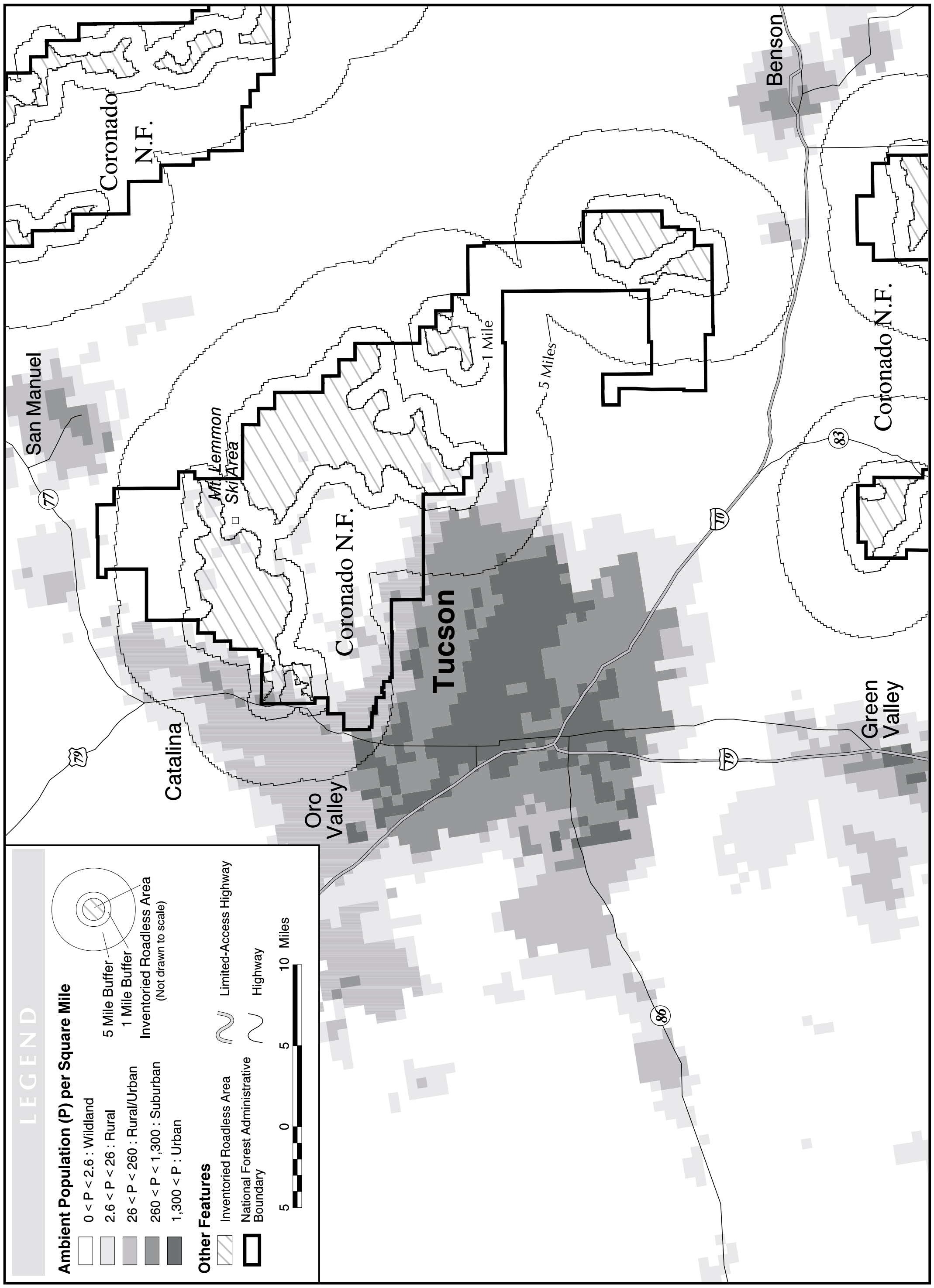
Appendix A: AMBIENT POPULAITON DENSITY MAP FOR TUCSON, ARIZONA



Appendix B: Comparison of the National and Salmon River Breaks Fire Condition Class and Regime Databases

Author: Tom Bobbe

At the request of the Office of Management and Budget, The Roadless Area Conservation Data Team compared two fire condition class and regime databases that cover a portion of central Idaho and southwestern Montana. The two fire condition class and regime databases are: 1) national scale fire condition class and regime database prepared by the Rocky Mountain Research Station (RMRS) – Missoula Fire Sciences Laboratory (Schmidt et al. in preparation) and 2) Salmon River Breaks database, produced by R1 and R4 Regional and Forest staff, which is an ad hoc revision of the national RMRS fire condition class and regime map.

The RMRS national scale fire condition class and regime database was developed through a well documented series of linkages to biophysical data that have themselves been critically reviewed, published, and accepted by the spatial science community (Bailey et al. 1994; Seaber et al 1987; USGS 1994; Kuchler 1975; Hardy et al 1998; Powell et al. 1992; Loveland et al. 1991; Zhu and Evans 1992). While the concept of condition class and regime is new, the logic in its development is scientifically sound. In addition to developing and invoking a comprehensive rule-set for the assignment of condition classes and regimes, the expert knowledge of 20 regional fire and ecology experts was used to verify the validity of the rule-sets and the consequent condition class and regime assignments.

The Salmon River Breaks database was prepared by revising the RMRS national scale condition class and regime maps. Regional and Forest staff visually inspected the maps at a mid to fine scale, and manually changed condition class and regime codes in the GIS database. Changes were not made to the underlying GIS layers or ecologically linked processes that were used to prepare the national database. The revisions were based on local knowledge and interpretations of the national condition class and regime data.

The Roadless Data Team does not recommend conclusions be made from this comparison. A valid comparison could be made if a statistically based field accuracy assessment were conducted. In addition, the two databases were prepared using different methods, and the Salmon River Breaks database used interpretations and assumptions that are not fully documented. It is not possible to test or validate assumptions that are not documented.

However, general observations can be made that the Salmon River Breaks database shows more acres in condition classes 2 and 3 within fire regimes 1 and 2, and the differences between the two databases are generally consistent across all land categories including inventoried roadless areas, Wilderness, and other NFS lands. For example, the

RMRS national database percent area for condition class 2 and 3 within fire regime 1 and 2 lists 5% for inventoried roadless areas, 10% Wilderness and 14% other NFS lands. The Salmon River Breaks database lists 28% for inventoried roadless areas, 36% Wilderness and 42% other NFS lands.

Appendix B, Table 1a. Fire regimes in national database displayed within inventoried Roadless area, NFS Wilderness, other NFS lands, and total NFS lands.

National Database	Fire Regime 1 and 2				Other Fire Regimes	
	Condition Class 1	Condition Class 2	Condition Class 3	Other Land Cover Classes	All Condition Classes and other Land Cover Classes	Total
	acres (%)[1]	acres (%)[1]	acres (%)[1]	acres (%)[1]	acres (%)[1]	acres
Within Inventoried Roadless Areas	252,386 (3%)	397,714 (5%)	29,251 (0%)	153,807 (2%)	7,157,383 (90%)	7,990,540
Within NFS Wilderness	349,065 (9%)	358,100 (9%)	43,413 (1%)	37,591 (1%)	3,291,302 (81%)	4,079,471
Within other NFS land	402,239 (8%)	711,104 (13%)	44,695 (1%)	174,934 (3%)	3,976,073 (75%)	5,309,045
Total NFS land	1,003,690 (6%)	1,466,917 (8%)	117,359 (1%)	366,332 (2%)	14,424,758 (83%)	17,379,056

Appendix B, Table 1b. Fire regimes in Salmon River breaks database displayed within inventoried Roadless areas, NFS Wilderness, other NFS lands, and total NFS lands.

Salmon River Breaks Database	Fire Regime 1 and 2				Other Fire Regimes	
	Condition Class 1	Condition Class 2	Condition Class 3	Other Land Cover Classes	All Condition Classes and other Land Cover Classes	Total
	acres (%)[1]	acres (%)[1]	acres (%)[1]	acres (%)[1]	acres (%)[1]	acres
Within Inventoried Roadless Areas	173,096 (2%)	1,296,910 (16%)	998,192 (12%)	394,625 (5%)	5,127,717 (64%)	7,990,540
Within NFS Wilderness	105,143 (3%)	636,926 (16%)	824,910 (20%)	50,347 (1%)	2,462,144 (60%)	4,079,471
Within Other NFS Land	106,517 (2%)	1,136,231 (21%)	1,118,346 (21%)	613,096 (12%)	2,334,855 (44%)	5,309,045
Total NFS land	384,756 (2%)	3,070,066 (18%)	2,941,449 (17%)	1,058,068 (6%)	9,924,716 (57%)	17,379,056

[1] Calculated as a percent of inventoried roadless areas, Wilderness, and other NFS acreages.
Other land cover includes non-vegetated, agriculture, urban, and water.

Appendix B, Tables 2a (Within Inventoried Roadless Areas), 2b (Within NFS Wilderness), 2c (Within other NFS lands) and 2d(Total NFS lands). Comparison of National and Salmon River Breaks Databases.

Table 2a.

Within Inventoried Roadless Areas	Fire Regime 1 and 2								Other Fire Regimes		Total
	Condition Class 1		Condition Class 2		Condition Class 3		Other Land Cover Classes		All Condition Classes and other Land Cover Classes		Total
	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres
National Database	252,386	(3%)	397,714	(5%)	29,251	(0%)	153,807	(2%)	7,157,383	(90%)	7,990,540
Salmon River Breaks Database	173,096	(2%)	1,296,910	(16%)	998,192	(12%)	394,625	(5%)	5,127,717	(64%)	7,990,540
Difference (acres)	*-79,289*		*899,196*		*968,941*		*240,818*		*-2,029,666*		
Difference (%)[2]	*-1%*		*11%*		*12%*		*3%*		*-25%*		

[1] Calculated as a percent of inventoried roadless areas, Wilderness, and other NFS acreages.
[2] Calculated as a percent change of land category total acres.
Other land cover includes non-vegetated, agriculture, urban, and water.

Table 2b.

Within NFS Wilderness	Fire Regime 1 and 2								Other Fire Regimes		Total
	Condition Class 1		Condition Class 2		Condition Class 3		Other Land Cover Classes		All Condition Classes and other Land Cover Classes		Total
	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres
National Database	349,065	(9%)	358,100	(9%)	43,413	(1%)	37,591	(1%)	3,291,302	(81%)	4,079,471
Salmon River Breaks Database	105,143	(3%)	636,926	(16%)	824,910	(20%)	50,347	(1%)	2,462,144	(60%)	4,079,471
Difference (acres)	*-243,923*		*278,826*		*781,497*		*12,757*		*-829,157*		
Difference (%)[2]	*-6%*		*7%*		*19%*		*0%*		*-20%*		

[1] Calculated as a percent of inventoried roadless areas, Wilderness, and other NFS acreages.
[2] Calculated as a percent change of land category total acres.
Other land cover includes non-vegetated, agriculture, urban, and water.

Table 2c.

Within other NFS land	Fire Regime 1 and 2								Other Fire Regimes		Total
	Condition Class 1		Condition Class 2		Condition Class 3		Other Land Cover Classes		All Condition Classes and other Land Cover Classes		Total
	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres
National Database	402,239	(8%)	711,104	(13%)	44,695	(1%)	174,934	(3%)	3,976,073	(75%)	5,309,045
Salmon River Breaks Database	106,517	(2%)	1,136,231	(21%)	1,118,346	(21%)	613,096	(12%)	2,334,855	(44%)	5,309,045
Difference (acres)	*-295,722*		*425,127*		*1,073,651*		*438,162*		*-1,641,218*		
Difference (%)[2]	*-6%*		*8%*		*20%*		*8%*		*-31%*		

[1] Calculated as a percent of inventoried roadless areas, Wilderness, and other NFS acreages.
[2] Calculated as a percent change of land category total acres.
Other land cover includes non-vegetated, agriculture, urban, and water.

Table 2d.

Total NFS land	Fire Regime 1 and 2								Other Fire Regimes		
	Condition Class 1		Condition Class 2		Condition Class 3		Other Land Cover Classes		All Condition Classes and other Land Cover Classes		Total
	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres	(%)[1]	acres
National Database	1,003,690	(6%)	1,466,917	(8%)	117,359	(1%)	366,332	(2%)	14,424,758	(83%)	17,379,056
Salmon River Breaks Database	384,756	(2%)	3,070,066	(18%)	2,941,449	(17%)	1,058,068	(6%)	9,924,716	(57%)	17,379,056
Difference (acres)	*-618,934*		*1,603,149*		*2,824,090*		*691,737*		*-4,500,042*		
Difference (%)[2]	*-4%*		*9%*		*16%*		*4%*		*-26%*		

[1] Calculated as a percent of inventoried roadless areas, Wilderness, and other NFS acreages.
[2] Calculated as a percent change of land category total acres.
Other land cover includes non-vegetated, agriculture, urban, and water.

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Appendix C: A Comparative Analysis Between Inventoried Roadless Areas and Other National Forest System Lands

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Introduction

Analysis work for the Roadless Rule Final Environmental Impact Statement included assessment of fire-related effects under various alternatives as related to the management of Inventoried Roadless Areas (IRAs). To provide assurance that such analyses are valid, it is necessary to illustrate that the datasets involved are independent of each other. Conclusions drawn from analyses in the FEIS may be limited if there are correlations or errors with respect to a particular fire attribute which only exist in the IRAs. In order to determine if such errors or correlations exist, a comparison was made which enumerated the proportion of various fire attributes within the IRAs and the balance of National Forest System (NFS) lands. A large difference in the proportion of these fire attributes on IRAs versus other NFS lands could indicate a bias in the classification of fire-related attributes with respect to IRAs.

This analysis specifically addresses relationships between current condition class (CCC) and fire regime (FR) datasets and IRAs. The approach taken first identified relationships between IRAs and other NFS lands (i.e., land inside NFS boundaries but not IRA) in the context of CCC and FR. Secondly, the analysis compared IRAs and other NFS lands with respect to the base spatial datasets that were originally used to create the CCC and FR datasets. This dual approach highlights the characteristics of IRAs as compared to other NFS lands and then looks for correlation between the characteristics and inputs to the CCC and FR datasets. The CCC and FR data sets cover the contiguous United States. These data are not available for Alaska or Hawaii.

Due to the coarse nature of the datasets being studied, absolute differences of 5% or less were determined, for practical considerations, to be insignificant. Differences of greater than 5% are potentially indicative of correlation errors and will be specifically discussed to explain the reasons.

Direct Comparisons

Current Condition Class

The tables that follow provide comparisons between IRAs and other NFS lands. Table 1 shows that IRA lands have a slightly higher percent of area that is Condition Class 1 (at low risk of losing key ecosystem components). IRA lands have a slightly lower percentage of land area that is in Condition Class 3 (those which have significantly departed from a historical fire regime and have a high risk of losing key ecosystem components). The difference in the proportion of IRA lands and other NFS lands in each Condition Class only exceeds the 5% “significant difference” threshold for Condition Class 1, with a 6% difference. Note that the losses in one category should match the gains elsewhere; however, rounding errors will occasionally mask such offsetting effects. That is the case in this circumstance. However, it is clear that a minor correlation exists which suggests that IRAs contain slightly less Condition Class 3 lands than do the other NFS lands. Forest types typically found in mid- to higher-elevation areas (as is the case for many IRAs) have evolved with longer fire return intervals, and thus IRAs would be expected to have a higher proportion of Condition Class 1 and a lower proportion of Condition Class 3.

Table 1. IRAs compared to other NFS lands outside of IRAs in terms of Current Condition Class.

Fire Condition Class	IRA *Acres	%	Other NFS Acres	%	Absolute Difference %
Condition Class 1	18,665	43%	47,035	37%	6 %
Condition Class 2	14,421	33%	42,235	33%	0 %
Condition Class 3	8,243	19%	29,805	24%	5 %
Other Condition Classes	2,409	6%	7,403	6%	0 %
Sum	**43,739**	**100%**	**126,479**	**100%**	

*All acres are rounded to the nearest 1,000 acres.

Fire Regime

Table 2 shows the comparison for fire regime. IRAs have a higher proportion of area located in Fire Regime 3 (35-100 year cycle, Mixed severity) and a lower proportion of area in Fire Regime 1 (0-35 year cycle, Low Severity). A slightly lower proportion of IRAs are also in Fire Regime 2 (0-35 year, Stand Replacement) as compared to other NFS lands, although the difference does not meet the 5% threshold discussed previously. The reasons for the significant differences in fire regimes 1 and 3 are not apparent without deeper examination of the three spatial elements used to create CCC and FR - elevation, current cover type, and potential natural vegetation and will be explained in the next section.

Table 2. IRAs compared to other NFS lands outside of IRAs in terms of Fire Regime.

Fire Regime	IRA Acres	%	Other NFS Acres	%	Absolute Difference %
1. 0-35 yrs; Low Severity	12,515	29%	54,914	43%	14 %
2. 0-35 yrs; Stand Replacement	2,004	5%	11,428	9%	4 %
3. 35-100+ yrs; Mixed Severity	17,895	41%	33,138	26%	15 %
4. 35-100+ yrs; Stand Replacement	5,181	12%	13,175	10%	2 %
5. 200+ yrs; Stand Replacement	6,065	14%	12,947	10%	4 %
Barren	36	0%	35	0%	0 %
Water	43	0%	842	1%	1 %
Sum	**43,739**	**100%**	**126,479**	**100%**	

*All acres are rounded to the nearest 1,000 acres.

Indirect Comparisons

Cover type as input to Condition Class and Fire Regime

The CCC and FR datasets were developed through the integration of several biophysical data layers. Three datasets that were key to the development of CCC and FR were current cover type, potential natural vegetation and elevation. The process used to create CCC and FR from the input datasets relied on panels of experts who developed successional pathway diagrams for all combinations of historical fire regimes and potential natural vegetation. IRAs and other NFS lands are compared with respect to these three spatial datasets in the following tables.

Table 3 shows that the significant differences (greater than 5%) between IRAs and other NFS lands occur in the oak – hickory, ponderosa pine, Douglas-fir and lodgepole pine cover types. Oak – hickory makes up a very small part of IRAs, suggesting that small variations in the areas involved could randomly drive the percentage figures above 5% due to the natural variations where IRAs are located. Essentially, there just isn't enough data to provide an explanation. In addition, there isn't enough acreage in the class to suggest that any relevant issue exists.

Table 3. IRAs compared to other NFS lands in terms of current cover type

Cover Types	IRA Acres	IRA %	Other NFS Acres	Other NFS %	Absolute Difference %
Agriculture	873	2%	3,131	2%	0 %
Grassland	1,052	2%	5,924	5%	3 %
Wetlands		0%	6	0%	0 %
Desert Shrub	1,729	4%	4,338	3%	1 %
Other Shrub	2,207	5%	4,769	4%	1 %
Oak - pine	257	1%	4,227	3%	2 %
Oak - hickory	578	1%	9,223	7%	6 %
Oak - gum - cypress	18	0%	781	1%	1 %
Elm - ash- cottonwood	8	0%	47	0%	0 %
Maple - beech - birch	263	1%	3,698	3%	2 %
Aspen - birch	1,099	3%	4,209	3%	0 %
Western hardwoods	1,115	3%	1,754	1%	2 %
White - red - jack pine	104	0%	2,004	2%	2 %
Spruce - fir (East)	153	0%	1,310	1%	1 %
Longleaf - slash pine	38	0%	1,123	1%	1 %
Loblolly - short leaf	53	0%	3,939	3%	3 %
Ponderosa pine	5,657	13%	22,881	18%	5 %
Douglas - fir	6,604	15%	11,123	9%	6 %
Larch	300	1%	978	1%	0 %
Western white pine	394	1%	599	0%	1 %
Lodgepole pine	8,424	19%	12,644	10%	9 %
Hemlock - Sitka spruce	47	0%	357	0%	0 %
Fir - spruce	5,244	12%	10,872	9%	3 %
Redwood	12	0%	43	0%	0 %
Pinyon - juniper	5,370	12%	10,132	8%	4 %
Alpine Tundra	609	1%	2,064	2%	1 %
Barren	36	0%	40	0%	0 %
Water	41	0%	844	1%	1 %
Urban/Development/Ag	1,454	3%	3,420	3%	0 %
Sum	**43,739**	**100%**	**126,479**	**100%**	

*All acres are rounded to the nearest 1,000 acres.

The other significant differences are in areas of ponderosa pine, Douglas-fir, and lodgepole pine. Analysis of the location of IRAs in relation to elevation provides the most likely explanation of these differences in cover type. Table 4 shows that 52% of all IRA acreage lies above 7,000 feet. Differences in cover type reflect the elevation differences between IRAs and other NFS lands. Ponderosa pine is typically located on lower- to mid-elevation sites, so it would be expected that proportionally more ponderosa pine cover type would be found in other NFS lands versus IRAs. This is consistent with ponderosa pine cover type making up 18% of other NFS lands, but only 13% of IRAs. Conversely, lodgepole pine often tends to be a cover type associated with high elevation areas. It makes up 19% of all IRAs, and only 10% of other NFS lands. This is consistent with the observation that IRAs tend to occur in high elevation zones. As a result, on many sites, it would be expected that increasing levels of Douglas-fir in IRAs would be seen in comparison to other NFS lands. Table 3 reflects this, with Douglas-fir making up 15% of all IRAs, but only 9% of all other NFS lands.

Table 4. IRAs compared to other NFS lands in terms of elevation.

Elevation Class	IRA Acres	IRA %	Other NFS Acres	Other NFS %	Absolute Difference %
0 - 1,000	243	1%	14,453	11%	10 %
1,001 - 2,000	952	2%	14,938	12%	10 %
2,001 - 3,000	2,176	5%	10,541	8%	3 %
3,001 - 4,000	2,730	6%	11,152	9%	3 %
4,001 - 5,000	3,582	8%	15,572	12%	4 %
5,001 - 6,000	4,752	11%	14,715	12%	1 %
6,001 - 7,000	7,235	17%	13,302	11%	6 %
7,001 - 8,000	8,600	20%	11,218	9%	11 %
8,001 - 9,000	6,568	15%	8,197	6%	9 %
9,001 - 10,000	4,009	9%	5,819	5%	4 %
10,001 - 11,000	1,892	4%	3,897	3%	1 %
11,001 - 12,000	745	2%	2,026	2%	0 %
12,001 - 13,000	233	1%	601	0%	1 %
13,001 - 14,000	21	0%	48	0%	0 %
Sum	**43,739**	**100%**	**126,479**	**100%**	

*All acres are rounded to the nearest 1,000 acres.

Potential Natural Vegetation as Input to Condition Class and Fire Regime

Potential natural vegetation (PNV) was also examined to help explain differences greater than 5%. In general, the differences found with PNV occur in the same categories as those found with cover class (Table 5, next page). Douglas-fir, viewed as a potential natural vegetation type, is proportionately greater in IRAs, again likely due to the correlation of IRAs to areas of higher elevation. Ponderosa pine potential natural vegetation is less prevalent in IRAs. As before, this is likely related to the lower proportion of IRAs found in low elevation sites. The other PNV type that occurs disproportionately in IRAs is spruce-fir. Several different forest cover types lead to a spruce-fir ecological climax, including many lodgepole pine cover types. It is likely that the same effects seen in the cover class analysis above hold true for spruce-fir. This PNV type appears on high elevation sites and overtakes lodgepole pine successional stages. It is logical for spruce-fir as a PNV type to make up 21% of IRAs and only 10% of other NFS lands.

Conclusion

Analysis of the relative proportions of fire condition class and fire regime showed that only a few categories of these classes vary significantly from IRA to non-IRA National Forest System lands. In the few cases where the variation is 5%, either geographic location or ecological conditions readily explain the difference. Based on this work, there is no reason to believe that there are significant errors or cross-correlations between IRAs and the fire condition or regime datasets.

Table 5. IRAs compared to other NFS lands in terms of potential natural vegetation.

Potential Natural Vegetation	IRA Acres	IRA %	Other NFS Acres	Other NFS %	Absolute Difference %
Pine forest	1,179	3%	9,785	8%	5 %
Great Basin Pine (NV, UT)	90	0%	155	0%	0 %
Pine - Douglas fir	2,569	6%	6,608	5%	1 %
Douglas fir	7,633	17%	8,831	7%	10 %
Mixed Conifer	1,150	3%	6,911	5%	2 %
Silver fir - Douglas fir	533	1%	3,218	3%	2 %
Grand Fir-Douglas fir	1,408	3%	4,533	4%	1 %
Red fir (CA)	228	1%	783	1%	0 %
Spruce - Fir - Douglas fir	2,737	6%	2,271	2%	4 %
SW Mixed Conifer (AZ, NM)	21	0%	258	0%	0 %
Redwood (CA)	5	0%	32	0%	0 %
Cedar - Hemlock - Pine (WA)	28	0%	133	0%	0 %
Cedar - Hemlock - Douglas fir	2,531	6%	5,718	5%	1 %
Spruce - Cedar - Hemlock (WA, OR)	72	0%	356	0%	0 %
Fir - Hemlock (WA, OR)	363	1%	1,282	1%	0 %
Spruce – fir	9,339	21%	14,465	11%	10 %
Lodgepole - Subalpine (CA)	435	1%	1,066	1%	0 %
CA Mix Evergreen (CA)	43	0%	95	0%	0 %
Oakwoods (CA)	355	1%	654	1%	0 %
Mosaic Cedar - Hemlock - Douglas fir & Oak(OR)	1	0%	10	0%	0 %
Alder - ash (OR, WA)		0%	2	0%	0 %
Juniper – Pinyon	5,868	13%	9,760	8%	5 %
Juniper Steppe	199	0%	682	1%	1 %
Mesquite bosques (NM)		0%		0%	0 %
Sagebrush	1,878	4%	2,667	2%	2 %
Chaparral	1,454	3%	3,371	3%	0 %
Southwest shrub steppe	131	0%	419	0%	0 %
Desert shrub	680	2%	1,562	1%	1 %
Shinnery		0%	56	0%	0 %
Annual grassland	29	0%	27	0%	0 %
Mountain grassland	188	0%	265	0%	0 %
Plains grassland	337	1%	6,049	5%	4 %
Prairie	18	0%	413	0%	0 %
Desert grassland	23	0%	202	0%	0 %
Texas savanna		0%		0%	0 %
Wet grassland		0%		0%	0 %
Alpine Meadows - Barren	498	1%	1,870	1%	0 %
Oak Savanna (ND)	13	0%	15	0%	0 %
Mosaic Bluestem/Oak - hickory	6	0%	418	0%	0 %
Cross timbers		0%	60	0%	0 %
Conifer bog (MN)		0%	5	0%	0 %
Great Lakes pine forest	11	0%	3,086	2%	2 %
Spruce - fir	180	0%	625	0%	0 %
Maple - basswood/Oak savanna	18	0%	32	0%	0 %
Oak - hickory	112	0%	3,027	2%	2 %
Elm - ash forest		0%	2	0%	0 %
Maple - beech - birch		0%	1	0%	0 %
Mixed mesophytic forest	15	0%	1,937	2%	2 %
Appalachian oak	712	2%	5,676	4%	2 %
Transition Appalachian Oak - Northern Hardwood	208	0%	1,472	1%	1 %
Northern hardwoods	38	0%	209	0%	0 %
Northern hardwoods - fir	97	0%	3,731	3%	3 %
Northern hardwoods - spruce	34	0%	1,032	1%	1 %
Northeastern oak - pine		0%		0%	0 %
Oak - hickory - pine	93	0%	6,925	5%	5 %
Southern mixed forest	50	0%	2,214	2%	2 %
Loblolly - shortleaf	21	0%	137	0%	0 %
Blackbelt		0%	23	0%	0 %
Oak – gum - cypress		0%	2	0%	0 %
Northern Floodplain	22	0%	187	0%	0 %
Southern Floodplain	10	0%	274	0%	0 %
Barren	36	0%	36	0%	0 %
Water	41	0%	844	1%	1 %
Sum	**43,739**	**100%**	**126,479**	**100%**	

*All acres are rounded to the nearest 1,000 acres.

Appendix D: Propagation of Uncertainty in Map Overlay Analysis

Authors: Mark V. Finco, Daniel Thompson, Thomas Bobbe

Introduction

Maps, by definition, are models of the “reality” that they represent. Mapmakers generalize and classify to present information in a way that makes it meaningful and interpretable to map users. This is true whether the maps are analog paper maps or digital data layers in a Geographic Information System (GIS). In the process of making the information more meaningful, the generalization process introduces some constraints on how the maps are used.

The term “conflation” is used in the geographic information science community to refer to the class of constraints introduced when performing analysis with data that were collected with different levels of generalization. There are many applications where conflation needs to be considered. Examples presented by Goodchild (1996) include, “combining digitized topographic maps with GPS data …, to edge matching misfit data across boundaries, to combining information from different sensors in remote sensing.” The University Consortium on Geographic Information Science (UCGIS 1998) recognized in its research priorities the issues of using multiple scale datasets when it acknowledged that disparate scales of data are often still the best available datasets for analysis.

The Map Overlay Process

Much of the analysis performed for the Roadless Area Conservation Draft and Final Environmental Impact Statement involved map overlays using geospatial data derived from different sources at different scales. Map overlay is the process used to quantify the spatial relationship between multiple thematic data layers.

The objective of the map overlay analysis was to characterize the Inventoried Roadless Areas (IRAs) in terms of some set of characteristics (e.g., Current Condition Class). The GIS process used involved three steps: (a) individual IRA polygons were spatially aggregated into larger IRA polygons, (b) the spatially aggregated IRAs and the characterization datasets were overlaid in GIS and (c) the results in terms of fractional IRA area for each of the classes of the characterization dataset were summarized. Aggregating the IRAs lessens the discrepancy in scale between the IRA dataset (fine) and characterization datasets (coarse).

Established practice states that the scale of the analysis is set by the scale or resolution of the coarsest dataset. The scale of the characterization layer is coarsest, and therefore places constraints on the conclusions drawn from the map overlay process. Specifically, the resolution or scale of the characterization layers constrains the size of the area that can be analyzed with any certainty.

Using an empirical approach, the following section demonstrates why the scale of the coarsest dataset places these constraints on the analysis. The section also demonstrates how categorizes the sources of uncertainty, and using Monte Carlo-like simulations shows that uncertainty can be minimized by increasing the size of the areas being analyzed.

Uncertainty Categorization & Case Studies

The uncertainty due to conflation can be divided into two categories: (a) uncertainty in the attributes and (b) uncertainty in the spatial properties of the data set. Modeling how these uncertainties propagate involves the creation of mathematical models that represent the mechanics whereby certain transform operators modify errors in the source layers. Development of such models rests firmly within the GIS research community. Models of uncertainty propagation described in the literature include using probability theory (Newcomer and Szajgin 1984) and Taylor series expansions (Heuvelink et al. 1989). More commonly, however, Monte Carlo simulation is used to assess the propogation of uncertainty in spatial analysis (Emmi and Horton 1995).

The following section explains in lay terms why uncertainty propagation occurs. Case studies using Monte Carlo-like simulations are used to demonstrate what the implications are for the Roadless Area Conservation Initiative spatial analysis.

Attribute Uncertainty

Attribute uncertainties exist because the spatial distribution of the characterization phenomena within the minimum mapping unit of the characterization dataset (e.g., 1-km^2) is unknown. For the sake of discussion, consider the overlay of 1:24:000 polygons on a 1-km raster dataset of “percent vegetation”.

If these layers are naively overlaid, a polygon from the categorization layer could lie entirely in a single grid cell of the characterization layer. Figure 1 presents both the polygon larger than a raster cell (Polygon A) and polygon smaller than a raster cell (Polygon B) cases.

The values in each cell of the characterization dataset represent the average properties of the ground represented by the cell. For example if the value of the characterization layer is 60, then 60% of the cell is covered by vegetation. The conflation uncertainty due to attributes is created because it can not be known how the 60% vegetation is distributed within the 1-km^2 raster cell. Figure 2 presents three possibilities (though there are an infinite number of possibilities).

This is important because the actual character of Polygon B can change dramatically given these different views of a 60% vegetation cover. By default we would assign Polygon B a value of 60%, but in reality the true value could be anywhere between 0% and 100%.

Case Study Methodology

The process used to demonstrate how uncertainties caused to measurement and sampling are affected by the size of the area that is being characterized is as follows. This case study uses a single characterization layer that has 6 classes and was developed at 30-meter resolution. The 30-meter characterization layer was resampled using a majority criterion to simulate coarser data sources at 100-, 250- and 1000-meter resolutions. Thirty, randomly location rectangles of 1000-, 3000- and 13,000-meters are sampled from each of the characterization layers. The results of the sampling are compared to the 30-meter resolution characterizations and a root mean squared error statistics are summarized in a graph.

Results

The results of this analysis are documented in Figure 3, which shows the relationship between uncertainty in the overlay results, resolution of the characterization layer, and size of the area being analyzed. Figure 3 can be viewed in two ways. The first looks horizontally across the graph at a single analysis area size (e.g., 3000-meters). Regardless of the analysis area size (1000-, 3000- or 13,000-meters) the root mean squared (RMS) error increases as the characterization layer becomes coarser. This result may be intuitive, however, comparing the three analysis size curves shows that the characterization layer resolution has less of an affect on large study areas (13,000-meters) compared to small areas (1000-meters).

The second method of viewing Figure 3 is vertically, holding the resolution of the characterization dataset constant. For any given resolution of characterization dataset, larger analysis areas give smaller RMS errors. The two observations together tell us that to compare areas using coarse characterization layers (e.g. 1-km Current Condition Class) the areas need to be large to keep the RMS error small. If the RMS error is too high, then areas that are seemingly different (i.e., the results of the overlay result in different values) may in a statistical sense be indistinguishable.

Positional Uncertainty

Positional uncertainty errors are caused by the fact that no map or digital dataset is perfectly geo-referenced (Goodchild and Longley, 1999). The way the positional accuracy is defined for vector maps is through National Map Accuracy Standards. Raster maps generally report positional RMS errors associated with the rectification of the raster. Note that this is not the same as the characterization RMS error discussed above. Positional RMS errors can be reported in a variety of units, often in numbers of pixels. Therefore, absolute positional accuracy of a 1-meter resolution dataset with a positional RMS of one is not the same as the absolute positional accuracy of a 1-km resolution dataset with a positional RMS of one.

A positional RMS error of less than one is the objective of many remote sensing projects. This can be loosely interpreted as meaning that the true position is on average within one raster size of its mapped position. The effects of positional uncertainty are shown in

Figure 4. Figure 4 shows the current position of a raster cell with three alternative locations with a polygon that is smaller than the raster cell. Note that the effect shown here affects all polygons that have relatively high perimeter to area ratios, and not just those that are smaller than the characterization cell size.

In Figure 4, polygon “B” is assumed stationary. If the raster is in alternate position 1, then polygon B is still inside the same raster cell. If the raster is in alternate position 2 or 3, however, then polygon B is would be inside the cell to the right and top of the original raster, respectively.

Case Study Methodology

This case study uses polygons of varying sizes to investigate the effects of alternative positions of the characterization grid (i.e., ± 1 pixel in all directions). In this case study the polygon locations are assumed unvarying and the characterization grid is shifted to each of the eight (8) nearest neighbor positions. The analysis consists of selecting all polygons in a particular size class (e.g., 500-1000 acres), characterizing the polygons using each of the nine characterization layers (i.e., original location plus 8 neighboring locations), and analyzing at the range of variability of the composition. The range of variability is calculated in terms of percent of mean value.

Results

The results of the analysis are presented in Table 1, below. As polygon size is increased, the range between the nine (9) alternative locations of the characterization grid is monotonically decreasing. In this example, at approximately 10,000 acres the range of the observations becomes asymptotic at around 1.0%. The polygons used in this case study were derived from the national inventoried roadless area dataset. In order to minimize the effects of positional uncertainty, the polygons need to be relatively large. In this example, the characterization layer resolution was 1-km (approximately 247 acres).

Polygon Size Class (acres)	Range (% of Average)
0 – 100	11.4%
101 – 500	10.7%
501 – 1000	8.5%
1001 – 5000	5.2%
5001 – 10,001	2.2%
10,001 – 50,000	1.0%

Table 1. Results of polygon size class on polygon classification stability.

Conclusions

In a perfect world, all data would be collected in a consistent manner. In the real world, however, data collection is done with varying protocols at various scales. In order to assess the environmental effects of the Roadless Area Conservation Project, the spatial analysis was required to use large-scale (i.e., detailed) inventoried roadless area GIS data with coarser, small scale characterization layers (e.g., fire condition class and fire regime). The scale and degree of generalization used to create the characterization layers did not impede the analysis, but simply put constraints on the types of conclusions drawn from the map overlay process. Specifically, the coarser data was used to define the implied precision of the analysis and constrained the minimum geographic size of areas that can be compared.

To minimize the effects of attribute and positional uncertainty, the analysis presented in this paper showed that the areas being analyzed needed to be relatively large. When aggregated at the state or regional scale, the IRAs meet this criterion. The interaction of positional uncertainties and attribute uncertainties was not investigated in this study. Nevertheless, they can be expected to compound, not counteract, each other. The conclusion is that the overlay of inventoried roadless areas and characterization layers provides comparisons that are appropriate and scientifically defensible only for large regions. Given this, the spatial analysis team took a conservative approach and restricted the comparisons to state and regional scales.

Figures for Appendix D

Figure 1. Example of a spatial overlay on a characterization dataset.

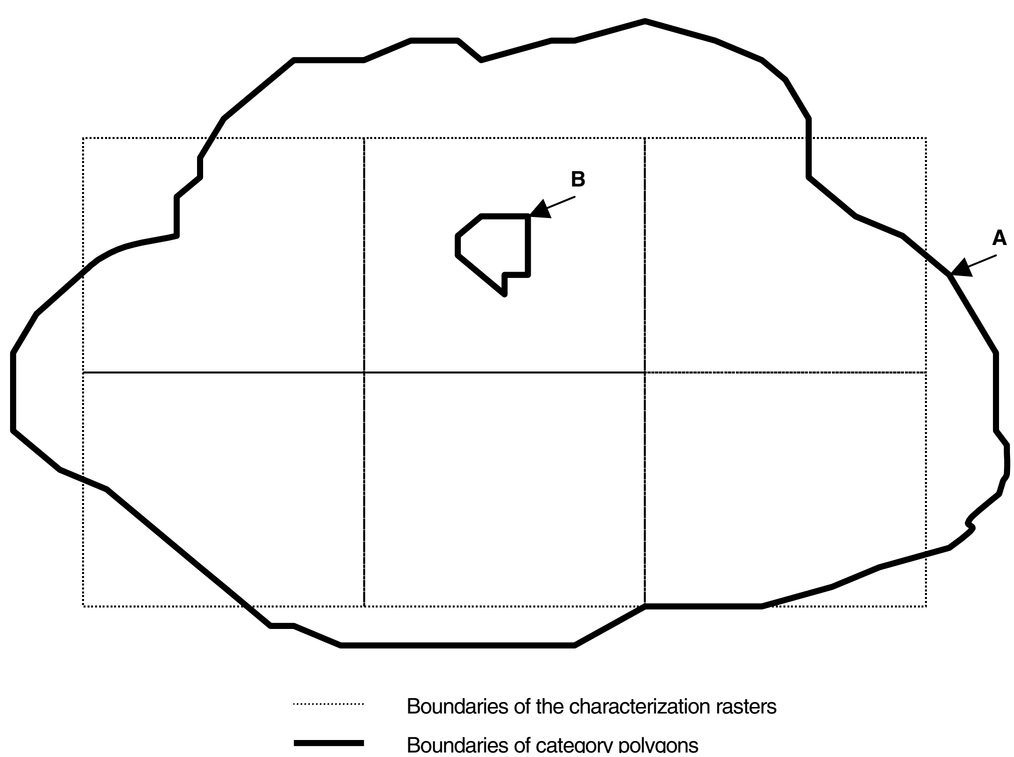


Figure 2. The spatial arrangement of the vegetation within a raster cell cannot be known.

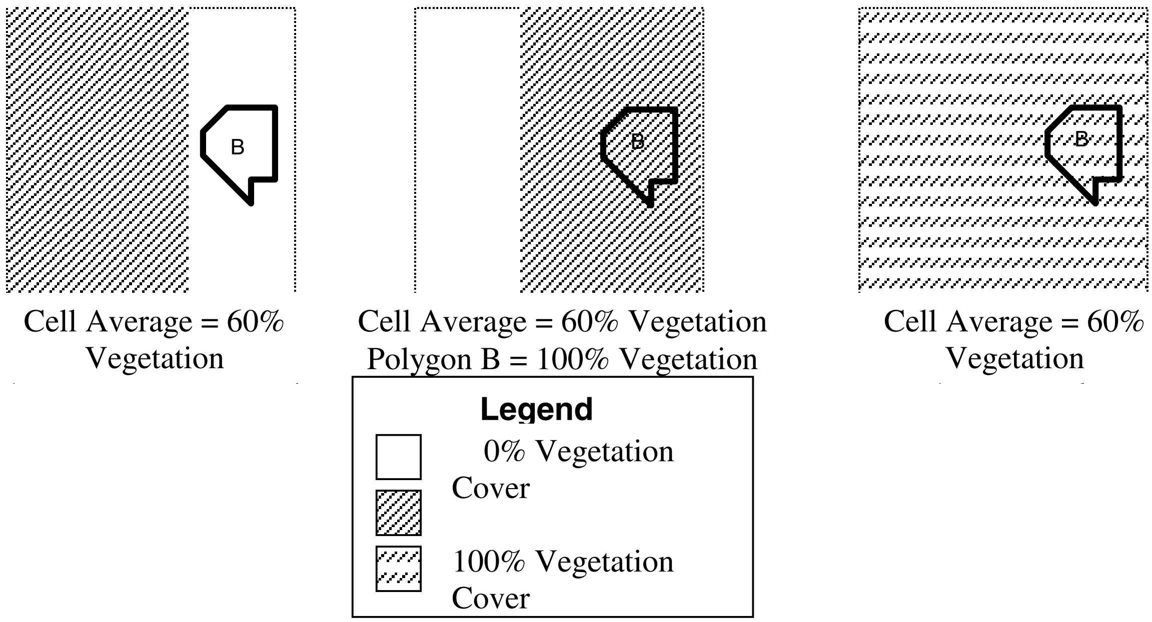


Figure 3. RMS error as a function of characterization grid cell size and analysis area.

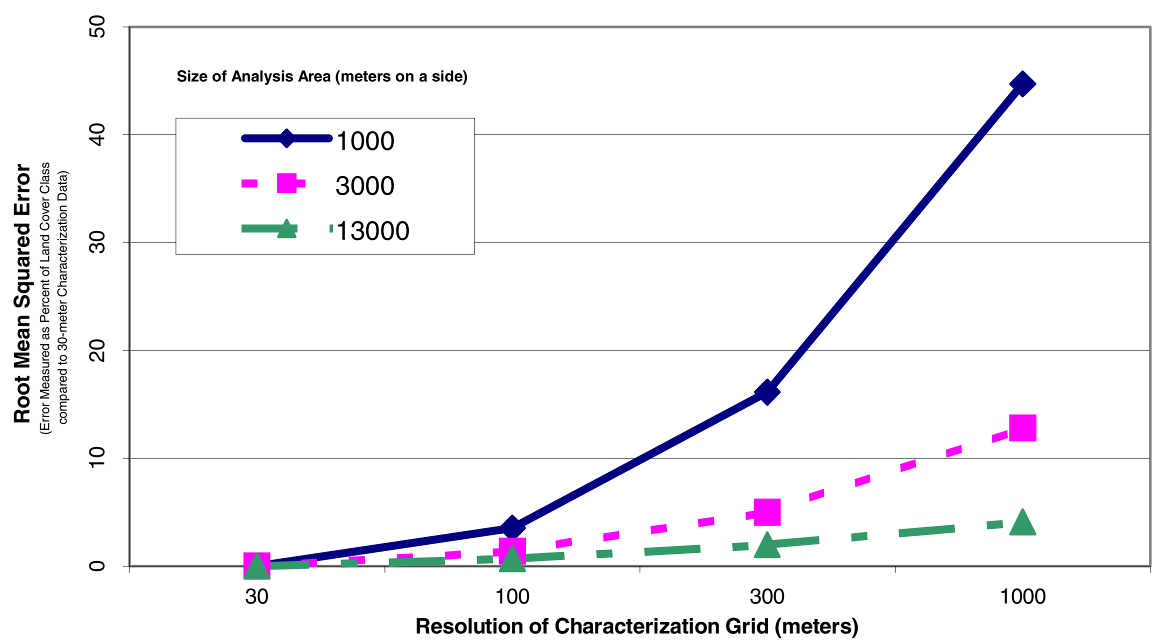
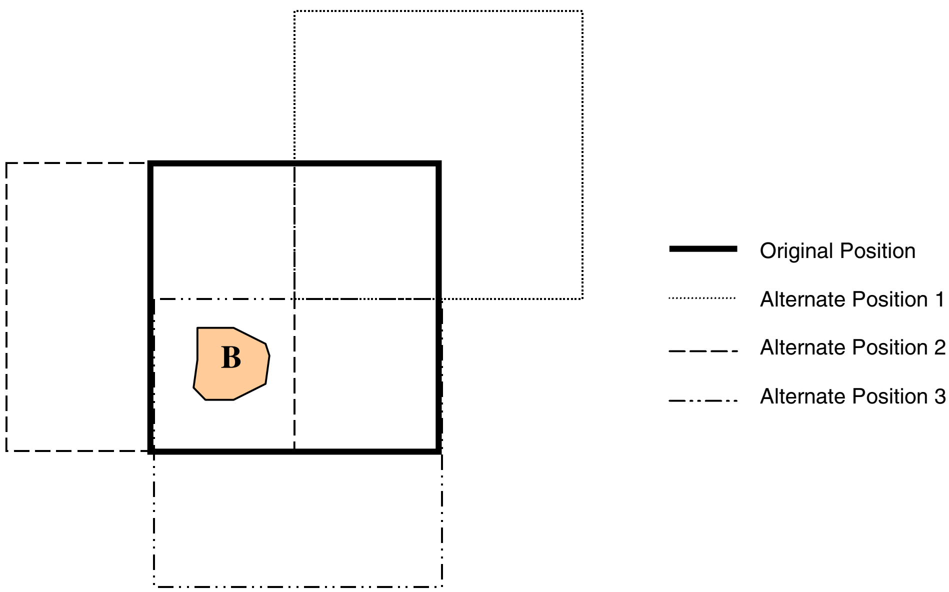


Figure 4. The original position of a raster cell with three examples of equally likely positions.



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Computer routines used in Appendix D

Arc Macro Language Simulation Code
Spatial Uncertainty Monte Carlo Routine

```
/* Filename: spatial_mc.aml

/* Investigating the effects of positional uncertainty on the
/* results of polygon overlay.
/* Original: 00/09/15, M.Finco
/*  Revised:

/* Define the characterization dataset root name
&sv char = cclass

/* *************************************************
/* First created the shifted characterization layers
grid
&do x &list -1 0 1
    &do y &list -1 0 1
        &if ^ [exist %char%_%x%_%y% -grid] &then ~
            %char%_%x%_%y% = %char%_0_0(%x%,%y%)
    &end
&end
q
/* *************************************************

/* ######################################################
/* Run thru analysis for various size thresholds of polys
/* with each shifted characterization grid
&sv lastmax = 0
&do A &list 100 500 1000 5000 10000 50000

    /* Create subsets of the ira coverage based on ploy size
    &if ^ [exists ira%A% -cover] &then
        &do
        ae; ec ira; ef poly
        sel acres le %A% and acres ge %lastmax% and acres le %A% and ownership = 'FS'
        put ira%A%
        q
        build ira%A% poly
        &end

    &sv lastmax = %A%

    /* Grid part of the analysis
    grid
    &if ^ [exists ira%A%_grd -grid] &then
        &do
        setwindow %char%_0_0; setcell %char%_0_0
        ira%A%_grd = polygrid (ira%A%, region)
        &end

    &do x &list -1 0 1
        &do y &list -1 0 1
            &do
            &type Working with %x% and %y%
            &if [exists i%A%_%x%_%y% -grid] &then kill i%A%_%x%_%y%
            i%A%_%x%_%y% = combine (ira%A%_grd, %char%_%x%_%y%)
            &end
        &end
    &end
    q


    /* Tables part
    tables
    /* first add and populate a "percent of category" field for
```

```
    /* each polygon in the ira grid
    &do x &list -1 0 1
        &do y &list -1 0 1
            &do
            &if [exists i%A%_%x%_%y%.sta -info] &then
                &sv del = [delete i%A%_%x%_%y%.sta -info]
            sel i%A%_%x%_%y%.vat
            statistics ira%A%_grd i%A%_%x%_%y%.sta
                sum count
                end
            relate add pctrel i%A%_%x%_%y%.sta INFO ira%A%_grd ira%A%_grd linear ro
            &if ^ [iteminfo i%A%_%x%_%y% -vat pct_%x%%y% -exists] &then
                additem i%A%_%x%_%y%.vat pct_%x%%y% 8 8 n 1 /* item for pct of class
            &type Calculating percentages for %x% %y%
            calc pct_%x%%y% = 0 /* Clear previous results
            calc pct_%x%%y% = 100 * count / pctrel//sum-count
            relate drop pctrel

            /* create a version with only condition class 3 in it
            /* and get rid of non-essential items
            &if [exists i%A%_%x%_%y%.dat -info] &then
                &sv d = [delete i%A%_%x%_%y%.dat -info]
            copy i%A%_%x%_%y%.vat i%A%_%x%_%y%.dat
            sel i%A%_%x%_%y%.dat
            &type Reselecting the records with condition class 3
            resel %char%_%x%_%y% ne 3
            purge
            y

            items
            &type Dropping unnecessary items ...
            dropitem i%A%_%x%_%y%.dat value count %char%_%x%_%y%
            &end
        &end
    &end

    /* secondly, create a table to keep all of the combine results for
    /* condition class 3
    &type Creating a file to store these results
    &if [exists ira%A%.dat -info] &then &sv d = [delete ira%A%.dat -info]
    copy ira%A%_grd.vat ira%A%.dat
    &type Adding item to join to ...
    additem ira%A%.dat ira%A%_grd 4 10 b
    sel ira%A%.dat
    calc ira%A%_grd = value
    dropitem ira%A%.dat value

    quit /* Tables ...

    /* At the ARC prompt ...
    /* Now join all of the results from the percentage calculations to
    /* the table that we just created ...
    &do x &list -1 0 1
        &do y &list -1 0 1
            joinitem ira%A%.dat i%A%_%x%_%y%.dat ira%A%.dat ira%A%_grd
        &end
    &end

    /* Produce dbf file
    tables
    sel ira%A%.dat
    list
    infodbase ira%A%.dat ira%A%.dbf
    q

&end  /* Goto next size class of polys
&return
```

Resolution Modification Routine

```
/* Filename: modres.aml
```

```
/* Attribute resampling routine
/* Original: 00/09/17, M.Finco
/*  Revised:

/* class30 = con(mrlc == 41, 1, mrlc == 42, 2, mrlc == 51, 3, ~
/*               mrlc == 81, 4, mrlc == 82, 5, 6)


&sv truth = class30
setwindow %truth%
mape %truth%

/* Create a bunch of coarser grids
&do I &list 3 9 27
    &sv res = %I% * 30

    &type Painting the 30-meter data ...
    gridpaint %truth%

    fmaj = focalmajority (%truth%, rectangle, %I%, %I%)

    &type Focal majority results at %I% ...
    gridpaint fmaj

    complete = merge (fmaj, %truth%)

    &type Fill in class grid ...
    gridpaint complete

    class%res% = resample (complete, %res%)

    &type Resampled grid at %res% ...
    gridpaint class%res%
    &pause &seconds 4

    kill fmaj; kill complete
&end
&return
```

Attribute Uncertainty Monte Carlo Routine

```
/* Filename: samples.aml
/* Create the sample areas for the analysis by finding
/* randomly selected center points, creating sample areas
/* at various sizes, then griding the polygons
/* Original: 00/09/17, M.Finco
/*  Revised:

/* ***********************************************************************
/* The grid part that creates all of the samples at various sizes and
grid
mape class30
&do S &list 810 3240 12960 /* ... The sizes of the sample areas in meters

   &sv S2 = %S% / 2
   &sv xmin = 409061 + %S2%
   &sv xmax = 465761 - %S2%
   &sv ymin = 4707332 + %S2%
   &sv ymax = 4750262 - %S2%
   &type Working at %S% - (%xmin%, %ymin%), (%xmax%, %ymax%)

   &do I = 1 &to 25 /* Number of samples at particular rectangle size

       &sv x = [random %xmin% %xmax%]
       &sv y = [random %ymin% %ymax%]
       &type Random Center Coords #%I% = ( %x%, %y% )

       /* find lower left and upper right coords
       &sv llx = %x% - %S2%
       &sv lly = %y% - %S2%
       &sv urx = %x% + %S2%
```

```
       &sv ury = %y% + %S2%

       setwindow %llx% %lly% %urx% %ury%

       &do G &list 30 90 270 810    /* generate subsets for each resolution
                                    /* of characterization grid
           &if [exists c%G%_%S%_%I% -grid] &then kill c%G%_%S%_%I%
           c%G%_%S%_%I% = class%G%
           clear
           gridpaint c%G%_%S%_%I%
       &end
    &end
&end
q /* grid

/* ***************************************************************************
/* Tables part that summarizes the results of the subsets
tables
&do S &list 810 3240 12960 /* ... The sizes of the sample areas in meters
    /* create an info file for all records for this sample size
    &if [exists all%S%.sum -info] &then &sv d = [delete all%S%.sum -info]
    copy c30_%S%_1.vat all%S%.sum nodata
    additem all%S%.sum sample 6 6 i
    additem all%S%.sum resolution 12 12 i
    sel all%S%.sum

    &do G &list 30 90 270 810 /* generate subsets for each resolution
        &do I = 1 &to 25 /* Number of samples at particular rectangle size
            &type Working with Sample size of %S%, Resolution of %G%, and Sample #%I%
            /* Create an identically formatted file to the summary file
            sel c%G%_%S%_%I%.vat
            additem c%G%_%S%_%I%.vat sample 6 6 i
            additem c%G%_%S%_%I%.vat resolution 12 12 i
            calc sample = %I%
            calc resolution = %G%
            sort value

            /* Save out to a binary disk file and append to the summary file
            &if [exists save.bin -file] &then &sv d = [delete save.bin -file]
            save save.bin
            sel all%S%.sum
            get save.bin
        &end
    &end

    /* Create class percentage statistics for all%S%.sum
    sel all%S%.sum
    additem all%S%.sum sampres 12 12 i /* to calculate total count
    additem all%S%.sum percent 8 8 n 1 /* to hold % of class information
    calc sampres = ( resolution * 100 ) + sample

    &if [exists sum.stats -info] &then &sv d = [delete sum.stats -info]
    statistics sampres sum.stats
        sum count
        end
    relate add pctrel sum.stats INFO sampres sampres linear ro
    calc percent = 100 * count / pctrel//sum-count
    relate drop pctrel
    dropitem all%S%.sum sampres

    /* Join the "truth" values to this table based on sample and class (value)
    /* First create a table with only the 30-m resolution values
    &if [exists all%S%.30 -info] &then &sv d = [delete all%S%.30 -info]
    copy all%S%.sum all%S%.30 nodata
    sel all%S%.sum
    resel resolution = 30
    &if [exists only30.bin -file] &then &sv d = [delete only30.bin -file]
    save only30.bin /* system file with only 30-m values

    /* create and populate the 30-m only table
    sel all%S%.30
    get only30.bin  /* put the values in the separate file
    additem all%S%.30 sampval 8 8 i
```

```
    additem all%S%.30 pct30 8 8 n 1
    calc sampval = ( sample * 10 ) + value
    calc pct30 = percent
    dropitem all%S%.30 value count sample percent resolution

    /* prepare the .sum table to be joinitem'd to
    sel all%S%.sum
    additem all%S%.sum sampval 8 8 i
    calc sampval = ( sample * 10 ) + value

    /* run the joinitem in ARC and bounce back into tables
    q /* tables
    joinitem all%S%.sum all%S%.30 all%S%.sum sampval
    tables
    dropitem all%S%.sum sampval
&end
q /* tables

/* **************************************************************************
/* Clean up directory ...
&do S &list 810 3240 12960 ... The sizes of the sample areas in meters
    &do G &list 30 90 270 810 /* generate subsets for each resolution
        &do I = 1 &to 25 /* Number of samples at particular rectangle size
            kill c%G%_%S%_%I%
        &end
    &end
&end
&return
```

Appendix D Computer Routine References

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Appendix E: Fire Condition Classes And Fire Regime Classes by State and for Risk of Mortality

Appendix E: Acreages within Fire Condition classes 1,2 & 3 and Fire Regime classes 1 or 2, and Risk of Mortality stratified by Inventoried Roadless Area categories 1B, 1B-1, 1C, and non-IRA land within NFS boundary, listed by state. Fire condition class and fire regime data were only available for the lower 48 states. This table does not include acreages in Alaska or Puerto Rico. All figures are shown in 1000s of acres. (*continues on page 74*)

State	All Land Inside Forest Boundary							
	CC1		CC2		CC3		OTHER	
	REGIME 1&2		REGIME 1&2		REGIME 1&2			
	Risk Not Present	Risk Present	Risk Not Present	Risk Present	Risk Not Present	Risk Present	Risk Not Present	Risk Present
Alabama	124	12	249	36	180	28	34	1
Alaska	Fire Condition Class and Fire Regime data were not available for Alaska							
Arizona	834	7	6,661	111	1,895	92	1,623	33
Arkansas	1,845		273		278		191	
California	1,510	108	2,784	210	6,154	497	8,959	474
Colorado	792		2,725	104	1,544	6	9,158	180
Connecticut								
Delaware								
District of Columbia								
Florida	1,074		12				67	
Georgia	366	18	363	3	66		49	1
Hawaii								
Idaho	964	163	1,772	491	241	59	11,586	5,182
Illinois	13		83		153		45	
Indiana			11		121		64	
Iowa								
Kansas	22		65				21	
Kentucky	138	1					658	2
Louisiana	322	81	127	47	3	1	20	3
Maine							53	
Maryland								
Massachusetts								
Michigan	60	10					2,569	219
Minnesota							2,611	226
Mississippi	591	86	288	24	40	8	118	4
Missouri	255		364		730		144	
Montana	378	9	487	570	146	196	9,642	5,465
Nebraska	38		230		1		90	
Nevada	977	2	1,806	7	818	35	2,152	35
New Hampshire							568	160
New Jersey								
New Mexico	1,489	21	3,963	70	2,111	74	1,503	96
New York			4		1		11	
North Carolina	741	18	309	7	97	6	66	
North Dakota	827						279	
Ohio			48	17	4	2	129	31
Oklahoma	163		70		14		150	
Oregon	314	7	2,194	224	4,555	474	7,459	430
Pennsylvania			49	14	41	13	310	87
Puerto Rico	Fire Condition Class and Fire Regime data were not available for Puerto Rico							
Rhode Island								

State	All Land Inside Forest Boundary							
	CC1		CC2		CC3		OTHER	
	REGIME 1&2		REGIME 1&2		REGIME 1&2			
	Risk Not Present	Risk Present	Risk Not Present	Risk Present	Risk Not Present	Risk Present	Risk Not Present	Risk Present
South Carolina	431	69	48	5	10	2	48	2
South Dakota	349	1	1,076	20	405	70	91	
Tennessee	426	9	183	5	27	1	47	
Texas	413	134	31	9	28	5	129	7
Utah	1,015	17	2,095	97	380	13	4,292	270
Vermont							373	4
Virgin Islands	Fire Condition Class and Fire Regime data were not available for the Virgin Islands							
Virginia	598	200	312	89	122	24	267	48
Washington	132	1	1,080	81	1,507	138	5,961	314
West Virginia	21	8	188	83	140	46	395	152
Wisconsin			1				1,497	25
Wyoming	126		1,615	22	54	10	6,435	975
SUM	**17,350**	**981**	**31,562**	**2,346**	**21,867**	**1,800**	**79,865**	**14,425**

Appendix F: Preliminary Fuel Treatment Costs and Acres Treated from Cohesive Strategy

Projected cost and acres treated for fuel reduction in fire regimes I and II, Condition Classes 1, 2, 3, based on coarse scale assessment for regions 1-6.

		Condition Class 1 (Acres in Millions)	Condition Class 2 (Acres in Millions)	Condition Class 3 (Acres in Millions)	Annual Acres Treated (Acres in Millions)	Annual Program Cost Millions (1999 $)
	Distribution Before Treatment	8	32	24		
Present	Acres Treated	0.14	0.28	0.15	0.57	$75
Year 1	Acres Treated	0.15	0.45	0.20	0.80	$137
Year 2	Acres Treated	0.25	0.70	0.50	1.45	$345
Year 3	Acres Treated	0.40	1.10	0.75	2.25	$525
Year 4	Acres Treated	0.50	1.50	1.00	3.00	$708
Year 5*	Acres Treated	0.50	1.50	1.00	3.00	$708
Year 10	Acres Treated	0.50	1.50	1.00	3.00	$708
Year 15	Acres Treated	0.50	1.50	1.00	3.00	$708

*Program continues at this sustained level through preliminary 15-year period. The 10th and 15th years are shown here to illustrate changes in condition as treatment progresses.

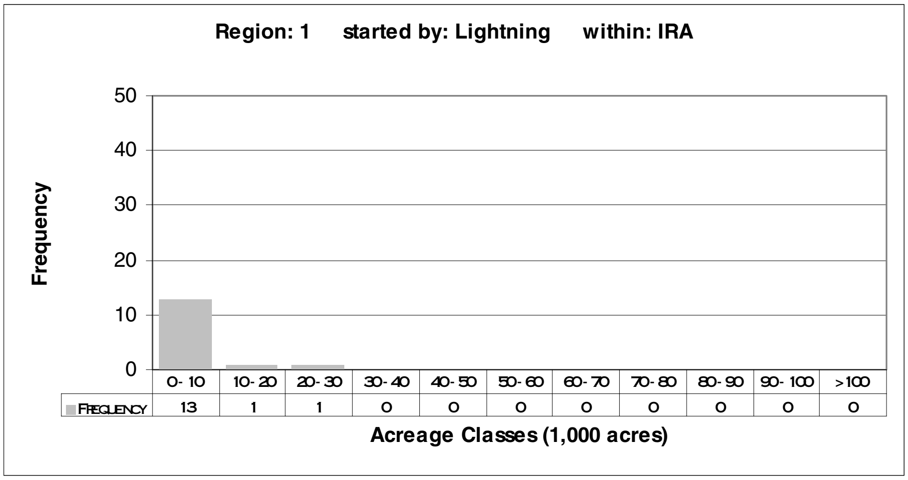
Projected Cost and acres treated for fuel reduction in fire regimes I and II, condition classes 1, 2, 3, based on coarse scale assessment for Regions 8 & 9.

		Condition Class 1	Condition Class 2	Condition Class 3	Annual Acres Treated	Annual Program Cost Millions
		Acres in Millions				(1999 $)
	Distribution Before Treatment	15	7	4		
Present	Acres Treated	0.63	0.11	0.01	0.75	$22
Year 1	Acres Treated	0.75	0.20	0.03	0.98	$33
Year 2	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 3	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 4	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 5*	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 10	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 15	Acres Treated	0.78	0.38	0.04	1.20	$37

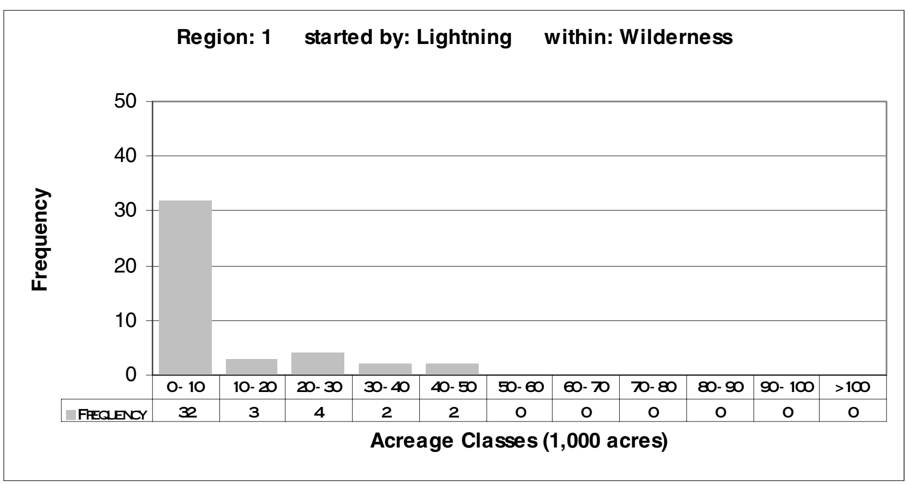
*Program continues at this sustained level through preliminary 15-year period. The 10th and 15th years are shown here to illustrate changes in condition as treatment progresses.

Appendix G: Statistical Analysis of Large Wildfire Occurrence Data By Forest Service Region

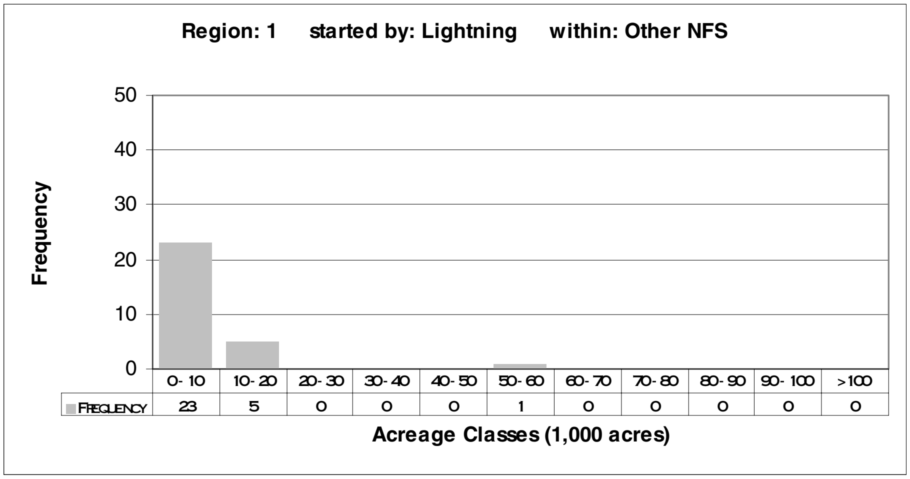
(Source: Roadless Geospatial Data Team 2000)



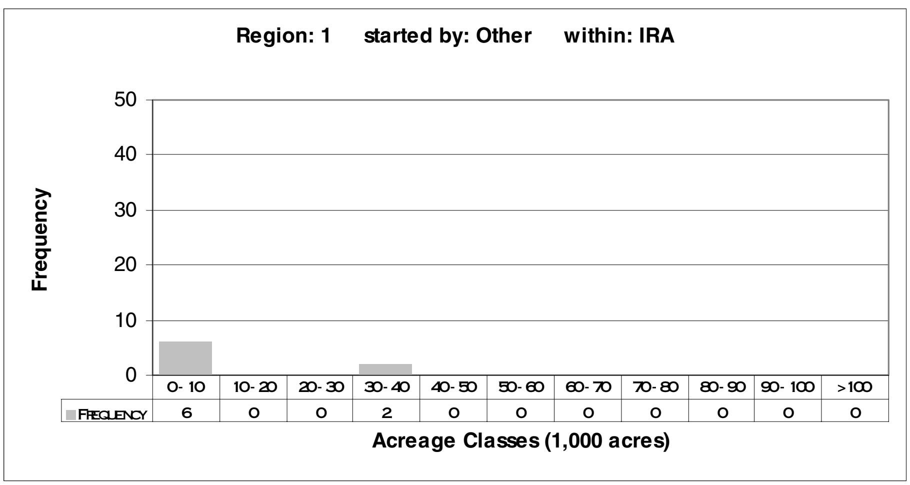
Number of Fires:	15
Avg Acreage:	5,631
Std Dev:	7,461
Median Acreage:	2,470
First Quartile:	1,430
Minimum Acreage:	1,002
Maximum Acreage:	29,520



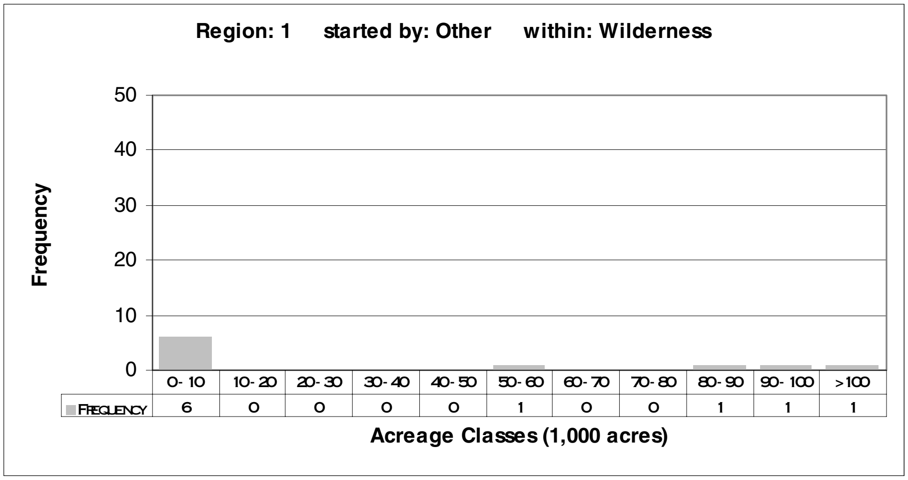
Number of Fires:	43
Avg Acreage:	9,489
Std Dev:	12,639
Median Acreage:	3,250
First Quartile:	1,538
Minimum Acreage:	1,000
Maximum Acreage:	50,000



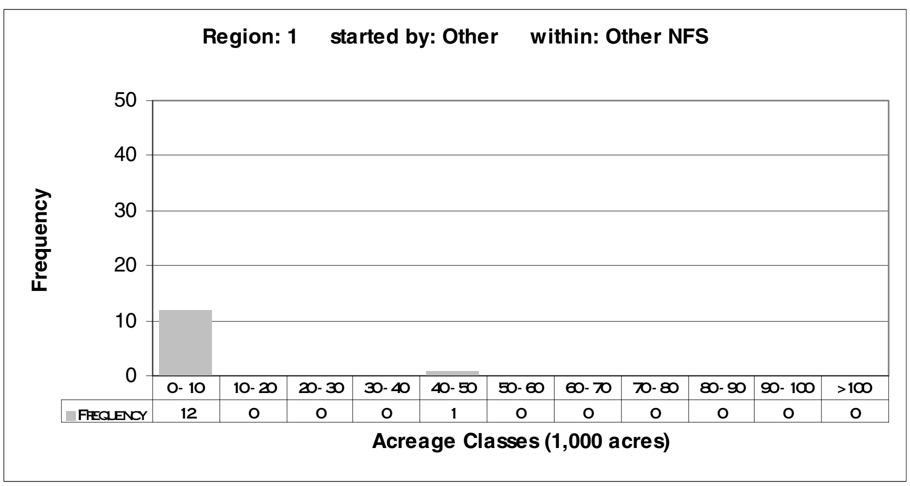
Number of Fires:	29
Avg Acreage:	7,077
Std Dev:	10,800
Median Acreage:	3,680
First Quartile:	1,592
Minimum Acreage:	1,000
Maximum Acreage:	58,220



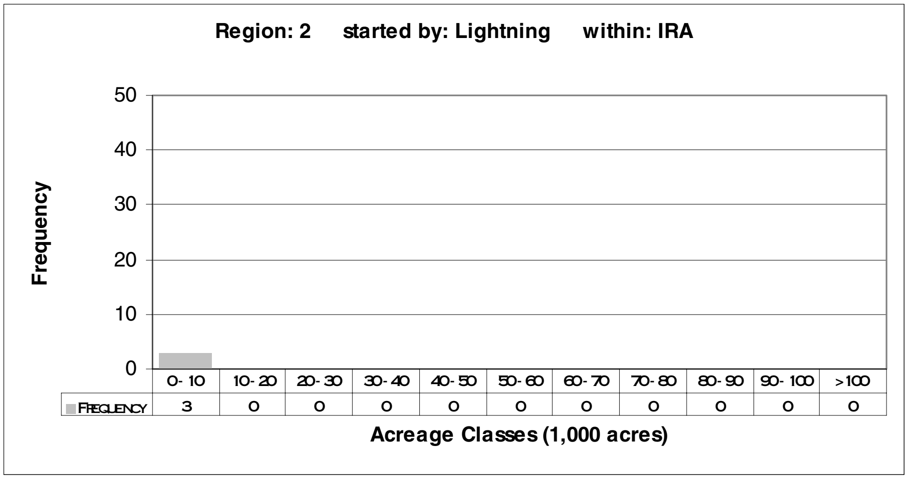
Number of Fires:	8
Avg Acreage:	11,549
Std Dev:	14,185
Median Acreage:	5,710
First Quartile:	1,351
Minimum Acreage:	1,072
Maximum Acreage:	35,358



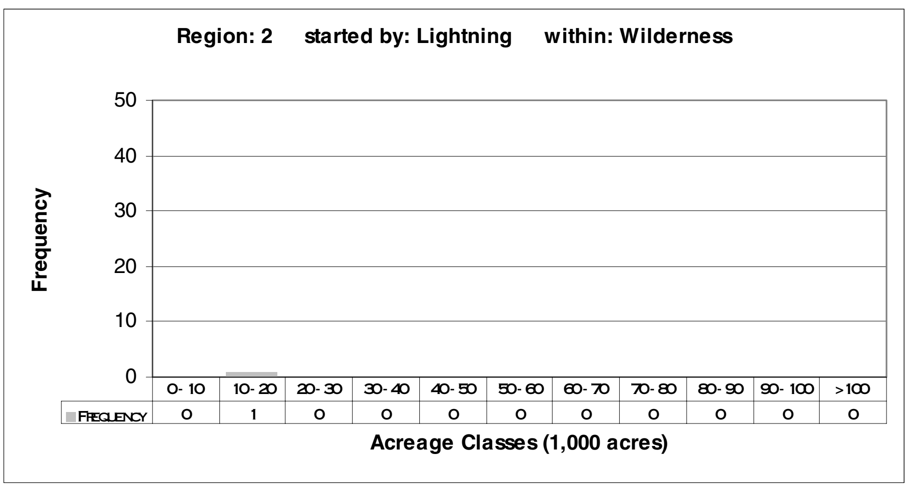
Number of Fires:	10
Avg Acreage:	37,048
Std Dev:	44,826
Median Acreage:	5,864
First Quartile:	3,115
Minimum Acreage:	2,434
Maximum Acreage:	108,942



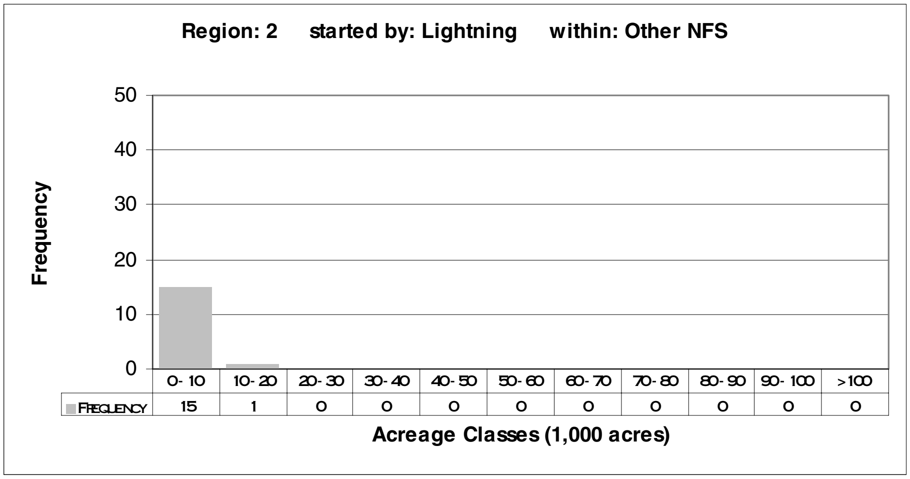
Number of Fires:	13
Avg Acreage:	5,881
Std Dev:	12,374
Median Acreage:	2,230
First Quartile:	1,715
Minimum Acreage:	1,045
Maximum Acreage:	46,900



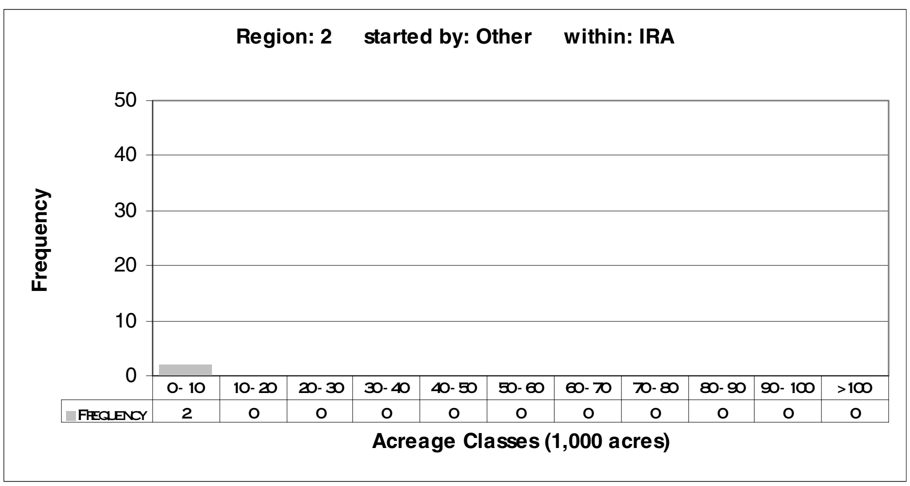
Number of Fires:	3
Avg Acreage:	2,832
Std Dev:	809
Median Acreage:	3,190
First Quartile:	2,548
Minimum Acreage:	1,906
Maximum Acreage:	3,400



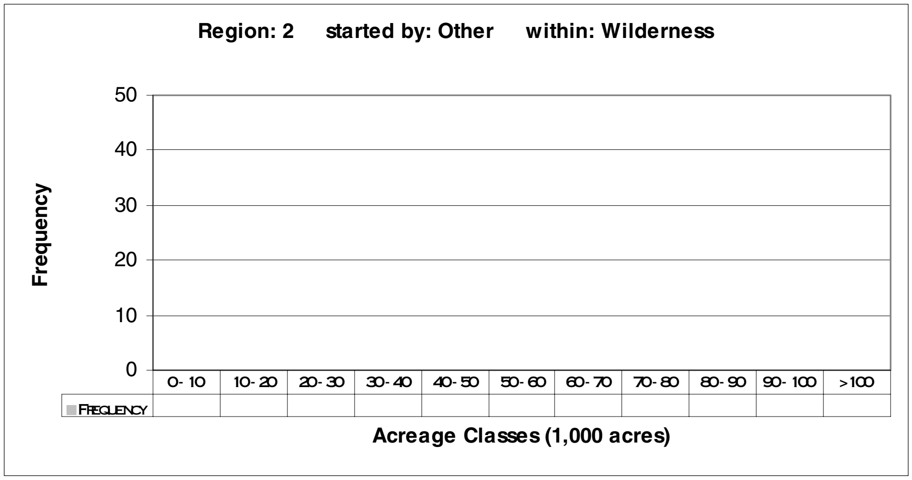
Number of Fires:	1
Avg Acreage:	13,100
Std Dev:	
Median Acreage:	13,100
First Quartile:	13,100
Minimum Acreage:	13,100
Maximum Acreage:	13,100



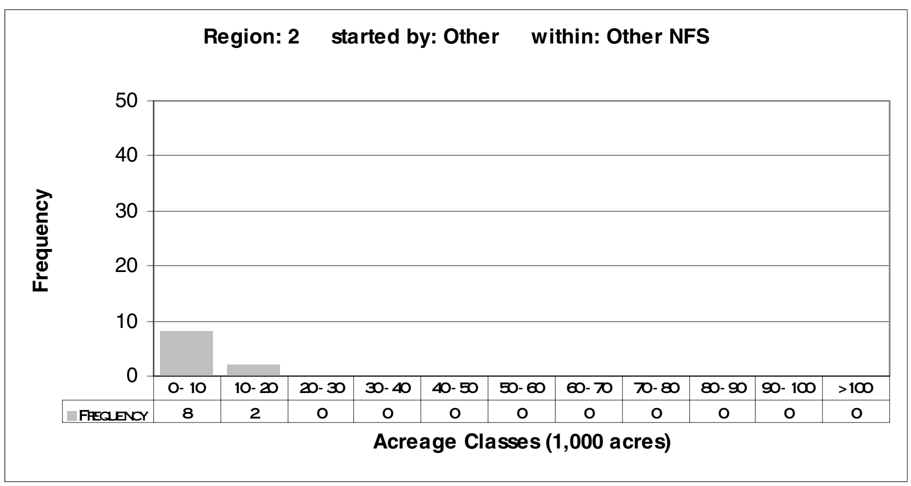
Number of Fires:	16
Avg Acreage:	4,744
Std Dev:	3,974
Median Acreage:	4,034
First Quartile:	1,751
Minimum Acreage:	1,135
Maximum Acreage:	16,667



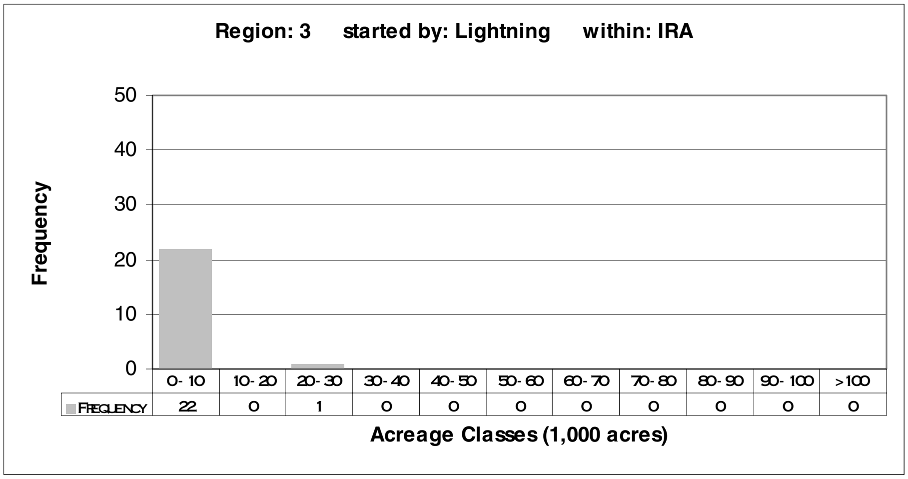
Number of Fires:	2
Avg Acreage:	1,572
Std Dev:	322
Median Acreage:	1,572
First Quartile:	1,458
Minimum Acreage:	1,344
Maximum Acreage:	1,800



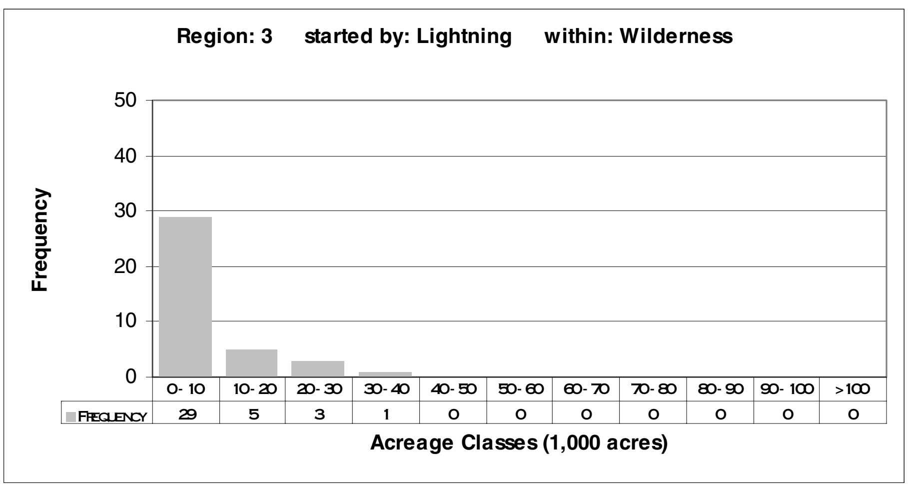
Number of Fires:	0
Avg Acreage:	0
Std Dev:	0
Median Acreage:	0
First Quartile:	0
Minimum Acreage:	0
Maximum Acreage:	0



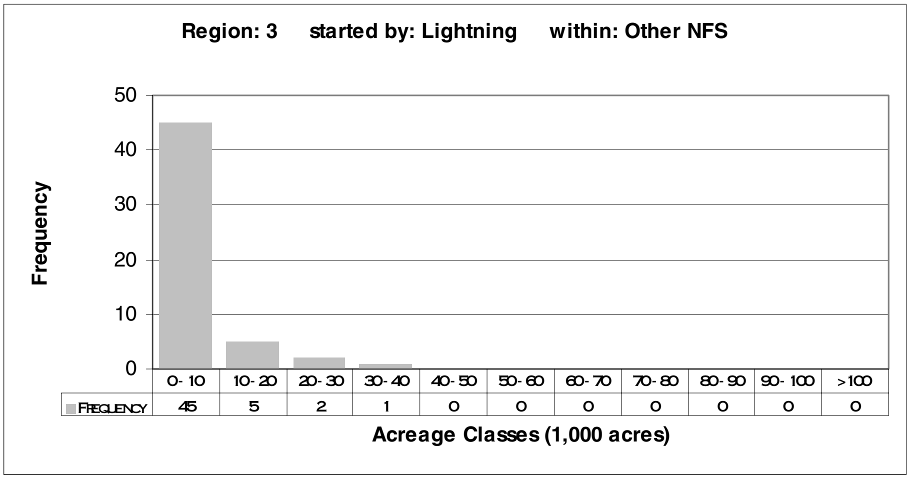
Number of Fires:	10
Avg Acreage:	4,176
Std Dev:	4,748
Median Acreage:	2,152
First Quartile:	1,485
Minimum Acreage:	1,066
Maximum Acreage:	14,193



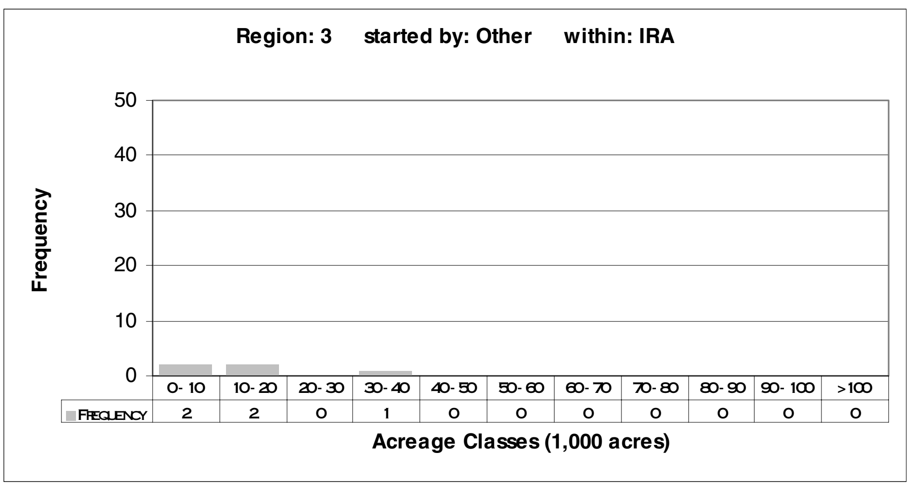
Number of Fires:	23
Avg Acreage:	4,165
Std Dev:	4,298
Median Acreage:	2,910
First Quartile:	2,321
Minimum Acreage:	1,275
Maximum Acreage:	22,200



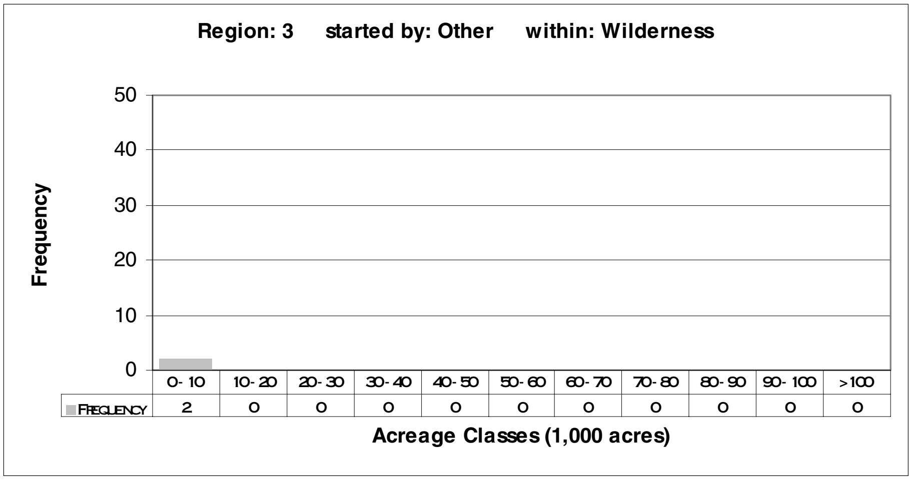
Number of Fires:	38
Avg Acreage:	7,425
Std Dev:	8,390
Median Acreage:	4,200
First Quartile:	1,868
Minimum Acreage:	1,062
Maximum Acreage:	32,000



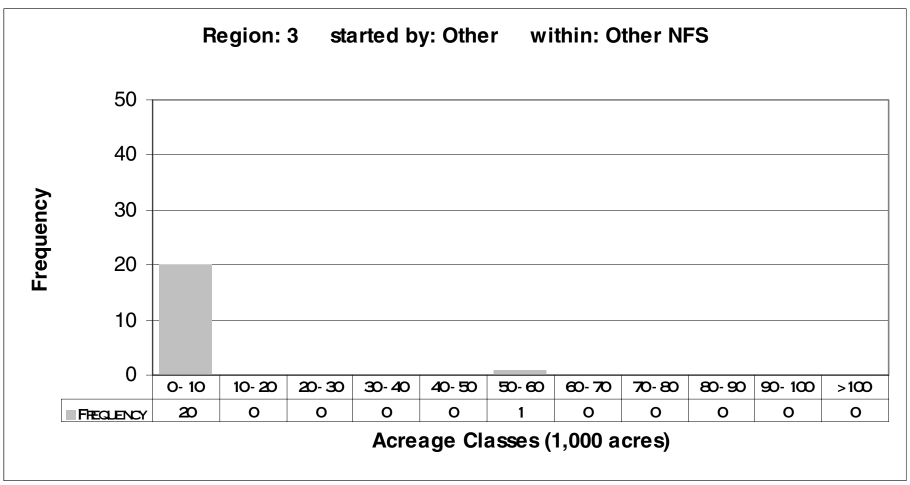
Number of Fires:	53
Avg Acreage:	5,717
Std Dev:	7,581
Median Acreage:	2,315
First Quartile:	1,484
Minimum Acreage:	1,000
Maximum Acreage:	35,907



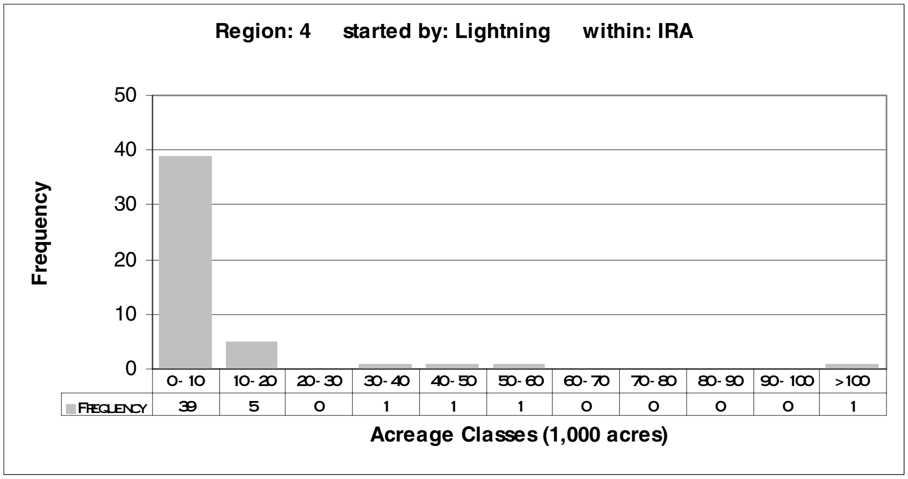
Number of Fires:	5
Avg Acreage:	14,841
Std Dev:	11,273
Median Acreage:	13,000
First Quartile:	6,716
Minimum Acreage:	4,779
Maximum Acreage:	33,135



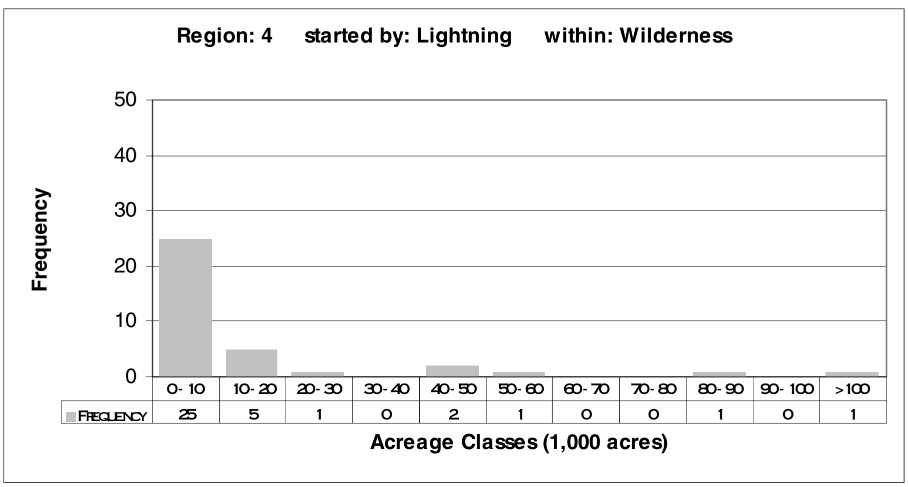
Number of Fires:	2
Avg Acreage:	1,237
Std Dev:	52
Median Acreage:	1,237
First Quartile:	1,219
Minimum Acreage:	1,200
Maximum Acreage:	1,274



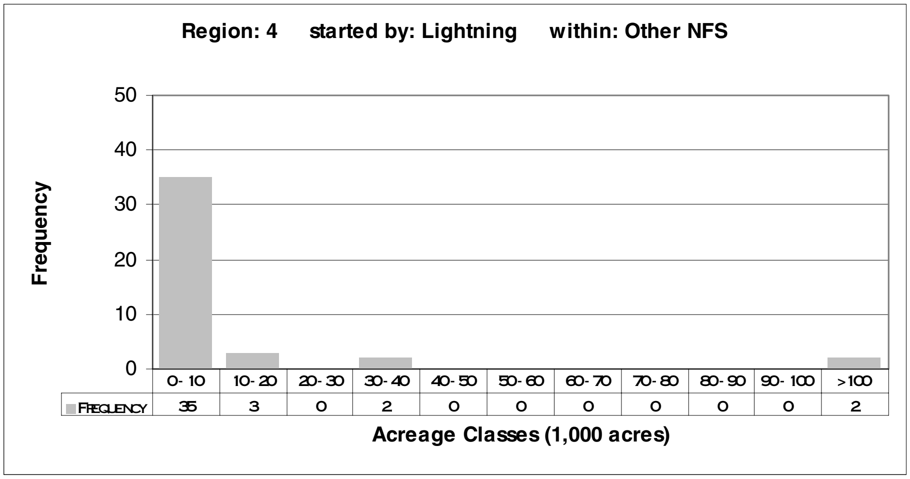
Number of Fires:	21
Avg Acreage:	6,142
Std Dev:	12,384
Median Acreage:	2,950
First Quartile:	1,400
Minimum Acreage:	1,000
Maximum Acreage:	58,960



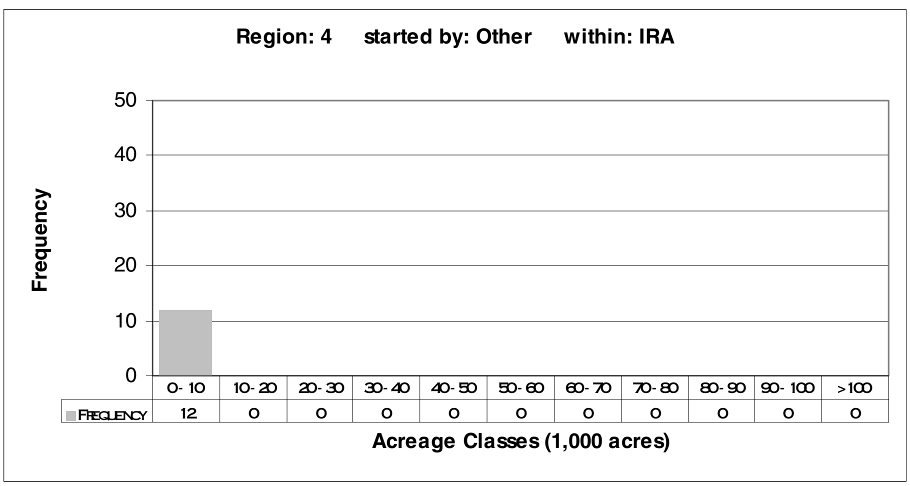
Number of Fires:	48
Avg Acreage:	10,690
Std Dev:	27,116
Median Acreage:	3,087
First Quartile:	1,488
Minimum Acreage:	1,000
Maximum Acreage:	177,544



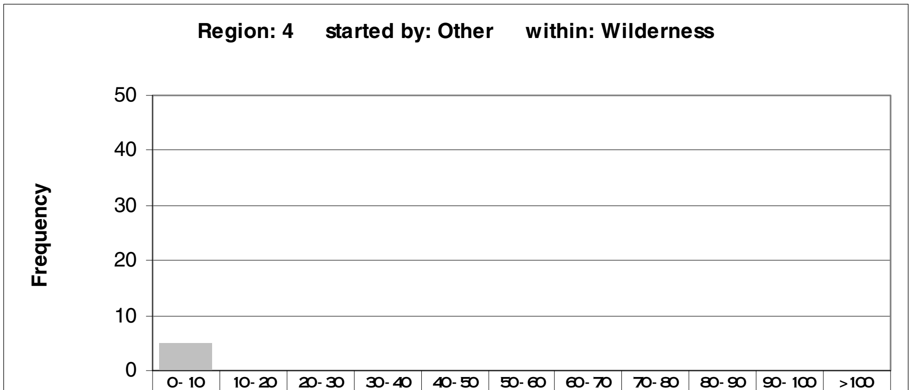
Number of Fires:	36
Avg Acreage:	15,887
Std Dev:	31,091
Median Acreage:	3,530
First Quartile:	1,975
Minimum Acreage:	1,043
Maximum Acreage:	164,560



Number of Fires:	42
Avg Acreage:	12,153
Std Dev:	28,182
Median Acreage:	4,068
First Quartile:	2,000
Minimum Acreage:	1,080
Maximum Acreage:	146,400

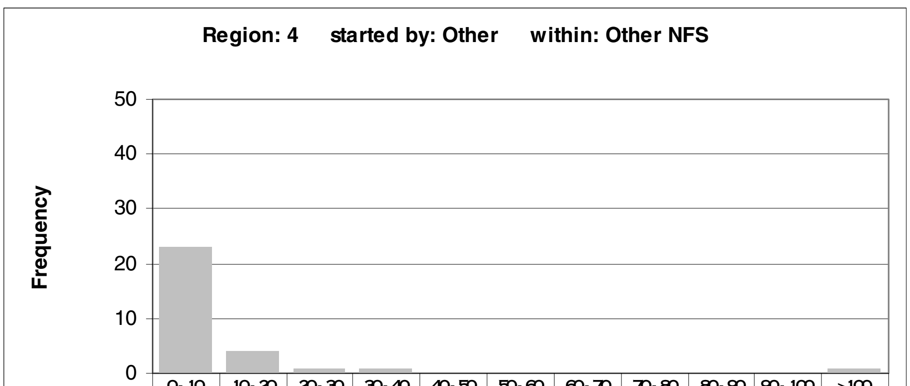


Number of Fires:	12
Avg Acreage:	2,925
Std Dev:	2,155
Median Acreage:	2,147
First Quartile:	1,493
Minimum Acreage:	1,000
Maximum Acreage:	8,487



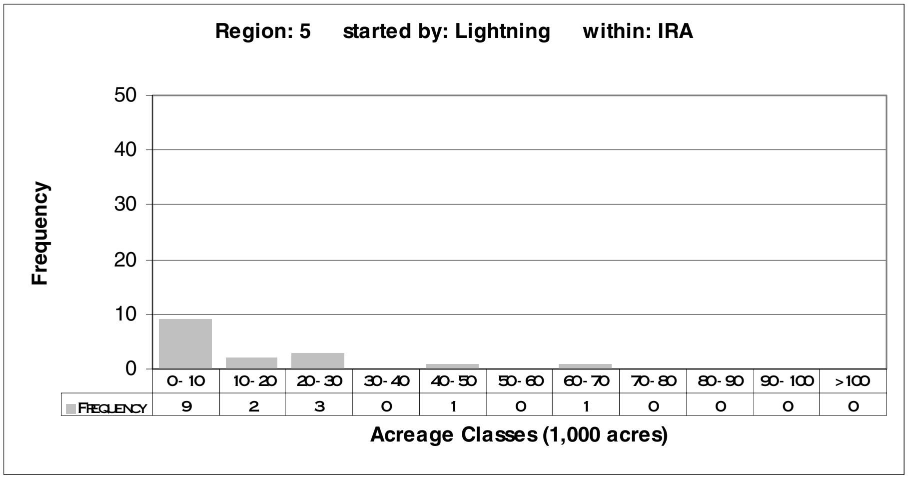
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
FREQUENCY	5	0	0	0	0	0	0	0	0	0	0

Number of Fires:	5
Avg Acreage:	4,563
Std Dev:	2,764
Median Acreage:	4,160
First Quartile:	2,365
Minimum Acreage:	1,600
Maximum Acreage:	8,150



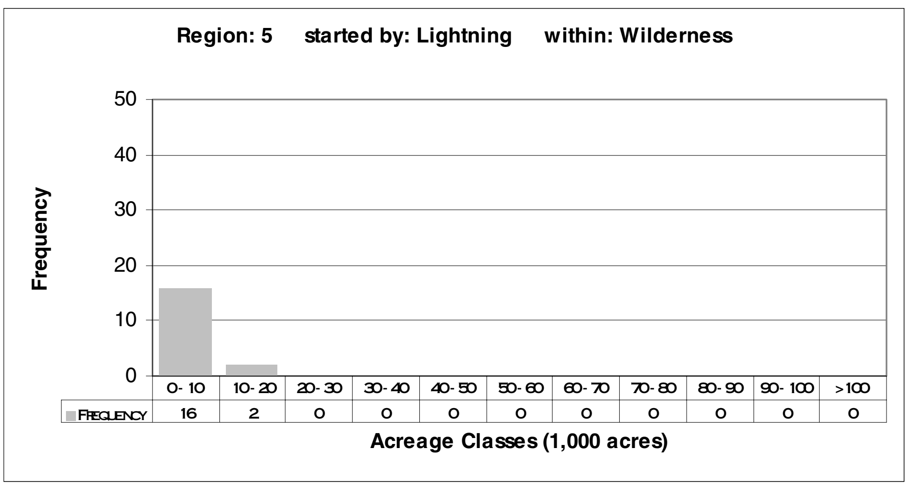
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
FREQUENCY	23	4	1	1	0	0	0	0	0	0	1

Number of Fires:	30
Avg Acreage:	19,892
Std Dev:	72,150
Median Acreage:	5,169
First Quartile:	2,024
Minimum Acreage:	1,001
Maximum Acreage:	400,100



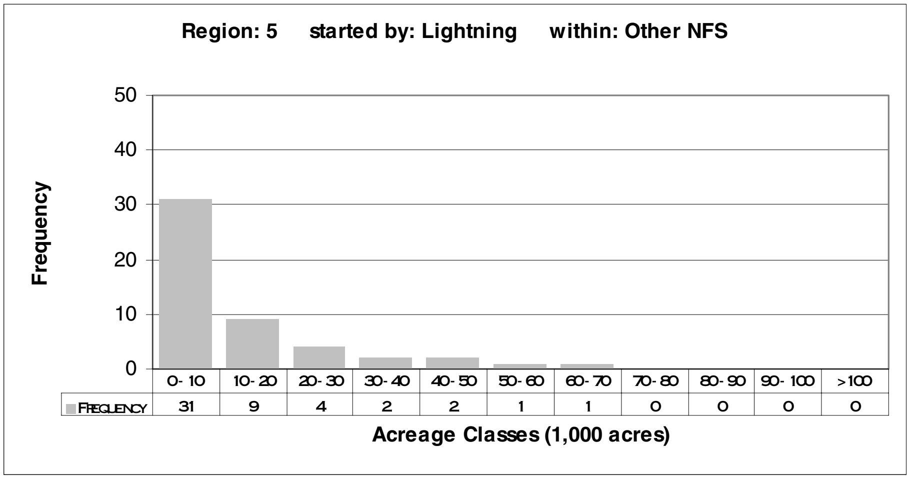
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
Frequency	9	2	3	0	1	0	1	0	0	0	0

Number of Fires:	16
Avg Acreage:	14,500
Std Dev:	18,024
Median Acreage:	4,840
First Quartile:	1,743
Minimum Acreage:	1,000
Maximum Acreage:	60,600

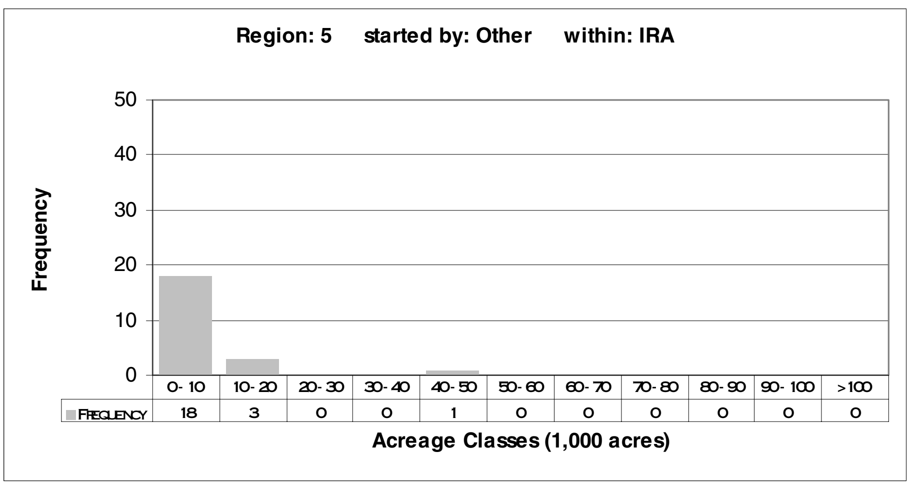


	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
Frequency	16	2	0	0	0	0	0	0	0	0	0

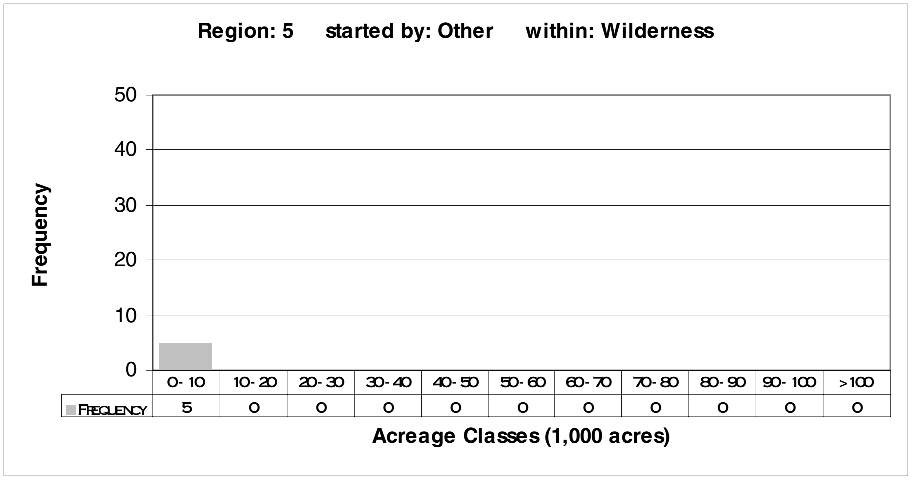
Number of Fires:	18
Avg Acreage:	5,732
Std Dev:	4,779
Median Acreage:	3,598
First Quartile:	2,066
Minimum Acreage:	1,100
Maximum Acreage:	19,100



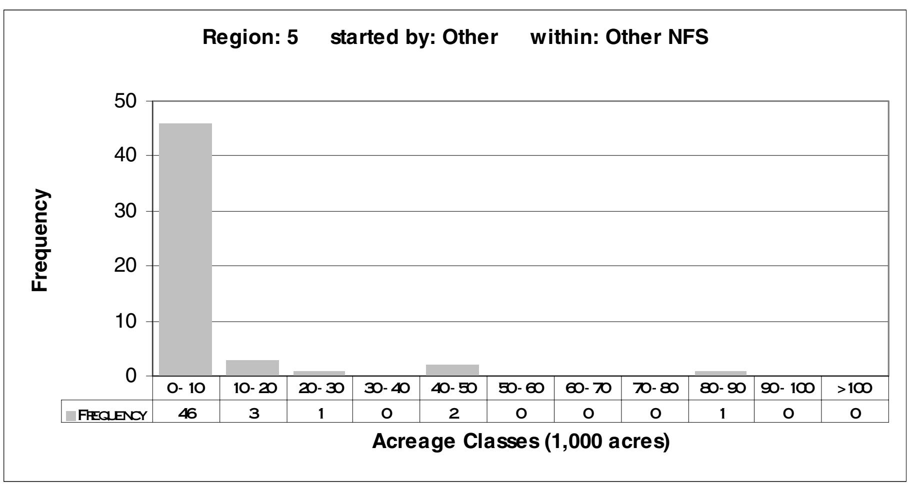
Number of Fires:	50
Avg Acreage:	12,420
Std Dev:	14,875
Median Acreage:	6,830
First Quartile:	1,921
Minimum Acreage:	1,035
Maximum Acreage:	60,165



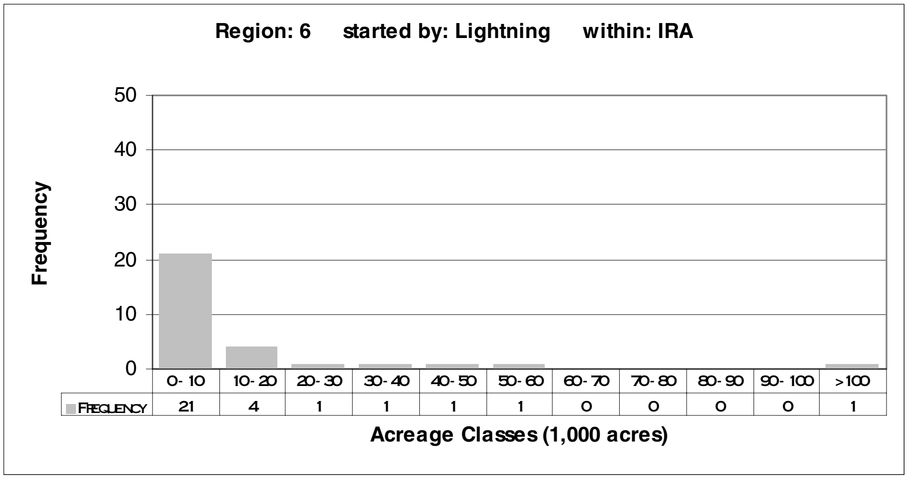
Number of Fires:	22
Avg Acreage:	5,686
Std Dev:	9,145
Median Acreage:	2,298
First Quartile:	1,530
Minimum Acreage:	1,039
Maximum Acreage:	43,201



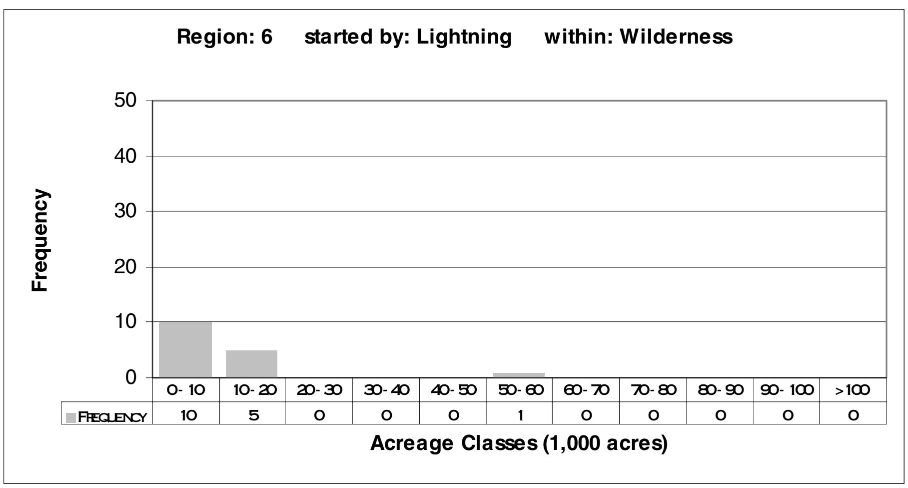
Number of Fires:	5
Avg Acreage:	3,421
Std Dev:	2,072
Median Acreage:	2,559
First Quartile:	2,285
Minimum Acreage:	1,240
Maximum Acreage:	6,420



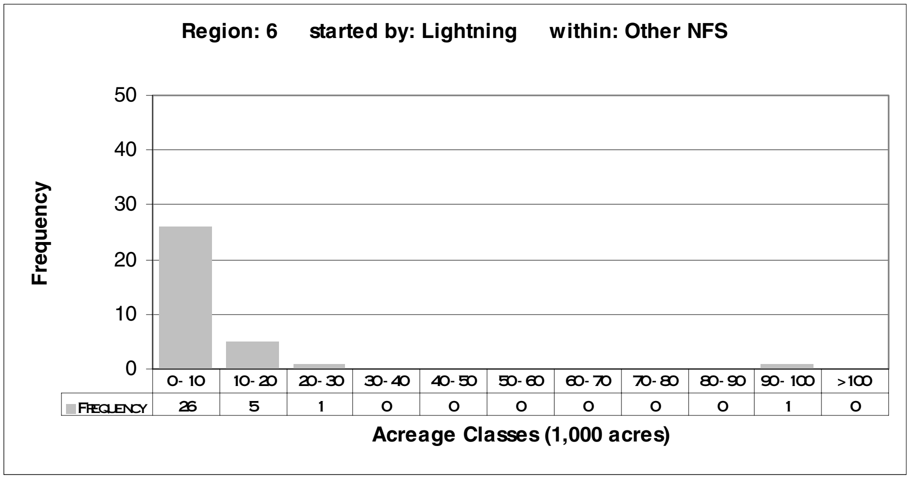
Number of Fires:	53
Avg Acreage:	6,997
Std Dev:	14,185
Median Acreage:	2,516
First Quartile:	1,443
Minimum Acreage:	1,000
Maximum Acreage:	83,323



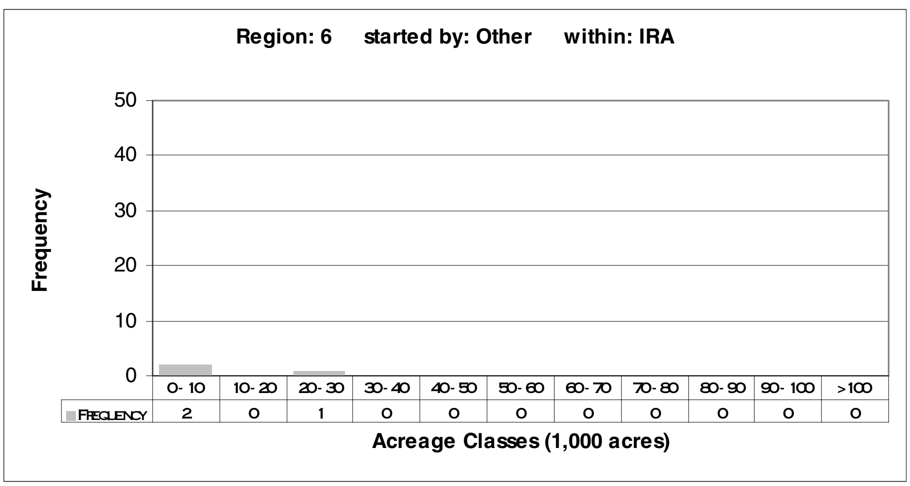
Number of Fires:	30
Avg Acreage:	13,693
Std Dev:	26,930
Median Acreage:	4,115
First Quartile:	2,100
Minimum Acreage:	1,000
Maximum Acreage:	140,000



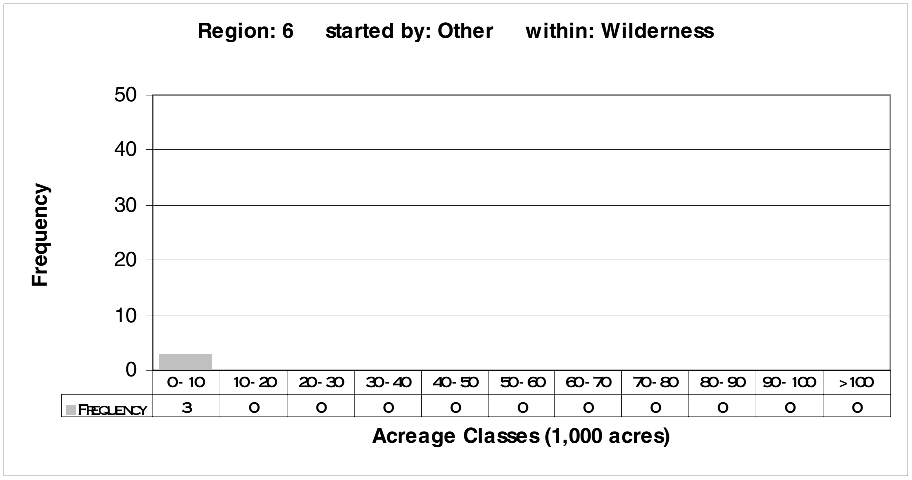
Number of Fires:	16
Avg Acreage:	8,922
Std Dev:	12,459
Median Acreage:	4,725
First Quartile:	2,451
Minimum Acreage:	1,231
Maximum Acreage:	52,600



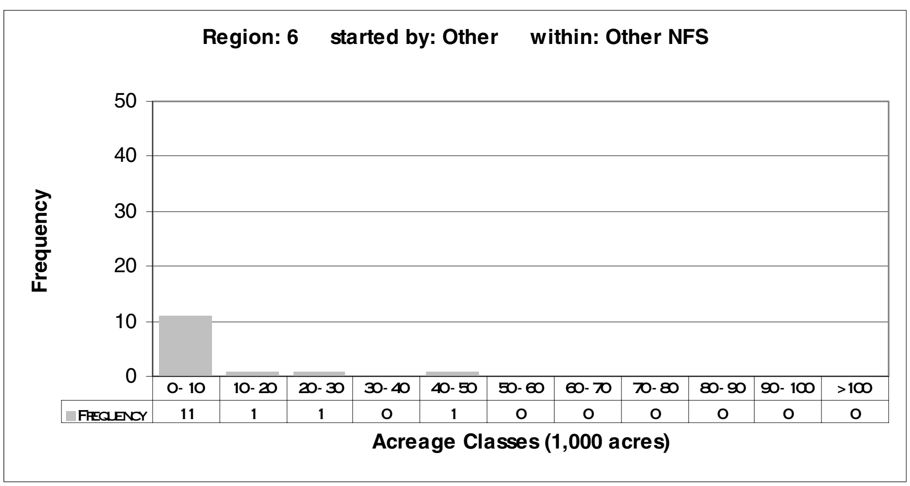
Number of Fires:	33
Avg Acreage:	8,649
Std Dev:	16,787
Median Acreage:	3,690
First Quartile:	1,630
Minimum Acreage:	1,008
Maximum Acreage:	96,310



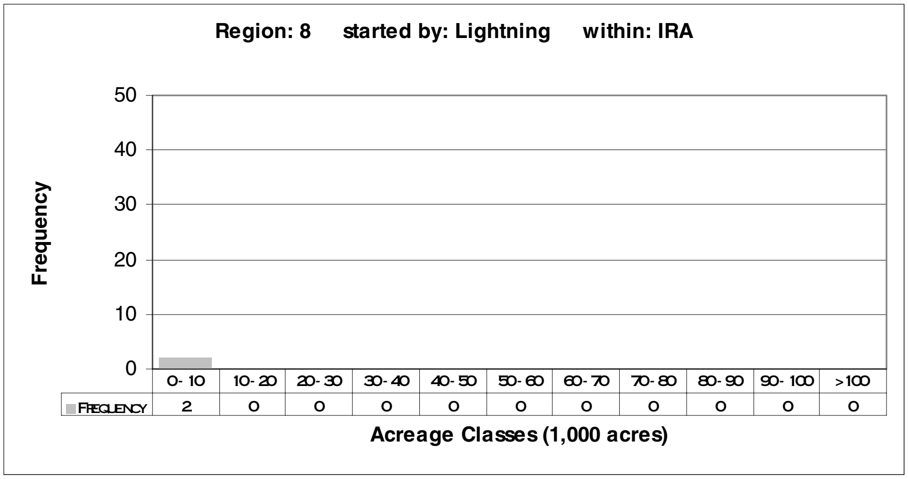
Number of Fires:	3
Avg Acreage:	13,692
Std Dev:	14,047
Median Acreage:	9,200
First Quartile:	5,820
Minimum Acreage:	2,440
Maximum Acreage:	29,435



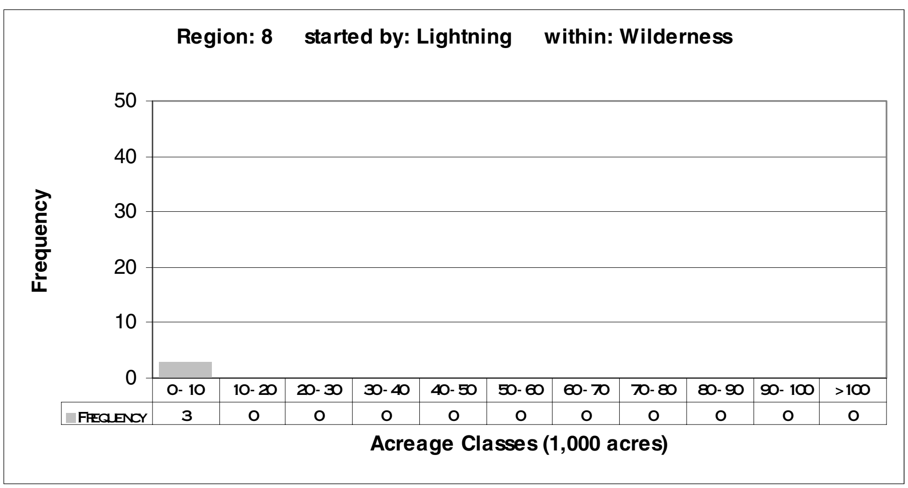
Number of Fires:	3
Avg Acreage:	2,516
Std Dev:	1,012
Median Acreage:	2,201
First Quartile:	1,950
Minimum Acreage:	1,699
Maximum Acreage:	3,648



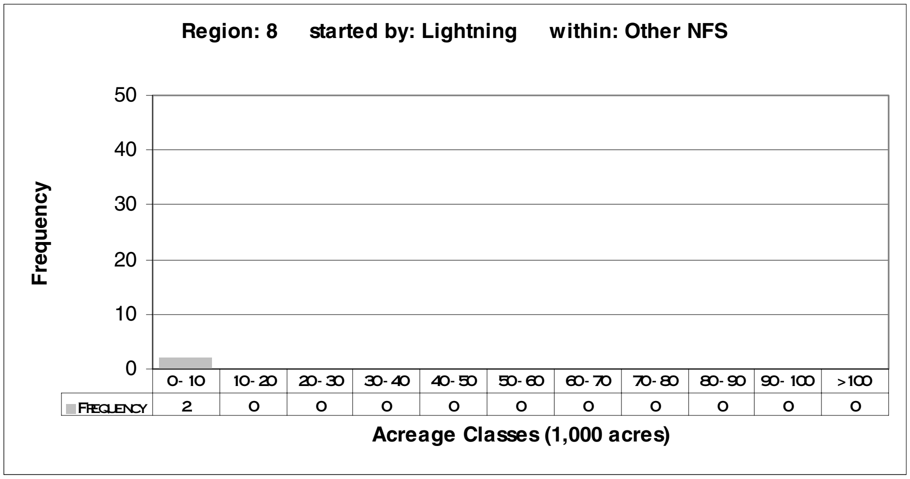
Number of Fires:	14
Avg Acreage:	7,947
Std Dev:	13,434
Median Acreage:	2,119
First Quartile:	1,437
Minimum Acreage:	1,039
Maximum Acreage:	49,603



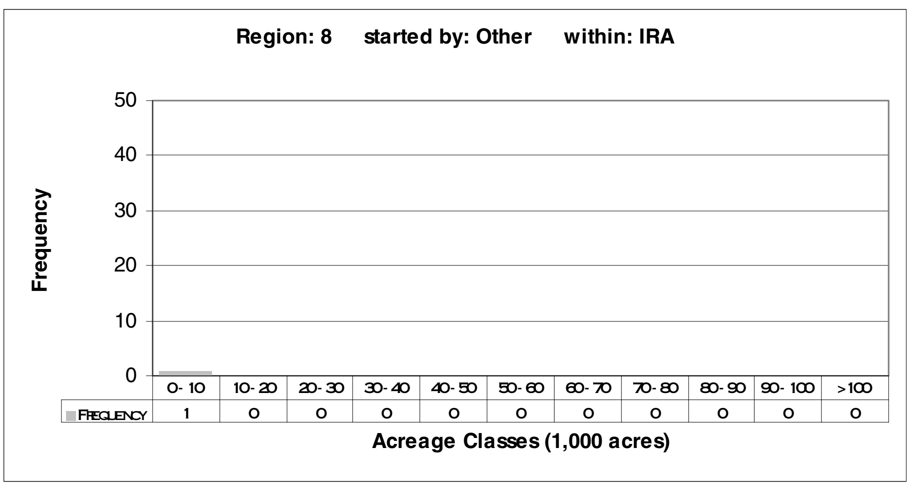
Number of Fires:	2
Avg Acreage:	1,115
Std Dev:	92
Median Acreage:	1,115
First Quartile:	1,083
Minimum Acreage:	1,050
Maximum Acreage:	1,180



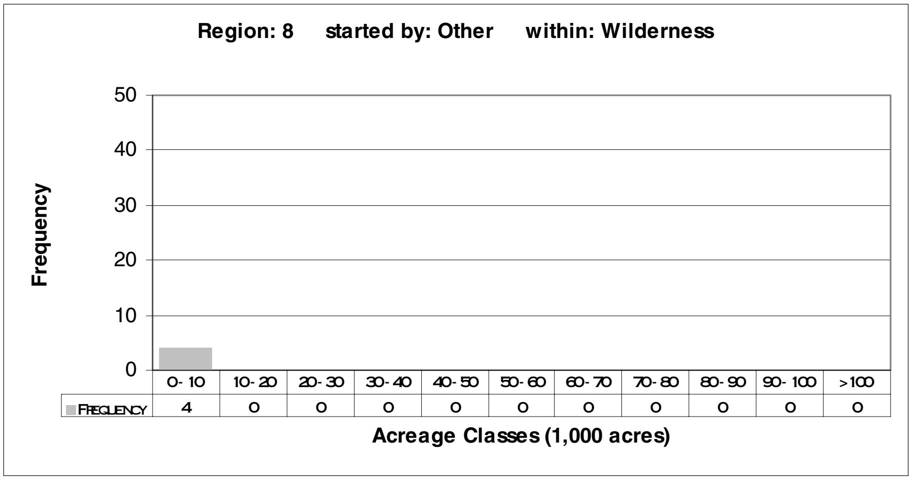
Number of Fires:	3
Avg Acreage:	3,565
Std Dev:	3,433
Median Acreage:	2,015
First Quartile:	1,598
Minimum Acreage:	1,180
Maximum Acreage:	7,500



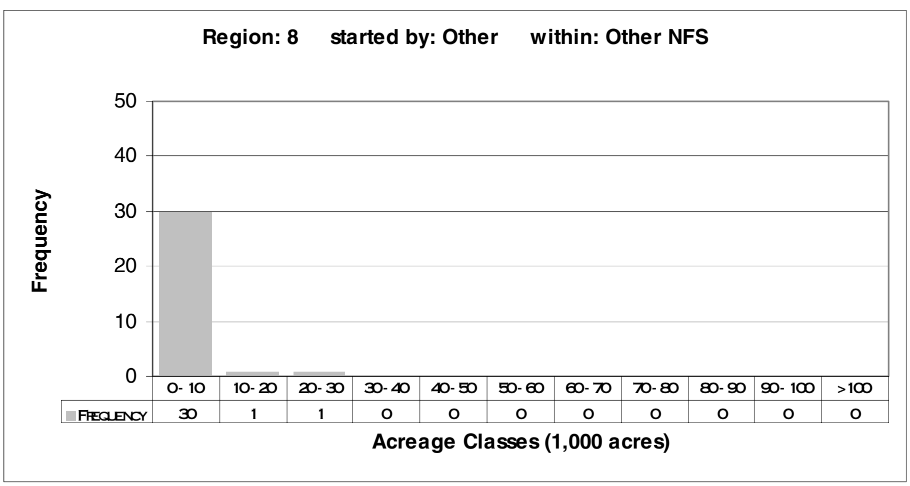
Number of Fires:	2
Avg Acreage:	1,225
Std Dev:	106
Median Acreage:	1,225
First Quartile:	1,188
Minimum Acreage:	1,150
Maximum Acreage:	1,300



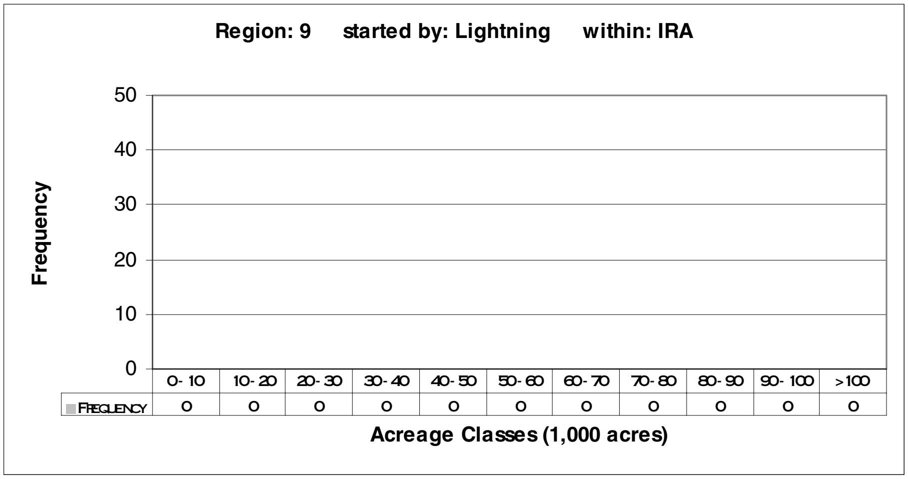
Number of Fires:	1
Avg Acreage:	3,400
Std Dev:	
Median Acreage:	3,400
First Quartile:	3,400
Minimum Acreage:	3,400
Maximum Acreage:	3,400



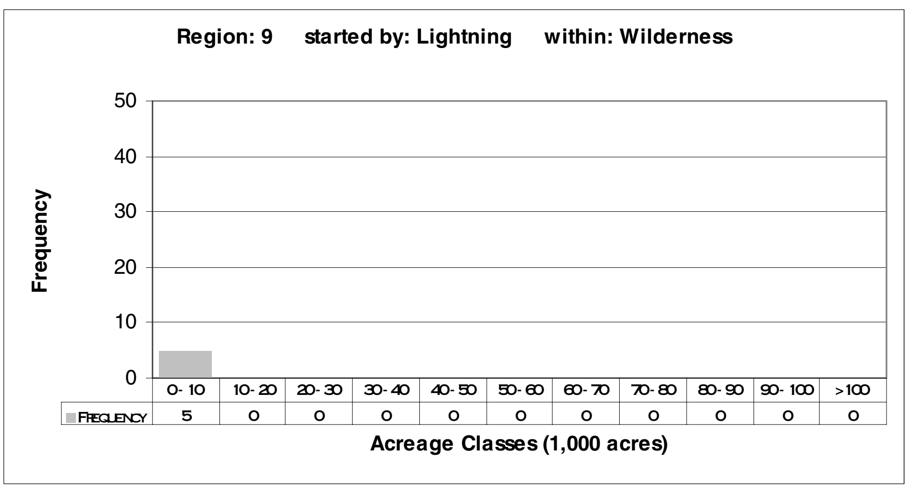
Number of Fires:	4
Avg Acreage:	2,144
Std Dev:	711
Median Acreage:	1,964
First Quartile:	1,763
Minimum Acreage:	1,500
Maximum Acreage:	3,149



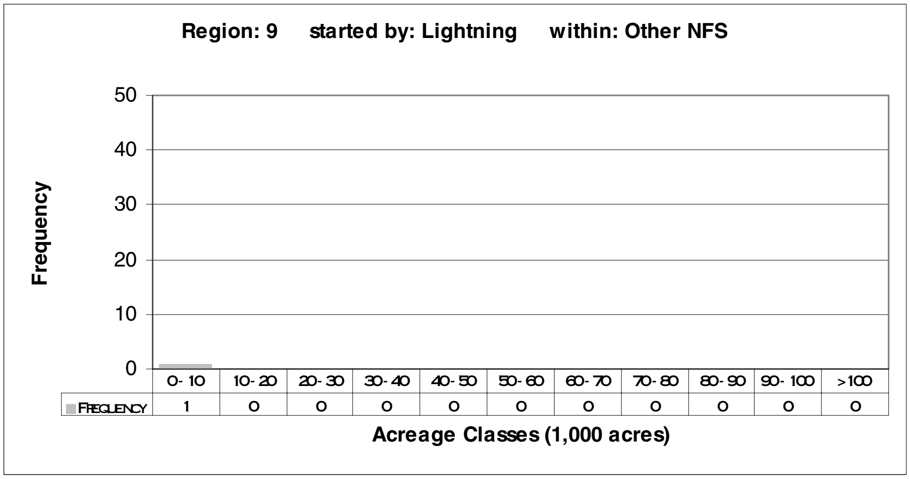
Number of Fires:	32
Avg Acreage:	3,268
Std Dev:	4,797
Median Acreage:	1,649
First Quartile:	1,338
Minimum Acreage:	1,076
Maximum Acreage:	24,600



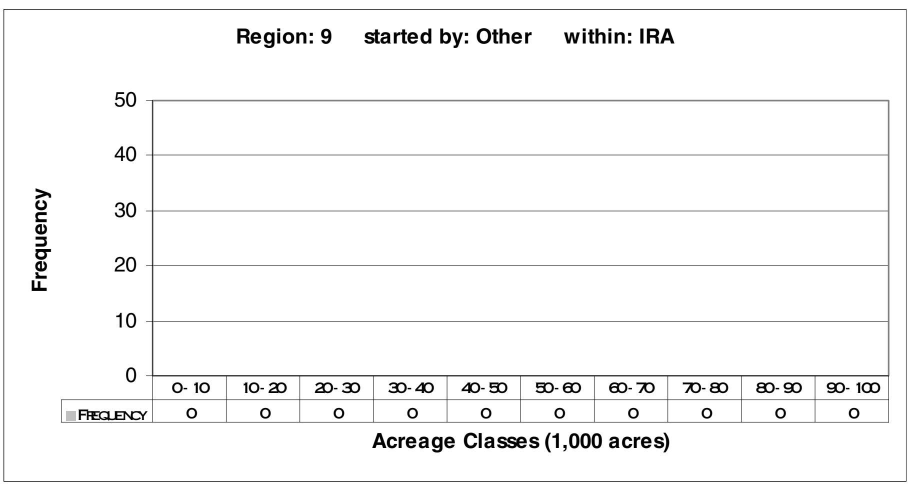
Number of Fires:	0
Avg Acreage:	0
Std Dev:	
Median Acreage:	0
First Quartile:	0
Minimum Acreage:	0
Maximum Acreage:	0



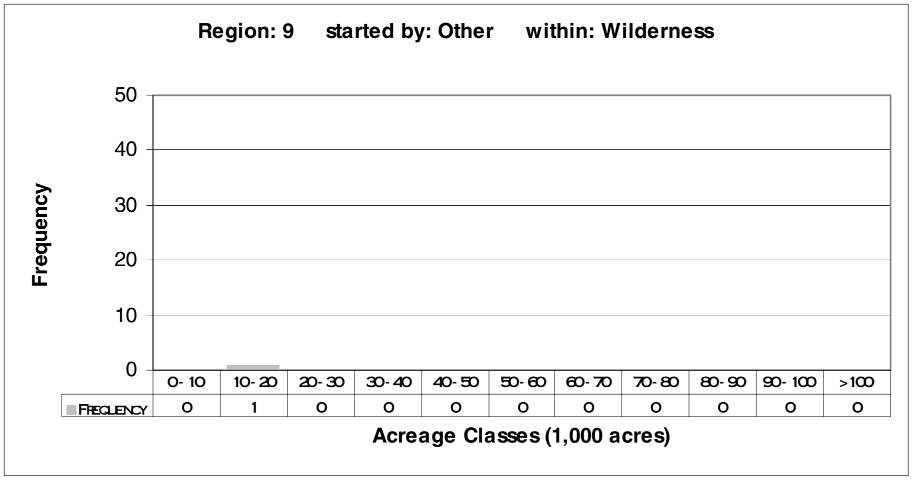
Number of Fires:	5
Avg Acreage:	2,841
Std Dev:	1,671
Median Acreage:	3,048
First Quartile:	1,269
Minimum Acreage:	1,010
Maximum Acreage:	4,750



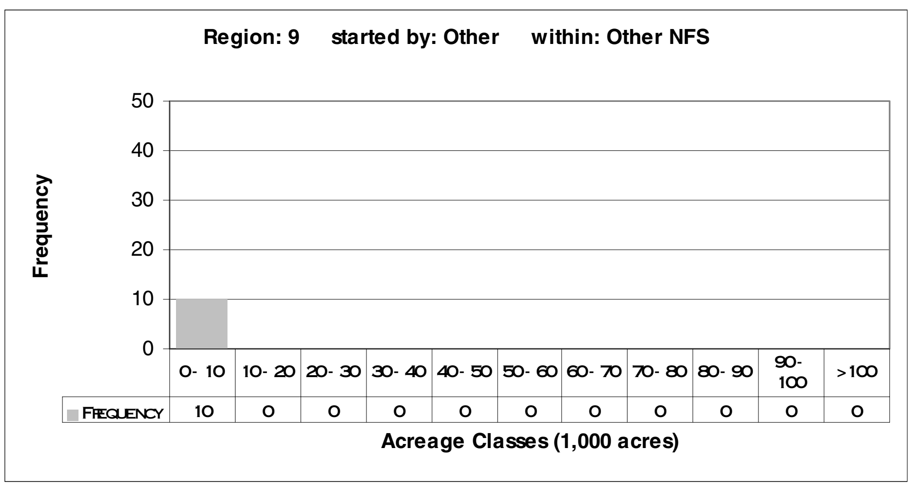
Number of Fires:	1
Avg Acreage:	1,210
Std Dev:	
Median Acreage:	1,210
First Quartile:	1,210
Minimum Acreage:	1,210
Maximum Acreage:	1,210



Number of Fires:	0
Avg Acreage:	0
Std Dev:	
Median Acreage:	0
First Quartile:	0
Minimum Acreage:	0
Maximum Acreage:	0



Number of Fires:	1
Avg Acreage:	12,600
Std Dev:	
Median Acreage:	12,600
First Quartile:	12,600
Minimum Acreage:	12,600
Maximum Acreage:	12,600



Number of Fires:	10
Avg Acreage:	1,589
Std Dev:	909
Median Acreage:	1,234
First Quartile:	1,168
Minimum Acreage:	1,069
Maximum Acreage:	4,010

Appendix H: Ambient Population Classes by State

Appendix H: Ambient population classes within 1-mile and 5-mile buffers of 1B, 1B-1, and 1C IRA categories stratified by state. Population data were not available for Alaska or Puerto Rico. All figures represent units equal to 1,000 acres.

STATE	1-Mile Buffer on 1B,1B-1,1C IRA						5-Mile Buffer on 1B,1B-1,1C IRA					
	Wildland	Rural	Rural/ Urban	Suburban	Urban	SUM	Wildland	Rural	Rural/ Urban	Suburban	Urban	SUM
AK	No Ambient Population data for Alaska						No Ambient Population data for Alaska					
AL	13	21	1			**36**	75	134	37	5		**251**
AR	124	46	1	11		**181**	673	302	33			**1,008**
AZ	1,368	47	9	4		**1,428**	4,944	245	144	31	5	**5,370**
CA	4,699	441	117		2	**5,258**	12,767	1,674	644	172	92	**15,350**
CO	4,470	303	102			**4,875**	9,687	833	346	56	5	**10,927**
FL	39	44	2	1		**85**	262	225	34			**522**
GA	64	73	9			**146**	191	324	98	14		**628**
ID	4,486	72	13			**4,572**	9,805	430	170	11	3	**10,418**
IL	21	14				**35**	133	159	14			**305**
IN	2	11	2			**14**	27	75	16	1		**119**
KY		8	3			**12**	14	86	38	5		**142**
LA	19	10				**30**	99	81	8			**189**
ME	28	1				**29**	68	24	3			**95**
MI	30	9				**38**	244	72	12			**328**
MN	131					**131**	758	4				**761**
MO	20	27	3			**51**	172	223	19	1		**414**
MS	1	8				**9**	22	50				**71**
MT	4,473	73	13			**4,559**	11,581	387	187	23	6	**12,182**
NC	154	115	33			**303**	417	519	348	28		**1,312**
ND	310					**310**	1,123	4				**1,127**
NE	12			3		**15**	83					**83**
NH	237	41	9	3		**290**	377	201	70			**648**
NM	1,746	90	19			**1,856**	5,731	326	145	31	8	**6,242**
NV	2,300	31	12			**2,344**	6,068	183	71	28	11	**6,360**
NY						**1**	9	18	3			**29**
OK	23	3				**26**	87	25				**112**
OR	2,670	170	30			**2,870**	8,665	625	139	16	4	**9,450**
PA	24	25	1			**50**	146	106	35	3	1	**290**
PR	No Ambient Population data for Puerto Rico						No Ambient Population data for Puerto Rico					
SC	11	14				**25**	59	92	15			**166**
SD	95	1				**96**	549	13	7	3		**571**
TN	49	62	28	17		**156**	147	294	234	16		**691**
TX	4	20	3	1		**27**	53	168	51	9		**281**
UT	2,762	179	57		7	**3,005**	6,310	569	325	127	76	**7,407**
VA	365	210	45		1	**621**	943	946	455	45	3	**2,392**
VT	36	38	1			**75**	210	163	32	1		**406**
WA	2,364	104	13			**2,482**	5,649	513	123	2		**6,287**
WI	85	4	2	1		**92**	586	40	3			**629**
WV	230	82	5			**318**	747	466	84	3	1	**1,301**
WY	2,374	14	11			**2,399**	6,013	87	70	5	1	**6,175**
SUM	35,841	2,412	544	44	10	**38,851**	95,492	10,685	4,013	634	217	**111,041**

Appendix I: Cumulative Effects Background Analysis

Introduction

This section of the specialist's report deals with the cumulative effects—the combination of individually minor effects of multiple actions over time. The goal of cumulative effects analysis "is to inject environmental considerations into the planning process as early as needed to improve decisions." (CEQ, 1997).

The methodology used to frame, analyze and discuss the cumulative environmental consequences of fuel management as it relates to the Roadless Conservation Rule (36 CFR 294) was taken from the Council on Environmental Quality handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (1997). This analysis follows the eight "principles of cumulative effects analysis" described in that guidebook.

Since the total land area covered by the Roadless Conservation Rule EIS encompasses over 30% of the National Forest System, and affects nearly every section of the United States, the cumulative effects analysis, like the effects portrayed for each alternative, will be described on a national basis as coarse-scale trends. Assumptions and a description of uncertainties will be described for each cumulative effect trend.

Methodology

Five primary analysis methods were used to tabulate and analyze the cumulative effects: (1) expert panels; (2) trend analysis; (3) overlay mapping and GIS; (4) checklists and (5) uncertainty analysis (Appendix J).

Expert panels

Early in the cumulative impacts assessment scoping process, a panel of fire management experts was convened to review national policies, assessments, and environmental impact statements affecting fire and fuel management, not only for Forest Service administered lands, but other federal agencies and States, as well. From this preliminary work, it was determined that the major environmental documents and national assessments used in this analysis were: the Forest Service's *Cohesive Strategy* (Laverty and Williams, 2000); the Federal Wildand Fire Policy (1995); the *Interior Basin Supplemental Draft Environmental Statement* (USDA 2000); and the Forest Service's proposed Transportation Policy rule (CFR 212). Other documents reviewed were: Sierra Nevada Framework; Herger-Feinstein (Quincy Library Group); National Grasslands assessment; Salmon-River Focus Fuels EIS; Northwest Plan.

Trend analysis

Three trend analyses, using time increments of 5, 20 and 40 years, and comparing the four alternatives described in the EIS against each other, were designed and displayed as tables or graphs.

Table 1 displays possible fuel treatment scenarios over the next 40 years by treatment method, alternative, annual acres treated, and annual cost of performing the treatment. It is assumed that of all the inventoried roadless areas actually needing treatment, that even under the best of circumstances, only a portion of that work could be accomplished. For purposes of this trend analysis, the total work needed by treatment method was reduced by 35%. A reduction factor was used since fire management professionals believe that even when fully budgeted and with fully trained personnel, it would be impossible to treat every acre of land requiring fuel treatment for forest health and restoration.

Definitions, production rates and uncertainties associated with each the treatment method described in Table 1.

Prescribed fire: As used in Table 1, a prescribed fire is a human ignited fire in a forest or rangeland where no mechanical pre-treatment is needed. It is estimated that in inventoried roadless areas, there are 7.5 million acres of such land. In comparison to prescribed fires that might be ignited in the wildland urban interface, or in other high value resource areas, prescribed fire costs in inventoried roadless areas are expected to be quite low. An estimate of $20 per acre was used for this analysis.

Thinning + mechanical removal of fuels: This heading describes a process whereby the forest is thinned for commercial purposes, and the slash created by the thinning is either yarded out of the forest or chipped and hauled-away. No prescribed burning is completed. Obviously, a road is needed to complete thinning + mechanical removal. Cost estimate used was $300 per acre.

Timber harvest: Using either the stewardship or traditional timber harvest to log and area, reducing the fuels in the process. There is no cost estimate given for this fuel treatment method, since the value of the timber removed for commodity purposes is assumed to off-set the cost of fuel management.

Thinning + prescribed fire: This is the cutting down of small diameter trees (1-3 inches), but not removing them from the forest, then lightning a prescribed fire in the fuels created by the thinning. The purpose of the thinning is to reduce the chances of the prescribed fire burning the smaller trees, creating enough heat and flame to climb into the canopy of the forest and becoming a crown fire. Cost estimates for this fuel management activity are $200 per acre for thinning and $20 per acre for prescribed burning.

Wildland Fire for Resource Benefit (WFURB): A lightning caused wildland fire that is allowed to burn because it meets the resource objectives outlined in the land management plan and a site specific set of objectives in a fire management plan.

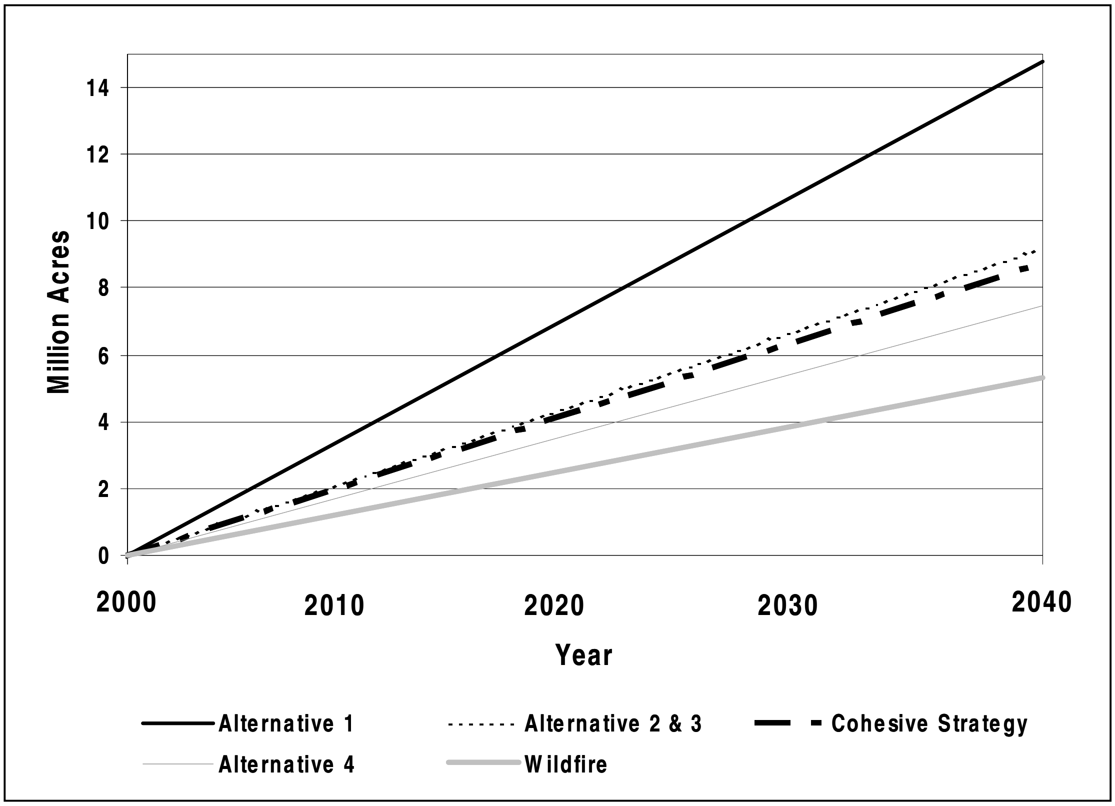
WFURB's are commonly used as a fire management strategy in Wildernesses. Cost estimates for these wildland fires are estimated at $40 per acre.

Table 1: Trendline for fuel treatment accomplishment in the next 40 years.

Fuel Treatment Method	Alt. 1- after 40 years (millions of acres)	Annual Acres Treated (1000 acres)	Annual Cost (million dollars)	Alt. 2- after 40 years (millions of acres)	Annual Cost (million dollars)	Alt. 3- after 40 years (millions of acres)	Annual Cost (million dollars)	Alt.4- after 40 years (millions of acres)	Annual Cost (million dollars)
Prescribed Fire	7.5	187.5	$3.75	7.50	$3.75	7.50	$3.75	7.5	$3.75
Thinning + mechanical	2.0	0.500	$15.0	0.32	$.240	.320	$.240	0.0	0.0
Timber harvest	0.5	12.50	-	0.10	-	0.03	-	0.0	0.0
Thinning + prescribed fire	5.0	125.0	$27.5	1.00	$5.50	1.00	$5.50	0.0	0.0
Wildland Fire for Resource Benefit	6.0	150.0	$6.0	6.00	$6.00	6.00	$6.0	6.0	$6.0
Total	21	545	$74.75	14.92	$15.49	14.85	<$15.49	13.5	$9.75
65% of Total	14	354	$48.60	9.70	$10.06	9.650	<$10.06	8.8	$6.30

Information from Table 1 was used to construct a trend line graph. Figure 1 compares the total amount of fuel management work by alternative that could possibly occur (in time increments of 5, 20 and 40 years) against the amount of acreage that is predicted to burn each year by wildland fires. The purpose of this graph is to visually display whether fuel treatment, by alternative, is expected to be higher or lower than the acres burned by wildfires. If fuel treatment acreages are higher than wildfire acreages, then a reduction in the amount of acreage burned by wildfires can be expected.

Figure 1: Trend line graph for EIS alternatives 1 through 4 matched against time, the Cohesive Strategy implementation schedule and the amount of acres burned by wildfire.



The second trend line summary is a graph (Figure 1) that compared the four alternatives to the implementation schedule outlined in the Forest Service's *Cohesive Strategy*. It assumes that all of the forest and rangeland fuels classified as Condition Class 1, 2, and 3, Fire Regimes 1 and 2, like the ponderosa pine forests of the interior West, will need treatment. It also assumes that inventoried roadless areas would be on equal priority with all other NFS lands, and that the fuel treatment work would begin immediately. In actuality, this is not expected to be the case.

Overlay mapping and GIS

The map data derived from using the strategic guidelines in the *Cohesive Strategy*---the forests and rangelands having the highest priority for fuel treatment would be those typed as Condition Class 1, 2 & 3, Fire Regimes 1 &2---was overlaid with two maps from the Interior Columbia River Basin Ecosystem Management Project (ICBEMP)

The first map (page 94, Chapter 3 of *ICEMP Supplemental Draft EIS*), titled "Broad-scale Landscape Restoration Priorities," depicted areas that had single resource restoration priorities and also a good opportunity for restoration to be achieved. The restoration of landscape succession/disturbance regimes through the use of prescribed fire is a primary o objective in establishing these restoration priorities. Table 2 shows the restoration priority ratings from the ICBEMP matched against inventoried roadless areas.

This table provides total acreage within each priority rating. For example, for a moderate restoration priority rating, 1,893,000 acres of inventoried roadless area fall within the geographic boundaries of ICBEMP.

Table 3 answers the question of how many acres of ICBEMP within inventoried roadless areas can be typed as Condition Class 1, 2 and 3, and Fire Regimes 1 and 2. Comparing Tables 2 and 3, it can be seen that 2.909 (nearly 19%) million acres of a total of 15.622 million acres of inventoried roadless area with ICBEMP boundaries fall into that category.

Table 2: Acreages within ICBEMP broad-scale landscape restoration priorities stratified by inventoried roadless area categories. All acreage figures are rounded to the nearest 1,000.

Restoration Priority	IRA Category			Sum
	1B	1B-1	1C	
Low	3,357	180	588	**4,125**
Moderate	1,455	249	189	**1,893**
High	7,266	1,247	1,091	**9,603**
Sum	**12,078**	**1,676**	**1,868**	**15,622**

Table 3: Acreages within ICBEMP broad-scale landscape restoration priorities, fire condition classes 1,2, & 3, and fire regimes 1 & 2 stratified by inventoried roadless area categories. All acreage figures are rounded to the nearest 1,000.

Restoration Priority	IRA (1B, 1B-1, 1C)			Sum
	CC 1	CC 2	CC 3	
	Regime 1&2	Regime 1&2	Regime 1&2	
Low	405	962	541	**1,907**
Moderate	68	151	68	**287**
High	15	352	348	**715**
Sum	**488**	**1,465**	**956**	**2,909**

Table 4: Acreages within ICBEMP broad-scale high restoration priority subbasins stratified by inventoried roadless area categories (in thousands of acres).

High Restoration Priority Subbasins	IRA Categories			Sum
	1B	1B-1	1C	
Biophysical, Economic, Tribal, Aquatic	3		67	**70**
Biophysical, Economic, Tribal	24		104	**128**
Biophysical, Economic, Aquatic	65		92	**157**
Biophysical, Tribal, Aquatic	56		10	**65**
Biophysical, Economic	78	40	126	**244**
Biophysical, Tribal	10		41	**51**
Biophysical, Aquatic	23		38	**61**
Economic, Tribal	139	45	245	**428**
Tribal, Aquatic	6		348	**353**
Biophysical	39	30	82	**151**
Economic	98	96	163	**357**
Tribal	12	16	91	**119**
Aquatic	1,224	705	2,260	**4,190**
Sum	**1,775**	**932**	**3,667**	**6,374**

Table 5: **Acreages within ICBEMP broad-scale high restoration priority subbasins, fire condition classes 1,2,& 3 and Fire Regimes 1 & 2 stratified by inventoried roadless area categories (in thousands of acres).**

High Restoration Priority Subbasins	IRA Categories (1B,1B-1,1C)			Sum
	CC 1	CC 2	CC 3	
	Regimes 1&2	Regimes 1&2	Regimes 1&2	
Biophysical, Economic, Tribal, Aquatic	1	13	38	**52**
Biophysical, Economic, Tribal				
Biophysical, Economic, Aquatic	2	47	88	**137**
Biophysical, Tribal, Aquatic		1	1	**3**
Biophysical, Economic	20	67	8	**95**
Biophysical, Tribal	1	26	6	**32**
Biophysical, Aquatic		10	31	**42**
Economic, Tribal	2	119	65	**186**
Tribal, Aquatic		5	2	**7**
Biophysical	1	11	15	**27**
Economic		28	53	**81**
Tribal		13	25	**38**
Aquatic	106	271	59	**436**
Sum	**133**	**611**	**392**	**1,136**

The second map (page 100, Chapter 3, *ICEMP Supplemental Draft EIS*), titled "High Restoration Priority Subbasins," identified high priority for restoration at the broad scale areas where concentrated restoration efforts (reestablishing fire, aquatic, water quality or vegetation management) could be most effective and efficient. This was the preferred alternative in ICBEMP. 6.374 million acres of inventoried roadless area fall within the "Broad-scale high restoration priority subbasins," and 1.136 million acres fall within Fire Regimes 1 and 2 and Condition Classes 1, 2 and 3. This equates to nearly 18% of ICEMP within these classification categories.

Checklists

Table 6: Checklist of types of cumulative effects (*continued on page 117.*)

Type	Main characteristics	Fuel management & fire suppression effects
1. Time crowding	Frequent & repetitive effects on system	1. Fuel management treatment does not keep pace with wildfire ignitions 2.
2. Time lags	Delayed effects	1. 80 years of fire suppression has radically changed the structure & composition of ecosystems in IRA's 2. 15 year delay in implementing *Cohesive Strategy*
3. Space crowding	High spatial density of effects on system	1. Increased density of forests and rangelands 2. Increased concentration of people near IRA's 3. High program of fuel related work change IRA characteristics
4. Cross-boundary	Effects away from source	1. Human communities near IRA's 2. Wildland urban interface intersections at IRA/private land boundaries 3. Fuel treatment outside IRA causes problems inside IRA's 4. More WFURB's in Wilderness allowed to burn
5. Fragmentation	Change in landscape pattern	1. Incidence of large fire increases 2. Condition Class 1 & 2 forests/rangelands become Condition Class 2 and 3 3. "Uneven" fuel profiles inside & outside of IRA's

6. Indirect effects	Secondary effects	1. Private landowners assume Federal or State agencies will complete fuel reduction work 2. Treating fuels is a continuous process 3. Lack of road access causes dramatic decrease in fire hazard reduction work 4. Building roads increase the chance of human ignitions
7. Triggers & thresholds	Fundamental changes in system behavior or structure	1. Fuels at such levels that restoration is impossible 2. Climate change cause more intense wildfires 3. Dramatic human population growth near IRA's

Table 7: ChecklistsA,B,C and D used to derive potential cumulative effects by alternative.

Checklist A.

Fuel management	**Past action**	**Present action**	**Future action**
Alternative 1			
• Wildand Urban Interface (number of intersections with IRA boundaries)	None to few	Few	Increase
• Wildfires (total acres burned and number of large fires per year)	<160,000 acres; < 17 large fires	>160,000 acres; >17 large fires	Less than 160,000 acres; <17 large fires
• Average cost of fuel treatment ($$$ per acre)	No fuel treatment occurring in IRA	$43-$150	$176-$276
• Fuel management implementation by treatment method (based on strategic schedule in *Cohesive Strategy)*			
o Prescribed fire	Very little	Some	Increase to 7.5 M acres
o Wildland Fire for Resource Benefit	None	None	Increase to 6 M acres
o Timber harvest	Some	94,000 acres	Increase to 500,000 acres
o Thinning + prescribed fire	Very little	Very little to none	Increase to 5 M acres

Checklist B.

Fuel management	Past Action	Present action	Future Action
Alternative 2			
• <u>Wildland Urban Interface</u> (number of intersections with IRA boundaries)	None to few	Few	Increase
• <u>Wildfires</u> (total acres burned and number of large fires per year)	<160,000 acres; < 17 large fires	>160,000 acres; >17 large fires	<160,000 acres; < 17 large fires
• <u>Average cost of fuel treatment</u> ($$$ per acre)	No fuel treatment occurring in IRA	$43-$150	$352-552
• <u>Fuel management implementation by treatment method</u> (based on strategic schedule in *Cohesive Strategy)*			
○ <u>Prescribed fire</u>	None	Some	Increase to 7.5 M acres
○ <u>Wildland Fire for Resource Benefit</u>	None	None	Increase to 6 M acres
○ <u>Timber harvest</u>	None	40,000 acres	Increase 100,000 acres
○ <u>Thinning + prescribed fire</u>	None	Very little to none	Increase to 1 M acres

Checklist C.

Fuel management	Past Action	Present action	Future Action
Alternative 3			
• Wildand Urban Interface (number of intersections with IRA boundaries)	None to few	Few	Increase
• Wildfires (total acres burned and number of large fires per year)	<160,000 acres; < 17 large fires	>160,000 acres; >17 large fires	<160,000 acres; <17 large fires
• Average cost of fuel treatment ($$$ per acre)	No fuel treatment occurring in IRA	$43-$150	$352-552
• Fuel management implementation by treatment method (based on strategic schedule in *Cohesive Strategy)*			
○ Prescribed fire	None	Some	Increase to 7.5 M acres
○ Wildand Fire for Resource Benefit	None	None	Increase to 6 M acres
○ Timber harvest	None	14,000 acres	Increase 30,000 acres
○ Thinning + prescribed fire	None	Very little to none	Increase

Checklist D.

Fuel management	Past Action	Present action	Future Action
Alternative 4			
• Wildland Urban Interface (number of intersections with IRA boundaries)	None to few	Few	Increase
• Wildfires (total acres burned and number of large fires per year)	<160,000 acres; < 17 large fires	>160,000 acres; >17 large fires	<160,000 acres; <17 large fires
• Average cost of fuel treatment ($$$ per acre)	No fuel treatment occurring in IRA	$43-$150	$352-552
• Fuel management implementation by treatment method (based on strategic schedule in *Cohesive Strategy)*			
○ Prescribed fire	None	Some	Increase to 7.5 M acres
○ Wildland Fire for Resource Benefit	None	None	Increase to 6 M
○ Timber harvest	None	None	None
○ Thinning + prescribed fire	None	None	None

Appendix J: Uncertainty Analysis Associated with Road Building and Fuel Treatment by Timber Harvesting

A standard process for creating risk-scenarios (Hammond, Keeney and Raiffa, 1999)[4] where one is uncertain of the actual outcome was used to develop the probabilities in the three scenario cases.

Assumptions:

- Time increments used will be 5 years, 20 years, and 40 years.
- Treatments will follow the strategic schedule outline in the *Cohesive Strateg*y; concentrate initial efforts in Fire Regimes 1 and 2, Condition Classes 2 and 3.
- Forests classed as Fire Regimes 3, 4 and 5 also need treatment to protect them from catastrophic wildfires, but they will not initially be scheduled for treatment during the first 20 year treatment cycle.
- A "realistic" amount of money would be spent on mechanical pre-treatment projects.
- The primary objective of fuel management is to restore forests and shrub lands that are at moderate to high risk from catastrophic forest fires to a low risk.
- All National Forest system lands at risk from wildfires would be of equal priority for mechanical pre-treatment whether they were inside or outside of inventoried roadless areas. In other words, for purposes of constructing the three scenarios, it was assumed that resource managers would want to treat all the hazardous fuels within inventoried roadless areas. It is highly unlikely that this would be the actual situation, for there are too many catastrophic fuel profiles outside inventoried roadless areas that need immediate treatment.
- Landscapes are considered "restored" whether the traditional timber harvest method or the stewardship timber harvest method is used to treat the hazardous fuel situation. The end-result of fire hazard reduction work is always the lessening of "uncharacteristic" forest fires and lowered resistance to control.
- Forests that need immediate restoration are classed as moderate to high risk from catastrophic forest fires, and fall into the frequent occurrence, low intensity fire regimes 1 and 2.

[4] Hammond, John S., Keeney, R. L and H. Raiffa. 1999. "Uncertainty," In Smart Choices: A Practical Guide to Making Better Decisions. Harvard Business School Press, Boston, Mass. p. 109-133.

The Situation

	Condition Class 1: Low Risk	Condition Class 2: Moderate Risk	Condition Class 3: High Risk
Total Acres Needing Treatment	3	7	4
Mechanical Pre-Treatment Needed	0	3.5	4

(Figures represent millions of acres)

Forests classed at low risk can be prescribed burned without mechanical pre-treatment. It is estimated that 50% of moderate forests will need to be mechanically pre-treated, and 100% of forests classed as high risk.

	Condition Class 1: Low Risk	Condition Class 2: Moderate Risk	Condition Class 3: High Risk	Total
Total Acres Needing Treatment	3	7	4	14
Mechanical Pre-Treatment Needed	0	3.5	4	6.5
Acres Estimated to be Treated in 15 Year Period	3.6	4.5	1.7	9.8

(Figures represent millions of acres.)

The Process for Dealing with Uncertainty

- What are the key uncertainties?
- What are the possible outcomes of these uncertainties?
- What are the chances of occurrence of each outcome?
- What are the consequences of each outcome?

Key Uncertainties:

- How much of the forest actually needs mechanical pre-treatment?
- The type of machine (heavy logging equipment, chainsaws, bulldozer) that would be needed to mechanically pre-treat a forest.

Definition of Outcomes

- A wildfire produces a **lethal burn pattern** (In forests, fires with less than 20% of the basal area or less than 10% of canopy cover remains; in range and shrub lands, fires where most of the shrub over story are killed.
- A wildfire produces a **non-lethal burn pattern** (In forests, fires where more than 70% of the basal area or more than 90% of the canopy cover survives; in range or shrub lands, fires where more than 90% of the vegetative cover survives.
- A wildfire produces a **mixed-severity burn pattern** (a mix between lethal and non-lethal)

Description of Scenario-1

Scenario 1: Chance of the outcome occurring over a 5, 20, and 40 year period for low risk from catastrophic wildfire forests, condition class 1, fire regime 1 and 2. (acres in millions)

			Consequences		
Outcome	Timeline (years)	Chance	Lethal (acres)	Mixed Severity (acres)	Non-Lethal (acres)
0% forests mechanically pre-treated & prescribed burned	5	"very unlikely"	-	-	4.0
	20	"very unlikely"	1.0	1.0	2.0
	40	"very unlikely"	1.5	0.5	2.0

Description of Scenario-2:

Scenario 2: Chance of the outcome occurring over a 5, 20, and 40 year period for moderate risk from catastrophic wildfire forests, condition class 2, fire regime 1 and 2 (acres in millions).

			Consequences		
Outcome	Timeline (years)	Chance	Lethal (acres)	Mixed Severity (acres)	Non-Lethal (acres)
50% forests mechanically pre-treated & prescribed burned	5	"very unlikely"	-	7	-
	20	"somewhat likely"	1.0	5.0	2.0
	40	"somewhat likely"	1.5	3.0	2.5

Description of Scenario-3:

Scenario 3: Chance of the outcome occurring over a 5, 20, and 40 year period for high risk from catastrophic wildfire forests, condition class 3, fire regime 1 and 2 (acres in millions).

Outcome	Timeline (years)	Chance	Lethal (acres)	Mixed Severity (acres)	Non-Lethal (acres)
75% forests mechanically pre-treated & prescribed burned	5	"very unlikely"	3.0	-	-
	20	"somewhat unlikely"	2.5	0.5	0
	40	"somewhat likely"	2.0	0.5	0.5

Methodology Used to Develop Outcomes, Chances, and Consequences:

Informal expert's panels were formed to discuss the acres at risk for each condition class and how those acreages change over time. Forests and shrub lands move in and out of the three condition classes depending on the amount of mechanical pre-treatment and prescribed burning an expert believes can be accomplished.

The scenario gaming rules established by and for the experts were:

- Any sort of mechanical treatment can be done as long as a road doesn't have to be constructed or reconstructed.
- Treatment costs were expected to be "realistic."
- The starting acreages for each scenario were established by mapping the condition class and fire regime data with the inventoried roadless area map data.
- Acres burned by wildfires were not to be taken into account, even though nearly 7 million acres are expected to burn by the year 2042.
- Human resources needed to accomplish the mechanical pre-treatment work were expected to be "realistic."
- Follow the strategic guidance established in the *Cohesive Strategy* by concentrating fuel treatment and restoration on Condition Class 2 and 3, Fire Regimes 1 & 2.
- Fire treatment is expected to occur on every acre by prescribed fire. In "real-time" this may not be the case. For example, an "indirect treatment" such as a defensible fuelbreak could be built around a timber stand that is at risk of burning in an uncharacteristic fashion.

- Forest and shrub lands classified as Condition Class 1 (low risk from uncharacteristic wildfire effects) and Fire Regime 1 and 2 can be prescribed burned cheaply and safely.

Timelines:

For purposes of consistency, the Roadless EIS-Regulations Interdisciplinary Team selected the 5, 20 and 40 periods for evaluating the environmental effects of each alternative. Data on road construction and timber harvest is available for 5 years out. However, the 20 and 40-year predictive periods have a great degree of uncertainty associated with them.

Definitions Used by the Expert Panels:

Active Management: Humans actively manipulate ecosystems through timber harvesting and thinning to improve forest health and to reduce fire hazard

Catastrophic Forest Fire: A wildland fire that harms singly or in combination such primary ecosystem components as soil, water, air, flora and fauna and threatened and endangered species. A wildfire that extensively threatens or damages human communities can also be labeled catastrophic. The term "catastrophic" is broadly defined to include both the adverse effects on ecosystem and human communities.

Cohesive Strategy: A Forest Service strategic document, formally titled *Protecting People and Sustaining Resources in Fire-adapted Ecosystems: A Cohesive* Strategy, that outlines how fire managers throughout the National Forest System are to prioritize their fire hazard reduction efforts. This strategy concentrates on short fire return interval forests (Fire Regimes 1 and 2) that are classed as moderate to high risk from catastrophic wildfires.

Low Risk from Catastrophic Wildfire (Condition Class1): Fire regimes within this class are within the historical range of variability for fire frequency and intensity. Forests and shrub lands within this class can be maintained by regular application of fire through prescribed burning, and do not need mechanical pre-treatment. If a wildfire occurs in this class, it is generally non-lethal.

Moderate Risk from Catastrophic Wildfire (Condition Class 2): Fire regimes are beginning to be altered since one or more wildfires have been suppressed allowing for forests to become noticeably denser especially with younger sapling trees. If a wildfire occurs in this class, it produces a mixed severity burn pattern. Experts predict that 50% of Moderate Risk forests would need mechanical pre-treatment.

High Risk from Catastrophic Wildfire (Condition Class 3): The fire regimes in this condition class are significantly altered, having missed many natural fires. Forests that were once open and park-like are now densely stocked. Experts predict that nearly 100% of this condition class will need mechanical pre-treatment before prescribed fire can be regularly used to keep fire hazards low and maintain forest health. A wildfire burning in this type would be of high intensity, killing most of the trees, and damaging keys components of the ecosystem.

Fire Frequency: The average time between fires in various forests and rangelands.

Fire Hazard: The overall threat of wildfire (the potential for combustion) in a vegetated ecosystem, often expressed as a combination of weight per unit area (tons per acre) of fuels on the ground and the probability that a crown fire might occur. To reduce the fire hazard in an area, managers must deal primarily with the fine fuels on the surface of the forest floor and with the smaller diameter trees growing in the understory of a forest that provide a ladder to the larger, dominant trees.

Fuel Management: The natural resource practice of evaluating, planning and executing the treatment of wildland fuels to restore forest health and to make future wildfires easier to control.

Fire Regime: The characteristics of a fire---its frequency, predictability, intensity and seasonality.

Mechanical pre-treatment: Preparing a forest for prescribed burning by thinning, commercial timber harvesting of larger standing live and dead trees, handpiling fine-fuels into piles for later burning, dozer-piling larger fuels into piles for later burning, raking of fine-fuels into piles to be burned at a later date. The objective of mechanical pre-treatment is to create a fuel bed where a prescribed fire can be ignited without undue risk of the fire escaping or killing the dominant trees on the site.

Passive (natural) Management: Human intervention in an ecosystem is minimal with natural processes such as fire and insects and disease infestations allowed to play out their "natural" role. For fire management, this would mean allowing some lightning fires to burn or allowing only prescribed fires with burning prescriptions that mimicked the natural fire regime in size, intensity and frequency.

Prescribed burning: The fire management technique of purposely igniting a fire in a vegetated ecosystem to restore forest health and to reduce fire hazard.

Resistance to Control: The difficulty of suppressing a wildland fire primarily determined by the fire's rate of spread (how fast it moves) and its intensity (how hot it will get).

Risk from Catastrophic Wildfire: Not the risk of a fire starting, but the risk that once a fire starts and gets large that it will damage the ecosystem or communities.

Scenarios: Predictions of future events and outcomes based on techniques of decision science. Scenarios are often expressed as "risk profiles," charts or tables that display the probability of an outcome occurring and its consequences.

Traditional Timber Harvest: Harvesting timber in a forest for economic gain, with other resources (water, wildlife, recreation) being lower priorities.

Uncharacteristic Wildfire: An increase in wildfire size, severity and resistance to control as compared to historical conditions prevalent before humans started effectively suppressing most wildland fires and timber harvesting forests.

Wildland Fire: A lightning or human caused fire that is either being suppressed or, if lightning caused, allowed to burn (see Wildland Fire for Resource Benefit). Often used synonymously with "wildfire" or "forest fire."

Wildland Fire for Resource Benefit: A lightning caused wildland fire that is allowed to burn because it meets the resource objectives outlined in the Land Management Plan and the site-specific prescriptive elements outlined in a Fire Management Plan.