Ecological Issues Underlying Proposals to Conduct Salvage Logging in Areas Burned by the Biscuit Fire

Photo:USDA Forest Service

Report by the

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Summary of Findings

Scientific Review of Fire, Recovery, and Post-Fire Management

- It is very important to distinguish between natural stand-replacing fire regimes from other regions where past fire suppression has shifted the natural understory fire regime to one of stand-replacement.
- Due to steep climatic and edaphic gradients and rugged topography, fire frequencies and severities have been highly variable in the Klamath-Siskiyou region and stand-replacing fires are common.
- Wildfire always favors some species and negatively impacts others; therefore, a full historical mix of species across the landscape depends on a shifting mosaic over space and time by major ecosystem drivers such as fire.
- Wildfires are one of the most important sources of landscape heterogeneity that determines the composition, structure, and function of large stand-replacing forest systems.
- Dead and dying trees provide important ecological functions to natural forest ecosystems.
- Post-fire salvage logging causes many of the same impacts to natural biodiversity as do green tree harvests.
- The elimination of post-fire habitat and regenerative processes by human intervention has made this habitat type rare.
- Any contention that an immediate, and aggressive post-fire response is needed to protect forests is unfounded.
- Natural post-fire recovery is generally rapid with no deleterious consequences; therefore, active post-fire rehabilitation of any kind is usually not needed, and may even be counter-productive.
- The notion that salvage logging and post-fire restoration (e.g., replanting, erosion and invasive species control) are intimately connected ecologically is a fallacy.
- Information on the environmental effects of post-fire salvage logging is severely limited, but what does exist overwhelmingly supports the position that post-fire salvage logging is at best benign but more typically damaging to biodiversity values and natural forest recovery.
- There is no scientific evidence that supports the claim that post-fire salvage and replanting of conifers reduces the intensity and severity of subsequent fires. On the contrary, post-fire logging has been shown to actually increase future fire risk because of the buildup of fine combustible fuels over the short-term.
- Natural post-fire recovery (including the dominance of shrubs and hardwoods in some areas) is important in the natural succession of conifer forests and their long-term sustainability. Many of these early successional species, which initially compete with young conifers, serve to (1) rapidly stabilize soils after fire, (2) fix nitrogen, (3) provide important soil mycorrhizae, (4) prevent establishment of invasive exotics, and (5) provide valuable wildlife cover and food.

- There is no ecological justification for post-fire salvage logging in any post-fire environment and most definitely not in the Biscuit Fire where so many important biodiversity values are rare and at risk.
- Post-fire salvage logging may be chosen as a management option on purely economic grounds, and it may be possible to minimize the ecological costs in some instances.

Post-fire Management of the Biscuit Fire

- The Biscuit Fire took place in a region of extraordinary natural richness, diversity, and beauty that was shaped in part by fire. Any proposal to shift the region away from its natural vegetation pattern to heavily managed conifer plantations is grossly misguided because it fails to recognize the conservation values of a region of global significance.
- Management options for the post-Biscuit Fire landscape should not be viewed as binary - action or inaction.
- The numerous administrative, operational, and ecological constraints within the Biscuit Fire area provide little economic opportunity for salvage logging.
- Immediate and aggressive restoration actions over much of the Biscuit Fire burn area are largely unnecessary.
- A total of 206,890 acres were mapped as moderate or high vegetation change according to Remote Sensing Application Center post-fire assessments. The distance from the moderate/high areas to the nearest no/little/low vegetation areas ranged from 30 to 1,050 meters with a mean of 113 meters. Eighty-four percent of the moderate/high area was located within 200 meters of a potential natural seed source.
- Given the high risk of doing further damage, silvicultural treatments should be applied only to previously managed lands already impacted by logging and other uses. Inventoried roadless areas should not be subjected to salvage logging.
- A major consideration of post-fire management in the Biscuit is to minimize the area potentially recruited into intensive silvicultural development.
- Management alternatives should promote the long-term ecological integrity of this forest system. If salvage logging is desired on economic grounds for the Biscuit Fire Area, it should be carried out on a small area under careful guidelines to minimize environmental damage.
- A more passive restoration approach may be the most effective for the Biscuit overall.
- In locations where salvage logging is carried out, the management recommendations provided by Beschta et al. (1995) should serve as one alternative in a carefully designed experiment. The experimental salvage experiment should emphasize stand as well as landscape level characteristics and processes and be carried out in cooperation with independent researchers.

Introduction

This report was prepared to provide an independent examination of the post-fire management options being considered for the Biscuit Fire (2002) within the Siskiyou National Forest in southwestern Oregon. This report has three main objectives: (1) summarize the ecological setting and impact of the Biscuit Fire, (2) review the scientific literature on post-fire management (including salvage logging) and (3) conduct a GIS-based mapping analysis that examines the ecological and administrative constraints to post-fire management of the Biscuit Fire. The primary intent of this last section was to demonstrate how planning for post-fire salvage should be conducted based on the best available data and important science principles applied to this particular region. The intent of the exercise was not to provide a final action plan per se, but to illustrate in a spatially explicit fashion the ecological sideboards necessary to develop an ecologically responsible salvage plan for the Biscuit.

The Klamath-Siskiyou

The Biscuit Fire burned nearly 500,000 acres of the northwestern portion of the Klamath-Siskiyou ecoregion of northwest California and southwest Oregon. The Klamath-Siskiyou ecoregion exhibits a high level of physical heterogeneity resulting in an extraordinarily rich flora and fauna (Whittaker 1960, 1961, Kruckeburg 1984, DellaSala et al. 1999). The region is recognized as a place of Global Botanical Significance by the World Conservation Union (IUCN) – one of only seven in North America (DellaSala et al. 1999), a global Centre of Plant Diversity (Wagner 1997), and a proposed World Heritage Site and UNESCO Biosphere Reserve (Vance-Borland et al. 1995). In a global analysis of terrestrial ecoregions, World Wildlife Fund identified the Klamath-Siskiyou as globally outstanding in species richness and endemism (Ricketts et al. 1999).

The Biscuit Fire did not burn just anywhere. It burned in a place of extraordinary natural richness, diversity, and beauty that was shaped in part by fire. Any proposal to shift the region away from its natural vegetation pattern to heavily managed conifer plantations is hugely misguided because it fails to recognize the conservation values of a region of global significance.

The Klamath-Siskiyou ecoregion is somewhat of a regional botanic melting pot with influences from six adjacent regions – Great Basin, Oregon Coast Range, Cascades Range, Sierra Nevada, California Central Valley, and Coastal California (Smith and Sawyer 1988). The region features highly dissected topography and numerous environmental gradients with abrupt changes in bedrock geology, soils, elevation, slope, aspect, and moisture (Whittaker 1960, Wallace 1983, Kruckeberg 1984). Portions of the ecoregion served as a refugium for many plants and animals resulting in active speciation for various taxa including plants and mollusks (Whittaker 1960, Smith and Sawyer 1988, Frest and Johannes 1998).

Fire continues to be one of the most important factors shaping the region's biological diversity as it operates synergistically with the physical variability of the region. The steep climatic and edaphic gradients and rugged topography results in fire frequencies and severities that are highly variable (Agee 1993, Taylor & Skinner 1998). This mixed-severity fire regime has resulted in a very complex dominant vegetation pattern (Martin and Sapsis 1992). Stand-replacing fire is common over a significant portion of the ecoregion.

This ecoregion supports a continental maximum of temperate conifer species (30) with as many as 17 conifer tree species recorded living together within a single stand. More than 3,500 plants, including 281 endemics (largely as the result of the region's harsh living conditions on the serpentine geology) are known to occur in the Klamath-Siskiyou (Sawyer 1996).

Fisheries biologists in developing the Northwest Forest Plan delineated important remaining watershed refugia for salmon and other aquatic species called "key watersheds" (FEMAT 1993). Approximately 41 percent of the total burn area occurred in key watersheds. The region is one of the last remaining strongholds for many salmonids in the Pacific Northwest. The Biscuit Fire burned portions of four key watersheds – Indigo Creek, Illinois River/Lawson Creek, Silver Creek, and North Fork of the Smith River.

The Klamath-Siskiyou contains over 1.1 million acres of inventoried roadless areas (including some very large blocks) – more than any other ecoregion in the Pacific Northwest. The inventoried roadless areas of the Klamath Siskiyou were found to be complimentary to the existing network of protected areas (Wilderness Areas primarily) contributing significantly to a wide range of conservation attributes (Strittholt and DellaSala 2001). The Biscuit Fire burned almost 211,000 ac of inventoried roadless areas.

There are important ecological values in every place, but the world's biodiversity is not distributed uniformly across its surface. Biodiversity varies due to the interplay of physical environment (climate, soil, terrain), geologic history, and natural disturbance regime. The Biscuit Fire did not burn just anywhere. It burned in a place of extraordinary natural richness, diversity, and beauty that was shaped in part by fire. It also burned in a location where the influence of industrial human activity has been far less than in many other parts of the Pacific Northwest as evidenced by the large proportion of the fire burning in either wilderness (178,385 ac) or inventoried roadless areas (210,913 ac) for a total of 389,298 ac (or approximately 78% of total burn area). Any proposal to shift the region away from its natural vegetation pattern to heavily managed conifer plantations is hugely misguided because it fails to recognize the conservation values of a region of global significance.

The Biscuit Fire

As the result of major lightening strikes across the region on July 13, 2002, four separate fires were ignited in backcountry locations, which later coalesced to form the Biscuit Fire. The subsequent post-fire assessment (USDA Forest Service 2003) notes the buildup of fuels in some areas as a pre-fire condition. However, it is unlikely that these fuels were abnormally high as the result of past logging and fire suppression over most of the burn area, which is dominated by wilderness and inventoried roadless areas, or was largely responsible for the size of the burn perimeter. Compared to other recent fire patterns, the Biscuit Fire appears to have behaved within its natural range of variability. While historic logging and fire suppression have resulted in abnormally high fuel levels in some forest types throughout the U.S. (e.g., some Ponderosa pine (*Pinus ponderosa*) forests, Covington et al. 1997) - essentially converting a frequent low intensity natural fire regime to a high intensity stand-replacing fire regime - that does not appear to be the situation over most of the Biscuit Fire area. Applying this documented shift in fire regime too broadly to include inappropriate forest types and natural fire regimes without sufficient evidence is a growing concern among ecologists and fire scientists (Gutsell et al. 2001, Keeley & Fotheringham 2001, Baker and Ehle 2001, Johnson 2003, Turner et al. 2003, Ehle and Baker, In Press, Odion et al. In Review).

The fire was vigorously fought at a cost of approximately $153 million and included fire line construction and extensive high-intensity backburning. There was no loss of human life as a result of the fire, but several structures were lost including 4 homes, 9 outbuildings, 1 lookout and numerous recreation structures. After the last fires were extinguished approximately two months later, the Biscuit Fire perimeter included approximately 500,000 acres with 92 percent located in the Siskiyou National Forest (Table 1).

Table 1. Ownership within the Biscuit Fire perimeter (Source: USDA Forest Service 2003).

Owner	Area (ac)	Percent
Siskiyou National Forest	460,607	92
Six Rivers National Forest	28,538	6
BLM Medford District	8,753	2
Other Public	66	<1
Private	1,978	<1
Unknown/Unlabeled	1,288	<1
Total	499,965	

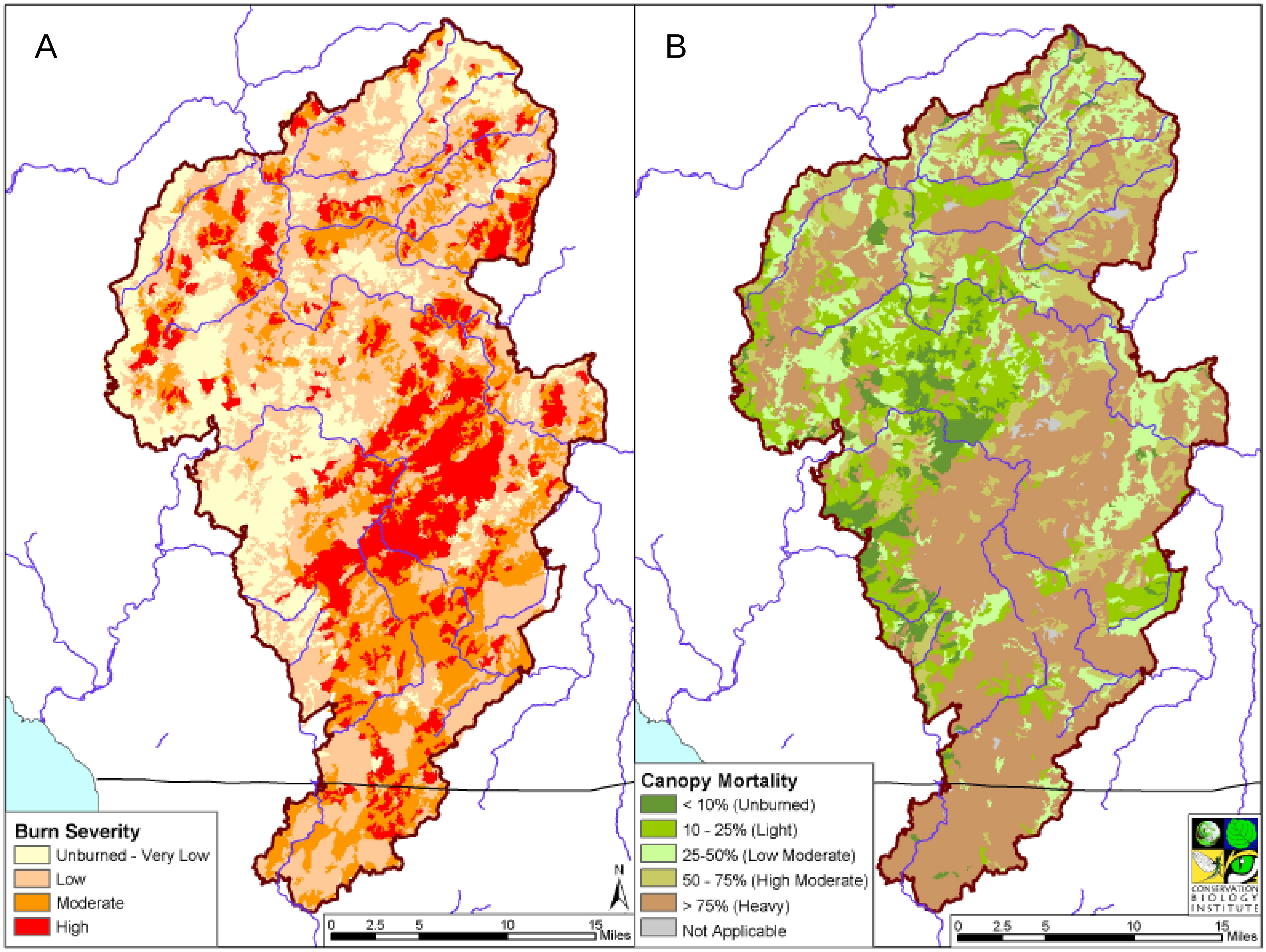
In typical fashion of most wildfire events, the Biscuit Fire did not burn uniformly across the landscape but in a patchwork of severities (Figure 1). The U.S. Forest Service mapped fire severity by interpreting Landsat 7 ETM+ satellite imagery (obtained post-fire) and validated their results using aerial reconnaissance (Map 1A). Using a minimum mapping unit of 50 acres, four severity classes were delineated (see Box 1 for burn severity class descriptions).

According to these data, approximately 20 percent of the Biscuit Fire perimeter was unburned or burned at very low severity. Forty-one percent burned at low severity, 23 percent at moderate severity, and 16 percent at high severity. Approximately 1/3 of the Biscuit Fire perimeter burned over a three-day period (July 28-30) due to excessively dry and windy weather conditions. This area accounted for 54 percent of the total high severity burn area and most of it was in wilderness or roadless areas. Fuel levels and terrain complexity (the other two components of the wildlife triad) factor less prominently in determining severity and burn pattern under these extreme weather conditions. Pre-fire management has little effect under the more extreme weather conditions.

Using aerial photo interpretation and a minimum mapping unit of 10 acres, canopy mortality was also mapped concurrently and independently (Map1B) and used in many of the post-fire management opportunities analyses. Canopy mortality was found to be >75% for 48 percent of the burn area (including all shrub communities) and another 12 percent of 50-75% canopy mortality. The remaining 40 percent experienced less than 50% canopy mortality.

Follow-up satellite image interpretation by the Remote Sensing Application Center (RSAC) resulted in additional information regarding impacts on the vegetation as a result of the fire. In this assessment, vegetation change was evaluated by comparing infrared reflectance of imagery acquired in 2001 to imagery immediately after the fire was contained. Four classes were mapped based on the degree of change: 1= little or no change, 2 = low change, 3 = moderate change, and 4 = high change (Map 2). For example, if an area was old-growth forest before the fire and experienced a low intensity under burn, it was labeled as experiencing little or no change. High change depicted high severity impacts on the pre-fire vegetation.

According to this assessment, approximately 30 percent of the area within the Biscuit Fire perimeter experienced little or no vegetation change. Twenty-seven percent was classed as experiencing low change, 25 percent moderate change, and 19 percent as high change.



Map 1. Burn Severity (A) and Canopy Mortality (B) as defined by the postfire assessment team (BAER 2002).

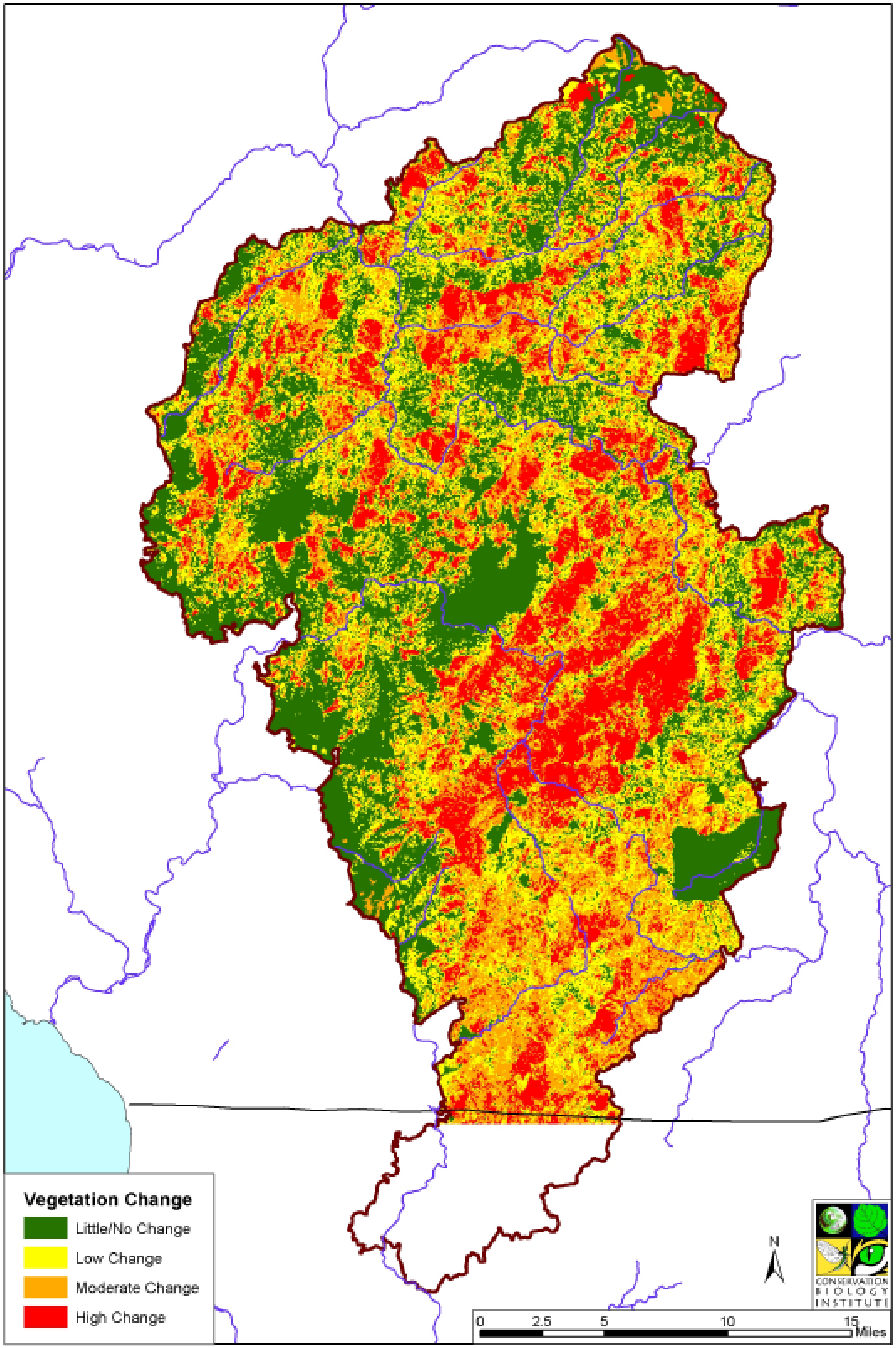
BOX 1 - Burn Severity Class Descriptions [Source: BAER 2002].

Unburned-Very Low: These areas are a mosaic of unburned areas and very low severity ground fire. In these areas where pre-fire vegetation is forest or shrub, consumption of ground cover (litter and duff) and vegetation mortality is minimal. Overstory canopy remains vigorous and green. Mortality of trees and shrubs is slight. This includes large contiguous areas of rock outcrop or bare soils.

Low: Low burn severity dominates in areas where pre-fire fuels were sparse or light, such as grasslands, sparse pines or shrubs with thin litter and duff layers, and includes areas where smaller but common areas of rock outcrop or bare soil occur and contribute to the sparse nature of the vegetation. The fire probably spread rapidly but residence time was short due to paucity of ground fuels. Soil structure is not altered, fine and very fine roots still exist in surface soil, surface 1mm or so of soil may or may not be weakly water repellant in places. Vegetation is lightly scorched, large trees are mostly not killed, very small diameter fuels have been consumed. In most areas grass, forbs, and shrubs are already sprouting. Low severity can also occur in more densely forested areas if fire behavior was not extreme, such as night burns in forested areas, or areas at higher elevations where fire behavior conditions (wind, humidity) were not conducive to extreme behavior.

Moderate: Moderate burn severity dominates in areas of moderately dense to dense shrub communities, and in areas where hardwood or conifer tree species were moderately dense to dense, but brown needles remain on trees. In the case of shrub communities, the lack of thick pre-fire litter and duff layers resulted in rapid spread but relatively short residence time of fire. Shrub canopy may be all or partly consumed, shrub skeletons and root crowns remain, there is some identifiable char and litter beneath a thin ash layer, soil structure is intact, fine and very fine roots remain. The top 1mm or so of soil may or may not be water repellant in spots. In areas where pre-fire vegetation consisted of hardwood or conifer trees, brown needles or leaves remain on trees, some identifiable char and litter may be present beneath the ash layer but much of the litter has been consumed. Soil structure is intact, fine and very fine roots remai and water repellency, if present, may be spotty. Fine fuels close to the ground may be all consumed and treesmay exhibit 40 to 80 percent mortality.

High: High burn severity occurs in isolated small patches, and more extensively in a few watershed areas where pre-fire vegetation consisted of dense conifer or hardwood trees. In these areas, pre-fire forest stands were more dense, litter and duff were generally deeper, fire and heat residence time were longer, and nearly complete consumption of ground cover has occurred. The ash layer may be 1 to 2 inches deep. Some, but little recognizable char is evident beneath the ash layer. Soil structural stability may be reduced due to more complete consumption of soil organi matter. Fine and very fine roots may have been consumed in the surface few centimeters of soil. Water repellency may or may not be present, and if so, is generally spotty over approximately 20 to 50% of the area, and is slight to moderate in the top 1 to 2 cm of soil below the ash. It is important to note that even in unburned areas, soils may exhibit some water repellant characteristics due to the nature of the leaf and needle litter or abundance of fungal mycelia. Complete consumption of tree crowns has occurred, few to no leaves or needles remain on trees, and mortality can be assumed to be close to 100%.

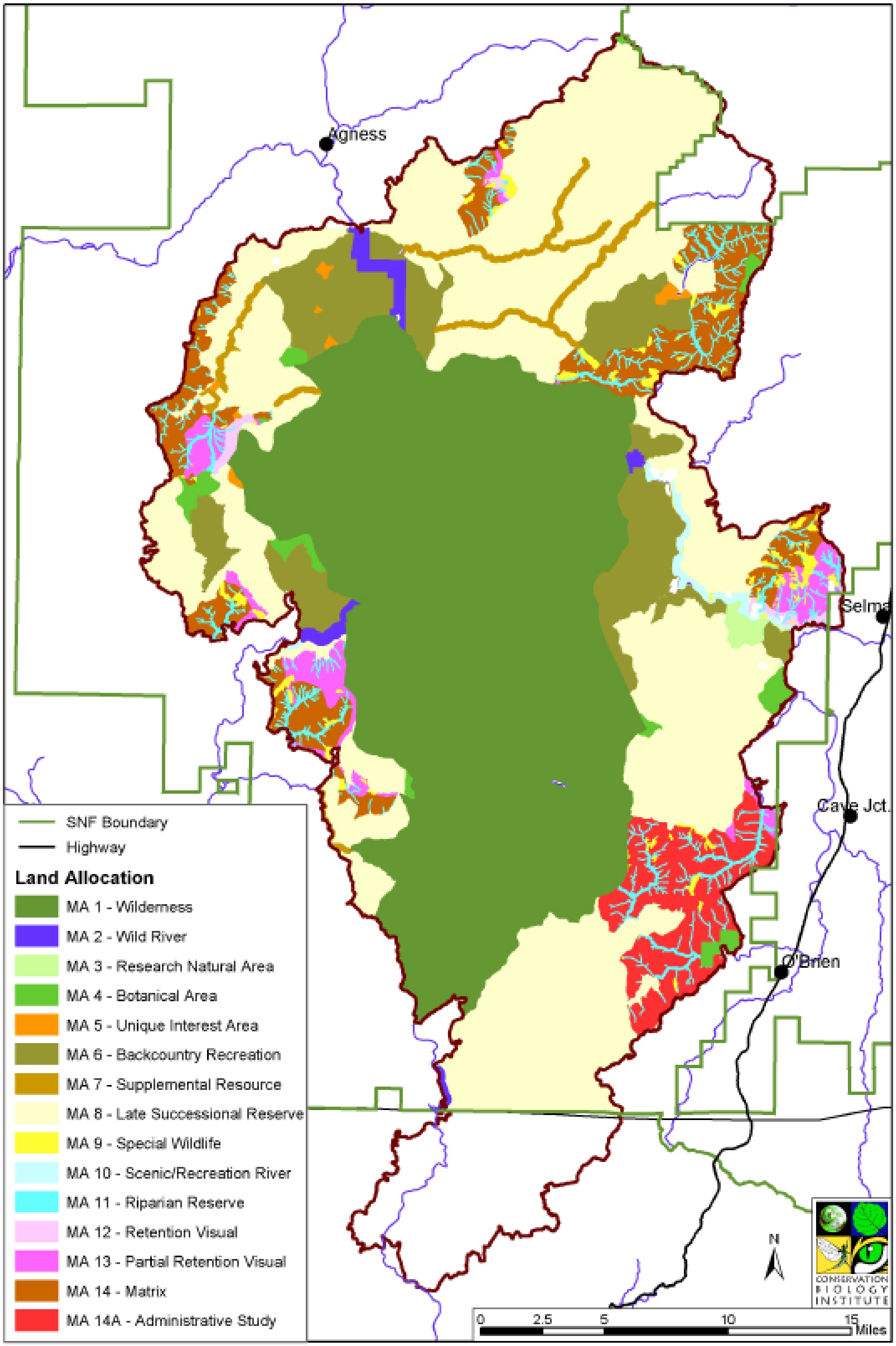


Map 2. Vegetation change within the Biscuit fire perimeter (Remote Sensing Application Center).

For the Siskiyou National Forest, the Biscuit Fire impacted 15 different management categories. Over 178,000 ac (or 39%) of the Biscuit Fire burned in the Kalmiopsis Wilderness. Another 158,606 ac (35%) was designated as Late Successional Reserve. The remaining 26 percent was designated in various special management types (e.g., Back Country Management, Botanical Areas, and Special Wildlife Sites) and matrix lands (Map 3). Canopy mortality figures are presented in Table 2 according to management status within the Siskiyou National Forest portion of the Biscuit Fire. The total area of inventoried roadless areas for this same area was 186,470 acres and will be discussed in greater detail later in this report. Table 3 summarizes the vegetation change results to ownership.

It is important to note that some trees scorched by fire and presumed dead by early aerial reconnaissance will survive, and other trees, which appear green and alive immediately following a fire, will succumb to unobserved damage by the fire around its base or to subsequent insect attack. Both the large remaining live as well as large dead trees provide important legacy functions instrumental in natural post-fire recovery of the native forest (Perry 1994, Franklin et al. 2000).

Figure 1. Bear Camp area in the Siskiyou National Forest. Note patchwork of burn severity in this particular landscape. Photo: USDA Forest Service]



Map 3. Siskiyou National Forest land allocation within the Biscuit Fire burn perimeter.

Table 2. Area (acres) of canopy mortality by land allocation (including inventoried roadless areas) for the Siskiyou National Forest.

Management Area	Canopy Mortality Categories					MA Totals
	0 – 10%	10 – 25%	25 – 50%	50 – 75%	75 – 100%	
MA 1 – Wilderness	17,065 (0)*	39,653 (0)	22,840 (0)	15,754 (0)	81,293 (0)	178,377 (0)
MA 2 – Wild River	159 (101)	823 (762)	425 (401)	946 (911)	1,115 (1,112)	3,468 (3,287)
MA 3 – Research Natural Areas	80 (80)	0	616 (612)	486 (483)	102 (102)	1,284 (1,277)
MA 4 – Botanical Areas	156 (24)	323 (80)	55 (37)	624 (323)	3,897 (1,625)	5,073 (2,089)
MA 5- Unique Interest	0	0	79 (78)	241 (215)	547 (535)	1,049 (828)
MA 6 – Backcountry Recreation	1,057 (1,048)	3,158 (3,156)	5,376 (5,294)	7,935 (7,577)	18,986 (15,429)	36,512 (32,504)
MA 7 – Supplemental Resource	116 (115)	1,180 (985)	1,889 (1,497)	941 (549)	2,479 (1,525)	6,610 (4,671)
MA 8 – Late Successional Reserves	4,479 (3,199)	19,089 (13,742)	33,423 (17,859)	20,609 (12,911)	80,329 (54,789)	158,606 (102,500)
MA 9 – Special Wildlife Sites	339 (70)	953 (427)	498 (314)	723 (368)	1,887 (1,113)	4,545 (2,292)
MA 10 – Scenic / Recreational Rivers	44 (4)	11 (9)	597 (6)	311 (28)	1,181 (40)	2,144 (87)
MA 11 – Riparian Reserves	700 (77)	2,469 (1,171)	1,561 (970)	2,189 (1,450)	4,646 (3,368)	11,589 (7,036)
MA 12 – Retention Visual	0	14 (0)	125 (78)	193 (51)	1,102 (456)	1,434 (585)
MA 13 – Partial Retention Visual	705 (70)	2,045 (822)	1,316 (519)	673 (111)	3,447 (1,935)	8,186 (3,457)
MA 14 – Matrix	1,959 (149)	4,304 (450)	3,445 (1,359)	4,377 (2,550)	10,872 (5,280)	25,019 (9,788)
MA 14A – Administrative Study Area	100 (100)	3,632 (3,632)	2,054 (2,054)	1,314 (1,312)	9,108 (8,935)	16,251 (16,033)
Totals	26,960 (5,041)	77,654 (25,242)	74,299 (31,079)	57,315 (28,847)	220,991 (96,261)	457,219** (186,470)

* - Acres of inventoried roadless areas
** - Areas delineated as NA in the post-fire assessment excluded

Table 3. Area (acres) of vegetation change by land allocation (including inventoried roadless areas) for the Siskiyou National Forest.

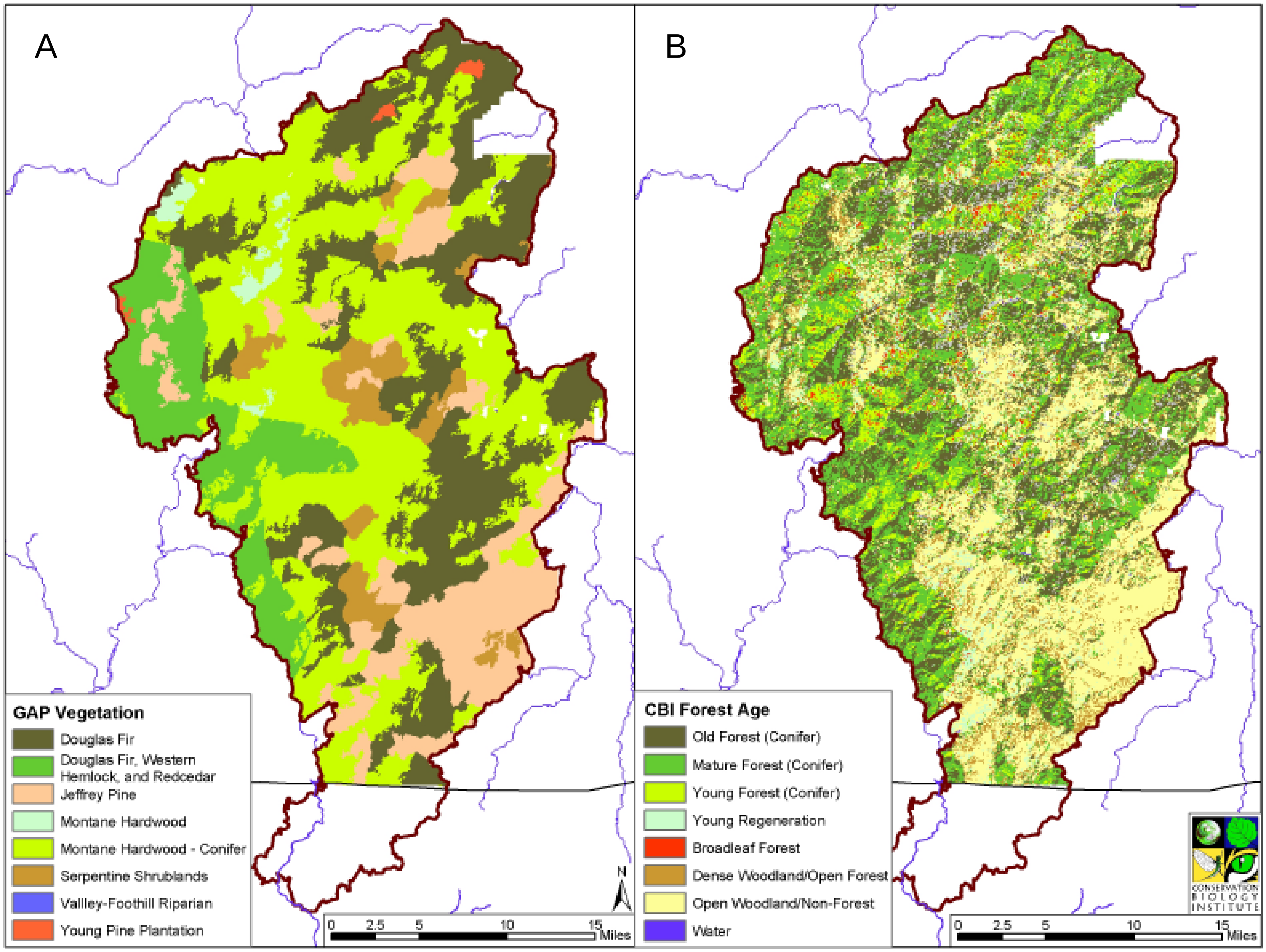
Management Area	**Vegetation Change Categories**				**MA Totals**
	No / Little Change	Low Change	Moderate Change	High Change	
MA 1 – Wilderness	53,595 (0)*	44,193 (0)	42,472 (0)	38,118 (0)	178,377 (0)
MA 2 – Wild River	1,097 (1,002)	1,327 (1,251)	757 (747)	287 (287)	3,468 (3,287)
MA 3 – Research Natural Areas	337 (333)	427 (426)	318 (318)	202 (202)	1,284 (1,279)
MA 4 – Botanical Areas	964 (255)	1,417 (547)	1,525 (633)	1,168 (672)	5,073 (2,107)
MA 5- Unique Interest	277 (268)	397 (385)	233 (221)	142 (136)	1,049 (1,010)
MA 6 – Backcountry Recreation	9,159 (8,912)	10,721 (10,014)	10,296 (8,674)	7,070 (5,643)	37,246 (33,243)
MA 7 – Supplemental Resource	2,028 (1,604)	2,655 (1,804)	1,490 (992)	438 (274)	6,610 (4,674)
MA 8 – Late Successional Reserves	44,226 (25,553)	43,793 (28,398)	41,302 (28,669)	29,286 (20,426)	158,606 (103,046)
MA 9 – Special Wildlife Sites	1,924 (946)	1,346 (639)	715 (390)	560 (457)	4,545 (2,433)
MA 10 – Scenic / Recreational Rivers	865 (46)	664 (28)	383 (12)	232 (4)	2,144 (91)
MA 11 – Riparian Reserves	4,936 (2,601)	2,835 (1,631)	2,380 (1,717)	1,438 (1,107)	11,589 (7,056)
MA 12 – Retention Visual	293 (165)	425 (185)	459 (125)	256 (107)	1,434 (581)
MA 13 – Partial Retention Visual	3,209 (1,065)	2,219 (998)	1,751 (885)	1,007 (514)	8,186 (3,462)
MA 14 – Matrix	9,441 (2,348)	6,254 (2,437)	5,117 (2,420)	4,207 (2,645)	25,019 (9,850)
MA 14A – Administrative Study Area	5,212 (5,205)	3,737 (3,652)	6,034 (5,956)	1,268 (1,266)	16,251 (16,079)
Totals	137,563 (50,303)	122,410 (52,395)	115,232 (51,759)	85,679 (33,740)	460,884 (188,197)

*Acres of inventoried roadless areas.

We also examined canopy mortality of dominant vegetation types using the most recent Gap Analysis vegetation data (Map 3A) for the burn area within the Siskiyou National Forest (Kagan et al. 1992) and forest age (which tells more about forest structure) data (Map 3B) available for the region derived from classified 2000 Landsat 7 ETM+ satellite imagery (Jiang et al. In Review).

Montane hardwood-conifer made up the greatest percentage (37%) of moderate-high canopy mortality (Table 4). Douglas-fir (*Pseudotsuga menziesii*) ranked second (31%) followed by Jeffrey pine (*Pinus jeffreyi*, 19%). Of the eight vegetation types in the burn perimeter, Jeffrey pine had the highest degree (78%) of moderate-high canopy mortality. It is difficult to say to what degree backburning influenced canopy mortality rates, but a portion of the high severity burn and high canopy mortality can be directly attributed to fire fighting measures. The total perimeter of the Biscuit Fire was approximately 187 miles, and total length of fireline was nearly twice that (365 miles).

We also looked at canopy mortality with regard to forest age, which is somewhat more meaningful than the plant community composition analysis for two reasons. The forest age data is represented at a finer resolution and vegetation structure is more important to fire behavior than is plant community composition in many instances. The Open Woodland/Non-forest class comprised almost a third (31%) of the moderate-high canopy mortality area followed by Mature Conifer forest (24%) and Old Conifer forest (18%; Table 5). Dense Woodland/Open Forest made up 10 percent of the higher canopy mortality area. Old Conifer, Mature Conifer, and Young Conifer forests, had the lowest percentages (49%, 52%, and 53% respectively) of moderate-high canopy mortality. The more open habitats (Young Regeneration, Dense Woodland/Open Forest, and Open Woodland/Non-forest) all experienced the same level of moderate-high canopy mortality (77%), while 63% of Broadleaf Forests had moderate-high canopy mortality.



Map 4. Plant community vegetation data according to the Gap Analysis Project (A) and forest age data (B) created by CBI for the Siskiyou National Forest within the Biscuit Fire burn perimeter.

Table 4. Siskiyou National Forest Biscuit Fire area (acres) by canopy mortality and plant community composition [Source: GAP vegetation (Kagan et al. 1992)].

Plant Community Composition	**Canopy Mortality**						**% of Canopy Mortality >50% for Region**	**% of Canopy Mortality >50% by Class**	**Total**
	NA	< 10%	10 – 25% (Light)	25 – 50% (Low Moderate)	50 – 75% (Moderate High)	> 75% (High)			
Douglas Fir	1,055	3,157	14,845	21,276	19,436	66,245	31	68	126,014
Douglas Fir, White Hemlock, and Red Cedar	9	8,293	15,809	9,252	6,687	15,030	8	39	55,080
Jeffrey Pine	791	499	7,824	6,307	5,388	46,404	19	78	67,213
Montane Hardwood	0	22	664	1,095	829	2,758	1	67	5,368
Montane Hardwood - Conifer	918	13,374	31,273	32,750	23,936	78,224	37	57	180,475
Serpentine Shrublands	886	1,557	7,036	3,261	1,007	11,432	4	51	25,179
Young Pine Plantation	0	66	206	378	20	965	<1	60	1,635
Total	3,659	26,968	77,657	74,319	57,302	221,059	100		460,964

Table 5. Siskiyou National Forest Biscuit Fire area (acres) by canopy mortality and forest age data [Source: CBI Forest Age data (Jiang et al. In Review)].

Forest Age	**Canopy Mortality**						**% of Canopy Mortality >50% for Region**	**% of Canopy Mortality >50% by Class**	**Total**
	NA	< 10%	10 – 25% (Light)	25 – 50% (Low Moderate)	50 – 75% (Moderate High)	> 75% (High)			
Old Conifer Forest*	178	9,912	23,255	18,844	15,634	33,946	18	49	101,769
Mature Conifer Forest **	267	10,218	23,020	28,694	18,865	47,255	24	52	128,319
Young Conifer Forest	67	3,072	6,550	7,350	5,616	13,800	7	53	36,455
Young Regeneration	272	527	2,584	2,004	1,827	16,032	6	77	23,246
Broadleaf Forest	106	390	1,634	1,493	1,114	4,977	2	63	9,714
Dense Woodland / Open Forest	349	751	3,708	4,131	4,138	24,357	10	77	37,434
Open Woodland / Non-Forest	2,264	1,679	13,901	9,203	8,164	76,895	31	77	112,106
Water / Clouds / Shadows	156	423	3,005	2,600	1,944	3,797	2	48	11,921
Total	3,659	26,968	77,657	74,319	57,302	221,059	100		460,964

* - conifer forest >150 years old   ** - conifer forest between 50 - 150 years old

Post-fire Management

Post-fire management can include a broad array of actions such as repair to existing roads and road structures, installation of erosion control measures, and repair or reconstruction of buildings. A wide range of site restoration activities are available including the control of invasive species, seeding of erosion prone sites, and planting of disease resistant seedlings. Two non-native tree diseases occur within the Biscuit Fire perimeter: white pine blister rust (caused by *Cronartium ribicola*), which effects both western white pine (*Pinus monticola*) and sugar pine (*Pinus lambertiana*), and Port-Orford-cedar root disease (caused by *Phytophthora lateralis*). Disease resistant cultivars are currently being tested for these ecologically important tree species, and successful disease resistant cultivars could be used to help restore these species to their former areas and abundance levels. By far, the most contentious potential post-fire management activity is the removal of dead or damaged trees, or salvage logging. Salvage logging and other management activities are often bundled together to describe post-fire management options. It is important to treat each post-fire management option separately and evaluate each one on its own ecological and economical merit.

Salvage logging and restoration activities are not necessarily tied together. It is important to treat each post-fire management option separately and evaluate each one on its own ecological and economical merit.

Salvage Logging

In general, salvage logging is the harvest of dead or dying trees due to fire, wind, flood, insects, or disease; however, salvage has never been specifically defined in legal terms (TWS/NAS 1996). Existing operating definitions stated in the National Forest Management Act of 1976 (NFMA) and the Emergency Supplemental Appropriations and Rescissions Act of 1995 clearly allow for the removal of live trees associated with dead and dying trees; however, not all dead and dying trees are salvageable. Some trees deteriorate quickly, and have no salvageable value. Some locations are inaccessible because of legal restrictions (e.g., congressionally withdrawn lands such as wilderness areas) or because of prohibitive costs (e.g., new road construction costs or extensive environmental damage control measures) (see Niemi 2003). Thus, only a portion of dead and dying trees can be salvaged due to administrative and operational constraints.

Contrary to arguments presented by timber interests, there is no scientific evidence supporting the position that salvage logging benefits forest ecosystem health or promotes late successional forest characteristics. In fact, most of the limited scientific papers show some level of damage (low to severe) from the practice.

In most ways, salvage sales do not differ from other timber sales except that they can sometimes be expedited (including bypassing proper administrative and judicial review) because the value of the burned timber quickly looses its economic value the longer it remains in place. Because of the lack of careful planning and review, salvage logging may have greater environmental impacts than routine timber sales (TWS/NAS 1996).

Contrary to arguments presented by timber interests, there is no scientific evidence supporting the position that salvage logging benefits forest ecosystem health or promotes late-successional forest characteristics. In the most extensive review of postfire logging effects to date, McIver and Starr (2000) found only 21 scientific papers worldwide that pertain to this specific topic. Of these, only 14 included unlogged controls and only 7 of these used replicates. Direct salvage logging activity effects studied have emphasized soil disturbance, erosion, sediment yield to streams, and changes in water yield. Indirect effects (or the effects due to the removal of merchantable material) have focused almost exclusively on the impacts on bird species assemblages. McIvar and Starr (2000) conclude that … "postfire logging is certain to have a wide variety of effects, from subtle to significant, depending on where the site lies in relation to other postfire sites of various ages, site characteristics, logging methods, and intensity of fire." With so few scientific papers of any kind on the subject, and for the ones that do exist, most report some level of environmental damage from the practice, how can salvage proponents claim so many positive ecological benefits?

The retention of biological legacies is imperative to maintain productive soils and healthy forests.

There is also a false public perception that dead and dying trees have little or no value. To forest ecologists they are known as "biological legacies", which are disproportionately important to maintaining the biodiversity of a natural forest. Biological legacies are organisms, organically derived structures, and organically produced patterns that persist after a major disturbance event (Franklin et al. 2000) and include standing dead trees (snags), downed logs, intact thickets, and large living trees. They have been described as keystone habitat elements benefiting many organisms (Perry and Amaranthus 1997). Biological legacies have a wide range of functions including:

- Survive, persist, and regenerate, becoming incorporated into the recovering stand
- Assist other species through a variety of functions (life-boating)
- Provide refugia for some species from which they can recolonize nearby recovering disturbed sites
- Influence patterns of recolonization in the neighboring disturbed area
- Provide a source of energy and nutrients for other organisms
- Modify and stabilize environmental conditions in the recovering stand

(Lindenmayer and Franklin 2002)

Downed logs and snags often persist after fire and both serve important ecological functions. Downed logs return much needed organic matter to the soil, help stabilize soil loss from erosion, and aide in the establishment of early successional species (including herbaceous plants and fungi) that condition soil for the natural reestablishment of conifers. Snags provide nesting and denning habitat for many species of birds and mammals (McComb and Lindenmayer 1999). In short, the retention of biological legacies is imperative to maintain productive soils and healthy forests (Beschta et al. 1995, Perry 1994, Perry and Amaranthus 1997, Franklin et al. 2000, Lindenmayer and Franklin 2002).

In the following section, we review the scientific literature as it pertains to four important hypotheses regarding salvage logging.

Hypothesis #1: Salvage logging and follow-up silvicultural treatment reduce the risk of recurring large-scale, high intensity fires.

Natural Fire Regime

With any discussion of post-fire management, it is important to consider the natural fire regime context. As shown in the previous section, the natural vegetation pattern within the Biscuit Fire perimeter is quite complex ranging from very dry Jeffrey pine savannas and shrub communities to moist Douglas-fir/Western Hemlock/Western Redcedar forest. While it is useful to visualize forest communities at relatively coarse spatial scales as presented in Map 4A, the vegetation communities throughout the region are far more intermixed than these renditions can accurately communicate. This high level of spatial variability and plant community interspersion makes it difficult to predict the fire regime for a particular forest patch, as it may be equally or more influenced by the spread of fire from adjacent vegetation (Taylor and Skinner 1998).

Historically, the natural fire disturbance regime in this region was highly variable in terms of fire frequency, severity, and spatial pattern. The most recently recorded and mapped fires in the region (11 separate fires since 1940) illustrate this. Some of these earlier fires were quite small (<100 ac) and burned at low severity, while others (e.g., Silver Fire of 1987) burned over a much larger area and with mixed severity (Harma and Morrison 2003). In a mixed-severity fire regime, fires burn primarily on the ground, in the canopy, or some combination of these depending on weather, fuels, and topography. The result is a mosaic of stands that are unburned or burned at low, moderate, or high severity (Frost and Odion 2002). This variability is believed to be a critical aspect of long-term ecosystem dynamics and function, and an important factor in defining the region's globally outstanding levels of biodiversity (Martin and Sapsis 1992). Ecologically, large stand-replacing fires, which results from canopy fires and hot and lethal sub-canopy fires, are an important source of landscape heterogeneity and play a pivotal role in the population structure, genetics, and evolution of some important species such as long-lived clonal plants (Turner et al. 2003).

Mounting scientific evidence suggests that in forests impacted by natural stand-replacing fire events, it is neither operationally or ecologically feasible to either exclude fire or impose an understory fire regime (Romme et al. In Press). In such systems, human interventions such as low-intensity prescribed fire and mechanical thinning to restore natural fire dynamics are largely inappropriate (Turner et al. 2003). However, in the Biscuit area, particular fire management treatments can be successfully applied to protect local communities to a degree. In areas with histories of natural stand-replacing fires, regional fire management plans must accept and incorporate large, severe infrequent fires throughout much of the landscape (Romme et al. In

Press). Management may be able to influence only the timing and intensity (under some weather conditions) of future wildfires in these regions (DellaSala et alIn Review).

Fire Fuels

There are no scientific studies that document a reduction in fire intensity in a stand that had previously burned and then logged (McIvar and Starr 2000). In fact, the few studies that have looked at this question have shown the opposite to be true.

The only known scientific literature reviews of the topic of salvage and fuels reduction (Beschta 1995, McIvar and Starr 2000) conclude there is no scientific evidence that salvage logging decreases the intensity of future fires on burned sites. Claims that removal of dead and dying trees are the main opportunity to reduce risk of recurring fires are unsubstantiated. Fire intensity and behavior, which have been empirically studied (Moritz 2003) and modeled (Turner & Romme 1994), are driven by three main factors: weather, terrain, and fuels, with weather always trumping the other two. No matter the terrain and fuels situation, if it is hot, dry, and windy enough, wildfires will burn with great intensity. Fuels that are consumed in a fire and contribute most to the burn severity are primarily the fine fuels. The contribution from large trees (>15 inches DBH) is almost negligible (Brown et al. in press) as they burn only when finer fuels are sufficient enough to ignite and sustain the flames. Large wood also burns mainly by smoldering combustion, which does not figure prominently into fire intensity calculations (Borchert and Odion 1995).

Figure 2. Stem remains after Biscuit burn in old growth conifer area. [Photo: USDA Forest Service]

After fire, the remaining dead stems begin to decay. Standing trees eventually fall with smaller diameter trees falling sooner than larger ones. Regardless of their size, by the time most standing trees fall, they have already lost their fine fuel component, made up of needles, twigs, and small limbs (Raphael and Morrison 1987). Larger trees can remain standing for as much as 30-80 years depending on the species (e.g., Figure 2; Everett et al. 1999) and are not likely to burn intensely in future events. However, these are the very stands highly prized for salvage logging. If reducing future fire intensity and severity is the desired management outcome for a region, fire management needs to concentrate on reducing fine fuels rather than on the removal of large wood through salvage logging.

Salvage does not reduce the incidence or severity of wildfires, but it has been shown that salvage can do the opposite. The treetops and branches left untreated after logging, can lead to increased fire severity (Weatherspoon and Skinner 1995). Combustible fine fuels were reported to increase between 3-13 tons per hectare in Oregon following salvage logging without slash treatment (Duncan 2002). Heavy logging slash (i.e., fuel model 13 of the National Fire Danger Rating System) is particularly problematic for potential future fires since it has been shown to generate the highest fireline intensity of anywildland fuel type when it is dry and windy (Andrews and Rothermel 1982). The usual treatment of salvage slash (burning) is not without its own ecological costs. For example, Grifantini et al. (1991) reported significant changes in future plant succession as the result of broadcast or slash burning.

Natural Succession After Fire or Plantations

Proponents of aggressive salvage logging followed by intensive silvicultural treatments of herbicides and conifer planting argue this alternative is necessary to prevent against future high-intensity fires and to reestablish conifer forests. Existing evidence runs counter to both arguments.

Even aged conifer plantations are more prone to higher intensity and severity of fire compared to natural forests.

Widespread conifer planting after any disturbance results in even-aged stands of trees that are usually closely spaced. This array of same age trees makes the stands prone to higher fire intensity and severity compared to natural forests because the fuels are available in combustible form over a wide area (Weatherspoon and Skinner 1995, Weatherspoon 1996, Sapsis and Brandow 1997, and Odion et al. In Review). Examining the spatial pattern of the 1987 fires in neighboring Klamath National Forest, Odion et al. (In Review) found that tree plantations had twice as much crown fire as the closed natural forest. Supporting this finding, Key (2000) analyzed patterns of severity after the 1994 Dillon Fire (inside this study area) and found that plantations and adjacent vegetation burned more severely than unlogged forests.

Natural conifer establishment requires favorable soil conditions, available nutrients, and a seed source. Seedlings depend upon the natural heterogeneity of the forest landscape, which provide “safe sites” (sites relatively safe from future high intensity fire over the short term) where seedlings can survive future fires when they are young and vulnerable (Russell et al. 1998, Keeley and Stephenson 2000). Plantations lack landscape heterogeneity and safe sites, and once a threshold proportion of even-aged plantations are established in the landscape, there is potential for a self-reinforcing cycle of stand replacing fire over a broader landscape area (Perry 1995).

Salvage logging proponents state planting is required to recover forest in a timely fashion in part because potential seed trees are so far removed from the burn areas where mortality was heavy. Studying the aftermath of the Yellowstone fires of 1988, Turner et al. (1994) found the majority of severely burned areas were within 50-200 m of unburned or lightly burned areas, suggesting that few severely burned sites were very distant from potential sources of propagules. In the Yellowstone region, fires also played an unexpected role in the establishment of new aspen clones, and as the authors point out, would never have been recognized had the area been quickly salvaged (Turner et al. 2003).

For the Biscuit Fire, we examined the distance from the most changed areas to the nearest potential natural seed source. First, the vegetation change data layer was converted to a cell-based (grid) file with a resolution of 30 m. Merging all moderate-high vegetation change cells into one group (covering 206,890 total acres) and all other change classes into another, we applied a Euclidean distance function to determine the distance from every moderate-highly disturbed cell to the nearest cell classed as little or no change. The resulting distance ranged from 30 m (artifact of the file resolution) to 1,050 m with a mean of 113 m. A total of 131,101 ac (63.4%) were within 100 m of a potential seed source and 173,600 ac (84%) within 200 m. These results are very much aligned with the results from the Yellowstone Fires of 1988 even though the fires occurred in different forest types. Claims for the need for widespread planting are simply not consistent with these results.

Hypothesis #2: Salvage logging followed by herbicide use and conifer replanting reduces aggressive native shrubs and hardwoods along with invasive weeds.

Natural post-fire recovery is generally rapid with no harmful consequences; therefore, active post-fire restoration of any kind is generally not needed, and may even be counter-productive).

Salvage logging and subsequent silvicultural management can significantly reduce the establishment of native shrubs and hardwoods; however, this is usually not a positive impact for biodiversity of natural forests. Natural forests have evolved recovery mechanisms after major disturbances including the rapid resprout and regeneration of shrubs, hardwoods, and herbaceous plants (see Figure 3). Natural recovery after fire requires the establishment of many different species that interact over space and time, shaping the forest landscape until the next fire event. These plants serve many important ecological functions. Rapid regrowth of these species helps (1) stabilize soils preventing erosion; (2) protect the soil from direct solar radiation; (3) increase soil moisture; (4) generate needed organic matter; and (5) provide important habitat for many native species of vertebrates and invertebrates. Some shrub species such as *Ceanothus spp.*, relying on seed survival after fire, fix nitrogen that helps restore soil productivity (Delwiche et al. 1965, Conard et al. 1985). Other shrub species like *Arctostaphylos* facilitate the maintenance of soil mycorrhizae, which is fundamentally important for conifer growth (Horton et al. 1999, Bode 1999).

Initially after fire, shrubs and hardwoods are generally better competitors than regenerating conifers (Stein 1986, Walstad et al. 1987) leading some to advocate for human intervention with the use of herbicide control and mass conifer seeding or planting. This may result in short-term gains in conifer growth, but at significant ecological and economic cost. By bypassing the natural early successional stage of a post-fire environment, managers reduce species richness and risk sacrificing long-term soil quality. Research has shown that despite slower initial conifer growth when in competition with shrubs higher conifer growth rates can result over time (Conard et al. 1985, Busse 2000). Therefore, controlling shrubs and hardwoods to speed up conifer regeneration is not only ecologically unwise but also unnecessary for old growth habitat restoration.

The removal of downed logs and snags through salvage logging increases the density of many of the early successional shrubs and hardwoods, because the ground is exposed to more sunlight. By creating large patches of disturbed soil, salvage logging also encourages the establishment of invasive exotic species relative to post-fire unlogged sites (Greenberg et al. 1994). In a study by Sexton (1994) on the Winema National Forest, salvage logging was shown to reduce overall vegetation biomass, increase invasive exotics, increase graminoid cover, and reduce overall plant species richness.

Figure 3. Resprout of sadler oak (*Quercus sadleriana*). [Photo: USDA Forest Service]

These effects are not trivial since natural post-fire habitat and regenerative processes that occurred previously in evolutionary history are now rare (Lindenmayer and Franklin 2002). Furthermore, southwestern Oregon is understood by most forest practitioners to be an extremely difficult environment to engineer silviculturally. The expansion of these efforts through extensive management including widespread herbicide treatments, road construction or modification, and planting of conifer nursery stock is fraught with considerable ecological risk and substantial economic investment.

Hypothesis #3: Salvage logging benefits wildlife.

Any natural disturbance event or management action (e.g., logging) favors some species at the expense of others. The argument that salvage logging enhances old growth dependent species is totally unsubstantiated and likely false under most environmental settings.

Any natural disturbance event or management action (e.g., logging) favors some species at the expense of others. The Biscuit Fire, which from all early indicators was not outside its range of natural variability, altered the largely unmanaged forest landscape in a very heterogeneous fashion. Populations of some species will increase dramatically, some will be suppressed for a time, and others will remain relatively unchanged. Of the 34 wildlife species of concern according to the Siskiyou National Forest management plan, the Biscuit Fire impacted 25 species in some way (Table 6). According to comments by the recovery team, most of the species will experience no long-term declines and many will even show substantial increases if natural recovery is permitted (Figure 4).

Table 6. List of species of concern by the U.S. Forest Service found within the Biscuit Fire burn perimeter with post-fire assessment team comments. [Source: USDA Forest Service 2003].

Common Name **Scientific Name**	**Comments**
Del Norte salamander Plethodon elongatus	Most survived, reduced veg canopy cover
Southern torrent salamander Rhyacotriton variegatus	Most survived, reduced veg canopy cover
Foothill yellow-legged frog Rana boylii	Most survived, reduced veg canopy cover
Western pond turtle Clemmys marmorata	Most, if not all, survived, habitat not affected
Common kingsnake Lampropeltis getula	Most survived, habitat will increase
Marbled murrelet Brachyramphus marmoratus	Most of fire not within range of the species
Northern spotted owl Strix occidentalis	Most survived, much nesting habitat lost
Peregrine falcon Falco peregrinus	No effect from fire, prey base may increase
Bald eagle Haliaeetus leucocephalus	No effect from fire, nest habitat may increase
Osprey Pandion haliaetus	No effect from fire, nest habitat will increase
Acorn woodpecker Melanerpes formicivorus	Greater amount of snag feeding/nesting habitat
Red-breasted sapsucker Sphyrapicus ruber	Greater amount of snag feeding/nesting habitat
Downy woodpecker Picoides pubescens	Greater amount of snag feeding/nesting habitat
Hairy woodpecker Picoides villosus	Greater amount of snag feeding/nesting habitat
White-headed woodpecker Picoides albolarvatus	Greater amount of snag feeding/nesting habitat
Northern flicker Colaptes auratus	Greater amount of snag feeding/nesting habitat
Pileated woodpecker Dryocopus pileatus	Greater amount of snag feeding/nesting habitat
Townsend's big-eared bat Plecotus townsendii	No effect to roosting habitat, caves, buildings
Long-legged myotis Myotis volans	Nests in caves, buildings, and snags (loss of snags)
Red tree vole Arborimus longicaudus	Some nests destroyed by fire, smoke effects
Roosevelt elk	More forage habitat in fire area = greater population

Cervus elaphus roosevelti	
Columbian black-tailed deer Odocoileus hemionus columbianus	More forage habitat in fire area = greater population
Marten Martes americana	Reduction of habitat capability in fire area
Wolverine Gulo gulo	May not be present in Fire area, neutral effect
Fisher Martes pennanti	Reduction of habitat capability in Fire area

Figure 4. Columbia black-tailed deer standing in old growth burn area of the Biscuit Fire will likely increase in abundance with the increase of forage. [Photo: USDA Forest Service]

Salvage logging always leads to changes in species composition (Blake 1982, Haim and Izhaki 1994). Species that prefer even-aged conifer stands (a common habitat type throughout Oregon) will undoubtedly benefit, but species that capitalize on a post-fire environment or sensitive to further structural changes will be harmed. Downed logs and standing dead wood are important to a wide range of vertebrates and invertebrate species (McComb and Lindenmayer 1999), many of which will likely be negatively impacted, some significantly, by the removal of these structures (or biological legacies). For example, species sensitive to maintenance of moist microsites such as salamanders would be severely affected due to increased solar radiation and the further drying of soils. Removal of snags would also negatively impact species like marten and fisher. These predators already suffered some habitat loss due to the fire, and the removal of the remaining structure, which helps support many small mammal populations within a vegetation structure that these predators utilize, worsens their ability to maintain viable populations.

Salvage logging has been shown to significantly reduce the abundance and nest density of cavity-nesting birds in four independent studies in the Intermountain West (Caton 1996, Hitchcox 1996, Hejl and McFadzen 1998, Saab and Dudley 1998). Most cavity-nesting bird species showed consistent patterns of decline after salvage logging, while only one species, Lewis' woodpecker (*Melanerpes lewis*), increased after logging. Most cavity nesting birds are insectivorous, so the removal of nesting and foraging habitat through salvage logging will reduce the natural regulation of post-fire insect outbreaks by cavity nesting birds (Torgersen et al. 1990). Seven cavity-nesting insectivores that appear on the Siskiyou National Forest species of concern

list would be negatively impacted by salvage logging at a time when higher populations of these species can help offset postfire insect outbreaks.
At the landscape level, wildfire creates a spatial heterogeneity that is attractive to many species (Hutto 1995). In order to maintain healthy metapopulations of many of these species, it is important to manage postfire patches with great care (McIvar and Starr 2000). Widespread salvage logging simplifies the landscape similar to green tree clearcutting.

Northern Spotted Owl

Of all the species of concern impacted by the Biscuit Fire, the Forest Service has the most data on the northern spotted owl. Of the 202 known owl activity centers on the Siskiyou National Forest, 49 (24%) were totaling or partially inside the Biscuit Fire burn perimeter. There are nine northern spotted owl Critical Habitat Units (CHU) in the Siskiyou National Forest of which 242,417 ac are allocated as Late Successional Reserves (LSRs). The Biscuit Fire impacted 67,540 ac of the LSR area (USDA Forest Service 2003). The Biscuit Fire reduced the suitable habitat for northern spotted owl in the region. It is too early to tell how the regional owl population will respond to the loss of suitable habitat, but the habitat will return to its former desirability for this species through natural revegetation and plant succession. Northern spotted owls are most often associated with multi-layered older forests (>80 years) that contain some large dead or dying trees (Bart and Forsman 1992) although they will utilize a variety of forest habitats to meet their life history needs. The key to recovering northern spotted owl habitat quickly is to retain the larger dead and surviving trees post-fire. Salvage logging followed by conifer planting will not recover northern spotted owl habitat quickly because it removes the important structural elements upon which the owls depend. If the salvage operation is complete (removal of all large trees), it will actually have the opposite affect.

Hypothesis #4: Salvage logging adds minimally to soil erosion.

Soil productivity is irreplaceable in human timescales; therefore, post-fire management actions must proceed with great caution to avoid increasing erosion or damaging the soils.

High severity wildfire causes predictable changes in soil characteristics and vegetation structure that can often lead to serious erosion problems (Durgin 1985, and DeBanao 1991). In extreme cases, water infiltration of the soils can be retarded by fire-induced effects and decreased evapotranspiration with the extensive vegetation kill (Mackay and Cornish 1982). Conventional ground-based salvage logging (including road construction and reconstruction), especially in stands having steep slopes or unstable soils likely will have the greatest potential for exacerbating the erosional problems routinely observed in burn areas (McIvar and Starr 2000). Logging slash can help decrease erosion by impeding overland flows (Shakesby et al. 1996), but this practice has an undesirable side effect of increasing fine surface fuels. Soil productivity is irreplaceable in human timescales; therefore, post-fire management actions must proceed with great caution to avoid increasing erosion or damaging the soils (Beschta et al. 1995).

These effects are particularly important with regard to aquatic integrity since some aquatic organisms are sensitive to high sedimentation levels. All riparian areas are important, and those that sustained high burn severities (Figure 5) should be managed very carefully. This is particularly true for the identified key watersheds within the burn perimeter including Indigo Creek, Illinois River/Lawson Creek, Silver Creek, and the North Fork of the Smith River.

Figure 5. High intensity burn site of the Biscuit in a riparian area. [Photo: USDA Forest Service]

While ground-based salvage logging can take some effective actions to mitigate erosion under certain conditions, it is more likely that salvage logging will have no effect or produce more sediment than produced by the fire alone (McIvar and Starr 2000). As McIvar and Starr (2000) conclude, "More importantly, we do not know how site-specific effects accumulate over watersheds, and this knowledge is essential if forest management is to be linked to aquatic integrity."

Administrative, Operational, and Ecological Constraints to Post-fire Management of the Biscuit Fire in the Siskiyou National Forest

After almost every major fire disturbance on unprotected public lands, the timber industry and others lobby vigorously for aggressive salvage. Frequently the arguments are economic although full cost accounting has demonstrated in many cases that the financial gains are rarely kept locally, insufficient dollars go to the management agency for other restoration activities, and the U.S. taxpayer pays substantially into the venture (Niemi 2003). More recently, these same interests have tried to defend aggressive salvage logging and replanting of conifers on numerous ecological grounds, but as this previous review demonstrates, the overwhelming scientific evidence does not substantiate these claims. The most ecologically responsible decision-making would take into account the natural setting of the proposed action, avoid sensitive areas altogether, and operate with great caution on the rest.

Two questions remain. If salvage logging is found to be desirable on economic grounds –

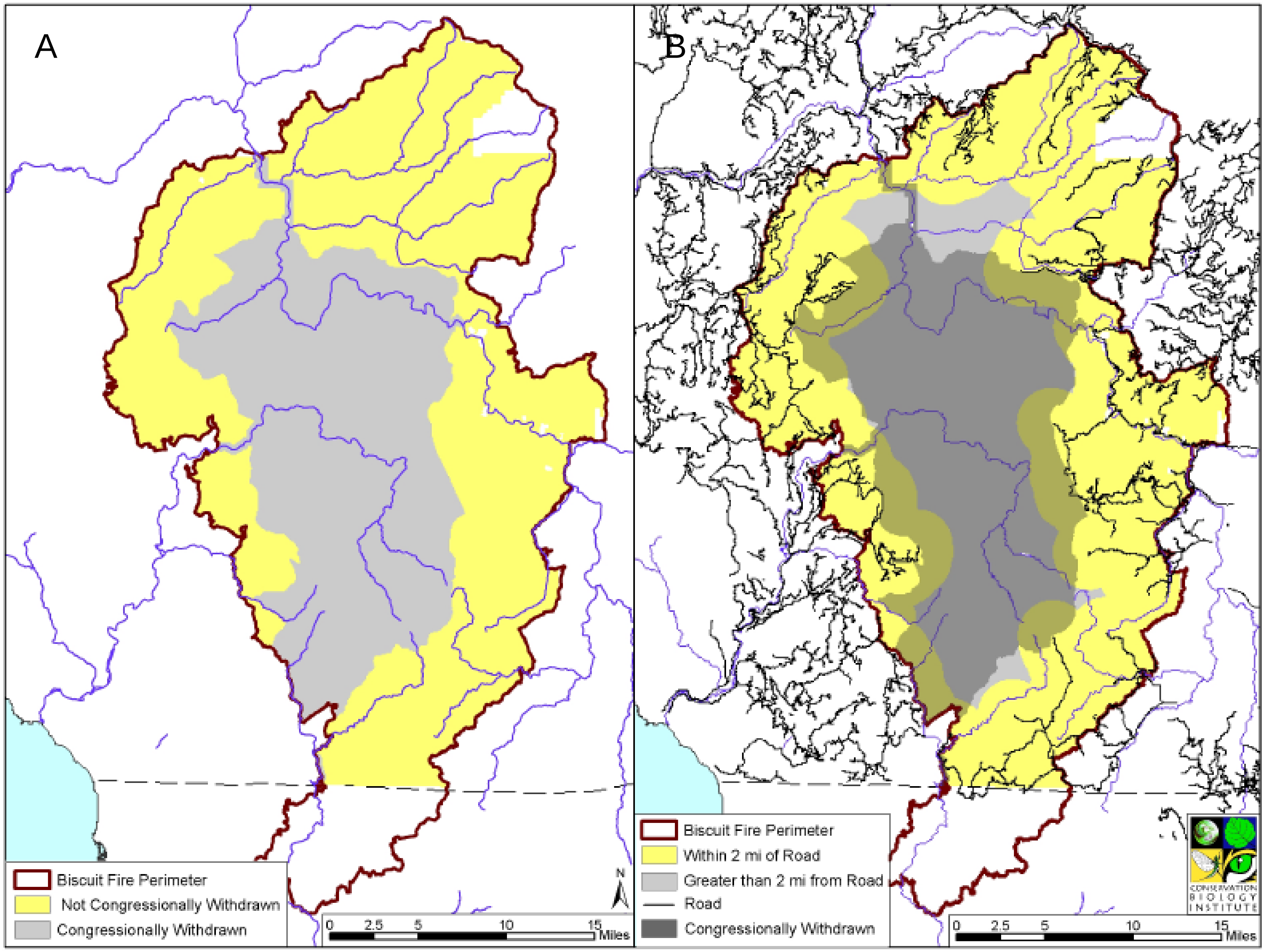
1. What are the administrative, operational, and ecological constraints of proposed salvage logging?
2. On the remaining area, what management guidelines should be used to implement salvage logging in order to minimize ecological damage?

The remainder of this report addresses these two questions as they pertain to the Biscuit Fire in the Siskiyou National Forest.

Administrative and Operational Constraints

Approximately 40 percent (181,845 ac) of the Biscuit Fire took place on congressionally withdrawn land (Map 5A), including the Kalmiopsis Wilderness (MA 1 in the management plan) and Wild River designations (MA 2 lands). Law does not permit salvage logging in these areas, which is a substantial administrative constraint in this situation. According to the Siskiyou National Forest management plan, Research Natural Areas (MA 3), of which 1,284 ac were involved in the fire, are also administratively excluded from any proposed salvage activity.

In addition, there are three major operational constraints that have been proposed by even the most aggressive salvage logging proponents. The first is an access issue. Potential salvage stands greater than 2 miles away from an existing road are not operationally viable. A simple buffer of the existing road system clearly shows how much of the burn area is eliminated due to this particular operational constraint (Map 5B).



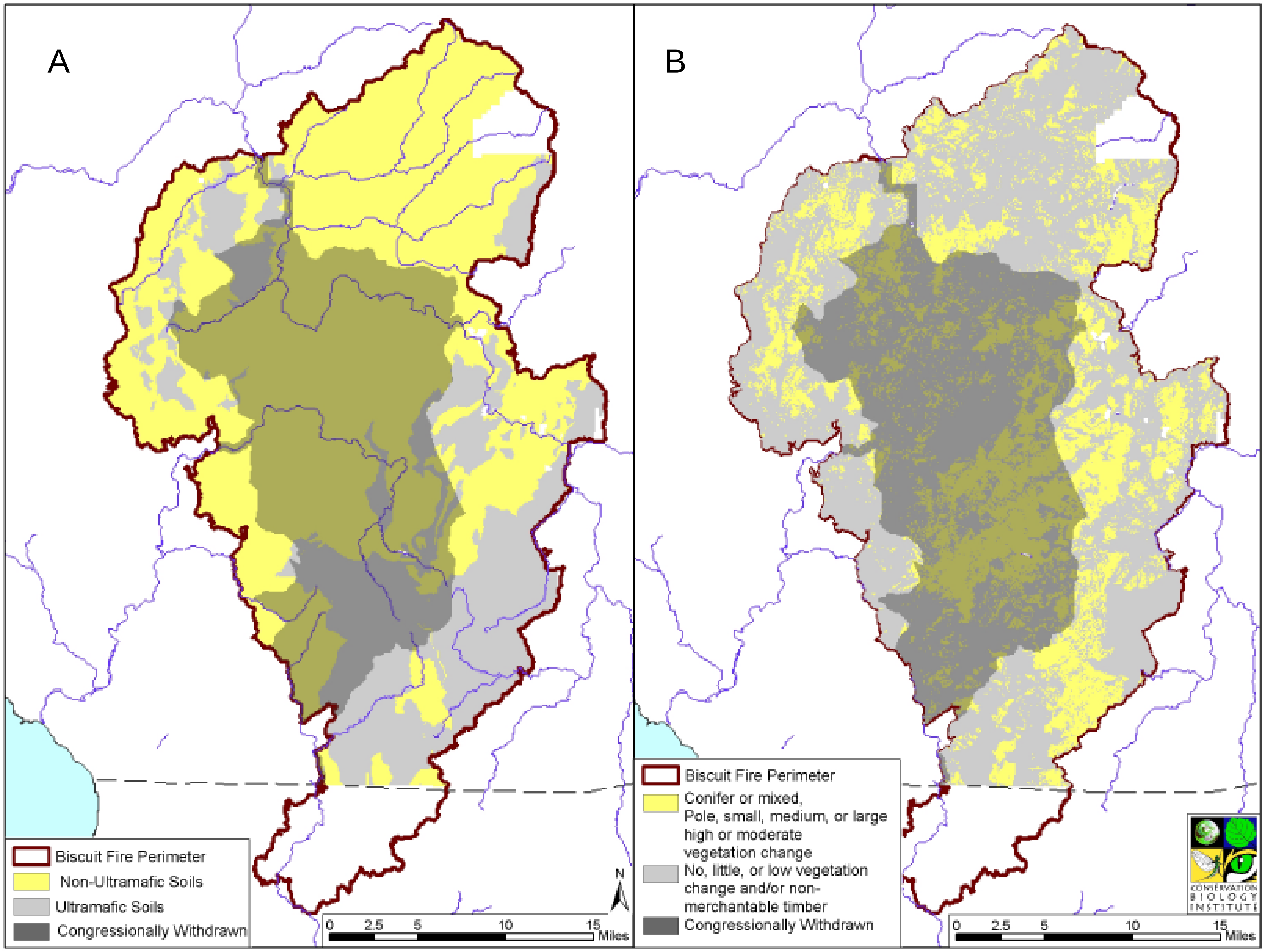
Map 5. Administrative exclusion from salvage logging (A) and exclusion of potential salvage opportunities based on distance from roads (B).

The second operational constraint, which is also an ecological one, is to exclude ultramafic (serpentine)-derived soils from potential salvage logging. Serpentine soils are widespread throughout the region and particularly well represented in a major portion of the burn area (Map 6A). These soils are deficient in exchangeable calcium (an essential element for plant growth and development) and contain high levels of magnesium. There are several other essential elements for plants that are deficient in these soils including nitrogen, phosphorous, and potassium. Soil pH values range from 6.5 - 7.5. In addition, serpentine soils contain high concentrations of toxic heavy metals including nickel, chromium and cobalt (Coleman and Kruckeburg 1999). While many plant species cannot tolerate the harsh nature of serpentine soils, some species have evolved competitive advantages. Jeffrey pine (*Pinus jeffreyi*) savanna is one signature plant community type found on serpentine soils in the Klamath-Siskiyou. Associated with Jeffrey pine are numerous shrubs (e.g., *Ceanothus*, *Arcostaphylos*, and *Lithocarpus*) and numerous herbaceous species. Serpentine communities are also high centers of species endemism. Succession of Jeffrey pine savannas following wildfire is very rapid and restorative (Jimerson et al. 1995). Salvage logging generally ignores serpentine sites for the same reason regular, green tree logging plans do – the trees are simply too scattered and/or stunted to make the operation economically viable. Soils tend to be shallow and erosive adding to the risk of additional environmental problems and expense to the logging operation in attempts to minimize the damage. Most serpentine areas in the ecoregion are not intentionally protected; rather, they are generally protected out of benign neglect (Coleman and Kruckeburg 1999).

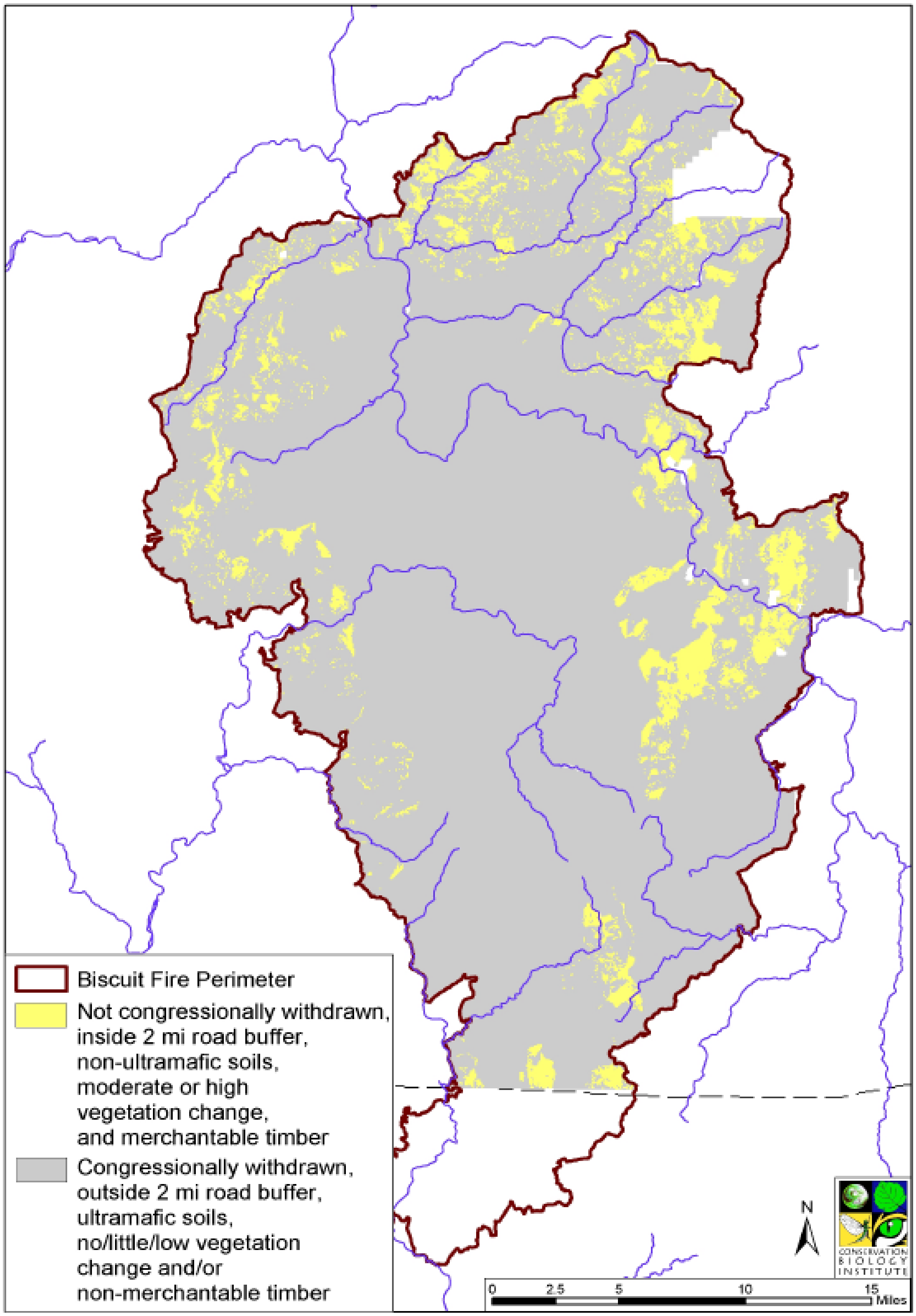
Serpentine soils within the Biscuit Fire perimeter are largely expressed in two different soil series – Oragran-Jayel-Walnett and Pearsoll-Dubakella-Cornutt. Soils mapping for this region is relatively coarse, but examining these spatially explicit data provide us with this second operational constraining filter (Map 6A). The total number of acres of serpentine soils within the Biscuit Fire perimeter was 137,104.

The final operational constraint is merchantable timber as defined by conifer and mixed wood stands with trees size >9 inches that experienced high mortality percentages. There are currently two different ways to map mortality resulting in different results. Using the canopy mortality data (>50%) as shown in Map 1B, the amount of total merchantable timber within the Biscuit Fire perimeter was 345,754 ac. Using the moderate and high change categories of the vegetation change data layer in conifer and mixed wood stands >9 inches (Map 2), the total area of non-merchantable timber drops to 316,782 ac (Map 6B). Since the vegetation change data layer is believed to be more reliable (McHugh, pers. comm.), we applied the second method in the modeling exercise.

The combination of these administrative and operational constraints results in a potential salvage area of 41,531 ac (Map 7). If we multiply total acres by the average timber volume (20,000 million board feet according to Forest Service estimates) we get the potential to cut over 830 million board feet from the Biscuit Fire within the Siskiyou National Forest. This is less than the 1.5 billion board feet reported by Sessions et al. (2003), who likely used the canopy mortality data for generating their estimate. For comparison, a total of 3.8 billion board feet of timber was cut from all lands in Oregon in 2002.



Map 6. Ultramafic soils (A) and merchantable timber based on moderate to high vegetation change of conifer or mixed stands > 9 inches (B).



Map 7. Potential salvage opportunities within the Siskiyou National Forest after administrative and operational constraints applied (yellow)

Of the 41,531 ac of potential salvage area, 27,327 ac (66%) are inside inventoried roadless areas. Potential salvage in other special management units within the existing forest plan highlight further sensitivity (Table 7). Proportions of each of these are contained in inventoried roadless areas, but considerable area remains outside roadless areas (14,204ac). Of the potential salvage area outside inventoried roadless areas, approximately 3,069 ac is within existing heavily managed areas (i.e., MA11 - MA14A).

Table 7. Land allocation (including inventoried roadless areas – IRA) for the Siskiyou National Forest within the potential salvage area after administrative and operational constraints applied.

Land Allocation	Area (ac) Inside IRA	Area (ac) Outside IRA	Area (ac) Total
MA 3 – Research Natural Areas	482	0	482
MA 4 – Botanical Areas	659	337	996
MA 5 – Unique Interest	231	17	248
MA 6 – Backcountry Recreation	5,307	750	6,057
MA 7 – Supplemental Resource	446	265	711
MA 8 – Late Successional Reserves	15,278	9,217	24,495
MA 9 – Special Wildlife Sites	318	343	661
MA 10 – Scenic / Recreational Rivers	11	208	219
MA 11 – Riparian Reserves	773	472	1,245
MA 12 – Retention Visual	189	154	344
MA 13 – Partial Retention Visual	651	386	1,037
MA 14 – Matrix	2,966	2,057	5,023
MA 14A – Administrative Study Area	15	0	15
Totals	27,327	14,204	41,531

If the most aggressive salvage proposal were implemented, the total amount of land recruited into intensive silvicultural development would be as much as 38,462 ac including 27,327 ac of roadless area and 11,135 ac of other special management lands outside of IRAs.

Additional Administrative and Ecological Constraints

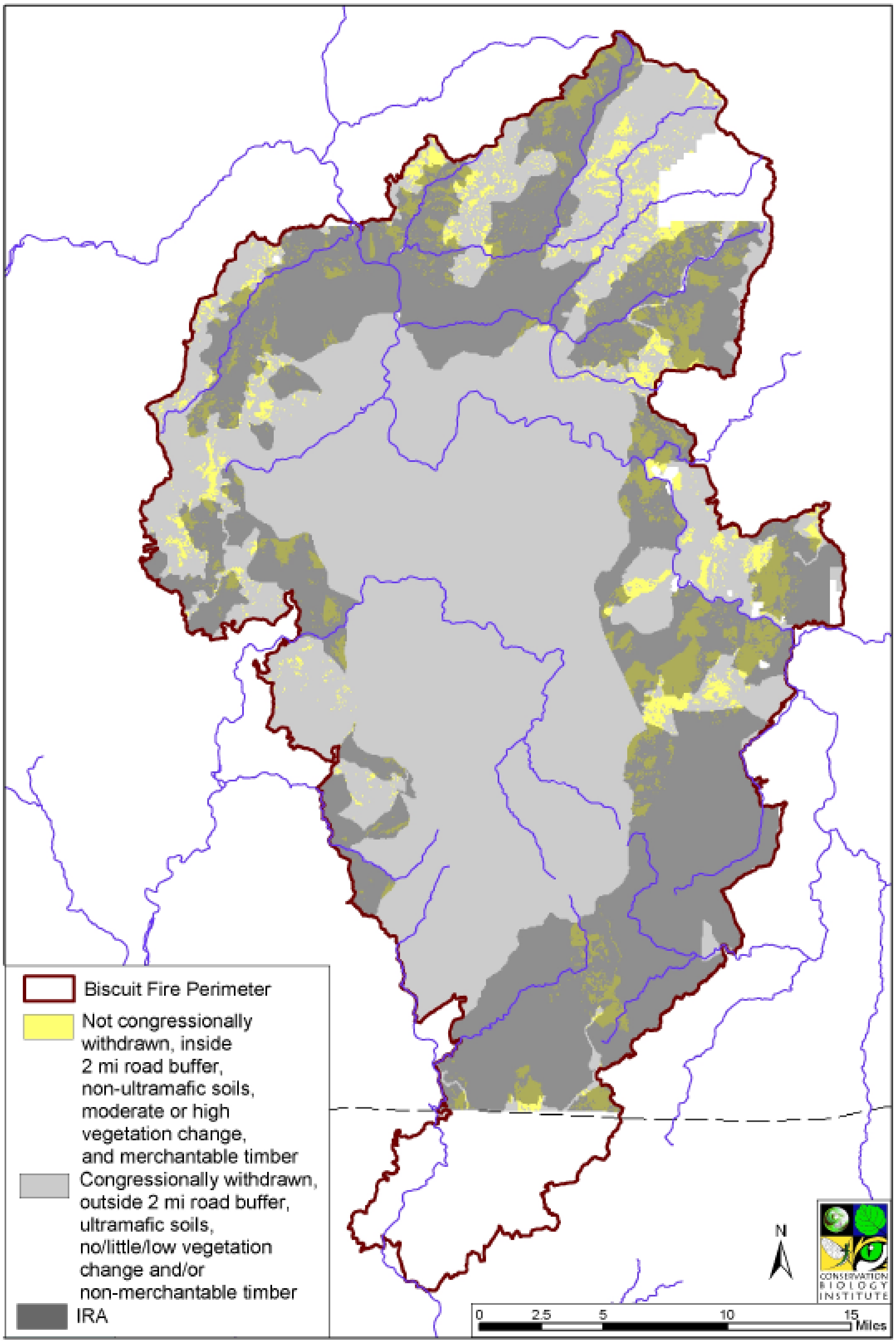
The single largest constraint, which is both administrative and ecological, is the exclusion of inventoried roadless areas (IRAs) from salvage logging consideration. The expressed intent of the Roadless Rule was to maintain wildland qualities on the last remaining substantially large areas within the national forest system. The rule was enacted after an extensive public comment period and 600 open meetings around the nation resulted in an unprecedented 1.6 million comments – overwhelmingly in favor of the rule – from citizens demanding that the degradation of environmentally sensitive roadless areas be halted.

The policy prohibits the cutting, sale, and removal of timber except under special circumstances, which include:

- For the cutting, sale, or removal of generally small diameter trees which maintains or improves roadless characteristics and:
    - To improve habitat for threatened, endangered, proposed, or sensitive species, or
    - To maintain or restore ecosystem composition and structure, such as reducing the risk of uncharacteristic wildfire effects.
- When incidental to the accomplishment of a management activity not otherwise prohibited by this rule.
- For personal or administrative use.
- Where roadless characteristics have been substantially altered in a portion of an inventoried roadless area due to the construction of a classified road and subsequent timber harvest occurring after the area was designated an inventoried roadless area and prior to the publication date of this rule (USDA Forest Service 2001).

None of these exceptions apply to the postfire environment of the Biscuit Fire. Some might argue that intensive management is needed to restore the ecosystem composition and structure and therefore reducing the risk of uncharacteristic wildfire. The key term is "uncharacteristic wildfire", which does not apply to the Biscuit Fire since it burned within its natural range of variability. Of all the areas within the forest management system, roadless areas are the least likely places where historic fire regimes have been altered by fire suppression (Beschta et al. 1995, Agee 1997).

Much of the remaining 58 million acres of IRAs scattered throughout the national forest system is not found on the most productive sites. In fact, these areas were still roadless during the time the roadless maps were generated (1970s and 1980s) because they contained lower timber values compared to neighboring sites and/or were difficult to access. Forests in roadless areas tend to be in the best ecological condition and the most vulnerable to damage from salvage logging (TWS/NAS 1996). IRAs provide many ecological amenities (DeVelice and Martin 2001), but their overall contribution to regional conservation varies significantly from region to region. The roadless areas of the Klamath-Siskiyou ecoregion and especially within the Biscuit Fire perimeter were found to be particularly important, containing many different conservation attributes including high concentrations of rare species and highly complimentary vegetation representaion (Strittholt and DellaSala 2001 and DellaSala and Strittholt 2002). Exposing these areas to salvage logging and follow-up silvicultural manipulation will undoubtedly damage these areas ecologically and, perhaps more importantly from a policy standpoint, will directly challenge the Roadless Rule, which continues to be reevaluated and contested in the courts. The exclusion of IRAs from the potential salvage composite results in the removal of 27,327 ac (Map 8), reducing the total potential salvage area to 14,204 ac.



Map 8. Potential salvage opportunities within the Siskiyou National Forest after administrative and operational constraints (yellow) applied with overlay of IRAs (shown as additional administrative exclusion).

The final ecological constraint is slope. The greater the slope, the more difficult it is to salvage, and the greater the risk of landslides and overall erosion damage. According to Oregon Department of Forestry, logging of steep slopes (>60%) should be avoided. In addition, slopes from 40-60% require careful management treatment to avoid serious and damaging outcomes. Within the potential salvage area, after removing the IRAs, 4,598 ac were found with slopes between 40 and 60 percent and 3,034 ac >60 percent slope (Map 9). The final potential salvage logging composite map, with areas >60 percent slope removed from consideration, totaled 11,170 ac (Map 10). If all of this area were fully salvaged using a 20,000 million board feet per acre multiplication factor, the total potential salvage timber volume would be approximately 223 million board feet.

Salvage Logging Management Options

The remaining 11,170 ac is the maximum potential salvage area on the Siskiyou National Forest using all of the filters we imposed. According to existing forest management guidelines, salvage logging is not prohibited from any of this area categorically, but extreme caution or outright exclusion would be the most appropriate action on the special management designations (e.g., Botanical Areas) identified in the current forest plan. The total area of these sensitive lands (including MA4, MA5, MA6, MA7, MA9, and MA10 management designations) was 1,411 ac.

Additional cautions are warranted on lands designated as Late Successional Reserve (LSR), which makes up the majority of the potential salvage area (7,136 ac). The intent of these lands is to promote older forest characteristics, and as explained in section two, the retention of legacy elements is extremely important over all lands, but especially on these special designations. Logging of the largest tree sizes in LSRs runs counter to the recovery of these sites as late successional. Aggressive salvage followed by herbicide treatment and conifer planting, as proposed by Sessions et al. (2003) guarantees an even-aged conifer plantation not a late successional forest. Late successional characteristics will be achieved faster with minimal salvage, leaving considerable amounts of the large woody structure in place (dead and green), with possible augmentation of strategic planting of selected species (e.g., Port-Orford-cedar along streams). Wherever salvage logging is carried out, care must be taken not to damage soils, degrade aquatic integrity, and introduce invasive species to uninfected areas.

Map 11 highlights three different precautionary zones consistent with existing management plans and the available scientific evidence. The red areas include land allocations outside inventoried roadless areas that belong to recognized sensitive land allocations (MA4, MA5, MA6, MA7, MA9, and MA10) totaling 1,411 ac. It is assumed that little or no salvage logging will take place in this zone. The orange area highlights LSRs (7,136 ac), and although not identified as requiring special management in a post-fire setting by the existing management plan, greater emphasis toward retaining important biological legacies is warranted over much of this area. The final yellow color (2,623 ac) includes those land allocations that require less restrictive post-fire salvage logging and follow-up silvicultural treatment (MA11, MA12, MA13, and MA14).

Because of the global importance of this region, salvage should error on the side of caution. Following the management recommendations provided byBeschta et al. (1995) is a reasonable operating position and considerable effort should be made to monitor the impacts on a wide range of environmental components. It is difficult to say what the final salvage timber volumes will be if these warranted precautions are actively considered, but it is likely to be between 75 and 95 million board feet.

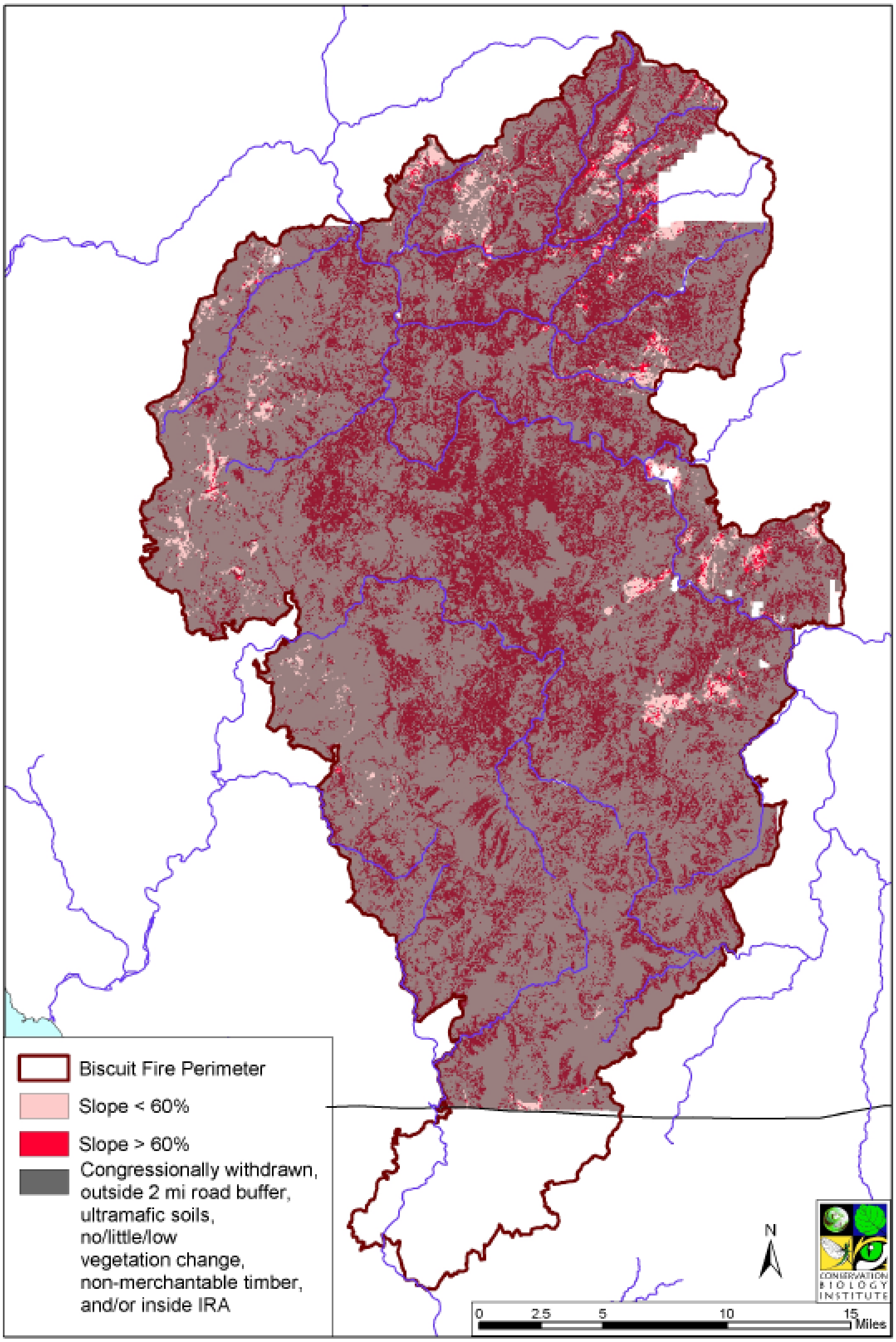
Conclusion

The Biscuit Fire was a large natural fire event that burned in the Klamath-Siskiyou ecoregion, a region of global biological significance. Any proposal to shift the region away from its natural vegetation pattern to heavily managed conifer plantations is grossly misguided from the outset because it fails to recognize the conservation values of a region that continues to be shaped and maintained by fire.

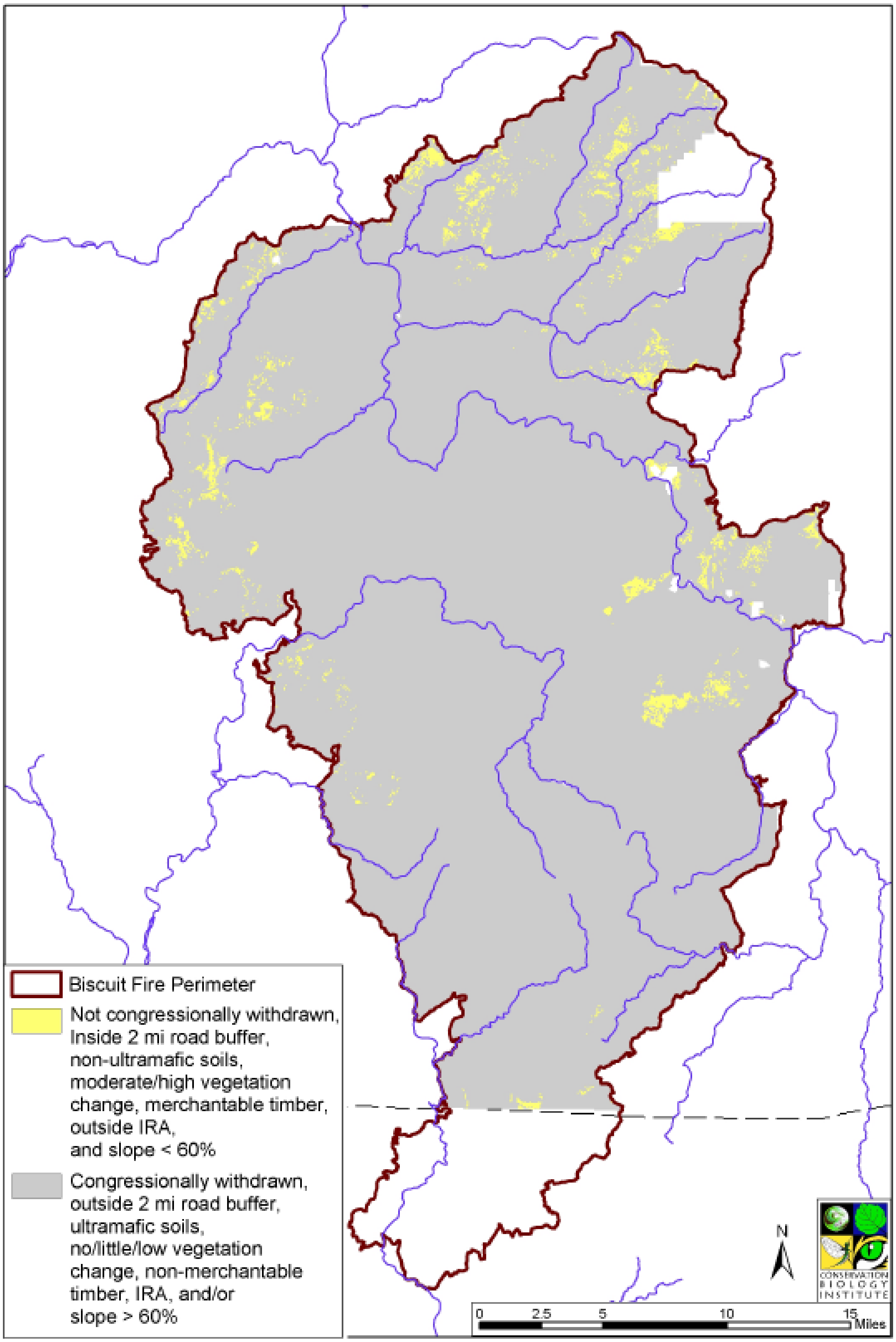
The preponderance of existing scientific evidence and our current ecological understanding shows absolutely no ecological rationale for aggressive post-fire management, especially salvage logging. Any contention that an immediate, and aggressive post-fire response is needed to protect forests is unfounded. The limited salvage logging research has shown the management practice to be at best benign, but more frequently damaging to biodiversity values and natural forest recovery, in some cases severely.

If a post-fire salvage logging plan, incorporating all administrative (including roadless areas), operational, and ecological constraints, can be demonstrated to be economically viable for the Biscuit area, our scientific understanding about the region's globally important ecological values and general forest ecology warrants extremely cautious and geographically constrained management response. Given the high risk of doing further damage, many scientists recommend limiting experimentalsilvicultural treatments to previously managed lands already impacted by logging and other uses (Henjum et la. 1994, Perry 1995, Beschta et al. 1995, DellaSala et al. 1995, McKelvey et al. 1996, Franklin et al. 1997,Hann et al. 1997, Aber et al. 2000). Restricted to existing heavily managed lands, salvage logging should be carried out as a carefully designed, replicated experiment. The experimental salvage experiment should emphasize stand as well as landscape level characteristics and processes and be carried out in cooperation with independent researchers.

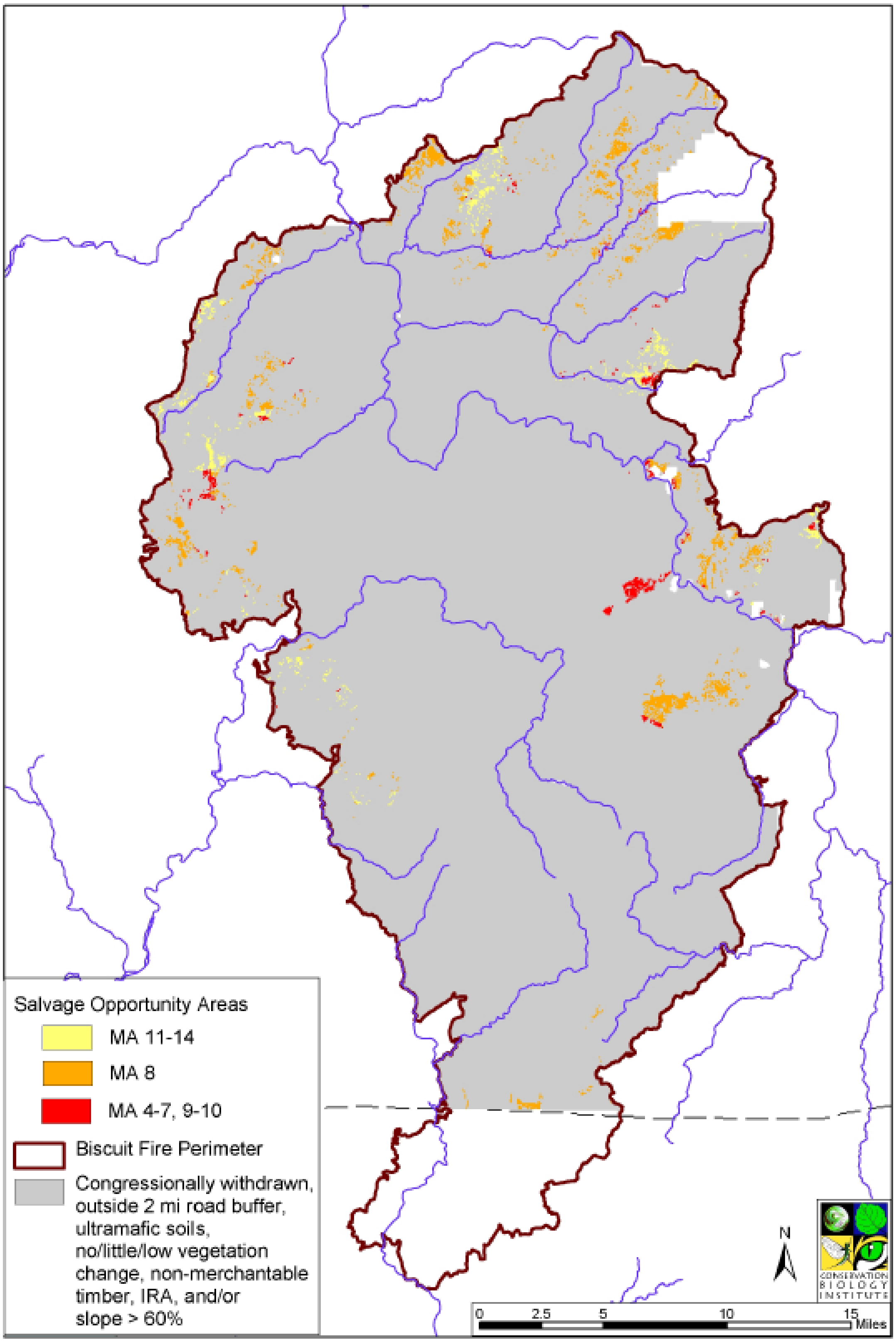
If Angermeier (1997) is correct and "successful restoration usually has less to do with skillful manipulation of ecosystems than it does with staying out of nature's way," then a more passive restoration approach may be the most effective for the Biscuit overall (Dale et al. 2000, DellaSala et al. 2003).



Map 9. Slope categories (pink and red) within potential salvage opportunity areas within the Siskiyou National Forest after administrative and operational constraints (slopes >60% in red and excluded).



Map 10. Final potential salvage opportunities within the Siskiyou National Forest (yellow) after administrative and operational constraints (including removal of IRAs and slopes >60%).



Map 11. Final potential salvage opportunities within the Siskiyou National Forest after administrative and operational constraints (including removal of IRAs and slopes >60%) showing three different caution zones.

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