Ecosystem-Based Management Treatments

Stephen F. Arno

The Need for Ecosystem Management

At Lick Creek, from 1906 until the 1980's carefully guided harvesting had selectively removed large trees, retaining vigorous ones but allowing unmerchantable small trees to proliferate. The small trees were occasionally thinned by hand, but this was expensive and generated hazardous slash fuels. In contrast, for hundreds if not thousands of years prior to 1900, frequent low-intensity fires had shaped the forest by killing most of the small trees and maintaining a low level of fuel loadings (Agee 1993; Arno and others 1995, 1997). Thus, the silvicultural activities evaluated by Gruell and others (1982) contrasted with the pre-1900 natural forest succession in having no counterpart or substitute for frequent low-intensity fires.

To understand why traditional forestry treatments failed to account for the ecological role of fires, we must recognize that the art and science of forestry was developed in a humid region—Prussia, Germany, and northern France—where fires were uncommon and were considered destructive and unnecessary. At the beginning of the 20th century, European concepts became the basis for forestry in the United States, where, however, forestry was being applied in environments where natural fires had a vital role in establishing and maintaining certain desirable forest conditions, as was initially recognized by Gifford Pinchot (1899). Nevertheless, wildfires, many of which were set by careless humans, had become a serious hazard. Thus, the fledgling forestry profession in the United States soon advocated eliminating fire in the forest.

By the mid-1900's, undesirable effects associated with exclusion of fire were becoming apparent in ponderosa pine ecosystems. The first forester to publish the case for restoring a semblance of the fire process in ponderosa pine was Harold Weaver (1943). By the 1970's and 1980's many National Forests were interested in integrating prescribed fire into ponderosa pine management, but this was not a simple matter of re-introducing natural fires. Fire could not be allowed to spread across millions of acres of public and private land as it had done prior to 1900 (Barrett and others 1997). Even if confined to designated stands, fire would have to be re-introduced cautiously so as to avoid damaging too many trees. The forests were now too dense with understory trees, and surface fuels had accumulated to high levels as a result of 70 or more years of fire exclusion efforts.

Forest Planning Sets the Stage

In 1987, the newly completed forest plan for the Bitterroot National Forest suggested that management take into account natural ecological processes. Soon afterwards, the Darby Ranger District conducted an Integrated Resource Analysis for the Lick Creek area, obtaining input from a broad range of interested publics and natural resource specialists to define objectives for the area. This process, guided by the National Forest Management Act, resulted in a "desired future condition" for the area and a list of management activities that would begin moving the Lick Creek landscape toward that goal.

During the meetings to identify pertinent issues, the idea of making the Lick Creek area a demonstration/research forest took shape. The historical photo sequences and records of early silvicultural cuttings and tree growth response were recognized as a unique and valuable asset. The original stands at Lick Creek and elsewhere in the ponderosa pine zone of the Bitterroot National Forest contained large trees primarily in an open park-like structure (Leiberg 1899). They were uneven-aged and largely self-perpetuating as a result of frequent fires (Arno and others 1997; Gruell and others 1982). In the 1980's, despite several harvest cuts and thinnings, conifer stands were very dense and wildlife forage (grasses and shrubs) was reduced compared to conditions shown in the 1909 to 1938 photographs (Gruell and others 1982). By the 1980's, insects and disease were impacting forest health. Also, the growing risk of severe wildfire was demonstrated by several wildfires that burned in the ponderosa pine forests in the Bitterroot National Forest and elsewhere in the Northern Rockies (Williams 1995).

The challenge that was identified during planning meetings was to guide management of the Lick Creek area toward stand structures that would improve wildlife habitat, esthetics, and tree growth. To this end, the Bitterroot National Forest, the Intermountain Research Station, and The University of Montana entered into a cooperative agreement in 1991 to conduct studies to provide a basis for ecosystem management in Lick Creek and similar landscapes.

Considerations for Ecosystem Management at Lick Creek

Ecosystem management is a broad topic with many themes (Overbay 1992). For Lick Creek, which is representative of similar forests covering millions of acres of Northern Rocky Mountain landscapes, we elected to conduct studies that focus on a return to stand structures that are sustainable and consistent with historical fire occurrence in the area. In these studies we feature management of ponderosa pine, the long-lived seral species at Lick Creek in pre-1900 times. The idea is to develop stands that have a significant component of large-diameter pine trees, along with younger age classes and to maintain a large-diameter class indefinitely through time. Prescribed low-intensity fires would be scheduled periodically to regulate conifer regeneration, especially that of shade-tolerant Douglas-fir and grand fir.

Timber harvests scheduled coincident with the burning would be tailored to develop and maintain uneven-aged stand structures with a significant number of large trees through time. To accomplish this, new adaptations of traditional silvicultural systems (shelterwood and selection) would be used. Thinning and whole-tree removal of the smaller merchantable trees could help restore a more open stand structure that would allow for safer application of prescribed fire. Harvests could also generate funding necessary to finance treatments (Fiedler and others 1997). The first application of fire after long periods of fire exclusion might stress the leave trees and invite bark beetle attacks. However, if the largest and healthiest trees are retained, reducing stand density might improve their vigor before fire is applied.

To mitigate against the effects of fuel accumulation, fire could be applied early in a drying cycle, when the lower duff and large woody fuels were still moist (wet burn). Conversely, there is a need to test burning under drier conditions (dry burn) in order to expand the narrow window of opportunity for applying prescribed fire and obtaining satisfactory results. More specifically, we need to better understand the range of fuel moisture and weather conditions under which fire will consume an appreciable fraction of the fuelbed but will not damage leave trees, be difficult to control, or cause excessive smoke problems to nearby residents or communities.

The silvicultural cutting and prescribed burning treatments would be designed to benefit wildlife habitat (especially forage production), esthetics and recreation, timber production, and forest protection (fire, insects, and disease) by complementing the natural ecological processes. The form of timber harvesting conducted here would contrast with earlier harvests, a primary difference being the strong focus on the reserve stand in terms of density, structure, and species composition. This harvest is being used to reduce stand densities while retaining the most vigorous trees, to manipulate species abundance, and to prepare the stands for low-intensity fire.

Experimental Treatments

Three kinds of ponderosa pine/Douglas-fir stands at Lick Creek covered areas large enough to allow for the kind of multiple treatment units (replications) preferred for scientific testing (fig. 16). Tree density in all three stand types was high enough so that individual pines were growing slowly and were vulnerable to severe wildfire or insect damage. Douglas-fir made up no more that 20 percent of the overstory in each experimental stand, but Douglas-fir saplings were numerous. In cooperation with the Darby Ranger District, we developed a different kind of silvicultural cutting treatment for each of the three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, we applied different underburning strategies as well as no burn treatments (table 5). Similar treatments were carried out operationally by the Darby Ranger District outside the experimental stands, so that the entire treatment area in the ponderosa pine forest at Lick Creek covered about 530 acres. This entire area was treated using a conventional timber sale. It produced 1.475 million board feet of sawlogs and plywood peeler logs and was purchased for $147,610 by Champion International Corporation of Missoula, Montana.

Leave trees were marked by National Forest crews with guidance from researchers. The harvesting was done in all three experimental stands in 1992 using conventional techniques—chain saw felling followed by winch yarding to designated trails and skidding by a crawler tractor. (Within a few years preferred logging techniques had changed to favor mechanical harvesting machines. Also, timber values had increased enough to allow use of low-impact harvesting equipment.) To control the amount of slash fuels created, limbs were left attached to the harvested logs. Limbs were removed, piled, and burned at roadside

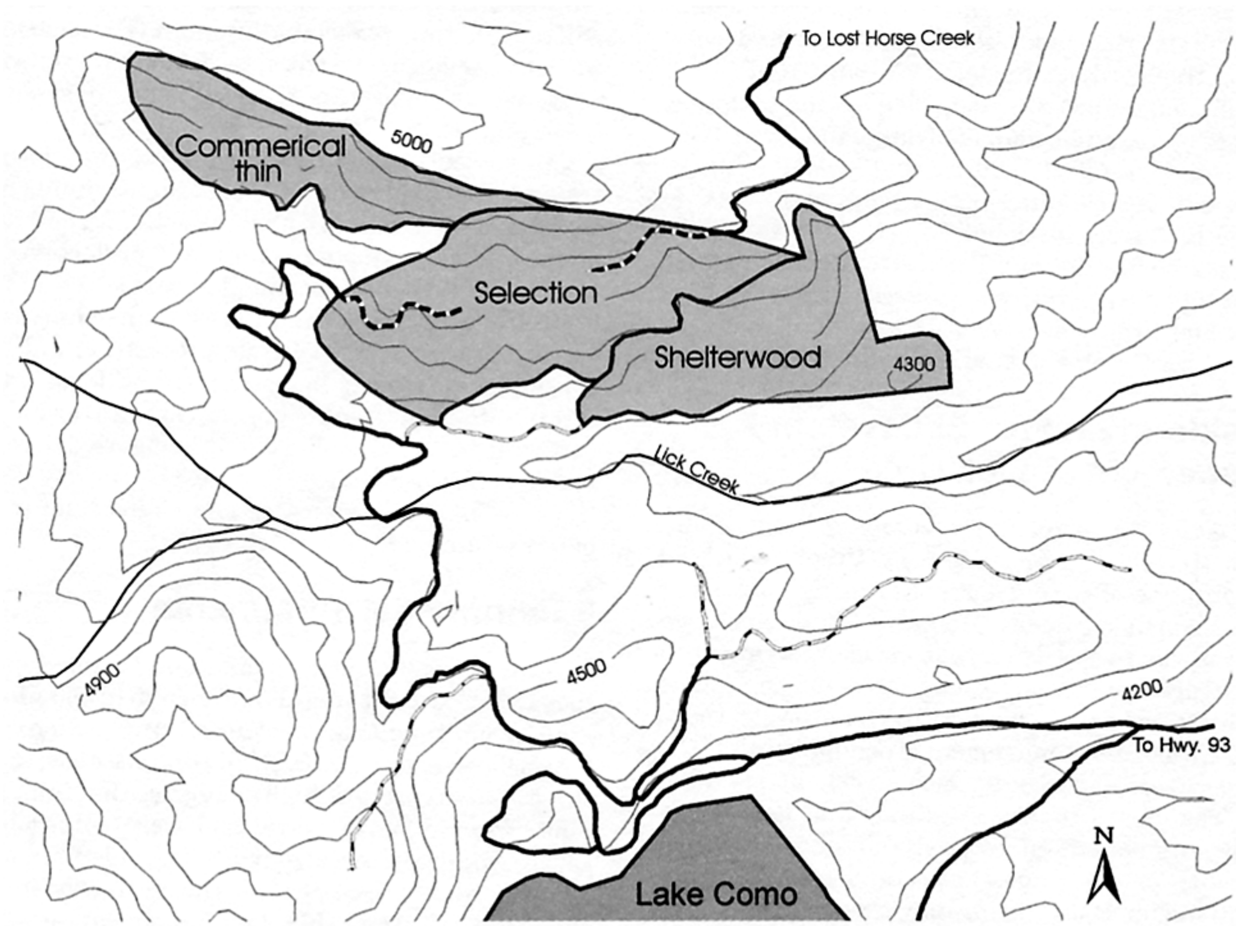

Figure 16—Location of 1990's ecosystem-based management treatment areas at Lick Creek.

landings. To provide an input of foliar nutrients and large woody debris to the soil, the tree tops—cut at about 6 inches in diameter outside the bark—were left on the site (Graham and others 1994). Broadcast underburns consumed the finer branches but not the green wood in the tops.

The following effects of the differential burn treatments were measured and compared: fuel reduction, tree mortality and growth response, undergrowth species response, tree regeneration, soil nutrients, and response of wildlife browse shrubs. Associated studies measured human visual preferences for different restoration treatments. Also, bird abundance and foraging behavior was measured in relation to shelterwood and underburning treatment, as was the comparative quality (for wildlife habitat) of snags

Table 5—Summary of experimental treatments applied within the shelterwood and selection cutting units and the commercial thin unit at Lick Creek.

	Shelterwood cutting	Selection cutting	Commercial thin
Control (no cut/burn)		X	
Cut/no burn	X	X	X
Cut/low consumption burn ("wet burn")	X		
Cut/intermediate burn ("intermediate burn")		X	
Cut/high consumption burn ("dry burn")	X		
Cut/fall burn			X
Cut/spring burn			X

created by fire versus mechanical girdling. A synopsis of study findings is reported in the next section, Effects of Ecosystem-Based Management Treatments.

Shelterwood Treatments

One of the experimental stands at Lick Creek was predominantly second-growth ponderosa pine 80 to 85 years of age that arose on what was originally private land. It is the area shown in photopoint 7, which was essentially clearcut in 1906 and later became part of the Bitterroot National Forest. By 1991, this stand was representative of many second-growth pine stands in the Northern Rocky Mountains. It supported an average of 240 trees and 120 square feet (ft^2) of basal area per acre. The dominant trees were mostly between 15 and 18 inches in dbh, and most of them were experiencing slow growth due to high tree density. Bark beetle mortality was occurring and might reach outbreak levels. Ladder fuels (patches of understory firs) and accumulating surface fuels were sufficient to create a risk of high tree mortality if a wildfire occurred. Many plants were being shaded out by dense tree cover.

The cutting treatment conducted in this experimental stand was a retention or irregular shelterwood in which the largest, healthiest pines were retained with a target stocking of 40 ft^2 basal area per acre. One goal of the cutting was to open the stand sufficiently to allow some successful regeneration of pine, which would then develop into a second age-class. In the future, periodic additional shelterwood cuts and underburns would be conducted, allowing more pine age classes to become established, until an uneven-aged stand with some large old trees had developed. At that point, a selection system could be applied to maintain the stand indefinitely into the future.

Three kinds of follow-up treatments were conducted, each on three separate experimental units of 4 to 10 acres. These were a "dry burn" (lower duff is dry), also referred to as a high consumption burn; "wet burn," referred to as a low consumption burn; and a "no burn" treatment (fuels left untreated). All burns were conducted in the spring of 1993.

Selection Treatments

Another experimental stand at Lick Creek comprised primarily uneven-aged ponderosa pine ranging from seedlings to old-growth trees up to 40 inches dbh and 400 years of age. Younger trees in this stand, under about 18 inches dbh, became established in response to past partial cuttings. A modified individual tree selection cutting prescription, developed by Carl Fiedler of The University of Montana's School of Forestry, was carried out in this stand in the fall of 1992. The stand had about 110 ft^2 of basal area per acre and was leave-tree marked to retain 50 ft^2 per acre of the most vigorous pines across the full range of diameters. Additionally, an average of one snag or potential snag per acre was retained for wildlife habitat. Scattered small openings of 1⁄4 to 1⁄3 acre were created in the marking process to provide conditions favorable for the regeneration of ponderosa pine. Approximately 20 percent more trees were left in each successively smaller (4-inch) diameter class to account for mortality over time and to ensure sufficient recruits into the larger size classes in the future. The long-term goal is to repeat selection cuttings at 25- to 30-year intervals for the purpose of regenerating ponderosa pine, adjusting species composition, and sustaining the uneven-aged structure.

In the spring of 1993, three selection cutting units were underburned with a prescribed fire when fuel moistures were intermediate, between a "dry" and "wet" burn (cut/burn treatment) (fig. 17). Three selection cutting units were left unburned (cut/no burn treatment) and three units received neither cutting nor burning (control treatment).

Commercial Thin Treatments

The third experimental stand was dominated by pole-sized ponderosa pine about 70 years of age, that arose after past partial cutting. The stand was precommercially thinned in the 1960's and slash left untreated. The trees responded to that thinning with rapid growth, and by 1991 the site supported an average of 85 to 100 ft^2 of basal area per acre. This is a high tree density for the steep, dry south-facing site; thus, by 1991 radial growth had slowed. The treatment was a commercial thinning with a goal of reducing the basal area to about 50 ft^2 per acre. This target basal area was calculated using the Growth Basal Area methodology (Hall 1987) to determine the basal area at which annual increment is predicted to be maximized. The merchantable tree boles, up to a 6-inch diameter top, outside the bark, were removed. The largest and most vigorous trees were retained. Thinning differs from a shelterwood harvest in that establishing pine regeneration is not a primary goal. Regeneration might be achieved regardless. If not, regeneration will be a goal after the next cutting, a retention shelterwood in 20 to 30 years.

Three thinning units were left unburned. To compare effects of the two different burning seasons, three units were burned in the fall of 1993 and three in the spring of 1994.

1992. Untreated second-growth (80-year-old) stand of ponderosa pine and Douglas-fir containing some older pines. Note large stump from 1907 to 1911 behind Douglas-fir in right front.

Figure 17—Example of ecosystem management treatements in the selection cutting unit at Lick Creek.

1992. Individual-tree selection harvest completed as described in the text. Douglas-fir in right front has been removed. Tree tops are left for nutrient cycling.

1994. One year later. Vigorous ground cover has developed.

1993. Two weeks after the prescribed burn to reduce slash fuel hazard. Note that herbaceous vegetation is beginning to emerge.

1997. Four years later. Percent ground cover has increased. Small pine seedlings (not visible) are present.