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Two-aged Silvicultural Treatments in Lodgepole Pine Stands Can Be Economically Viable

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Abstract—Economically viable silvicultural options are critical for management activities that provide wood products, reduce forest fuels, improve forest health, and enhance wildlife habitat. The Tenderfoot Research Project was developed in the late 1990s to evaluate and quantify ecological and biological effects of two-aged silvicultural treatments including prescribed fire in lodgepole pine forests. Research treatments were designed and installed on the Tenderfoot Creek Experimental Forest to create reserve stand structures that emulate stands created by natural fires, and to evaluate hydrologic and vegetative response. Timber products extracted through this research project included sawlogs, stud logs, posts, rails, firewood, and pulpwood. There was a net profit from the sale of products removed from the 649 acres treated.

Introduction

Fire-dependent lodgepole pine (*Pinus contorta* Loud.) forests comprise nearly 14.8 million acres of commercial stands in the United States and over 49 million acres in the Canadian provinces of British Columbia, Alberta, and the Yukon Territory (Koch 1996). Lodgepole pine occurs in 10 States in the Western United States, and is the fourth most extensive timber type west of the Mississippi River. It is the third most extensive type in the Rocky Mountains and covers more than 4.8 million acres in Montana alone (Arno 1980; Koch 1996). These forests provide wood products, wildlife habitat, livestock forage, water, recreational opportunities, and expansive viewsheds. Many lodgepole pine communities are in late-successional stages and fuel loading is high following more than 60 years of fire suppression. Consequently these communities are at risk to insect infestation and catastrophic-scale fires.

Most mature lodgepole pine stands in the Western United States range in age from 100 to 250 years old, have slow or stagnated growth and high mortality rates resulting in high fuel loading. Silvicultural treatments are the most useful tool managers have to reduce fuel loading, regenerate new stands, achieve nontimber objectives, provide forest products, and sustain lodgepole pine ecosystems (Barger and Fiedler 1982).

Lodgepole pine is a high-value species and, as a prime commercial tree in the Western United States and Canada, is one of the two or three major lumber species in the world. Koch (1996) value-ranked several lodgepole pine products in the following order from highest value to lowest: poles and pilings; house logs; laminated-veneer lumber; machine stress rated lumber; posts, rails, and tree stakes; dimensional lumber; plywood and flakeboard structural panels; pulp chips; and industrial/home fuel (firewood).

In the mid 1980s, a timber market trend showed a preference for lodgepole pine for industrial roundwood products (Van Hooser and Keegan 1985). Utilization of lodgepole pine increased due to a dwindling old-growth timber supply of other species, improved milling technology, and a concern about the future of this resource due to mortality from mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (Fiedler 1987). These trends continued into the mid 1990s; however, decline in sawmill capacity in that decade was primarily due to the reduction of timber supplies from Federal lands. Outbreaks of mountain pine beetles have caused increased harvest of lodgepole pine in Canada, and recent outbreaks throughout the Western States may increase harvesting in the United States.

Because lodgepole pine stands are typically viewed as even-aged and compositionally nearly pure, silvicultural treatments have focused on clearcutting to recreate pure, even-aged, and structurally homogeneous stands. There has been less use of multiple-entry, uneven-aged silvicultural treatments—lodgepole pine tends to easily wind-throw and seedlings are highly shade-intolerant.

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However, such treatments may be highly relevant to managers planning hazardous fuel or stewardship projects (USDA 2004). The Tenderfoot Research Project was conceived in the mid 1990s to test shelterwood with reserve treatments (thinning and prescribed fire), and to evaluate two-aged methods for regenerating and restoring mature lodgepole pine stands. Alternative harvest systems such as shelterwood with reserves can be used in lodgepole pine stands but little is known about the economics of these treatments (Alexander and others 1983).

Objective

The objective of the Tenderfoot Research Project was to test the potential of implementing two-aged shelterwood with reserve systems to regenerate and restore healthy lodgepole pine forests by emulation of natural wildfire disturbance patterns. Economic viability was not part of the original objective; however, cost estimates from Forest Service and sale purchaser proceeds were obtained after treatment completion to evaluate the economic feasibility of two-aged silviculture in lodgepole pine stands. The objective of this paper is to describe the economic outcome of research treatments in this case study.

Study Area

The Tenderfoot Research Project was developed on the 9,125 acre (3,693 ha) Tenderfoot Creek Experimental Forest (TCEF) in the Little Belt Mountains of central Montana. Treatment unit elevations range from 7,150 to 7,500 ft (2,179 to 2,286 m). Stand composition is dominated by lodgepole pine with some stands containing admixtures of subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). Baseline data collection began in the early 1990s and included streamflow, sediment production, stream chemistry, stream channel profiles, and stream channel characterization. Other data collected prior to installation of research treatments included fish habitat surveys, wildlife population estimates including mammals, birds, and fish, stand structure, understory vegetation, geology, soils, and climate.

It is commonly assumed that lodgepole pine, more than any other western conifer, forms pure or nearly pure even-aged stands (Pfister and McDonald 1980; Schmidt and Alexander 1985; Koch 1996). These stands are usually large patches of pure even-aged trees resulting from stand-replacing disturbances such as fire. A fire history study on Tenderfoot Creek Experimental Forest indicates that 54 percent of the lodgepole pine stands are two-aged (Barrett 1993) (table 1). Plot inventories indicate two distinct stand structures, perhaps resulting from varying disturbance patterns. One pattern suggests that fires spread throughout stands in a mosaic configuration, leaving individual and small groups of live trees somewhat evenly distributed. The second more prevalent pattern suggests that fires burned varying sized and shaped groups or swaths of trees. These burns resulted in almost 100 percent mortality and left unburned tree groups that created an indistinct mosaic of small stands.

Table 1—Vegetation types, acres, percent of total area, and percent of forested area for lodgepole pine stands on the Tenderfoot Creek Experimental Forest in central Montana.

		Percent of	
Vegetation type	**Acres (ha)**	**total area**	**forested area**
Nonforested	808 (326 ha)	8.9	
One-aged LPP stands	3,837 (1,590 ha)	42.0	46
Two-aged LPP stands	4,480 (1,816 ha)	49.1	54
Total	9,125 (3,693 ha)	100	100

Study Design

The Tenderfoot Research Project was designed to evaluate changes in water quantity and quality, understory and overstory vegetation response, fuel reduction techniques, and a variety of other biological parameters such as noxious weed invasion, snag longevity, and blowdown. A total of 16 experimental treatment units were installed in 2000 across two treatment subwatersheds (fig. 1). Eight treatments were installed in each of the two subwatersheds: Spring Park Creek (1,032 acres (418 ha)), and Sun Creek (856 acres (346 ha)). Two control subwatersheds were located adjacent to and immediately downstream from the treatment subwatersheds.

Two shelterwood-with-reserve treatment types were tested within each treatment subwatershed, four units with trees evenly distributed and four with trees left in uncut groups ranging in size from one-half to 2 acres in size. Two of four units of even- and group-distribution were broadcast burned, and the remaining two were left unburned. Treatment units ranged in size from 9 to 78 acres (4 to 32 ha) and had a mean size of 41 acres (16 ha) (table 2). All treatments were randomly located within a subwatershed with only minor location adjustments for prescribed burn units.

Silvicultural treatments were accomplished through a timber sale contract between the Lewis and Clark National Forest and Pyramid Lumber Company from Seeley Lake, Montana. Conifer Logging from Lincoln, Montana was subcontracted for logging the treatment areas.

Trees were cut and piled using a TIMBCO 445 Feller-Buncher with a Hotsaw head and a Timber-Jack Feller Buncher. Trees were full-length yarded to landings along existing and newly constructed roads using D5H Cat skid dozers with grapples and John Deer 648 rubber-tired skidders with grapples. Track-mounted slide-boom delimbers processed trees at landings by removing limbs, cutting trees to specified lengths, and stacking logs according to product specifications (table 3). Nonmerchantable wood and tree limbs that were placed in slash piles on landings along road corridors and within treatment units were burned in 2001.

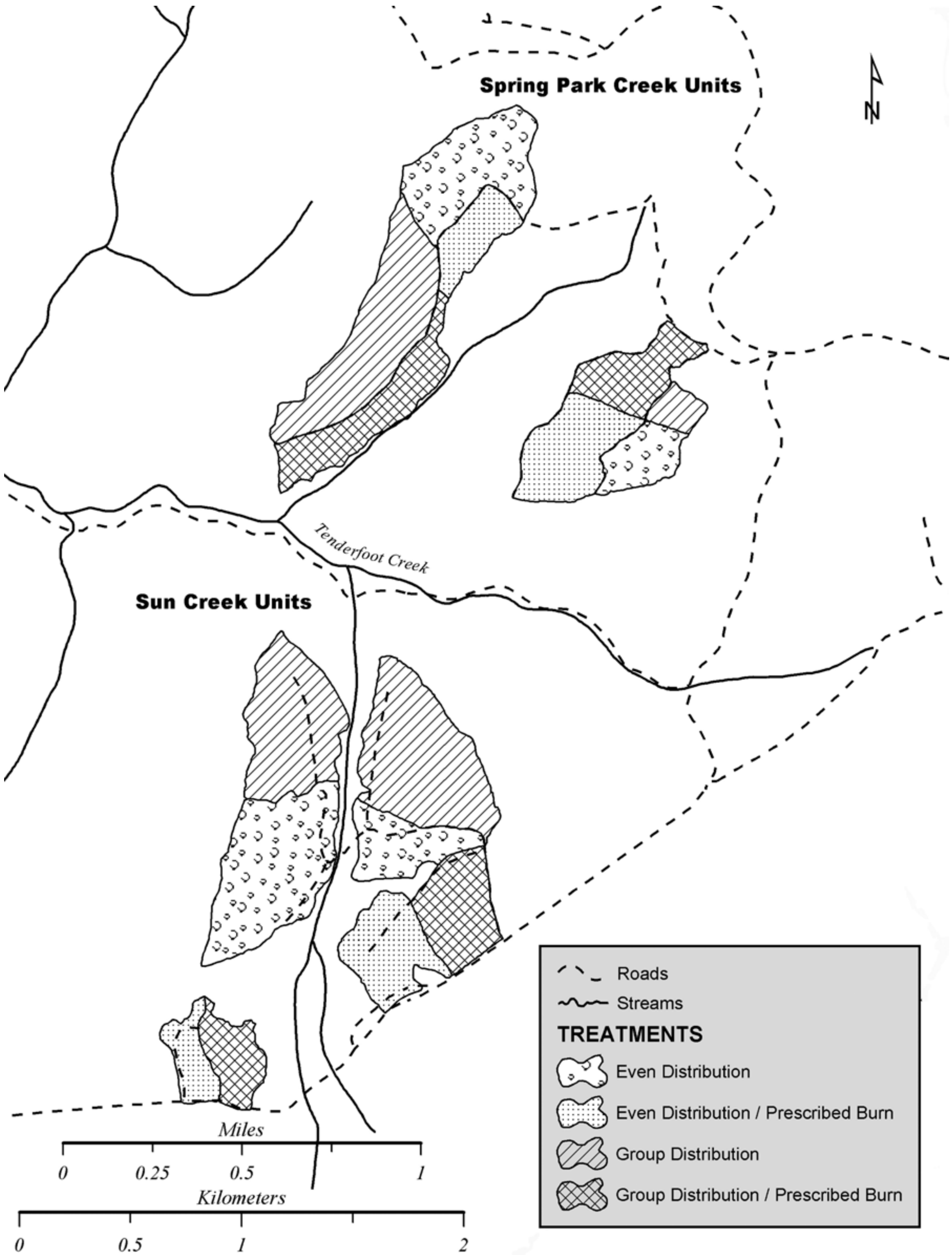

Figure 1—Schematic layout of 16 silvicultural treatments established for the Tenderfoot Research Project on the Tenderfoot Creek Experimental Forest in central Montana.

Table 2—Acres treated by silvicultural treatment in Sun Creek and Spring Park Creek subwatersheds on the Tenderfoot Creek Experimental Forest in central Montana. Silvicultural treatments included a shelterwood with reserve system with and without prescribed burning.

	Sun Creek	Spring Park Creek
Silvicultural treatment	Acres (ha)	Acres (ha)
Shelterwood w/reserves, even distribution	78 (31)	9 (4)
Shelterwood w/reserves, group distribution	61 (25)	73 (30)
Shelterwood w/reserves, even distribution	30 (12)	21 (8)
Shelterwood w/reserves, group distribution	77 (31)	54 (22)
Shelterwood w/reserves, even distribution, prescribed burn	36 (15)	42 (17)
Shelterwood w/reserves, even distribution, prescribed burn	16 (6)	22 (9)
Shelterwood w/reserves, group distribution, prescribed burn	36 (15)	30 (12)
Shelterwood w/reserves, group distribution, prescribed burn	22 (9)	42 (17)
Total treated acres	**356 (144)**	**293 (119)**

Table 3—Product specifications for trees extracted from treatment units on the Tenderfoot Creek Experimental Forest in central Montana.

Product	Specification
Sawlogs[1], lodgepole pine—live	>7 inches (18 cm) diameter breast height (dbh) and >5.6 inches (14 cm) top diameter inside bark (dib), 8 ft (2.4 m) length.
Sawlogs[1], other species—live and dead	>8 inches (20 cm) dbh and >5.6 inches (14 cm) top dib, 8 ft (2.4 m) length.
Sawlogs[1], lodgepole pine—dead	>8 inches (20 cm) dbh and >7 inches (18 cm) top dib, 16 ft (4.9 m) length.
Small sawlogs[1], all species	From tops of sawlog trees between 5.6 inches (14 cm) dib and 4.6 inches (12 cm) dib, plus LPP >6 inches (15 cm) dbh that have an 8 ft (2.4 m) piece to a 4.6 inch (12 cm) top dib but not a 5.6 inch (14 cm) top; other species >7 inches (18 cm) dbh that have an 8 ft (2.4 m) piece to a 4.6 inch (12 cm) top dib but not a 5.6 inch (14 cm) top.
Roundwood	Material from trees below the diameter required for sawlogs and material from the tops of trees used for pulp or sawlogs >16 ft (4.9 m) in length and top dib >3 inches (8 cm). Free from sweep or crook.
Pulp	Any material not included above but generally crooked or forked green trees not making other products, or large, dead trees not making another product.

[1]Includes both sawlogs and stud logs.

Research specifications called for marking "leave trees" in even distribution units and marking the leave group perimeters in group treatments. Location of skidding corridors in even distribution units were identified by feller-buncher operators and approved by a Forest Service sale administrator. Skidding corridors within group treatments were approved in advance by a Forest Service sale administrator to minimize the area impacted by skidders. Riparian zones were not entered, maintaining an adequate sediment filter between treatment units and streams. Feller bunchers and skidders worked around previously established research plot markers.

Three units were harvested in late 1999 and the 13 remaining units were harvested in 2000. The three units harvested in 1999 were prone to wet soils in average or above average precipitation years; therefore, because of a dry summer and fall, it was decided to reduce soil compaction potential by treating them early.

Discussion

Products extracted from treatment units included 3 million board ft (MMBF) (7,196 m^3) of sawlogs, 1.3 MMBF (3,118 m^3) of stud logs, and 1,800 tons of roundwood that sold as pulpwood, firewood, posts, and rails (table 4). Stand quadratic mean diameters ranged from 8.6 to 12.6 inches for the 16 treatment units.

Making timber sales profitable is an important economic aspect in managing National Forest Lands. On the Tenderfoot Research Project, the contractor requested and was granted an adjustment to the logging contract during the summer of 2000, allowing them to respond to increased pulpwood market demands. The contractor was able to extract pulpwood from slash piles consisting of crooked and forked green trees, nonmerchantable subalpine fir, and large dead trees unsuitable for other products. Receipts

Table 4—Volume extracted, costs, and revenue versus cost (profit) realized by sale contractor[1] for products removed from the Tenderfoot Creek Experimental Forest.

Product	Volume extracted	Costs ($)	Revenue versus costs
Sawlogs	2,972 MBF[2] (7,129 m^3)	1,262,656	5% profit
Stud logs	1,328 MBF[2] (3,186 m^3)	562,024	10% profit
Pulpwood and firewood	445 T (404 MT)[2]	15,894	Subsidized
Posts and rails	1,350 T (1,225 MT)[2]	3,096	Equal

[1] Information obtained from Pyramid Lumber Company.
[2] MBF = 1,000 board feet; T = tons; MT = metric tons.

showed that the contractor made a 5 percent profit on sawlogs, 10 percent on stud logs, broke even on the sale of posts and rails, and subsidized the sale of 445 tons of pulpwood (table 4).

Minimal logging cost was another reason this sale was profitable for the contractor and logging subcontractor. All wood extracted from treatment units came from two subwatersheds located approximately 1 mile apart. Harvest units located close together eliminated the need to transport logging equipment between harvest units, which could result in lost production when logging trucks are idle and no inventory is being added to the mill. A logging company may lose $5,000 to $6,000 per day from lost production during a move between job sites. Expenses incurred during a move include wages paid for loading, moving, and unloading equipment and rental for moving and logging equipment. Gross revenue lost by the contractor and logging subcontractor could total $15,000 to $20,000 per move.

National Forest stumpage receipts on the Tenderfoot Research Project totaled $847,100 with an additional $101,512 collected for slash and road maintenance work. Stumpage receipts included the sale of 60 cords of firewood that had been extracted from slash piles that would have otherwise been burned for fuel reduction. Program costs, including planning and sale administration, were $505,457 for a net return to the National Forest of $443,155.

This research project was an above-cost sale for the Forest Service and the timber company. Private companies typically monitor demand for a wide range of products during a sale to maximize profits in a volatile wood market. Flexibility by the Lewis and Clark National Forest allowed the contractor to utilize smaller trees for posts and rails and capitalize on forked and dead trees for a short-term pulp market. Efficiency in accessing a large number of treatment areas within a small area also helped make this sale cost effective.

Below cost timber sales in the past resulted from depressed markets due to low-cost wood imported from Canada and reduced sale bid prices in the United States. Regional and national markets can change dramatically depending on future United States and Canadian trade agreements.

Performance-based stewardship contracts are another way to make timber sales affordable and give the National Forest System and the Bureau of Land Management another option to efficiently and economically manage their lands. These contracts enable the government agency to bundle related services and sale products based on a number of resource issues such as improving wildlife habitat, reducing forest fuels, accomplishing road maintenance or reclamation, rehabilitating watersheds or streams, initiating precommercial thinning, or offsetting the cost of other Forest related activities.

The Tenderfoot Research Project demonstrates that even with research restrictions, managing lodgepole pine with a two-aged silvicultural system can be economically viable. Making profitable or break-even timber sales in lodgepole pine stands will depend on contract flexibility, utilizing a landscape approach to treatment area layout (relying on larger units in close proximity), and the use of stewardship contracts.

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