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Relationship of Seed Microsite to Germination and Survival of Lodgepole Pine on High-Elevation Clearcuts in Northeastern Utah

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Abstract—On two high-elevation sites (~3,000 m) in northeastern Utah, lodgepole pine (*Pinus contorta* var. *latifolia*) seeds germinated best (53 percent) on large mineral microsites (5 x 5 m), and percentage survival of germinating seeds was best on microsites covered with forest floor material. Seed predation was severe at both study sites; protecting seeds increased germination three to ten times. On harvested sites dependent on natural regeneration for seedling establishment, some predation control may be necessary to achieve rapid and complete stocking. After harvesting, maintenance of a combination of mineral soil and forest floor is critical for long-term seedling success.

Introduction

In the Intermountain West, lodgepole pine (*Pinus contorta* var. *latifolia*) occupies a niche in high-elevation forest sites. It is well known as a seral species and can regenerate rapidly if soil and site conditions are favorable. In fact, in areas where competition is not severe, mineral soil is exposed, serotinous and nonserotinous cones are available, and daytime ambient air temperatures average 24 °C, lodgepole has a regenerative advantage over other conifer species (Lotan 1975). On some high-elevation sites, however, regeneration may take years to establish.

Often, predation is the primary reason for lodgepole pine seed mortality or loss from a site because it is an important source of food for many small mammals (Lotan and Perry 1983). After dispersal from cones, lodgepole pine seeds are often consumed by mice (*Peromyscus* spp.), voles (*Microtus* spp. and *Clethrionomys* spp.), or chipmunks (*Eutamias* spp.) (Halverson 1986; Lotan and Perry 1983). Seed germination may be enhanced by the use of rodent exclosures or reforestation cones (the cones modify temperature and moisture conditions around the seeds). Consequently, our objective was to determine seed germination and seedling success after seedbed modification and protection on a variety of high-elevation forest microsites after harvest and site preparation.

Methods

We selected two sites on the Ashley National Forest in the Uinta Mountain Range of northeastern Utah. Both sites have similar elevations (~3,000 m), aspect (north), and habitat type. Soils are loamy-skeletal, mixed, Oxyaquic Cryoboralf with quartzite parent material (Soil Survey Staff 1999). Soil coarse-fragment content ranged from 10 to 55 percent with scattered bedrock outcroppings. Mean annual precipitation is 191 cm with snowfall comprising 81 percent of the total (Western Regional Climate Center 2000). Mean annual air temperature for January is –6 °C and for July is 21 °C. Both sites were clearcut in 1995; the logging slash was piled on one-half of the site and burned. Clearcut size was approximately 2 hectares.

Lodgepole cones from surrounding uncut stands were collected in July 1999. Seeds were extracted after submerging cones for approximately 50 seconds in a 78 °C water bath

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(Krugman and Jenkinson 1974). Cones were spread on drying racks and placed in a greenhouse for 1 week where daytime temperatures reached 43 °C. Following drying, cones were manually shaken and pulled apart to release seed. Viability of extracted seed was nearly 100 percent under laboratory conditions (8 hours of light at 30 °C and 16 hours of dark at 20 °C).

At each site, three microsite types were delineated: (1) large area (5 x 5 m) with mineral soil exposed microsite, (2) small area (1 m^2) with mineral soil exposed, and (3) no mineral soil exposed area (3 x 3 m) covered with forest floor material. The small-mineral and forest-floor-only microsites were a mosaic within the treatment area. In September 1999, five replications of each microsite were located at each site, and 20 seeds each were placed either (1) on the soil surface with no predation protection (fig. 1), (2) on the soil surface with a predation cage surrounding the seed (fig. 2), or (3) on the soil surface with a reforestation cone for climate modification and a predation cage. Reforestation cones were made of durable plastic and measured 7.5 cm on the bottom, 1.8 cm on the top, and were 8 cm tall (fig. 3). Seeds were placed into a 7-cm metal ring to aid in relocation. Predation cages were constructed of 6-mm mesh wire folded to form a square, open-bottomed box (12 x 10 cm). Metal rings, reforestation cones, and predation cages were all secured to the ground with a 15-cm-long landscape staple. Onset Stowaway temperature loggers (Onset Corp, Pocasset, MA) were secured to the soil surface both inside and outside of the reforestation cones to monitor soil surface temperature from September 1999 through September 2000.

Germinants were counted July 2000, and first growing season survival was tallied in September 2000. Germinants were considered successful when the primary root had penetrated the soil surface and cotyledons were present.

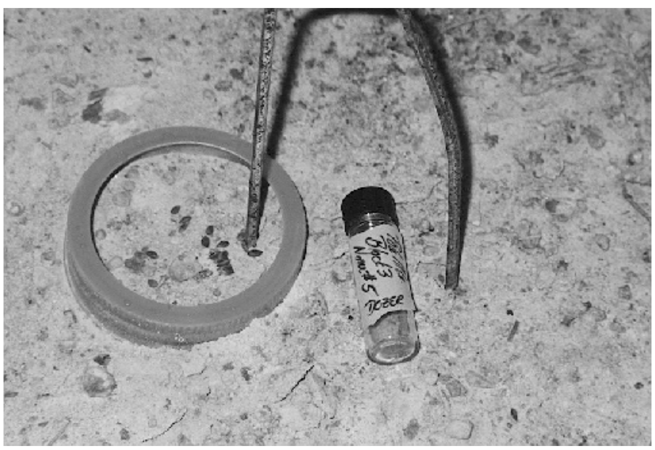

Figure 1—Seeds without predation protection on a mineral soil microsite.

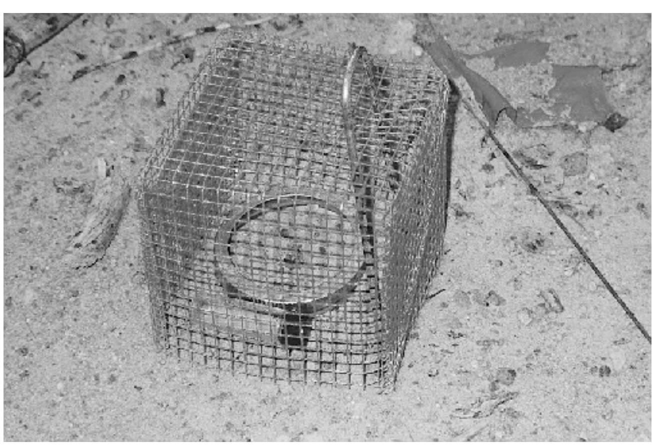

Figure 2—Seeds and predation control cage on a mineral soil microsite.

Figure 3—Putting a reforestation cone over the seeds. Predation cages were placed over the reforestation cone on this typical forest floor microsite.

Results and Discussion

Lodgepole pine is prolific in its regeneration success, particularly after disturbance. However, where lodgepole pine is a climax species, regeneration can be limited by temperature extremes or lack of moisture, or seed may be a preferred food source for birds and rodents (Lotan and Perry 1983).

Often, soil surface temperature determines the success of germination (Lotan and others 1985). Seed for this study was placed on site in the fall of 1999, and this likely subjected the seeds to damage by frost, as minimum surface temperatures reached –10 °C prior to snowfall (data not shown). During the growing season of 2000, soil surface mean high temperatures for reforestation cones versus no cone were within 0.2 °C (fig. 4). Yearly average, minimum, and maximum temperatures were not significantly affected by surface soil condition. Temperatures recorded during the field season of 2000 did not reach the threshold level of 15 °C known to suppress lodgepole pine seed germination (Lotan and Perry 1983).

Seed germination rate and number of surviving seedlings were lowest on the forest floor microsites. However, overall seedling survival rate and number of seeds versus surviving seedlings was greatest on microsites with surface organic matter (table 1). This may be due to the slightly warmer

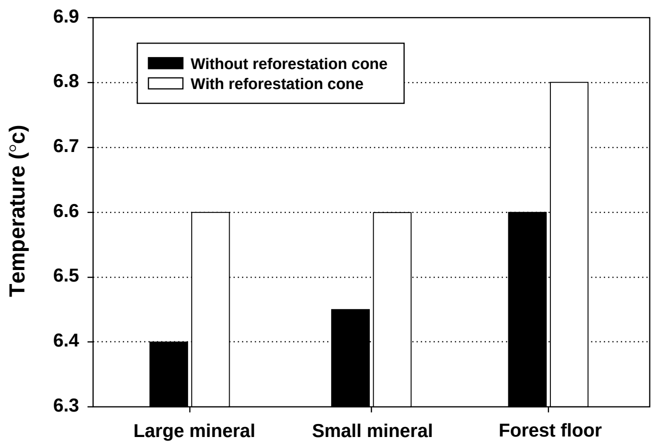

Figure 4—Soil temperature as affected by soil microsite and presence of reforestation cone.

Table 2—Lodgepole pine seed germination and seedling survival (percent) among soil microsites with predation cages or reforestation cones.

Microsite	Predation control	Germination	Survival
		.... *percent*	
Forest floor	None	3 (0.1)[a]	4 (0.2)
	Predation cage	10 (0.3)	7 (0.5)
	Predation cage and reforestation cone	18 (1.9)	14 (1.6)
Small mineral	None	8 (0.8)	5 (0.2)
	Predation cage	22 (1.5)	16 (1.3)
	Predation cage and reforestation cone	78 (3.2)	40 (2.4)
Large mineral	None	18 (1.3)	17 (1.4)
	Predation cage	70 (3.3)	30 (1.5)
	Predation cage and reforestation cone	60 (3.3)	43 (2.5)

[a]Values in parentheses are standard error of the mean.

temperatures recorded during the growing season (fig. 4). In contrast, Schmidt and Lotan (1980) determined that mineral soil seedbeds were more conducive to warm temperatures and, therefore, greater germination. The forest floor material may have acted to modify temperature extremes, evaporation rates, or frost heaving in the spring (Cochran 1973). All these factors could have improved germinant success on forest floor material. In addition, sites with forest floor intact or accessible to seedling roots after germination may have better growth and health because organic matter can provide a source of moisture and nutrients (Page-Dumroese and others 1990). Organic materials may also act to physically protect seed from soil erosion by slowing down the rate of water movement on the soil surface (Elliot and others 1999).

In a study conducted by Lotan and Perry (1977), the ratios of onsite seed to successful seedlings are often extremely high (625:1 to 2,160:1). On our study sites, this ratio is much better (3:1 to 12:1), depending on soil microsite conditions, but is likely due to protection from predation on 66 percent of the microsites.

Although laboratory germination was nearly 100 percent, seed germination in the field was much less. Overall, seed germination was most successful on the large mineral soil microsites (53 percent); however, total surviving seedlings in this microsite at the end of the growing season was only 58 percent. In contrast, seedling germination rate in the microsites with forest floor was extraordinarily low, but seedling survival of the seeds that germinated was 35 percent greater than the large mineral soil microsite.

Seed protection from predation is a key factor for seeds to reach seedling stage on these sites (table 2). All microsites showed substantial increases in germination and seedling survival with a predation cage over the seeds. Improving the seed germination environment with a reforestation cone also produced an environment more conducive to seed germination and growth than seed exposed on the soil surface.

Management Implications

On these high-elevation sites, seed viability does not seem to be the limiting factor in regeneration success. Predation appears to be the largest single factor in determining the success of seed germination on any given soil surface microsite. Large areas of exposed mineral soil provided the best opportunity for germination; however, the largest number of seedlings produced from germinated seed was on the forest floor microsites. A balance between mineral soil for germination and forest floor material for temperature moderation and moisture retention, along with some form of predation control, can provide the optimum conditions for natural regeneration of lodgepole pine. Although reforestation cones increased seed germination success along with predation cages, cone usage may be limited to sensitive or

Table 1—Comparison of lodgepole pine seed germination, survival, and seed versus germinant and seedling ratios among microsites in high-elevation clearcuts in northeastern Utah.

Microsite	Seeds germinated[a]	Germination rate	Seeds: germinants	Surviving seedlings	Survival rate	Seeds: surviving seedling
		percent			*percent*	
Forest floor	486	9	11	432	89	12
Small mineral	2,052	38	3	1,026	50	5
Large mineral	2,862	53	2	1,674	58	3

[a]5,400 total seeds were put on each soil microsite type.

fragile areas with very little seedling success, as they are time and labor intensive.

References

Cochran, P. H. 1973. Natural regeneration of lodgepole pine in south-central Oregon. Res. Note PNW-RN-204. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Station. 18 p.

Elliot, W. J.; Page-Dumroese, D. S.; Robichaud, P. 1999. The effects of forest management on erosion and soil productivity. Chapter 12. Soil quality and soil erosion. New York: Soil Water Conservation Society: 195–209.

Halvorson, C. H. 1986. Influence of vertebrates on conifer seed production. In: Conifer tree seed in the Inland Mountain West; 1985 August 5–6; Missoula, MT. Gen. Tech. Rep. INT-GTR-203. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 201–222.

Krugman, S. L.; Jenkinson, J. L. 1974. *Pinus* L. Pine. In: Schopmeyer C. S., tech. coord. Seeds of woody plants in the United States. Agric. Handb. 450. Washington, DC: U.S. Department of Agriculture, Forest Service: 598–638.

Lotan, J. E. 1975. Regeneration of lodgepole pine forests in the Northern Rocky Mountains. In: Baumgartner, D. M., ed. Management of lodgepole pine ecosystems symposium proceedings; 1974. Pullman: Washington State University Cooperative Extension Service: 516–535.

Lotan, J. E.; Perry, D. A. 1977. Effects of residue utilization on regeneration of lodgepole pine clearcuts. In: Terrestrial and aquatic ecological studies of the Northwest; 1976 March 26–27; Cheney, WA. Cheney: Washington State College Press: 125–133.

Lotan, J. E.; Perry, D. A. 1983. Ecology and regeneration of lodgepole pine. Agric. Handb. 606. Washington, DC: U.S. Department of Agriculture, Forest Service. 51 p.

Page-Dumroese, D. S.; Loewenstein, H.; Graham, R. T.; Harvey, A. E. 1990. Soil source, seed source, and organic matter content effects on Douglas-fir seedling growth. Soil Science Society of America Journal. 54: 229–233.

Schmidt, W. C.; Lotan, J. E. 1980. Establishment and initial development of lodgepole pine in response to residue management. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 16 p.

Soil Survey Staff. 1999. Soil taxonomy: a basic system of soil classification for making and interpreting soil surveys. Washington, DC: U.S. Department of Agriculture, Natural Resource Conservation Service, U.S. Government Printing Office. 869 p.

Western Regional Climate Center. 2000. Precipitation maps for the Western United States, 1961–1990. URL: http://wrcc.sage.dri.edu (accessed April 2000).

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