Cone and Seed Production of Western Larch in Response to Girdling and Nitrogen Fertilization—An Update

Russell T. Graham
Jonalea R. Tonn
Theresa B. Jain

This file was created by scanning the printed publication.
To enable searches, the text was digitized using
OCR software but some spelling errors may occur.

Abstract—Western larch (*Larix occidentalis* Nutt.) is a sporadic cone and seed producer. Because the species is such an important component of the Northern Rocky Mountain forests, methods of increasing seed production are needed. Girdling, fertilizing, and a combination of the two were used on 75-year-old western larch in northern Idaho. Girdling at the base of the live crown was effective in stimulating cone production, while the combination of fertilizing with ammonium nitrate and girdling did not increase seed yield. Fertilizer alone appeared to decrease the number of seeds per cone. Cones from trees fertilized, girdled, and both fertilized and girdled contained heavier seeds than cones produced by untreated trees. Germination of seeds produced on treated trees was greater than on control trees.

Western larch (*Larix occidentalis* Nutt.), an important forest component in much of the Northern Rocky Mountains, is an aggressive pioneer species occurring as a seral component in a variety of forests. Western larch is resistant to most forest diseases and has few serious insect pests. It is highly resistant to damage by fire; mature and older trees can survive repeated surface fires. Because the species grows rapidly and has excellent properties for use in building construction, it is a valuable commercial species throughout the Northern Rocky Mountains.

Cone production by western larch has been sporadic. Cone crops have been infrequent, making seed collection for artificial regeneration difficult and the use of natural regeneration methods doubtful. For example, since 1965 there have been only 2 years (1965 and 1991) that the Coeur d'Alene nursery processed good quantities of larch cones (fig. 1). Because western larch is an important component of Northern Rocky Mountain forests and an unpredictable cone producer, any method or technique that increases seed production would be valuable. This paper reviews an earlier study we conducted on cone stimulation and updates some of our thoughts and conclusions on stimulating western larch seed production (Graham 1986).

Paper presented at the Symposium on Ecology and Management of Larix Forests: A Look Ahead, Whitefish, MT, USA, October 5-9, 1992.
Russell T. Graham, Jonalea R. Tonn, and Theresa B. Jain are, respectively, Research Forester, Forester, and Forester, Intermountain Research Station, Forest Service, U.S. Department of Agriculture, Moscow, ID 83843, USA.

CONE STIMULATION

Several cone and seed stimulation trials and experiments have been conducted on different tree species. In northern Idaho female strobilus production was increased in western white pine (*Pinus monticola* Dougl.) by thinning stands; spacings of 9 m (30 ft) proved to be more effective than 6-m (20-ft) spacings (Barnes 1969). Wenger (1954) and Bilan (1960) showed that thinning increased cone production in loblolly pine (*P. taeda* L.).

Fertilization, primarily nitrogen, has been used to stimulate cone production. Western white pine (Barnes 1969), coastal Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco.) (Ebell 1962, 1971), and Rocky Mountain ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engelm.) (Heidmann 1984) increased cone production in response to the application of nitrogen fertilizer. Application of the ammonium forms of nitrogen fertilizer appears to be more effective in stimulating cone production, especially when fertilizer is applied immediately after the initiation of vegetative buds in the spring (Ebell 1972). Fertilization rates have varied from 225 kg/ha (200 lb/acre) to 1,800 kg/ha (1,607 lb/acre) of nitrogen.

Girdling tree stems increased cone production up to 300 percent in loblolly pine (Bilan 1960), Douglas-fir (Ebell 1971), and eastern white pine (*P. strobus* L.) (Stephens 1964). Up to a 20-fold increase in cone production was reported as a result of girdling red pine (*Pinus resinosa* Ait.) (Holst 1959). Girdling at the base of the live crown can be four times as effective as girdling at breast height (Holst 1959). The most effective girdles appear to be overlapping cuts up to an internode apart on the stem or branch that sever the phloem on two sides. Cuts as narrow as a single saw kerf and as wide as 2.5 cm (1 inch) have been used successfully to stimulate cone production.

Because both girdling and fertilization have been used successfully in stimulating cone production in a variety of conifers we elected to test these methods on the sporadic cone producer western larch.

METHODS

Even with infrequent cone production, natural stands of western larch have developed in northern Idaho. Western larch, being an early seral species, regenerated aggressively after wildfires in the St. Joe, Priest, and Coeur d'Alene River drainages. One such area was in the Idaho

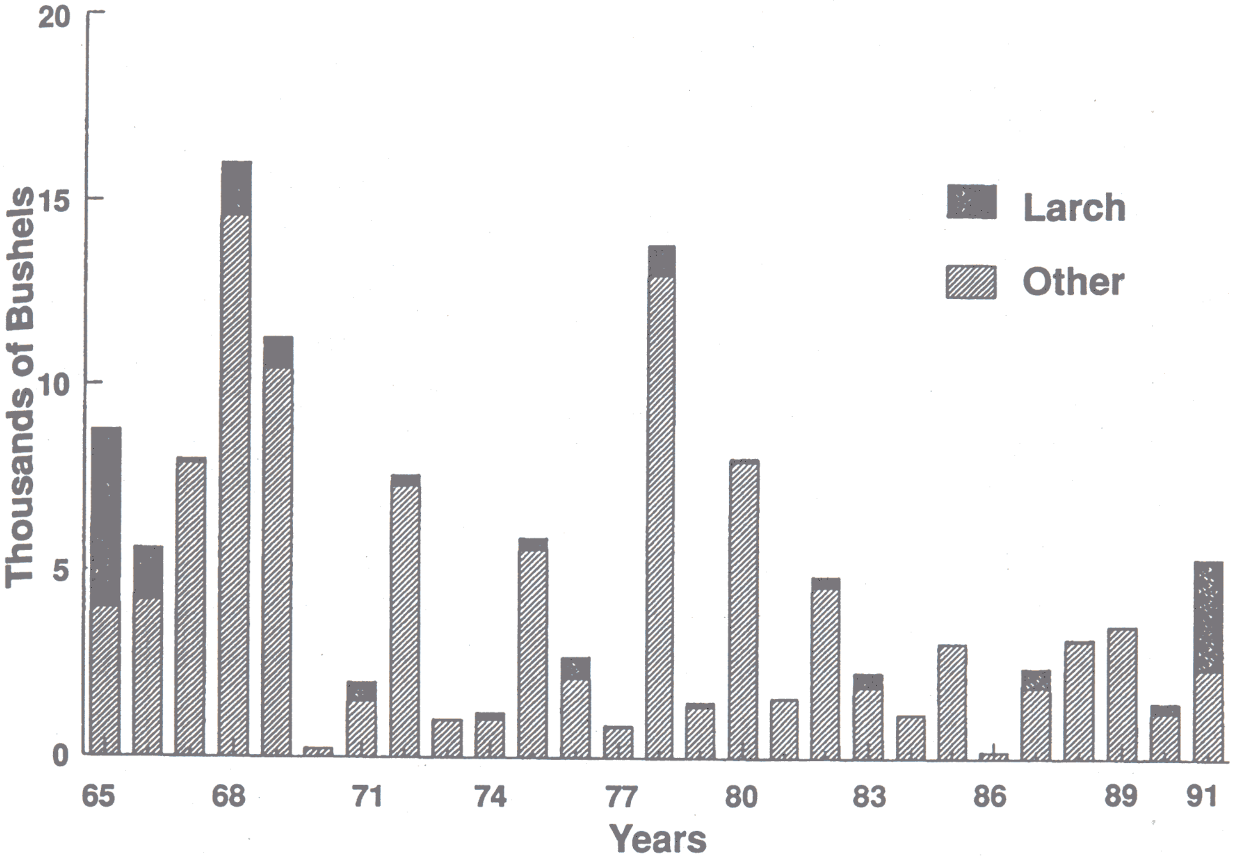

Figure 1—Western larch cones and other species cones processed at the Coeur d'Alene nursery from 1965 through 1991.

Panhandle National Forests near the Idaho-Montana border in the Wallace Ranger District (fig. 2). The 75-year-old stand chosen for use in this study had sporadically produced cones in the past.

The entire stand was thinned to a residual basal area of 9 to 14 m^2/ha (40 to 60 ft^2/acre). Logging debris was dozer piled. Because western larch initiates growth early, often before snow melt, the treatments were applied late in the fall.

The 72 most vigorous, well-formed western larch trees in the stand were chosen for inclusion in the study. They were divided into 12 six-tree groups with three groups assigned to a replication. Three treatments and a control were applied randomly to the groups within each replication:

- *Fertilize:* 336 kg/ha (300 lb/acre) of nitrogen in the form of ammonium nitrate was applied with a hand spreader under the drip line of the selected trees.

- *Girdle:* The trees were climbed using spurs, and at the base of the live crown one-half the circumference of the phloem was severed using a hand pruning saw. At a bole circumference length below the first, a similar girdle on the opposite side of the tree was cut. This process resulted in two overlapping cuts (fig. 3).

- *Girdle and fertilize:* Six trees were girdled and fertilized in each of the three replications.

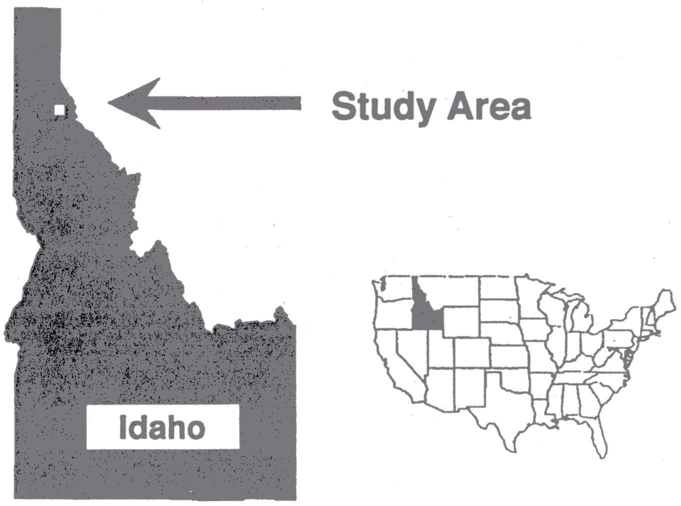

Figure 2—Location of the study area.

Eighteen trees were reserved as controls, receiving only the thinning treatment. This treatment strategy resulted in a randomized complete block experiment.

In the fall 2 years after treatment, the trees were climbed using spurs and cones collected from each tree in the study. Seeds were extracted and cleaned at the

Forest Service, U.S. Department of Agriculture, nursery in Coeur d'Alene, ID. Cones per tree, seeds per cone, and seed weight were recorded. A germination trial was conducted using 0, 14, and 28 days of stratification. An analysis of variance for a randomized complete block design was used to the analyze the data. The means were separated using Duncan's multiple range test.

RESULTS

Girdling alone produced the most cones per tree (fig. 4). No differences were detected in cone production among the control and other treatments. The application of fertilizer appeared to depress the number of seeds per cone; the other treatments all produced about equal numbers of seeds (fig. 5). All of the treatments appeared to increase seed weight compared to seeds produced on the untreated trees (fig. 6).

The stand and tree characteristics in the various treatments were very similar. No tree or stand characteristic appeared to influence cone production (table 1). Based on a significance of 0.163, tree crown ratio was the only characteristic close to explaining a portion of the variance in cone production.

Germination of seeds produced by the treatments was good compared to that of seeds from the control trees. Of the seeds from the treated trees, 12 percent germinated with no stratification, 95 percent after 14 days of stratification, and 96 percent after 28 days of stratification. In contrast, 80 percent of the seeds from the control trees germinated (for 14 days) after 28 days of stratification (fig. 7).

Figure 3—Girdling of western larch with a hand pruning saw.

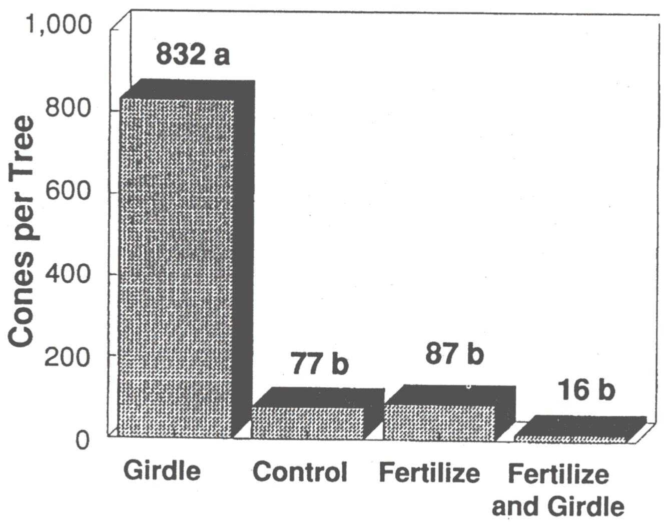

Figure 4—Mean cones per tree produced by western larch after girdling, fertilization, girdling and fertilization, and by control trees. Different letters indicate significant ($P \leq 0.05$) differences among means.

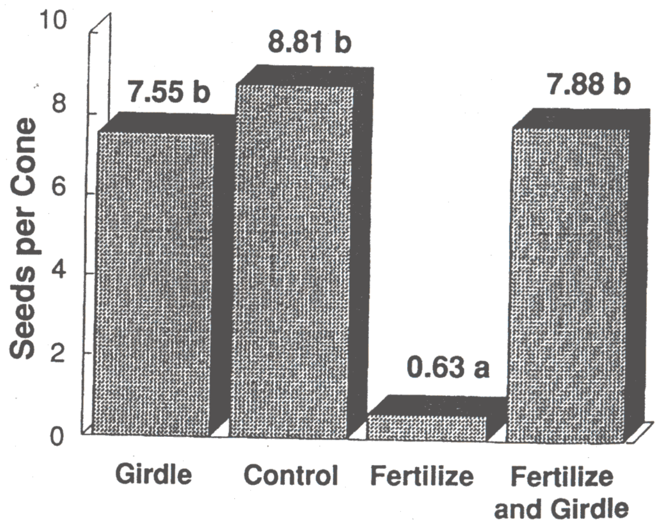

Figure 5—Mean numbers of seeds per cone from western larch after girdling, fertilization, girdling and fertilization, and by control trees. Different letters indicate significant ($P \leq 0.05$) differences among means.

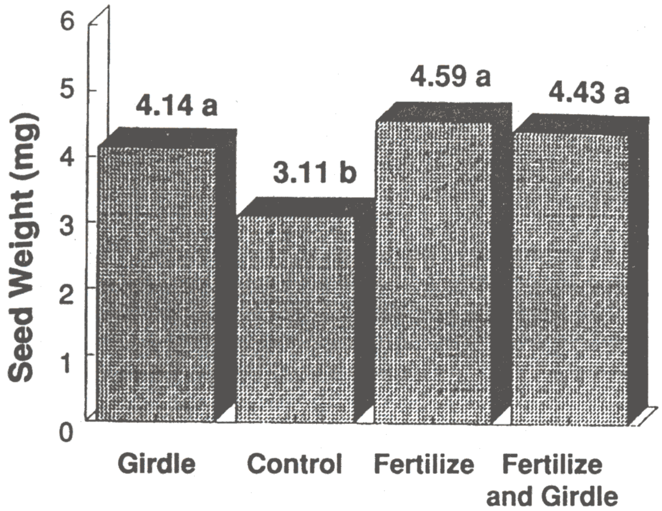

Figure 6—Mean weights of seed produced by western larch after girdling, fertilization, girdling and fertilization, and by control trees. Different letters indicate significant ($P \leq 0.05$) differences among means.

Table 1—Mean tree and stand characteristics for western larch in northern Idaho by treatment and their significance in explaining cone production

Treatment	D.b.h.	Height	Crown ratio	Residual basal area	Crown density
	cm	*m*	*Percent*	*m²/ha*	
Control	34.0a[1]	28.9ab	31.7ab	8.66a	Good
Fertilize	35.3a	29.6a	35.0a	8.43a	Good
Girdle	33.5a	27.5bc	31.7ab	7.90a	Good
Fertilize and girdle	32.8a	27.0c	29.4b	6.89a	Good
Significance	0.752	0.367	0.163	0.752	0.583

[1]Different letters indicate significant ($P \leq 0.05$) differences among treatments.

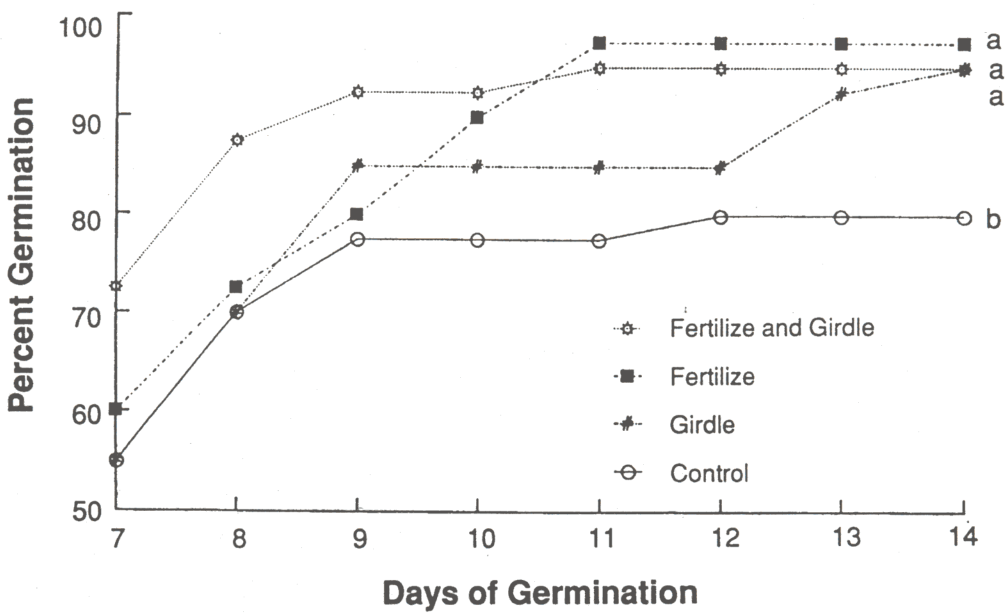

Figure 7—Germination after 28 days of stratification for seeds produced by western larch after girdling, fertilization, girdling and fertilization, and by control trees. Different letters indicate significant ($P \leq 0.05$) differences among means after 14 days of germination.

DISCUSSION

The results from this study were similar to those reported for Douglas-fir (Ebell 1971) that showed girdling was effective in stimulating cone production. Even though the mechanisms initiated by girdling that stimulate cone production are not fully understood, girdling at the base of the live crown could direct solutes back toward the crown. If these solutes contain hormones, nutrients, or a wounding compound that stimulate cone production, they would be at their maximum concentration near the crown. Also, the over-lapping cuts could have increased the moisture stress in the crowns, possibly triggering some type of hormonal or chemical response that stimulated cone production. Some studies used wide cuts (2.5 cm, 1 inch) but the narrow saw kerf widths used in this study healed quickly allowing for retreatment of the trees.

In contrast to studies with other species (Barnes 1969; Heidmann 1984), fertilization alone at 336 kg/ha (300 lb/acre) did not increase cone production. Of the treatments applied in this study, fertilization was the only one that decreased the number of seeds per cone. The effect of fertilization in combination with girdling might have countered the effects of the girdling by increasing the vigor of the trees. Fertilization at higher rates might be more effective in stimulating cone production. Higher fertilization rates may go beyond increasing tree vigor and growth and actually increase stress. This approach may be more effective than the light application of fertilizer used in this study. Fertilizer rates as high as 1,000 to 2,500 kg/ha (893 to 2,232 lb/acre) could be tried.

Tree climbing is dangerous, expensive, and damages trees. Western larch has brittle branches, making working in the crowns of 30-m (98-ft) trees hazardous. The use of climbing spurs damages the tree along the entire stem. Girdling at breast height has been shown to be effective in species such as Douglas-fir (Ebell 1971) and red pine (Holst 1959). Because girdling was so effective in this study it possibly could be effective in stimulating western larch cone production on an operational scale.

APPLICATION

Since we first published the initial results from this study, girdling has been applied throughout the Northern Rocky Mountains. The results of these applications have been highly variable. In eastern Oregon girdling at breast height effectively stimulated cone flower production, but few cones were produced. Likewise, in northern Idaho attempts to girdle western larch to stimulate cones ranged from very effective to very ineffective.

Often the application of girdling is confounded with damage from frost. Frost that occurs when cones are being formed in the early spring often results in empty cones or few cones produced. Therefore, evaluation of the effects of girdling must be balanced with the losses caused by frost.

Where girdling has been applied at breast height, the cuts have often weakened the trees, which made them unsafe to climb and prone to loss from wind. Cuts should be carefully applied so as not to weaken trees if they are going to be climbed or preserved.

With western larch's importance both ecologically and commercially, care needs to be taken to ensure the species is sustained. The use of cultural treatments such as girdling and fertilization to stimulate cone production is viable on some sites and stands. But often more than one contributor exists in the success or failure of a cultural treatment. Therefore, all factors that can affect cone production must be evaluated when considering the use of girdling or fertilization to stimulate cones in western larch.

REFERENCES

Barnes, Burton V. 1969. Effects of thinning and fertilizing on production of western white pine seed. Res. Pap. INT-58. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 14 p.

Bilan, M. V. 1960. Stimulation of cone and seed production in pole-sized loblolly pine. Forest Science. 6: 207-220.

Ebell, L. F. 1962. Growth and cone production responses of Douglas-fir to chemical fertilization. Branch Report B.C. 62-8. Vancouver, BC: Canadian Department of Forestry Research. 22 p.

Ebell, L. F. 1971. Girdling: its effect on carbohydrate status and on reproductive bud and cone development of Douglas-fir. Canadian Journal of Botany. 49: 453-466.

Ebell, L. F. 1972. Cone-induction response of Douglas-fir to form of nitrogen fertilizer and time of treatment. Canadian Journal of Forest Research. 2: 317-326.

Graham, R. T. 1986. Effect of nitrogen fertilizer and girdling on cone and seed production of western larch. In: Shearer, R. C., comp. Proceedings—conifer tree seed in the inland mountain West symposium. Gen. Tech. Rep. INT-203. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 166-170.

Heidmann, L. J. 1984. Fertilization increases cone production in a 55-year-old pine stand in central Arizona. Forest Science. 30: 1079-1083.

Holst, M. J. 1959. Experiments with flower promotion in *Picea glauca* (Moench) Voss. and *Pinus resinosa* Ait. In: Recent advances in botany. Vol. 2. Toronto, ON: University of Toronto Press: 1654-1658.

Stephens, G. R., Jr. 1964. Stimulation of flowering eastern white pine. Forest Science. 10: 28-34.

Wenger, K. F. 1954. The stimulation of loblolly pine trees by pre-harvest release. Journal of Forestry. 52: 115-118.