INFLUENCE OF FIRE SEVERITY ON RESPONSE OF EVERGREEN CEANOTHUS

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ABSTRACT: Fire plays an important role in *Ceanothus velutinus* habitat. Its impact varies with season and severity of fire. Knowledge of the interaction between fire severity and evergreen ceanothus habitat can assist managers in estimating the effect of fire on evergreen ceanothus and in developing burning prescriptions.

INTRODUCTION

Ceanothus velutinus (Dougl.), evergreen or snowbrush ceanothus, is an important wildlife browse species that provides a critical winter food resource for deer and elk (Klebenow 1962; Martinka 1976). Evergreen ceanothus is a component of seral shrub fields, as well as of open xeric or developing early seral conifer stands. Evergreen ceanothus is also of special interest to managers because it fixes nitrogen (Zavitkovski and Newton 1968; Jurgensen and others 1979) and competes with tree seedlings (Gratkowski and Lauterback 1974). Fire plays a prominent, if not critical, role in establishing and maintaining these shrub fields and forest stands. Fire can be used in managing stands with a *Ceanothus* component (Hall 1977).

The following discussion of the response of evergreen ceanothus to fire emphasizes the effect of fire treatment severity. This paper summarizes information on the biology of evergreen ceanothus and emphasizes management strategies for using fire to encourage or discourage reproduction and growth.

SPECIES CHARACTERISTICS

Evergreen ceanothus commonly grows in dense clumps or patches but ranges from scattered individual plants to nearly complete site domination. There are two varieties of *Ceanothus velutinus*. *Ceanothus velutinus* var. *laevigatus* (Hook.) Torr. and Gray is distinguished by smooth (glabrous) leaves, at least on the veins on the underside of the leaves. Its range is the west Cascade Mountains from British Columbia to northern California. *Ceanothus velutinus* var. *velutinus* has pubescent leaves covered with short fine hairs. It is found east of the Cascade Mountains from British Columbia to California and Nevada and east to South Dakota and Colorado (Hitchcock and Cronquist 1961). Evergreen ceanothus is known under several aliases, including shinyleaf, varnish leaf, buckbrush, wild-lilac, stickylaurel, grease wood, and tobacco-brush. The seasonal growth patterns of evergreen ceanothus in the Rocky Mountains can be inferred from published phenological information (Schmidt and Lotan 1980; Schopmeyer 1974). The western variety (*laevigatus*) is sometimes treelike and reaches a maximum height of 20 ft (6 m) (Little 1979). The eastern variety (*velutinus*) is approximately 2 to 6 ft tall (0.5 to 2 m), occasionally up to 13 ft (4 m) Hitchcock and others 1961).

In Montana, Morris and others (1962) associate evergreen ceanothus with Douglas-fir and spruce-fir zones. In north central Washington, evergreen ceanothus is responsible for much of the difference in shrub cover in the ponderosa pine and Douglas-fir forests (Tiedemann and Klock 1976). Average cover 4 years after burning was 12.7 percent on south slopes compared to 6 percent on the west aspects.

Explosive flammability in these stands is attributed to retention of dead leaves on sclerophyllous (thick hard leaves) understory vegetation such as evergreen ceanothus. Fuel from winter dieback of evergreen ceanothus could increase flammability. Stickney (1965) attributed dieback during the winter of 1962-63 in the Missoula, Mont., area to a severe drop in temperature followed by a mild period.

Some of the species that dominate early successional phases often have dormant, ground-stored, fire-activated seeds. This is true of evergreen ceanothus, whose seeds are characteristically small (61,400 to 152,000/lb) (Schopmeyer 1974), rounded to spherical, smooth texture, and without obvious means of dispersal much beyond the limits of the parent plant (Lyon and Stickney 1976). Evergreen ceanothus seeds are long-lived, viable on forest sites for 200 to 300 years (Gratkowski 1962), and require heat treatment to germinate (Dyrness 1973). Pressure of the two edges of the hilar fissure against each other is sufficient to prevent moisture penetration into the seed. Heat induces germination by opening the hilar fissure sufficiently to permit passage of water into the seed (Gratowski 1962). The species can resprout from the root crown after being burned and is intolerant to shade.

Lyon and Stickney's (1976) model for predicting a plant species' success links fire survival strategy to its abundance in early seral communities. Evergreen ceanothus fits two fire survival categories.

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When the on-site survival mechanism (meristematic tissue) is sprouting from burned root crowns, their model predicts a minor decrease in response to severe wildfire. If the survival mechanism is long viability on-site seed, a large increase after these severe wildfires is expected.

FIRE SEVERITY

The concept of fire severity combines the effect of the heat pulse up to the above-ground vegetation and down into the soil (Ryan and Noste in press). The heat pulse down has been termed ground char and is evaluated by classifying postburn soil and fuel characteristics. When used in relation to *Ceanothus velutinus* reproduction and regeneration, the term "fire severity" inplies that the heat pulse is down to the soil. It is difficult to separate fire intensity and the upward heat pulse from ground char in evaluating measures to characterize fire in relation to fire effects. In the literature, ceanothus response has been related to several fire measures such as intensity and percent duff reduction. This information will be interpreted in accordance with the concept of fire severity.

Critical soil temperature inducing germination range from 113° to 149° F (45° to 65° C) (Gratowski 1962). A minimum 8-minute exposure to dry heat induces germination, with further exposure having no additional influence. Mortality increases heat treatment information on the western variety (*laevigatus)*, and it is commonly inferred that it also applies to the variety *velutinus*. Solar insolation on unburned sites apparently also is often sufficient to stimulate germination (Dyrness 1973). The general relationship of *Ceanothus velutinus* to fire severity is illustrated in table 1.

Table 1.--Response of *Ceanothus velutinus* (CEVE) to fire severity[1]

Preburn condition	Response				
Extant plants (CEVE shrubs present)	Aerial crown	Kill		Shrub	Mortality
	All shrubs resprout	Most shrubs resprout		Few shrubs killed	Many shrubs killed
Dormant, viable seed (CEVE seed present in forest floor or ground)	Untreated (below critical temperature)	Fire treated (above critical min. temp.)			
		Nonlethal range		Lethal range	
	Seeds remain dormant	Uppermost seeds activated	Most activated	Few seeds killed	Many seeds killed
No seeds or extant plants present (CEVE absent from site in all forms)	NO RESPONSE No resprouts or seedling evident in postfire community				
	Low	FIRE SEVERITY GRADIENT			HIGH

[1] Personal communication, Peter F. Stickney, Missoula, Mont.: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Feb. 1984.

FIRE SEVERITY RELATIONSHIP

Preliminary results of a study by Arno and Simmerman (1982) describe a relationship between fire severity and establishment of evergreen ceanothus. On the Douglas-fir/ninebark (*Pseudotsuga menziesii/Physocarpus malvaceus*) habitat type (Pfister and others 1977), a medium or hot wildfire or broadcast burn on a site with evergreen ceanothus seed in the soil produces an evergreen ceanothus community type. In Douglas-fir/blue huckleberry (*Pseudotsuga menziesii/vaccinium globulare*) types, a severe burn produces an evergreen ceanothus community type.

In a forest succession study, Stickney (1980) provides data on plant response in relation to fire severity for the larch/Douglas-fir forests of western Montana. There was no evergreen ceanothus on the plots before treatment. The subalpine fir/ queencup beadlily (*Abies lasiocarpa/Clintonia uniflora*) habitat type was treated at the Miller Creek prescribed fire study area on the Flathead National Forest. Evergreen ceanothus became established at low levels (5 and 7 percent cover in 6 years) on two south exposure plots burned by wildfire (table 2). This wildfire could be judged severe based on Stickney's observation that no duff layer remained (DeByle 1981).

The western redcedar/queencup beadlily (*Thuja plicata/Clintonia uniflora*) grand fir/queencup beadlily (*Abies grandis/Clintonia uniflora*), and Douglas-fir/blue huckleberry habitat types were sampled at the Newman Ridge prescribed fire study area on the Lolo National Forest (Stickney 1980). The cold, north-slope western redcedar/queencup beadlily site had no ceanothus response (see unit N2 in table 2).

The four plots in the grand fir/queencup beadlily habitat type had varied response, with no evergreen ceanothus on a west exposure plot (W2) burned by a relatively severe fire. Lack of seed source may explain the absence.

A west slope site on Newman Ridge burned (W3) by a low-severity fire had a relatively high evergreen ceanothus cover (24 percent in 6 years). When treated with fires of similar severity, evergreen ceanothus cover was 22 percent after 6 years on a south slope (S2) compared to 11 percent on an east slope. A Douglas-fir/blue huckleberry plot on a south slope treated with a severe fire had 41 percent cover in 6 years, which must approach the maximum potential for evergreen ceanothus establishment and growth.

Table 2.--Fire effects on Miller Creek-Newman Ridge sites in western Montana (Stickney 1980)

Location, unit no.	Habitat[1] type	Fire intensity (water loss)	Postburn duff depth	Duff reduction	Evergreen ceanothus Preburn	Evergreen ceanothus 6-year postburn
		gm	cm	Percent	Percent	Percent
Miller Creek						
N6	Subalpine fir	303	7.0	14	0	0
N7	Subalpine fir	242	4.5	49	0	0
N8	Subalpine fir	266	6.0	6	0	0
E6	Subalpine fir	243	2.7	49	0	0
E8	Subalpine fir	881	6.6	31	0	0
E9	Subalpine fir	834	4.7	38	0	0
S1	Subalpine fir	286	4.3	16	0	0
S2	Subalpine fir	--	--	--	--	--
W3	Subalpine fir	423	4.5	11	0	0
W10	Subalpine fir	519	2.4	52	0	0
W15	Subalpine fir	228	6.4	11	0	0
Newman Ridge						
E3	Grand fir	820	2.0	35	0	11
N2	Western redcedar	1,297	2.7	51	0	0
S2	Grand fir	813	1.9	47	0	22
W2	Grand fir	1,253	2.2	59	0	0
W3	Grand fir	283	1.0	63	0	24
S3	Douglas-fir	1,976	.3	94	0	41
Wildfire in standing timber						
S12	Subalpine fir	--	--	--	--	7
S13	Subalpine fir	--	--	--	--	5
W6	Subalpine fir	--	--	--	--	0

[1] All units were in the *Clintonia uniflora* phase of the habitat type except unit S3, which is in the *Vaccinium globulare* phase.

Percent duff reduction is an index of depth-of-char, so the concept of fire severity can be applied to the data in table 2. There is a direct trend between percent duff reduction and ceanothus cover. The wildfires and prescribed fires with ceanothus response were severe.

SPRING AND FALL BURNS

The effect of spring and fall prescribed burning is being studied on a seral shrub field in a Douglas-fir/ninebark (*Pseudotsuga menziesii/physocarpus malvaceous*) habitat on O'Keefe Creek near Missoula, Mont. The area is a critical big game winter range, and evergreen ceanothus is an important browse species on the site. The idea that more severe fall prescribed fires provide an alternative to traditional spring fires to rejuvenate seral shrub fields is being evaluated. Fall fires are generally more severe because the larger fuels are drier and soil moisture lower.

Plots of 50 and 125 acres (20 and 50 ha) were burned on October 3, 1979, and April 16, 1980, respectively. The fall of 1979 was dry, and the fire was intense considering the limited fuels on the site. Flame lengths on the fall fire averaged 9 ft (3 m) and contrasted to 3 ft (1 m) flame lengths on the spring burn. A detailed description of fuel loadings, fuel moisture, weather conditions, and fire behavior, which were needed to develop a burning prescription, has been published along with vegetation sampling methods (Noste 1982).

Twenty individual evergreen ceanothus plants were observed before the burns and 1 year after (1980). Twelve of 20 marked plants were killed on the more intense fall burn; there was no mortality on the spring burn. Thus, first growing season survival rates of mature plants were 40 percent on the fall burn and 100 percent on the spring burn.

Evergreen ceanothus seedlings were not counted the first growing season after the fall burn (1980), but many were present. Wildlife grazing during the relatively open (free from snow) 1980-81 winter severely reduced the number of ceanothus seedlings. In 1981, evergreen ceanothus seedlings occurred on 38 percent of the plots (0.5 by 0.5 m) on the fall burn, and the seedlings count indicated a density of 18,000 seedlings per acre (45,000/ha). Seedlings have not been seen on the spring burn. A sample of 50 plots (0.5 by 0.5 m) in both the spring and fall burn during the fourth growing season (1983) indicates 6,500 seedlings per acre (16,000/ha) surviving on the fall burn and none on the spring burn.

The differential response of evergreen ceanothus to fall and spring burning is shown in measurements of percent cover in the following tabulation:

Treatment year	Percent cover
Spring	
preburn	11.5
1980	12.7
1981	19.6
1982	21.5
Fall	
preburn	18.5
1980	0.2
1981	6.7
1982	10.4

During the first growing season following the spring burn, treatment cover (12.7 percent) exceeded the preburn value (11.5 percent). Cover has nearly doubled (21.5 percent) during the third growing season. All of these plants resprouted from root stocks. The fall burn set evergreen ceanothus cover back to 0.2 percent the first year and in the third growing season had expanded to about half of preburn coverage (18.5 and 10.4 percent). This cover nearly all originated from plants that resprouted; small seedlings accounted for very little.

DISCUSSION

Knowledge of the relationship between fire severity and evergreen ceanothus can facilitate development of burning prescriptions. Severe fires are generally needed to establish evergreen ceanothus seedlings. Some interactions between fire severity, aspect, and habitat type are also significant. More severe fires are needed in cool moist habitat types than in warm habitat types. The greatest potential for establishing evergreen ceanothus is on south slopes, followed in order by west and east slopes. The Douglas-fir habitat types have more potential for ceanothus than grand fir habitat types. Subalpine fir habitat types have more potential for evergreen ceanothus than western redcedar habitat types on north slopes or northeast slopes.

Success in regeneration and rejuvenation of evergreen ceanothus following burning is extremely variable, presumably due to variation in duff moisture and fire severity (Wright and others 1979). Late summer or fall burns, however, do increase the number of seedlings and resprouts (Wright and others 1979). The O'Keefe Creek results support this claim. The more intense fall fire produced seedlings at O'Keefe Creek, whereas the spring fire increased evergreen ceanothus cover in the short run.

Martin (1982) has described an effort to reduce evergreen ceanothus in central Oregon ponderosa pine (*Pinus ponderosa*). A burning treatment is designed to exploit stress on the plant and increase the probability of mortality. The treatment combines a preharvest underburn to weaken mature plants and germinate some seed, with a subsequent postharvest burn. This concept of frequent, less intense fires is being evaluated. Successive fires at relatively short intervals have been shown to retard shrub growth (Isaac 1940; Gratowski 1962).

The information presented here, although not in the form of a predictive model, can be used as a guide for estimating the effect of fire on evergreen ceanothus. The manager wanting to increase or decrease the evergreen ceanothus component of a seral shrub field or a forest stand can be more specific in setting objectives and evaluating results and through this process can learn to manipulate this species through the use of fire. Weather conditions and fuel availability may limit attaining the severity of treatment required to accomplish burning objectives.

Low-severity spring burns can increase ceanothus cover immediately and relatively inexpensively through regrowth from root crowns. Severe summer and fall burns stimulate germination of ground-stored seed to produce young plants, thus providing a long-term increase. Multiple low-severity fires provide an approach for reducing the ceanothus component. Objectives should reflect realistic attainable increases in cover or number of seedlings and should only reduce ceanothus cover enough to allow tree seedlings to compete.

REFERENCES

Arno, Stephen F.; Simmerman, Dennis G. Forest succession on four habitat types in western Montana. Missoula, MT: U.S. Department of Agriculture, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Fire Effects Research and Development Program; 1982. Review draft.

DeByle, Norbert V. Clearcutting and fire in the larch/Douglas-fir forests of western Montana--a multifaceted research summary. General Technical Report INT-99. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 73 p.

Dyrness, C. T. Early stages of plant succession following logging and burning in the Western Cascades of Oregon. Ecology. 54(1): 57-69; 1973.

Gratkowski, H.; Lauterback, P. Releasing Douglas-fir from varnishleaf ceanothus. Journal of Forestry. 72(3): 150-152; 1974.

Gratkowski, H. Heat as a factor in germination of seeds of *Ceanothus velutinus* var. *laevigatus*. Corvallis: Oregon State University; 1962. 122 p. Ph.D. thesis.

Hall, F. C. Ecology of natural underburning in the Blue Mountains of Oregon. Region 6-Ecology-79-001. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; 1977. 11 p.

Hitchcock, C. Leo; Cronquist, Arthur. Flora of the Pacific Northwest. Seattle: University of Washington Press; 1976. 730 p.

Hitchcock, C. Leo; Cronquist, Arthur; Ownbey, Marion; Thompson, J. W. Vascular plants of the Pacific Northwest, part 3. Seattle: University of Washington Press; 1961. 614 p.

Isaac, L. A. Vegetative succession following logging in the Douglas-fir region with special reference to fire. Journal of Forestry. 38: 716-721; 1940.

Jurgensen, M. F.; Arno, S. F.; Harvey, A. E.; Larsen, M. J.; Pfister, R. D. Symbiotic nitrogen fixation in the management of temperate forests. In: Proceedings, Workshop; 1979 April 2-5; Corvallis, OR. Corvallis: Oregon State University, Forest Research Laboratory; 1979: 294-308.

Klebenow, Donald A. Ecology and productivity of a Montana forest winter deer range, western Montana. Missoula: University of Montana; 1962. 93 p. M.S. thesis.

Little, Elbert L., Jr. Checklist of United States trees (native and naturalized). Agriculture Handbook 541. Washington, DC: U.S. Department of Agriculture, Forest Service; 1979. 375 p.

Lyon, L. J.; Stickney, P. F. Early vegetal succession following large northern Rocky Mountain wildfires. In: Proceedings, Tall Timbers fire ecology conference No. 14 and Intermountain Fire Council fire and land management symposium; 1974 October; Missoula, MT. Tallahassee, FL: Timbers Research Station; 14: 355-375; 1976.

Martin, Robert E. Shrub control by burning before timber harvest. In: David Baumgartner, ed. Proceedings of the site preparation and fuels management on steep terrain symposium; 1982 February 15-17; Spokane, WA: 1982: Pullman, WA: Washington State University, Cooperative Extension; 1982: 35-40.

Martinka, C. J. Fire and elk in Glacier National Park. In: Proceedings, Tall Timbers fire ecology conference No. 14 and Intermountain Fire Research Council fire and land management symposium: 1974 October; Missoula, MT. Tallahassee, FL: Tall Timbers Research Station; 1976: 377-390.

Morris, M. S.; Schmautz, J. E.; Stickney, P. F. Winter field key to the native shrubs of Montana. Bulletin No. 23. Bozeman, MT: Montana State University, Forest and Conservation Experiment Station; 1962. 70 p.

Noste, Nonan V. Vegetation response to spring and fall burning for wildlife habitat improvement. In: Baumgartner, David M., ed. Proceedings of the site preparation and fuels management on steep terrain symposium; Pullman, WA: Washington State University, Cooperative Extension; 1982 February 15-17; Spokane, WA. 1982 125-132.

Pfister, Robert D.; Kovalchik, Bernard L.; Arno, Stephen F.; Presby, Richard C. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Ryan, Kevin C.; Noste, Nonan V. A technique for evaluating fire severity. In: Proceedings, wilderness fire symposium; Missoula, MT; 1983 November 15-18; Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; [in press].

Schmidt, Wyman C.; Lotan, James E. Phenology of common forest flora of the Northern Rockies--1928-1937. Research Paper INT-259. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 20 p.

Schopmeyer, C. S., technical coordinator. Seeds of woody plants in the United States. Agriculture Handbook 450. Washington, DC: U.S. Department of Agriculture, Forest Service; 1974. 883 p.

Stickney, P. F. Note on winter kill of *Ceanothus velotinus*. Proceedings Montana Academy of Science. 25: 52-57; 1965.

Stickney, P. F. Data base for post-fire succession, first 6 to 9 years, in Montana larch-fir forests. General Technical Report INT-62. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 153 p.

Tiedemann, A. R.; Klock, G. O. Development of vegetation after fire, seeding, and fertilization on the Entiat Experimental Forest. In: Proceedings, Tall Timber fire ecology conference No. 14 and Intermountain Fire Research Council fire and land management symposium; 1974; Missoula, MT: Tallahassee, FL: Tall Timbers Research Station; 1976: 171-192.

Wright, H. A.; Neuenschwander, L. F.; Britton, C. M. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: a state-of-the-art review. General Technical Report INT-58. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 48 p.

Zavitkovski, J.; Newton, M. Ecological importance of snow brush, *ceanothus velutinus*, in the Oregon Cascades. Ecology. 49: 1134-1145; 1968.

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