

# NATURAL REGENERATION MICROSITES FOR DOUGLAS-FIR IN CENTRAL IDAHO

Kathleen Geier-Hayes

## ABSTRACT

Suitable microsites for natural regeneration vary by species and environment. Natural regeneration depends not only on the availability of seed, but also the availability of microsites. Management activities including timber harvesting and site preparation create and destroy microsites. Therefore, potential microsites must be identified to plan appropriate management activities.

Natural regeneration microsites (seedbeds and covers) were surveyed for Douglas-fir on four Douglas-fir and three grand fir habitat types in central Idaho. Results indicate that regeneration most often occurs on shaded, disturbed seedbeds in many habitat types. Most often, vegetation provides the shade. However, not all potential vegetation species provide suitable microsites. Some vegetation species appear to increase natural regeneration establishment while other species may impede establishment and some are important in some habitat types but not in others. Potential mechanisms for these differences are addressed.

**Keywords:** Natural regeneration, Douglas-fir, microsites, central Idaho

## INTRODUCTION

When land managers prescribe natural regeneration they often focus much of their attention on manipulating seed supply. While certainly a fundamental element for obtaining seedlings, the seed comprises only a portion of the essentials. The seed must fall into a spot (a microsite) that provides the requisite conditions for germination, establishment, and initial growth and development. Without these appropriate microsites natural regeneration will fail.

Across the landscape suitable microsites may be many or few depending on the species. Microsites must provide adequate moisture and nutrients, appropriate growing temperatures, and protection from predators and pathogens (Harper 1977). Many species can germinate and establish within a wide range of environmental conditions, and suitable microsites may therefore be numerous. Other species, however, may require exacting circumstances, specific light or soil conditions to germinate, and only a few suitable microsites may exist. For example, Day and Duffy (1963) found that in the Crowsnest Forest in southwest Alberta, mineral soil was the best seedbed for lodgepole pine while spruce and fir regenerated more often on decayed wood or duff seedbeds than on mineral soil.

It can be difficult and frustrating to determine exactly what microsites a species requires since many variables are involved.

For management purposes, however, we often think of microsites for natural regeneration as seedbeds, that is, the germination substrate. However, the microenvironment above (or below) the seedbed also influences both seed germination and can have a profound effect on seedling development.

The seedbed requirements of most major conifer species have been described. For Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), most research shows that treatments that expose mineral soil most often obtain natural regeneration (Roe 1952; Williamson 1973; Twilight 1973; Day and Duffy 1963; Daniel and Schmidt 1971). Both Day and Duffy (1963) and Krauch (1956) also found that thin litter layers over mineral soil benefit regeneration by providing a mulch, which may protect the soil from raindrop impact and reduce soil surface moisture loss. However, Krauch (1956) noticed that certain kinds of litter, including the needles of Douglas-fir, prevented Douglas-fir establishment. Daniel and Schmidt (1972) also found that incorporated O horizon material, composed of Douglas-fir needles mixed with potting medium, reduced Douglas-fir germination. Even though Douglas-fir litter mixed with soil may not provide suitable seedbeds, "mixed" soil-organic debris seedbeds may still be important for regeneration, as well as moss mats and rotten wood (Day and Duffy 1963; Harvey 1982).

The seedbed, however, is only one aspect of a microsite; microsite covers (including overstory and understory vegetation or debris) are also important. Many investigators have extensively debated the effect of vegetation on natural regeneration. Most often land managers attempt to reduce vegetation, which is thought to compete with desired conifers for moisture, nutrients, and light. Many studies have shown conclusively that vegetation reduces growth rates of conifers (Flint and Childs 1987; Ellison 1949; Minore 1986; Day 1964). However, many of these same investigations showed that vegetation can increase germination and establishment rates of natural Douglas-fir regeneration as well as survival rates of planted Douglas-fir, particularly on hot, dry sites. Overstory and understory vegetation and debris (logs, slash, etc.) benefit seedling germination and establishment (Roeser 1924; Coffman 1975; Isaac 1943; Minore 1986, 1987; Day 1964). Vegetation and debris can ameliorate the physical environment by reducing soil surface evaporation rates, temperature extremes, and wind speeds as well as affecting light intensity and quality (Hunter and Aarssen 1988). Vegetation produces organic matter that can change a soil's physical and chemical characteristics. Vegetation can also protect plants that occur near them by excluding or repelling predators or pathogens. The importance of vegetation for germination and establishment of other species is especially evident in the desert (Hunter and Aarssen 1988; Muller 1953). Here, some species appear not only to benefit from microsites created by other species but may actually require them. Franco and Nobel (1989) found that certain species perform this "nurse

plant" function more often than others. The growth form of some vegetation species may provide better microsites than others (Minore 1986; Muller 1953). Some species produce highly nutritious litter compared to other species in the same environment (Daubenmire 1953; Conard *et al.* 1985; Hauessler and Coates 1986).

On mesic sites, however, vegetation may not provide any benefit to natural regeneration (Minore 1986). In these environments vegetation does not ameliorate site conditions because both moderate temperatures and adequate moisture are already provided. Here, vegetation may only compete with conifers without benefiting them. Additionally, some species may inhibit establishment of other species by producing chemicals that reduce their germination or growth rates (allelopathy) (del Moral and Cates 1971; Ferguson and Boyd 1988; Muller 1969; Pickett and Baskin 1973; Fisher 1980; Evanari 1949; Conard 1985; Younger *et al.* 1980).

The Intermountain Research Station initiated a survey of natural regeneration in 1979 on disturbed sites on the Boise and Payette National Forests of central Idaho. The objective of the survey was to determine natural regeneration microsites of all conifer species and the harvest regeneration-site preparation treatment combinations that produce favorable microsites. The following Douglas-fir and grand fir habitat types (h.t.s) were surveyed: Douglas-fir/elksedge (*Pseudotsuga menziesii/Carex geyeri*) h.t., Douglas-fir/pinegrass (*Pseudotsuga menziesii/Calamagrostis rubescens*) h.t., Douglas-fir/white spirea (*Pseudotsuga menziesii/Spiraea betulifolia*) h.t., Douglas-fir/ninebark (*Pseudotsuga menziesii/Physocarpus malvaceus*) h.t., Douglas-fir/mountain maple (*Pseudotsuga menziesii/Acer glabrum*) h.t., grand fir/white spirea (*Abies grandis/Spiraea betulifolia*) h.t., grand fir/mountain maple (*Abies grandis/Acer glabrum*) h.t., and grand fir/blue huckleberry (*Abies grandis/Vaccinium globulare*) h.t. (Steele *et al.* 1981). These habitat types delineate a variety of environments from cool, dry to cool, and moist (Figure 1). This paper describes the results of that survey for Douglas-fir.

## METHODS

Sample sites were located in the study area "subjectively but without preconceived bias" as described by Mueller-Dombois and Ellenberg (1974). In all, 304 sites were surveyed within the seven habitat types. Habitat types were identified and stands selected to represent the range of harvest regeneration methods (clearcut, seed-tree, shelterwood, and group selection) and site

preparation (none, broadcast burn or underburn, light mechanical scarification from dozer piling of logging slash, and heavy scarification from contour terracing). Sample points were located to represent uniform treatments. Only sites with disturbances older than 5 years were sampled. At each site, five 108-ft.<sup>2</sup> (10 m<sup>2</sup>) circular plots were located with one at the center and four peripheral, with two perpendicular and two on the contour, from the center point. Aspect, slope, elevation, topographic position, and disturbance age were recorded for each site. Data recorded for each plot included percentage of plot covered by various seedbeds (litter-covered mineral soil, bare mineral soil, moss mats, residual duff, rotten wood, stumps, and rocks), percentage coverages of vegetative species and debris, number of conifer seedlings by species, seedbed, and species of or kind of overhanging vegetation or debris. Only natural seedlings older than 3 years were recorded. Data were summarized by calculating percent occurrence of seedlings based on number of seedlings and number of plots for various treatments.

## RESULTS AND DISCUSSION

Douglas-fir in central Idaho ranges across broad segments of environmental conditions both as a seral species in the grand fir habitat types and as a climax species in the Douglas-fir habitat types (Steele *et al.* 1981), and because of this, it can regenerate within a wide array of microsites. Several trends suggested for Douglas-fir by investigators in other areas also held true for Douglas-fir in central Idaho. Seedbeds of undisturbed duff usually precluded regeneration establishment (Table 1). Disturbed seedbeds like mineral soil and litter-covered mineral soil more often regenerated seedlings. Many seedlings also occurred on early seral, upright mosses that usually colonize mineral soil. Whether the moss or seedlings occurred first could not be determined; the mosses may produce microenvironments that facilitate germination and establishment of regeneration, or the presence of the moss on the microsite may merely indicate microsites suitable for both the seedlings and the moss. Whatever the relationship, moss mats and seedlings often occurred together in all habitat types.

In both the Douglas-fir and grand fir habitat types, seedlings commonly occurred on either mosses, bare mineral soil, or litter-covered mineral soil. However, in the more moist grand fir habitat types, organic seedbeds, particularly rotten wood, were also important. Organic material (rotten wood or duff) supported 22% of the regeneration in the warm, dry grand

-----DRY-----		-----MOIST-----		Douglas-fir Seral Status
Cool	Warm	Moderate	Cool	
Douglas-fir/ elksedge	Douglas-fir/ white spirea	Douglas-fir ninebark	Douglas-fir/ mountain maple	Climax
	Grand fir/ white spirea	Grand fir/ mountain maple	Grand fir/ blue huckleberry	Seral

Figure 1.—Relative environmental position of seven central Idaho habitat types.

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Table 1.—Occurrence of Douglas-fir seedlings on various seedbeds for 4 Douglas-fir and 3 grand fir habitat types in central Idaho.

	Average cover	PSME/ CAGE	PSME/ SPBE	PSME/ PHMA	PSME/ ACGL
Number of seedlings		27	153	76	196
<b>Microsite seedbed</b>					
Litter covered		-----percent-----			
mineral soil	55	17	11	18	12
Bare mineral soil	39	55	11	6	4
Moss mats	2	27	63	77	75
Residual duff	3	0	4	0	2
Rotten wood	1	0	11	0	8
			ABGR/ SPBE	ABGR/ ACGL	ABGR/ VAGL
Number of seedlings			95	138	31
<b>Microsite seedbed</b>					
Litter covered		-----percent-----			
mineral soil	63		10	13	12
Bare mineral soil	25		14	20	17
Moss mats	7		54	44	18
Residual duff	3		0	10	0
Rotten wood	2		22	13	53

fir/white spirea h.t., 23% in the mesic grand fir/mountain maple h.t., and 53% in the cool, moist grand fir/blue huckleberry h.t. Day and Duffy (1963) also found that rotten wood was an important seedbed for Douglas-fir on a moist site in Canada. Even though both rotten wood and duff occurred in the Douglas-fir habitat types, organic seedbeds in these habitat types may dry out too quickly to provide suitable rooting environments (Potts 1985).

Regeneration in dry environments occurred most often on sites with harvest regeneration methods and/or site preparations that provided site protection (Table 2). In the cool, dry Douglas-fir/elksedge h.t., most Douglas-fir regeneration occurred in underburned shelterwood stands where site protection was provided from both the overstory and the understory. In the warmer, drier Douglas-fir/white spirea habitat type, most regeneration occurred in clearcuts and seed-tree cuts, particularly on sites that had been broadcast burned. However, while most of the regeneration occurred in clearcuts, only 3% established in the open (Table 3). Burn treatments usually stimulated more vegetative cover than scarification treatments. Many shrub species resprout with renewed vigor following top-kill from burning, and burning can also stimulate shrub germination from buried seed (Steele and Geier-Hayes 1987, 1989a).

In more mesic habitat types such as Douglas-fir/ninebark and Douglas-fir/mountain maple, scarified clearcuts and seed-tree cuts and group selection cuts all produced regeneration (Table 2). Here, more favorable conditions exist for regeneration, and site protection is not as critical as in the drier habitat types. These habitat types also support a higher diversity of vegetation species and scarification treatments expose mineral soil without producing excessive competition from resprouting shrubs. Additionally, shrub species with buried seed, primarily *Ribes*, often germinates following scarification. This species produces less

shrub competition for seedlings than *Ceanothus*, which usually appears following broadcast burning. While Douglas-fir utilizes many of the microsites created by broadcast burning (Steele and Geier-Hayes 1987, 1989a), high intensity burning on these sites can create excessive vegetative competition. Minore (1987) states that on mesic sites competition from vegetation can preclude any site protection benefits because favorable conditions already exist for conifer regeneration. On mesic sites that must be burned, low intensity broadcast burns usually create a mosaic of conditions which should provide some favorable microsites for natural regeneration. In the drier Douglas-fir/elksedge and Douglas-fir/white spirea h.t.s, particularly in clearcuts, high intensity broadcast burning may be necessary to create site protection for natural regeneration.

Survey results in the grand fir habitat types were similar to the Douglas-fir habitat types. In the warm, dry grand fir/white spirea h.t. scarified shelterwood cuts and broadcast burned clearcuts and seed-tree cuts accounted for 73% of the regeneration, and as with the mesic Douglas-fir habitat types, scarified site preparation treatments produced the most regeneration in the mesic grand fir/mountain maple h.t. (Table 2). In the cooler grand fir/blue huckleberry h.t. all the regeneration occurred in clearcuts, though no seedlings were found in the open (Table 4). Broadcast burning in the grand fir/blue huckleberry h.t. also accounted for more than half the regeneration. Here, cooler temperatures limit vegetation development, and burning treatments likely do not produce as much vegetative competition as can occur in the grand fir/mountain maple h.t. Of all the habitat types sampled, grand fir/mountain maple supports the greatest vegetation species diversity, and shrubs usually attain their largest size here (Steele and Geier-Hayes 1989b). Broadcast burning in this habitat type resulted in the fewest number of seedlings.

Table 2. — Occurrence of Douglas-fir seedlings under various harvest regeneration-site treatment combinations for 4 Douglas-fir and 3 grand fir habitat types in central Idaho.

	Number of stands	PSME/ CAGE	PSME/ SPBE	PSME/ PHMA	PSME/ ACGL
Number of seedlings		27	153	76	196
<b>Regeneration Method</b>					
Clearcut and seed-tree			percent		
No site preparation	12	—	11	19	4
Broadcast burn	25	8	39	19	16
Scarification	86	7	24	15	59
Group selection					
No site preparation	3	0	—	—	5
Broadcast burn	3	0	—	0	—
Scarification	11	17	11	47	5
Shelterwood					
No site preparation	4	0	—	0	0
Underburn	1	68	—	—	—
Scarification	14	0	15	—	11
			ABGR/ SPBE	ABGR/ ACGL	ABGR/ VAGL
Number of seedlings			95	138	31
<b>Regeneration Method</b>					
Clearcut and seed-tree			percent		
No site preparation	8	—	0	22	—
Broadcast burn	14	—	32	2	56
Scarification	86	—	24	21	44
Group selection					
No site preparation	3	—	—	5	—
Broadcast burn	0	—	—	—	—
Scarification	11	—	—	18	0
Shelterwood					
No site preparation	5	—	3	0	—
Underburn	1	—	0	—	0
Scarification	16	—	41	32	0

While Douglas-fir regeneration appears to be favored by vegetative protection on many habitat types, not all vegetation species are equally suited as cover. Graminoids and forbs do not provide good cover for regeneration (Tables 3, 4). In the drier Douglas-fir habitat types regeneration more often occurred under early seral vegetation species than under late seral or climax species. Del Moral and Cates (1971) found that many of the late seral and climax genera occurring in central Idaho had high inhibitory ratings when tested against three other species including Douglas-fir. *Symphoricarpos*, *Sorbus*, and *Vaccinium*, all late seral and climax species in the Douglas-fir and grand fir habitat types, showed some interference with Douglas-fir. Early seral genera, *Ceanothus* and *Populus*, and late seral and climax genera, *Rubus* and *Physocarpus*, all exhibited low inhibition rates for germination of Douglas-fir. One exception was *Sambucus*, an early seral species, which was highly inhibitory for Douglas-fir germination.

The inhibition noted by del Moral and Cates (1971) may indeed preclude some species as potential covers, particularly in drier habitat types where chemicals may not be leached from the soil as quickly as in more moist habitat types. Ninety-seven

percent of the regeneration in the Douglas-fir/elksedge h.t. and 60% of the regeneration in the Douglas-fir/white spirea h.t. occurred under early seral shrubs and trees (species with low inhibitory effect on Douglas-fir regeneration) (Table 3). In the Douglas-fir/elksedge h.t., no seedlings were found under *Symphoricarpos*, a near climax shrub species which had a high inhibitory rate for Douglas-fir germination even though *Symphoricarpos* occurred in more than half the plots. Similarly, few seedlings were found under either *Sambucus* or *Symphoricarpos* in more moist habitat types. *Prunus*, a mid-seral shrub species and a suspected allelopath (Fisher 1980; Muller 1966), had high canopy coverages over one-quarter of the plots, but no seedlings were found under *Prunus*.

Other species including *Ceanothus velutinus*, *Alnus sinuata*, *Populus tremuloides*, and *Purshia tridentata*, all early seral and mid-seral shrub species, may benefit seedling establishment because they produce litter or other debris high in nutrients (Haeussler and Coates 1986; Conard *et al.* 1985; Bormann 1988). *Ceanothus velutinus* (Conard *et al.* 1985), *Alnus sinuata* (Haeussler and Coates 1986), and *Purshia tridentata* (Bormann 1988) support organisms which fix nitrogen and therefore may

provide microsites with higher nitrogen levels. *Populus tremuloides* also produces litter rich in many essential nutrients (Daubenmire 1953; Haeussler and Coates 1986). However, *Populus tremuloides* may also produce allelopathic compounds (Younger *et al.* 1980). While species that produce nutritious litter and debris can potentially provide microsites for seedling regeneration, their importance may diminish with increasing moisture (Haeussler and Coates 1986). *Ceanothus velutinus*, which supports organisms that fix nitrogen, was important for cover on the Douglas-fir/elksedge h.t., where 21% of the seedlings occurred under *Ceanothus* (Table 3). Fewer seedlings oc-

curred under *Ceanothus* on more moist sites (Tables 3, 4). *Purshia tridentata*, like *Ceanothus*, supports nitrogen fixing organisms and occurred in the Douglas-fir/elksedge and Douglas-fir/white spirea habitat types; 6-7% of the Douglas-fir regeneration was found under *Purshia*. Haeussler and Coates (1986) noted that while *Alnus sinuata* also supports organisms which fix nitrogen, this species only benefits regeneration on nitrogen-deficient soils. *Alnus* was present on the grand fir/mountain maple and grand fir/blue huckleberry h.t.s, but no Douglas-fir seedlings were found under *Alnus* in either habitat type.

Table 3.—Occurrence of Douglas-fir seedlings under various microsite covers in 4 Douglas-fir habitat types in central Idaho.

	Potential Effect <sup>1</sup>	Constancy (Cover)	PSME/CAGE	PSME/SPBE	PSME/PHMA	PSME/ACGL
Number of Seedlings			27	153	76	196
<b>Miscellaneous cover</b>			-----percent-----			
No cover	-/-		2	3	20	3
Slash	-/-	69 (12.1)	<1	7	5	2
Forbs	-/-	96 (17.7)	1	2	2	1
Graminoids	-/-	93 (15.8)	0	<1	3	1
Total			<4	<13	30	7
<b>Early seral shrubs and trees</b>						
<i>Artemesia tridentata</i>	-/-	1 (16.3)	0	0	—	—
<i>Ceanothus velutinus</i>	N <sup>2</sup> /-	34 (17.0)	21	12	13	3
<i>Chrysothamnus spp.</i>	-/-	1 (4.0)	0	0	0	—
<i>Pinus contorta</i>	-/-	3 (11.1)	70	4	—	—
<i>Populus tremuloides</i>	N <sup>3</sup> /A <sup>4</sup>	4 (42.1)	0	2	0	0
<i>Purshia tridentata</i>	N <sup>5</sup> /-	7 (10.7)	6	7	—	—
<i>Ribes spp.</i>	-/-	17 (13.4)	0	35	4	1
<i>Sambucus racemosa</i>	-/A <sup>6</sup>	3 (7.8)	0	0	0	0
Total			97	60	17	4
<b>Mid-seral shrubs and trees</b>						
<i>Pinus ponderosa</i>	-/-	28 (19.0)	0	5	4	14
<i>Prunus spp.</i>	-/A <sup>7</sup>	34 (12.0)	0	<1	0	1
<i>Salix scouleriana</i>	-/-	7 (20.8)	0	5	10	<1
Total			0	<11	14	<16
<b>Late seral to climax shrubs and trees</b>						
<i>Acer glabrum</i>	N <sup>8</sup> /-	11 (15.0)	—	0	0	2
<i>Amelanchier alnifolia</i>	-/-	25 (10.2)	0	4	13	2
<i>Berberis repens</i>	-/-	33 (5.4)	0	2	0	1
<i>Lonicera utahensis</i>	-/-	1 (6.5)	—	0	0	16
<i>Physocarpus malvaceus</i>	-/-	10 (14.5)	—	0	17	16
<i>Pseudotsuga menziesii</i>	-/A <sup>9</sup>	5 (14.2)	0	0	0	10
<i>Rubus parviflorus</i>	-/-	2 (12.5)	—	0	0	5
<i>Shepherdia canadensis</i>	N <sup>5</sup> /-	<1 (6.3)	—	—	—	—
<i>Sorbus scopulina</i>	-/A <sup>6</sup>	4 (11.4)	0	0	0	1
<i>Spiraea betulifolia</i>	-/-	45 (14.6)	0	8	9	10
<i>Symphoricarpos spp.</i>	-/A <sup>6</sup>	39 (9.9)	0	2	0	1
<i>Vaccinium globulare</i>	-/-	<1 (10.5)	—	—	0	8
Total			0	16	39	72

<sup>1</sup>N = Nutritious litter, A = Allelopathic

<sup>2</sup>Haeussler and Coates 1986; Conard *et al.* 1985

<sup>3</sup>Daubenmire 1953; Haeussler and Coates 1986

<sup>4</sup>Younger *et al.* 1980

<sup>5</sup>Bormann 1988

<sup>6</sup>del Moral and Cates 1971

<sup>7</sup>Fisher 1980; Muller 1966

<sup>8</sup>Haeussler and Coates 1986

<sup>9</sup>Daniel and Schmidt 1971

Table 4.—Occurrence of Douglas-fir seedlings under various microsite covers in 3 grand fir habitat types in central Idaho.

	Potential Effect <sup>1</sup>	Constancy (Cover)	ABGR/ SPBE	ABGR/ ACGL	ABGR/ VAGL
Number of Seedlings			95	138	31
<b>Miscellaneous cover</b>			-----percent-----		
No cover	-/-		9	7	0
Slash	-/-	65 (9.0)	5	5	18
Forbs	-/-	96 (19.3)	3	3	3
Graminoids	-/-	89 (9.7)	4	0	0
<b>Total</b>			21	15	21
<b>Early seral shrubs and trees</b>					
<i>Ceanothus velutinus</i>	N <sup>2</sup> /-	27 (30.0)	10	6	3
<i>Larix occidentalis</i>	-/-	1 (16.7)	—	0	0
<i>Pinus contorta</i>	-/-	1 (20.5)	0	—	0
<i>Populus tremuloides</i>	N <sup>3</sup> /A <sup>4</sup>	3 (32.1)	0	0	—
<i>Ribes spp.</i>	-/-	51 (7.0)	0	8	5
<i>Sambucus racemosa</i>	-A <sup>5</sup>	3 (8.6)	0	0	0
<b>Total</b>		10	14	8	
<b>Mid-seral shrubs and trees</b>					
<i>Alnus sinuata</i>	N <sup>6</sup> /-	6 (43.3)	—	0	0
<i>Pinus ponderosa</i>	-/-	27 (18.4)	17	4	1
<i>Prunus spp.</i>	-A <sup>7</sup>	7 (16.8)	0	6	0
<i>Pseudotsuga menziesii</i>	-A <sup>8</sup>	11 (11.3)	0	2	0
<i>Salix scouleriana</i>	-/-	29 (20.1)	7	5	4
<b>Total</b>			24	17	5
<b>Late seral to climax shrubs and trees</b>					
<i>Abies grandis</i>	-/-	10 (21.3)	18	2	0
<i>Acer glabrum</i>	N <sup>6</sup> /-	11 (15.8)	0	4	—
<i>Amelanchier alnifolia</i>	-/-	4 (8.0)	0	0	0
<i>Berberis repens</i>	-/-	3 (6.1)	0	0	—
<i>Lonicera utahensis</i>	-/-	24 (9.7)	10	10	2
<i>Physocarpus malvaceus</i>	-/-	14 (12.8)	0	2	0
<i>Picea engelmannii</i>	-A <sup>8</sup>	1 (16.4)	—	0	0
<i>Rubus parviflorus</i>	-/-	19 (13.8)	0	15	45
<i>Shepherdia canadensis</i>	N <sup>9</sup> /-	1 (12.9)	—	0	0
<i>Sorbus scopulina</i>	-A <sup>5</sup>	3 (12.6)	—	0	0
<i>Spiraea betulifolia</i>	-/-	36 (10.0)	17	3	0
<i>Symphoricarpos spp.</i>	-A <sup>5</sup>	10 (10.2)	0	0	0
<i>Vaccinium globulare</i>	-/-	21 (19.6)	—	12	11
<b>Total</b>			45	54	66

<sup>1</sup>N = Nutritious litter, A = Allelopathic<sup>2</sup>Haeussler and Coates 1986; Conard *et al.* 1985<sup>3</sup>Daubenmire 1953; Haeussler and Coates 1986<sup>4</sup>Younger *et al.* 1980<sup>5</sup>del Moral and Cates 1971<sup>6</sup>Haeussler and Coates 1986<sup>7</sup>Fisher 1980; Muller 1966<sup>8</sup>Daniel and Schmidt 1971<sup>9</sup>Bormann 1988

Douglas-fir often does not regenerate under itself. Only in the Douglas-fir/mountain maple h.t. did seedlings occur under Douglas-fir (Tables 3, 4), and even then none were on seedbeds of Douglas-fir litter. Krauch (1956) found similar occurrences of seedlings in the Southwest. He noted that where Douglas-fir occurred under itself, most of the seedlings were on seedbeds composed of materials other than Douglas-fir needles. Even though del Moral and Cates (1971) found no inhibition of Douglas-fir germination from Douglas-fir leaf or litter extracts, Daniel and Schmidt (1971) reported reduced germination rates of Douglas-fir in potting medium with incorporated O horizon material derived from Douglas-fir needles. This suggests that

where Douglas-fir shelterwoods may be required to protect regeneration on extreme sites, site preparation will be necessary not only for duff reduction but to remove Douglas-fir litter and expose other seedbeds.

## CONCLUSIONS

Suitable microsites for natural regeneration of Douglas-fir usually vary depending on the environment, the site vegetation, and the disturbance. In central Idaho, Douglas-fir occurs both as a climax dominant in the Douglas-fir habitat types and as a major mid-seral species in the grand fir habitat types.

Litter-covered mineral soil, bare mineral soil, and moss mats all supported more Douglas-fir regeneration than duff. Litter or duff derived from Douglas-fir may also preclude regeneration. In more moist habitat types such as the grand fir habitat types, rotten wood seedbeds may also be important.

Douglas-fir regeneration appears to require more site protection in dry habitat types compared to more moist habitat types. In dry habitat types, shelterwood cutting provided the most microsites for Douglas-fir regeneration. Burning can also stimulate shrubs already present and stimulate additional shrubs from buried seed providing seedling protection. In more moist habitat types, including Douglas-fir/ninebark, Douglas-fir/mountain maple, grand fir/mountain maple, and grand fir/blue huckleberry, scarified openings produced from either group selection cutting or clearcutting and seed-tree cutting, provided more favorable microsites for Douglas-fir regeneration than other treatments. In these habitat types, broadcast burning often produces fewer microsites by creating excessive competition for seedlings. This is especially true in the mesic grand fir/mountain maple h.t. where amenable environmental conditions allow vegetation to attain large heights and diameters.

Not all vegetation covers provide favorable microsites. Many shrub species, particularly late seral and climax, may be allelopathic. These allelopathic effects may be especially pronounced in drier habitat types. Early seral species may also be important for Douglas-fir regeneration since many of the more common early seral shrub species produce nutritious litter. These species may be more important in drier environments.

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## Author

Kathleen Geier-Hayes  
 Research Forester  
 Intermountain Research Station  
 USDA Forest Service  
 316 E. Myrtle St.  
 Boise, ID 83702