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Stump Sprouting of Pacific Yew

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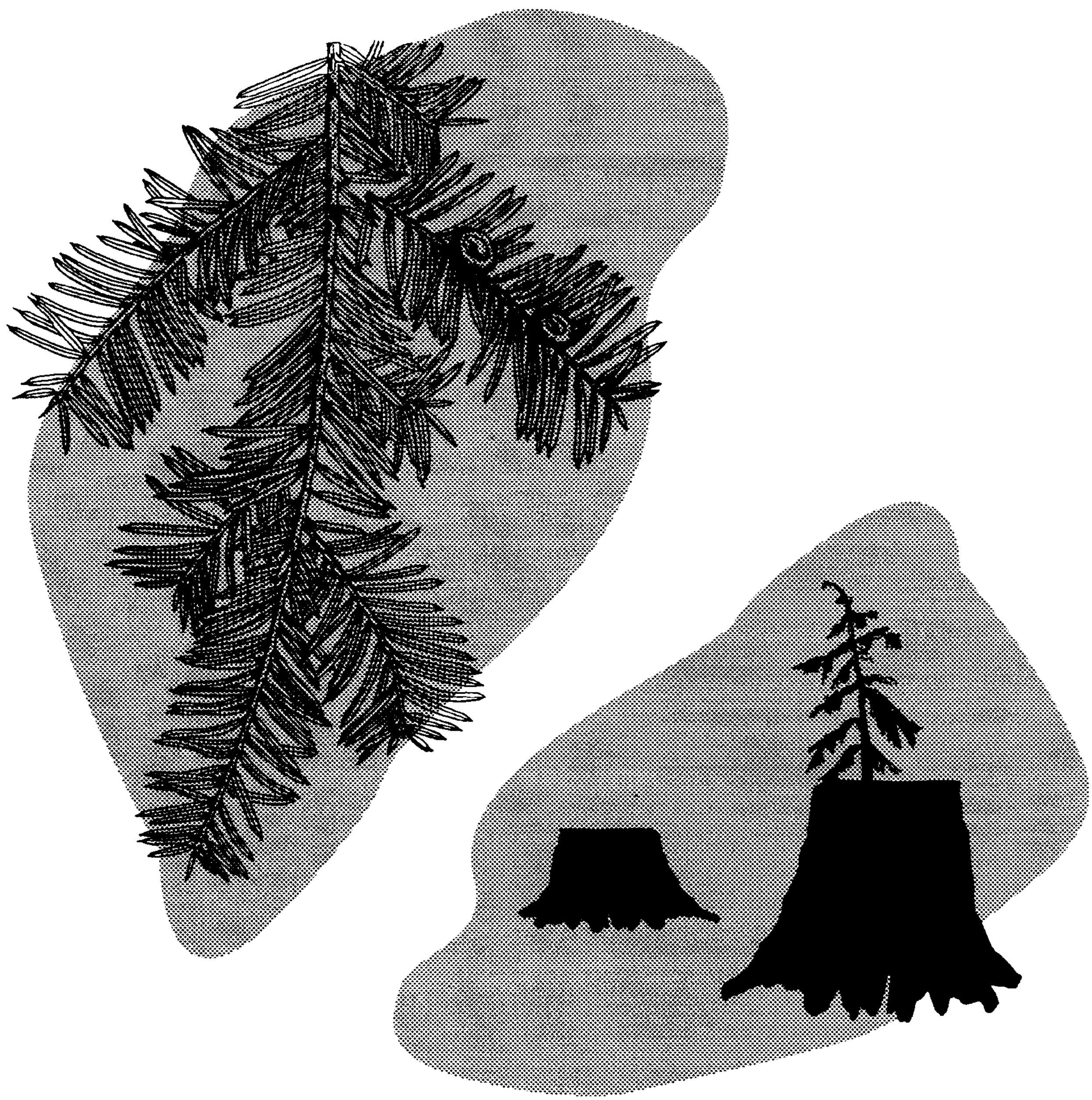

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Abstract

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Large numbers of Pacific yew (*Taxus brevifolia* Nutt.) trees have been cut to supply bark for taxol production, and replacement of those trees may depend on their ability to sprout from the stump. Stump characteristics were related to the initiation and survival of epicormic branches (sprouts) on 100 yew stumps in each of 11 recently harvested stands during 1992. Half of the stumps were artificially shaded, and all were remeasured in 1993. The number of living stumps in each stand was positively correlated with average stump height and average percentage of bark retained. Postharvest sprouting was most abundant on stumps with established sprouts or live branches. For individual stumps, the number and length of preharvest sprouts were the only variables consistently related to number of postharvest sprouts. Artificial shading did not promote sprouting.

Keywords: Regeneration, growth, survival, height, bark, *Taxus brevifolia*.

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Introduction

Pacific yew (*Taxus brevifolia* Nutt.) often sprouts from the stump after the crown has been killed or cut (Bolsinger and Jaramillo 1990). Those stump sprouts may survive and grow in the shaded understories of undisturbed stands, and they may be a critical element in the preservation of yew gene pools when overstory removal or other major disturbance damages or destroys existing yew crowns. Stump sprouts also may be an important source of winter food for browsing ungulates and other animals.

Stump sprouting is particularly important now that large numbers of mature yew trees have been cut to supply the bark needed for taxol production. Maintenance of Pacific yew in harvested stands, preservation of local gene pools, and a continuing supply of browse may depend on the ability of this species to sprout from the stump.

Sprouting from the stump is common in several other tree species, where it tends to increase with stump height and decrease with stump age (Dutt and Urmila 1987, Johansson 1987, Khan and Tripathi 1986). Successful sprouting often declines with increasing stump diameter (Johannson 1992, Khan and Tripathi 1986, Neal 1967), and small-diameter stumps of Pacific yew in Idaho were observed to sprout more successfully than larger stumps.[1] Nevertheless, Cabanettes and Pagès (1992) found that large stump diameters benefit the height growth of stump sprouts in chestnut (*Castanea sativa* Miller). Sprouting sometimes declines with stump age (Kauppi and others 1988, Lynch and Bassett 1987, Neal 1967), It also declines with shading in some species (Finney 1993; Johansson 1987, 1991), but the partial shade afforded by an overstory canopy has been thought to favor adventitious bud development and sprout survival on yew stumps (USDA Forest Service 1992).

The prevalence of successful stump sprouting in Pacific yew and the factors that affect rates of success are unknown. Our study was designed to provide that information by relating environmental factors and stump characteristics to the percentage of live stumps in harvested areas, to the number of sprouts per stump in those areas, and to the effects of shading on sprout survival and growth.

Methods

Sale areas where at least 100 yew stumps had been cut during a short time were located and examined in the Rogue River and Willamette National Forests of western Oregon. Cutting dates differed among the sale areas. At each area, 100 eligible stumps were numbered, measured, and mapped as they were encountered. Eligible stumps retained at least 50 percent of their bark. They were located and first measured in 1992, then relocated and remeasured 1 year later, in 1993. The following variables were measured at each stump:

- Stump height (cm)
- Stump diameter (cm)
- Stump age (age of tree at time of cutting)
- Bark retained (percent)

[1] Green, Pat; Ward, Roger. 1991. Yew sprout assessment, Nez Perce National Forest, Idaho. 1 p. Unpublished report. On file with: Yew Technical Committee, USDA Forest Service, Pacific Northwest Region, P.O. Box 3623, Portland, OR 97230.

- Number of preharvest sprouts
- Number of postharvest sprouts
- Length of longest preharvest sprout (cm)
- Length of longest postharvest sprout (cm)
- Total overstory canopy density (percent)
- Radiation index
- Soil moisture (percent) at 0 to 30 centimeters

Preharvest sprouts were distinguished from postharvest sprouts by counting internodes—a method confirmed through the presence of tree-marking paint on some preharvest sprouts. Canopy density was measured at each stump with a spherical densiometer (Lemmon 1957). Radiation index is a measure of potential solar insolation derived from slope, aspect, and the tables of Frank and Lee (1966). Soil moisture was measured on the north side of each stump by time domain reflectometry (Topp and Davis 1985). Half of the eligible stumps in every sale area were randomly chosen and artificially shaded by piling bark, slash, and other readily available debris against their south and west sides.

Averaged sale-area variables (stump height, percent bark retained, and overstory canopy density) were related to the number of stumps that survived in those sale areas with a stepwise multiple regression (n = the number of sale areas, $\alpha = 0.01$). Individual stump variables (height, diameter, age, percent bark retained, overstory canopy density, soil moisture, number of preharvest sprouts, and length of preharvest sprouts) were related to the number of postharvest sprouts on those stumps in separate regressions for each sale area (n = 100, $\alpha = 0.05$). The effects of artificial shading were examined in analyses of variance that included all the sale areas as experimental blocks.

Results

Eleven sale areas (1,100 stumps) were measured in 1992 and remeasured in 1993. Harvest dates ranged from June 1991 through July 1992, but stump sprouting was not correlated with season or year of cutting. Sprouting was erratic, and the number of postharvest sprouts per stump ranged from 0 to over 500. Those sprouts developed on the sides of the stump and not on the root collar. Sixty-seven percent (739) of the stumps were alive (had living preharvest or postharvest sprouts) in 1993, but only 28 percent (311) of the 1,100 stumps measured had living postharvest sprouts. Stump survival in the individual sale areas ranged from 13 to 94 percent (table 1) and was significantly ($P < 0.01$) related to the average stump heights and average percentages of bark retained in those sale areas:

$$\text{Live stumps (percent)} = 0.90(\text{stump height}) + 2.33(\text{percent bark}) - 163.98 \,,$$

where

$R^2 = 0.93$,

$S_yx = 8.23$, and

n = 11.

Table 1—Sale area characteristics and variables

Sale area	Elevation	Radiation index[a]	Cutting date	Average stump height[b]	Average stump diameter[b]	Average stump age[b]	Average bark retained[b]	Average canopy density[b]	Live stumps in 1993[c]
	Meters			– – *Centimeters* – –		*Years*	– – – – – *Percent* – – – – –		
A	750	0.42	5/92	30.0	18.6	120	81	31	68
B	1375	.44	7/92	49.8	33.0	151	91	63	94
C	1125	.41	6/92	43.3	13.0	106	92	33	90
D	1200	.42	4/92	40.1	18.2	158	96	90	93
E	875	.46	5/91	15.1	21.1	145	88	84	46
F	1425	.48	5/91	22.9	29.1	143	72	16	19
G	975	.41	10/91	18.5	29.1	179	70	85	13
H	975	.35	7/91	36.0	12.6	91	87	44	80
I	1375	.47	7/91	43.6	43.8	248	88	55	75
J	1450	.48	6/91	66.9	23.4	141	85	27	88
K	1375	.47	6/91	43.3	27.5	170	84	43	74

[a] A measure of potential solar insolation derived from slope, aspect, and the tables of Frank and Lee (1966).
[b] Based on 100 measurements in a given sale area.
[c] Stumps having at least 1 live sprout in 1993.

The number of postharvest sprouts on any given stump usually was related to the number and length of preharvest sprouts on that stump, but other within-sale variables were not consistently related to sprout abundance (table 2). Artificial shading did not benefit sprout development or survival, but shading did increase the length of postharvest sprouts (table 3).

Discussion and Conclusions

Widely differing numbers of sprouts tended to obscure the correlation of stump characteristics or environmental factors with sprout production on individual stumps in a sale area. The stumps within a given sale area differed in size, age, bark retained, and overstory canopy density; and the number of sprouts occurring on those stumps often ranged from zero to several hundred. We tried to record all the measurable variables present after yew harvest and hoped to find environmental variables associated with this enormous variation in number of sprouts. That attempt failed. Unmeasured, preharvest factors (for example, stump gender or genotype) may be responsible for the number and length of preharvest sprouts, and those preharvest sprouts are the best indicators of postharvest sprout abundance. They may provide the photosynthesis needed to maintain a stump in vigorous sprouting condition. Alternatively, the presence of preharvest sprouts may be just an indication of tree vigor and the ability to sprout.

Shading stumps by piling slash, bark, and debris against their south and west sides did not benefit the initiation and survival of sprouts. Indeed, the physical damage associated with occasional collapse of the piled material may have been detrimental to existing sprouts. Surviving sprouts tended to become longer when shaded in this way, however, and that additional growth may be important in the future.

Table 2—Correlations[a] of postharvest sprout abundance[b] with other local variables, by sale area

Sale area	Stump height	Stump diameter	Stump age	Bark retained	Overstory canopy	Soil moisture	Number of preharvest sprouts	Length of longest preharvest sprout
A			0.222				0.274	0.255
B							.588	
C	0.276						.648	.263
D		-0.271					.396	
E				0.242			.673	.352
F							.286	.406
G						-0.245		.216
H			.351				.731	.255
I							.632	.520
J							.432	
K							.376	.275

[a] Significant ($P < 0.05$) correlation coefficients.
[b] $\log_{10}$(number of postharvest sprouts alive in 1993).

Pacific yew tends to grow in the understory, and exposure tends to dry out both stumps and sprouts, so the absence of any correlation of sprouting with overstory canopy was surprising. Although postharvest canopy densities ranged from 0 to 97 percent, the shade provided by overstory trees did not significantly affect sprout initiation, sprout growth, or stump survival. Preharvest canopy densities may have been important influences on the development of preharvest sprouts, however, and overstory canopy should not be completely discounted as a factor in the sprouting of yew stumps.

The number of stumps that retained or developed sprouts, and thus remained alive in 1993 in any given sale area, was positively related to average stump height and average percentage of residual bark. That relation is logical, because those two factors also tend to be associated with the presence and survival of existing preharvest sprouts, and stumps with preharvest sprouts tend to be more vigorous than stumps without them.

Tall yew stumps and stumps with intact bark have a better chance of sprouting and surviving for 2 years than short stumps or stumps with damaged bark. Similar 2-year results for the survival of birch (*Betula pendula* Roth) stumps were also true after 5 years (Johansson 1992), even when many sprouts died on the tallest stumps (Kvaalen 1989). Future harvesting of Pacific yew probably should employ maximal stump height and minimal stump-bark removal when sprouting is to be maximized. Stump sprouting of Pacific yew is erratic, however, and it should not be relied on to regenerate harvested yew trees or stands.

Table 3—Effects of artificial shading[a] on mean development, survival, and growth of stump sprouts[b]

Stump treatment	Number of living sprouts/stump in 1992[c]	Number of living sprouts/stump in 1993[d]	Live stumps in 1993	Length of longest postharvest sprout in 1993
			Percent	*Centimeters*
Shaded[e]	14.2a	18.0a	67.6a	7.2a
Unshaded[e]	14.2a	24.2a	67.1a	5.8b
Standard error[f]	4.2	6.9	5.9	1.0

[a] The piling of slash and bark against the south and west sides of shaded stumps.
[b] Means in the same column that are followed by the same letter are not significantly different ($P < 0.05$).
[c] At time of shading.
[d] 1 year after shading.
[e] N = 11 sale means. The mean for each sale was based on 50 stumps.
[f] Standard error of the mean.

Acknowledgments

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