Native Shrubs as a Supplement to the Use of Willows as Live Stakes and Fascines in Western Oregon and Western Washington

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Abstract

In the Pacific Northwest USA, willows *(Salix* spp.) are the primary species used for soil bioengineering and related streambank protection measures, including live stakes and fascines. Previous work also demonstrated satisfactory application of redosier dogwood *(Corpus sericea* var. *occidentalis)* and Douglas spirea *(Spiraea douglasii).* However, other native shrubs that root readily from dormant hardwood cuttings have not been well evaluated, if at all. Therefore, the purpose of this work is to test additional species for their ability to root from older wood and perform as live stakes and fascines.

Greenhouse experiments illustrate that snowberry *(Symphoricarpos albus),* Pacific ninebark *(Physocarpus capitatus),* and black twinberry *(Lonicera involucrata)* can root as well or better from three year versus one or two year old wood. Therefore, they should have good potential as live stakes. In contrast, salmonberry *(Rebus spectabalis)* rooted well from first year wood but more poorly from older stems. It appears to have less potential. Secondary results indicated no apparent benefit from Wood's rooting compound (IBA+NAA) and detrimental effects from bottom heat (75°F) for all four species.

In addition to greenhouse trials, these and other native shrubs are under evaluation at four streambank sites, two in western Oregon and two in western Washington. To date, snowberry, salmonberry, ninebark, and twinberry are performing successfully as live stakes and/or fascines at one or more of these locations. It

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appears all four could be used as supplemental species for soil bioengineering, and may have special application to sites less suitable for willows (i.e. shaded or summer dry environments). Ecotype, site factors, quality of stock, installation technique, and handling can substantially affect results. While unlikely to outperform willows, these species provide options for improving habitat diversity.

Key words

Native shrub, soil bioengineering, live stake, fascine, *Symphoricarpos albus, Lonicera involucrata, Rubus spectabilis, Physocarpus capitatus*

Introduction

It is widely know that most native, riparian willows *(Salix* spp.) in the Pacific Northwest USA root easily from dormant hardwood stock, including older wood, allowing for their successful use in soil bioengineering practices such as live stakes, fascines, or brush mattresses. While willows are the mainstays of these stream and shoreline protection measures, native shrubs that root easily (from hardwood cuttings) may provide restoration alternatives, improve habitat diversity, and perform as well or better in shade or other conditions less suitable for willows.

Live stakes, more so than fascines, require that a species root easily from branches three years of age or older. The stem must be old and sturdy enough to withstand being tapped or "pounded" into the ground. Previous rooting trials indicate that black twinberry *(Lonicera involucrata),* Pacific ninebark *(Physocarpus capitatus),* snowberry *(Symphoricarpos albus),* and salmonberry *(Rubus spectabilis)* are among those native Northwest shrubs with the highest potential for use in soil bioengineering (Darris et al. 1998). Willows, redosier dogwood *(Cornus sericea* spp. *occidentalis),* black cottonwood *(Populus balsamifera* var. *trichocarpa)* (King County DNR undated), and Douglas spirea *(Spiraea douglasii)* (Darris and Flessner 2000) have already proven to be fair to good candidates. While other potential species are found on national and regional lists (Bentrup and Hoag 1998, Goergia Soil and Water Conservation Commission 1994, King County Dept. of Public Works 1993, USDA-NRCS 1996) their actual performance is not always well tested or documented. Therefore, the purpose of this work is to conduct studies and demonstrations that evaluate the ability of select western Oregon and western Washington native shrubs to root from older wood and perform as live stakes and fascines under actual streambank conditions.

Figure I (USDA-NRCS 1996) illustrates the soil bioengineering practice of "live fascines", the method most commonly used in the evaluations. In this example, two rows of fascines (wattles or bundles 6-8" in diameter)

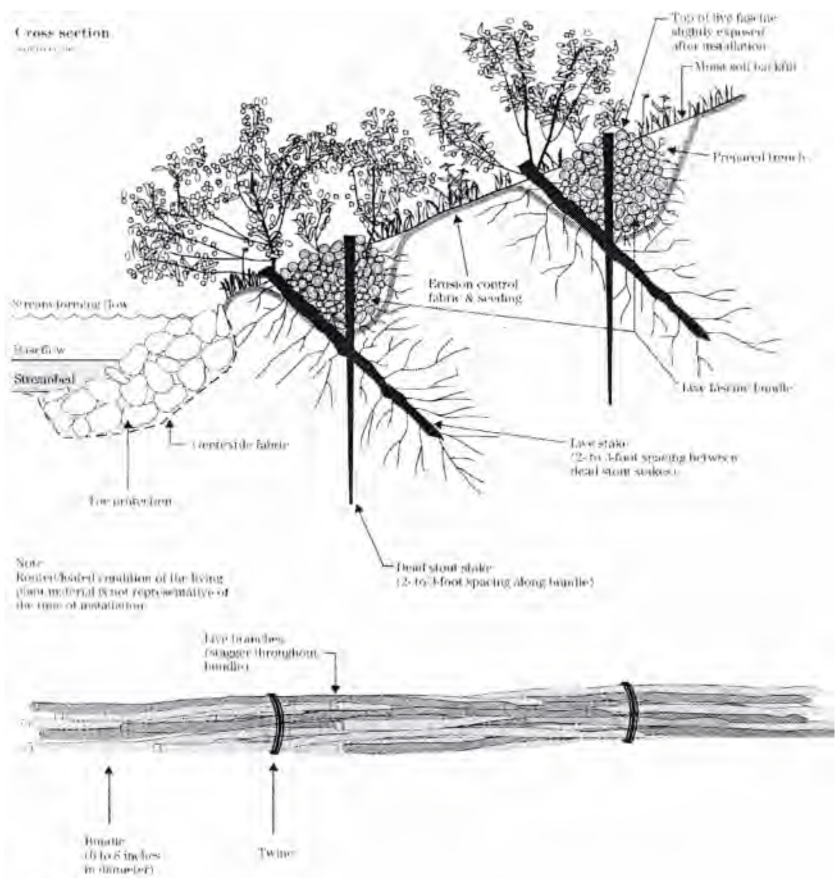

Figure 1.

are buried in shallow trenches parallel to the stream. Only the very top layer of branches in the bundle remains partially exposed. The fascines are anchored in the center by dead stout stakes and on the down slope side by dormant live stakes, 2 I/2 to 3 ft. long. The unrooted fascines help to hold the soil on the face of the slope and create mini "terraces" that reduce slope length. Root development soon reinforces the structure. Fascines can also be placed perpendicular to the stream in order to increase channel roughness, or are used in combination with other practices such as brush mattresses (Bentrup and Hoag 1998, Goergia Soil and Water Conservation Commission 1994, King County Dept. of Public Works 1993, USDA-NRCS 1996). When using live stakes, 3/4 to 4/5 of their length should end up below the surface while one or more nodes must remain above ground. Live stakes are also used alone to secure erosion mats or installed with other soil bioengineering and erosion control practices. They may offer a low cost alternative to nursery stock. In the figure, rock is not necessarily the only or best means to protect the toe of the slope.

Rooting Trials

Methods and materials

As a follow up to earlier studies, rooting experiments were conducted in a greenhouse mist bench in 2001 to test the ability of snowberry, Pacific ninebark, black twinberry, and salmonberry to root from hardwood cuttings comprised of 1, 2, and 3-yr (±) old wood (Factor C). Secondary objectives were to determine the effect of Wood's Rooting Compound (WRC: 1.03% IBA and 0.66% NAA diluted 5:1 with water) (Factor B) and bottom heat (75°F) (Factor A) on adventitious rooting. Minimum greenhouse temperature was 65°F and the day length was 16 hours. Rooting media consisted of I part peat moss to 4 parts perlite. Experimental design was a randomized complete block with four replications and five, 8 inch cuttings per replication. Analysis of variance (ANOVA) was conducted and Fisher's Protected Least Significant Difference test (FPLSD) was used to separate means at the P=0.05 level. Note that WRC, a mixture of two plant growth regulators (PGRs), is interchangeably referred to as "hormones" in this text.

Results and discussion

Results for the experiments appear in Table I. For snowberry, as with all species tested, significant differences depended on the variable measured. However, cuttings from 3 year old wood generally rooted and grew as well or better than those from I and 2 year old wood. The highest overall ranking was achieved by 3 year wood without hormones and no bottom heat. There were no significant factor interactions. Bottom heat (75°F) was detrimental to root formation and growth across all ages. WRC significantly improved shoot length and plant vigor in I year old cuttings, but did not have similar effects on 2 and 3 year old cuttings. Rooting was primarily nodal, but substantial amounts formed at the basal ends with minor amounts along the internodes, regardless of age.

For Pacific ninebark, cuttings from 2 and 3 year old stems clearly rooted and grew better than those from I year old shoots. Bottom heat appeared to diminish root development and WRC did not significantly change rooting for either 1 or 2 year old cuttings, regardless of the variable measured. Significant BxC factor interactions for some variables may be attributed in part to the poor rooting of 3 year wood with bottom heat in combination with WRC. The top overall ranking was achieved by 3 year old wood without hormones or bottom heat. Rooting occurred most regularly at the nodes but with fair amounts along the internodes, regardless of age.

In contrast to the other three species under identical conditions, black twinberry appeared to produce a greater abundance of roots. Also, performance was consistently good regardless of age or treatment. Bottom heat decreased basal rooting, but the overall effect was minor, if any. This species roots primarily along the internodes with some basal rooting. As with overall performance, internodal rooting did not diminish with age. Highest overall ranking was for 3 year old cuttings with hormones and without heat, but the results were not significantly higher than those without hormones and no heat.

Table 1. Effect of bottom heat, rooting compound, and age of wood on rooting ability of common snowberry (SYALL), Pacific ninebark (PHCA11) black twinberry (LOIN5), and salmonberry (RUSP) from hardwood cuttings (in a greenhouse mist bench).

Species	Bottom Heat (A)	Rooting Hormone(B)	Age of Wood(C)	Minimum Caliper(mm)	Percent Rooted	No. of Shoots	Shoot Length (cm)	Root Abundance	Root Length (cm)	Plant Vigor	Location of Roots	Overall Ranking
SYALL	No	No	1	3.6	75abcd	2.6	24.1bc	5.5bc	17.7	6.1bc	**N**,B,i	6th
	No	No	2	4.0	85ab	2.6	33.7ab	7.1ab	20.0	7.6ab	**N**,B,i	2nd
S	**No**	**No**	**3**	**5.6**	**90ab**	**3.1**	**35.7a**	**7.7a**	**22.1**	**8.3a**	**N**,b,i	**1st**
N	No	Yes	1	4.2	85ab	2.6	29.8abc	5.4bc	17.1	6.6abc	**N**,B,i	5th
O	No	Yes	2	4.6	100a	2.6	30.1abc	6.2abc	17.6	7.2ab	**N**,B,i	3rd
W	No	Yes	3	5.9	85ab	2.3	30.7abc	6.0abc	16.2	6.8abc	**N**,B,i	4th
B	Yes	No	1	4.8	50d	2.4	21.5c	4.6c	13.5	5.4c	**N**,b,i	
E	Yes	No	2	4.6	70bcd	2.3	26.7abc	4.9c	16.0	5.8bc	**N**,B,i	
R	Yes	No	3	5.1	53cd	2.5	23.5bc	4.7c	17.2	6.0bc	**N**,i	
R	Yes	Yes	1	3.9	80abc	2.5	23.0c	4.7c	15.7	5.4c	**N**,b,i	
Y	Yes	Yes	2	5.1	50d	3.2	26.5abc	5.0c	18.1	6.2bc	**N**,b,i	
	Yes	Yes	3	5.4	65bcd	2.9	24.5bc	5.0c	15.7	6.0bc	**N**,b,i	
Mean					74	2.6	27.5	5.6	17.2	6.4		
LSD					30	NS	10.4	2.1	NS	1.8		
Significant Factor (ABC) Interactions:							none	none	none	none	none	none
PHCA11	No	No	1	6.0	60abc	1.3cde	16.4bc	5.6	16.8	6.0abc	**N**,I	6th
	No	No	2	5.2	90ab	3.1ab	20.6abc	6.3	17.2	6.9abc	**N**,I	2nd(tie)
	No	**No**	**3**	**6.9**	**89ab**	**3.9a**	**34.4a**	**7.4**	**19.8**	**8.9a**	**N**,i	**1st**
N	No	Yes	1	5.1	50cde	1.5cde	21.5abc	5.3	16.8	5.9abc	**N**,i	
I	No	Yes	2	5.8	85ab	2.0cd	31.1ab	6.8	18.6	7.5ab	**N**,I	4th
N	No	Yes	3	5.1	90ab	1.8cd	28.3ab	6.0	14.3	6.4abc	**N**,I	2nd(tie)
E	Yes	No	1	5.6	25de	1.1de	14.5bc	3.9	7.0	4.0cd	**N**,i	
B	Yes	No	2	5.2	25de	2.0cd	18.4abc	5.8	18.6	6.5abc	**N**,I	
A	Yes	No	3	4.7	55dcd	2.3bc	25.1ab	7.1	19.0	6.8abc	**N**,I	5th
R	Yes	Yes	1	7.3	25de	1.6cde	17.8abc	4.9	11.0	4.8bcd	**N**,i	
K	Yes	Yes	2	6.3	20e	2.0cd	26.6ab	6.0	21.5	6.2abc	**N**,i	
	Yes	Yes	3	5.5	30cde	0.8e	6.5c	2.8	9.1	2.7d	**N**,I	
Mean					54	1.9	21.8	5.6	15.8	6.0		
LSD					35	1.1	16.7	NS	NS	3.1		
Significant Factor (ABC) Interactions:							None	BxC	BxC	none	none	BxC

Rooting Hormone = Experimental Factor B, Wood's Rooting Compound (WRC) at 10:1 dilution. **Minimum caliper** is the minimum caliper which rooted.

Root Abundance and **Plant Vigor** based on scale of 10=best, 1=poorest. Means with the same letter are not significantly different at P=.05. **LSD**=Least Significant Difference.

Root Location refers to location of roots on the cutting: B(b) =basal. N(n) = nodal. I(i) = internodal. Bold, upper case letters indicate predominant position of roots. Upper case letters (not in bold) indicate 2nd most common root position. Lower case letters indicate minor location of roots. **NS** = not signficant.

Overall ranking indicates summary of ability to root based on all parameters (dependent variables) measured. Top 6 of 12 treatments.

Table 1. Continued.

Species	Bottom Heat (A)	Rooting Hormone(B)	Age of Wood(C)	Minimum Caliper(mm)	Percent Rooted	No. of Shoots	Shoot Length (cm)	Root Abundance	Root Length (cm)	Plant Vigor	Location of Roots	Overall Ranking
LOIN5	No	No	1	4.3	100a	2.2abc	16.7cd	6.8bcd	21.5bc	6.9bcd	I,B	
	No	No	2	4.7	95a	2.0bcde	23.1abcd	7.1bcd	22.6abc	7.2abcd	I,b	3rd
T	No	No	3	6.8	85ab	2.4a	29.0ab	8.1ab	27.9abc	8.0ab	I,b	2nd
W	No	Yes	1	4.7	100a	2.1abcd	14.8d	6.4cd	24.3abc	6.4cd	I,B	6th
I	No	Yes	2	4.7	95a	1.8cde	23.7abcd	7.0bcd	24.1abc	7.1bcd	I,b	5th
N	**No**	**Yes**	**3**	**6.6**	**90a**	**2.3ab**	**31.4a**	**8.6a**	**30.5a**	**8.6a**	I,b,n	**1st**
B	Yes	No	1	4.7	60cd	1.8cde	19.1bcd	5.9d	21.1c	6.3cd	I,B	
E	Yes	No	2	5.3	65bcd	1.6e	24.6abcd	6.7cd	26.1abc	6.9bcd	I	
R	Yes	No	3	6.5	50d	1.8cde	17.0cd	7.0bcd	29.3ab	6.1cd	I	
R	Yes	Yes	1	4.6	80abc	1.7de	14.3d	6.4cd	24.4abc	5.8d	I,b,n	
Y	Yes	Yes	2	5.0	80abc	1.9bcde	22.0abcd	6.4cd	27.3abc	6.8bcd	I,n	
	Yes	Yes	3	5.9	80abc	1.8cde	26.7abc	7.5abc	27.9abc	7.6abc	I,b,n	4th
Mean					82	1.9	21.8	7.0	25.6	7.0		
LSD					24	0.4	11.2	1.4	8.0	1.4		
Significant Factor (ABC) Interactions:							AxB	none	none	none	none	none
RUSP	**No**	**No**	**1**	**6.7**	**75a**	**1.8**	**21.5a**	**6.2a**	**19.6a**	**6.7a**	I,N,b	**1st**
S	No	No	2	8.6	70a	1.4	13.0ab	4.4a	11.9a	4.9ab	N,i,b	2nd(tie)
A	No	No	3	12.4	40bc	1.4	14.6ab	6.1a	19.6a	4.9ab	N,i,b	4th
L	No	Yes	1	7.2	60ab	1.2	12.0b	5.3a	13.4a	5.5ab	I,N,B	2nd(tie)
M	No	Yes	2	10.0	10ef	1.3	8.6bc	4.3a	10.8ab	4.1abc	N,i,b	
O	No	Yes	3	11.1	25cde	1.7	7.6bc	3.8ab	16.6a	3.3bc	N,i	6th(tie)
N	Yes	No	1	7.0	33cd	1.3	12.6b	6.3a	17.5a	4.9ab	I,B,n	5th
B	Yes	No	2	8.8	15def	0.9	8.2bc	3.6ab	11.6a	4.2abc	N,i	
E	Yes	No	3	15.0	15def	1.8	14.9ab	4.5a	13.8a	6.4a	N	
R	Yes	Yes	1	7.3	20cdef	1.1	12.1b	4.5a	12.6a	5.1ab	I,N	6th(tie)
R	Yes	Yes	2	<>	0f	0.8	3.0c	1.0b	0b	1.3c	<>	
Y	Yes	Yes	3	<>	0f	0.8	2.5c	1.0b	0b	1.3c	<>	
Mean					30	1.3	10.9	4.2	12.3	4.4		
LSD					21	NS	8.9	3.1	11.2	3.1		
Significant Factor (ABC) Interactions:							none	none	none	none	none	none

Rooting Hormone = Experimental Factor B, Wood's Rooting Compound (WRC) at 10:1 dilution. **Minimum caliper** is the minimum caliper which rooted.

Root Abundance and **Plant Vigor** based on scale of 10=best, 1=poorest. Means with the same letter are not significantly different at P=.05. **LSD**=Least Significant Difference.

Root Location refers to location of roots on the cutting: B(b) =basal. N(n) = nodal. I(i) = internodal. Bold, upper case letters indicate predominant position of roots. Upper case letters (not in bold) indicate 2nd most common root position. Lower case letters indicate minor location of roots. **NS** = not significant.

Overall ranking indicates summary of ability to root based on all parameters (dependent variables) measured. Top 6 of 12 treatments.

Salmonberry rooted more poorly that the other three species, but achieved the most satisfactory results from cuttings of 1 year old wood, without hormones and without heat (top overall ranking). In general, WRC did not significantly change results regardless of age. Heat in combination with hormones was lethal for 2 and 3 year old wood. There were no significant factor interactions. This species rooted randomly from nodes, internodes, and basal ends, but internodal rooting diminished with cuttings of 2 and 3 year old wood.

In summary, snowberry, Pacific ninebark, and black twinberry generally rooted as well or better from 3 year old compared to I year old cuttings, suggesting that they have good to excellent potential as live stakes, and possibly fascines. This improvement, especially in ninebark, may be the result of larger carbohydrate reserves in older, thicker cuttings. In contrast, salmonberry rooted more poorly from 3 year old cuttings and appears to have less potential for live stakes. However, it still may work in fascines. This species, unlike the other three, may lose juvenile traits as it ages or the bark thickens, becoming less likely to root along the internodes. Finally, for all four species, there appeared to be little if any benefit in the use of Wood's rooting compound (WRC) under the conditions of this experiment and bottom heat (of 75°F) was generally detrimental.

Streambank Soil Bioengineering Trials

Site 1: Schneider Creek

The purpose of this demonstration is to evaluate the ability of eight native shrubs to perform as parallel and perpendicular fascines along a streambank. The planting is located along Schneider Creek on the Wynne Farm in Thurston County, WA. Installed March 17, 1999, in a silty clay loam on a gentle slope, trenches were back filled with non-native top soil, fencing was used in 2000, and deer repellent was applied once in 1999. No fertilizer or supplemental water has been applied.

Third year (2001) mean data are shown in Table 2. Despite substantial deer browse and grass competition, sprouting and growth after three growing seasons has been fair to excellent for all species except red elderberry *(Sambucus racemosa)* which failed to establish (I shoot left alive). Perpendicular fascines are outperforming the parallel ones, possibly because of better moisture or soil quality. Pacific ninebark, salmonberry, black twinberry, and redosier dogwood are roughly similar in performance.

As expected, growth and vigor was the highest for both Sitka willows *(Salix sitchensis),* although Douglas spirea produced more stems *per* meter than all other species.

Site 2: Minnihaha Creek

At a streambank site on the Willamette National Forest (Minnihaha Creek, 2:1 side slopes, elev. 3100 ft.), fascines of nine different shrubs were installed in a droughty, cobbly sand on November 9, 1998. Each fascine was replicated twice, once on a lower tier and once on an upper tier. The lower tier was installed with coir fabric and the upper tier was fertilized at planting (14-14-14 slow release). Trenches were back filled with native soil. A single application of deer repellent was made in 1999. Supplemental water was applied only once each summer. The area was sown to blue wildrye and

Table 2. Schneider Creek fascines – 2001 results

Species	Vigor[1]	Ht.(cm)	Wth.(cm)	Deer Br.[1]	Stems/m
Sitka willow 'Plumas'	9.0	150	150	3.0	33
Sitka willow (local)	9.0	154	147	1.5	40
Redosier dogwood	6.0	70	59	5.0	10
Douglas spirea	6.0	60	49	2.5	43
Black twinberry[2]	6.7	88	50	4.0	12
Pacific ninebark[2]	5.7	63	60	2.0	11
Salmonberry	6.5	70	58	3.5	16
Red elderberry	1.0	40	18	—	0.5

[1]1=lowest, 10=highest. [2]Mean of 3 plots (fascines).
As expected, growth and vigor was the highest for both Sitka willows

mulched. After three growing seasons, mock orange *(Phildelphia lewisii)* and salmonberry are unexpectedly the best performing species (Table 3). Their potential on course soils merits further evaluation. Snowberry is alive but in poor condition, as are single fascines of Indian plum *(Oemlaria cerasiformis)* and Pacific ninebark. Red flowering current *(Ribes sanguineum)* failed to sprout and redosier dogwood, and Scoulers willow *(S. scouleriana)* died by August of the second growing season. The lower tier (rep. 2) is performing slightly better than the upper tier (rep. 1). Low fertility and poor soil moisture holding capacity are probably the major limiting factors at this site, not weed competition.

Table 3. Minnihaha Creek fascines – 2001 results

Species	Vigor[1]	Ht.(cm)	Deer Browse[1]	Stems/m
Mock orange[2]	**6.3**	**45**	**4.3**	**5.8**
Salmonberry	6.5	42	4.0	3.5
Redosier dogwood	1.0	—	—	—
Sitka willow	4.0	58	3.0	2.8
Scouler willow	1.0	—	—	—
Pacific ninebark[3]	3.0	27	2.0	1.3
Snowberry	2.5	17	5.0	8.5
Indian plum	2.5	49	2.0	0.5
Red flowering currant	1.0	—	—	—

[1]1=lowest, 10=highest. [2]Mean of 3 plots (fascines). [3]One plot.

Site 3: Frazier Creek

The objective of this study is to evaluate salmonberry, snowberry, redosier dogwood, and Pacific ninebark as both fascines and live stakes. Live stakes of black twinberry are also being evaluated. The plots were installed along Frazier Creek (PMC, Benton Co., OR, elev. 225 ft., 42 inch precip. zone) in a clay soil on February 9 and 12, 2001. Fascines were approximately 6 inches in diameter, 5 feet long, and replicated three times. Live stakes were 2 feet long and replicated twice (5 stakes per plot). Trenches were back filled with a non-native sandy loam. Slow release fertilizer (14-14-14) was used during installation and supplemental water was applied five times. The soil has a high shrink-swell capacity.

First year results are shown in Table 4. Initial performance (June) was initially fair to good for all species except ninebark. Vigor, survival, and stems/meter substantially declined by October. At the end of one growing season, snowberry fascines are performing the best. Because of their construction, they may have had better soil/stem contact and fewer air pockets compared to the other three species. Snowberry may also root more rapidly or is more drought tolerant. Redosier dogwood fascines rank second in performance, followed by salmonberry. Both showed signs of severe drought stress by early October. Only one of three Pacific ninebark fascines produced an acceptable number of shoots (15/meter) in the spring. It may have completely died from drought by fall. While live stakes of redosier dogwood initially survived and grew the best (June), twinberry had the highest survival by October, followed by redosier dogwood, and

Table 4. Frazier Creek fascines and live stakes – 2001 results

Species – fascines	Vigor[1]		Ht.(cm)		Wth.(cm)		Stems/m	
	Jun	Oct	Jun	Oct	Jun	Oct	Jun	Oct
Snowberry	**8.0**	**5.3**	**42**	**36**	**31**	**36**	**37**	**34**
Redosier dogwood 'Mason'	5.3	1.7	31	38	24	38	10	2
Salmonberry	4.7	2.3	33	10	21	10	6	1
Pacific ninebark	3.3	1.0	14	—	19	—	6	—
Species – live stakes	**Vigor[1]**		**Ht.(cm)**		**% Surviv**		**Stems/ls**	
Snowberry	5.7	4.0	31	42	50	30	1.7	1.5
Redosier dogwood 'Mason'	6.8	5.0	34	37	100	40	5.1	4.7
Salmonberry	3.3	1.0	15	—	50	0	1.0	—
Pacific ninebark	5.6	3.0	26	24	50	10	3.4	3.0
Black twinberry	6.8	4.5	31	32	90	78	3.1	1.9

[1]1=lowest, 10=highest. ls=live stake. Wth.=width.

snowberry. Soil "cracks" at the insertion points, compaction, and grass competition may have reduced survival during the dry summer.

Site 4: Boyce Creek

A fourth installation consisting of salmonberry and sikta willow fascines was made along Boyce Creek in Kitsap Co., WA, in mid-September of 2000 (elev. < 100 ft). The site consists of two planting areas with silt loam soils and 2.5:1 or flatter slopes. Area I has both parallel and perpendicular fascines and is shaded. Area 2 contains over 30 feet of fascines. Leaves were stripped prior to planting. Trenches were back filled with native soil and no fertilizer or supplemental water has been used. At least initially, results suggest that salmonberry (vigor=7.4, ht= 79cm, stems/m= 24) may perform as well or better that sitka willow (vigor= 6, stems/m= 21, ht= 58cm), on moist, shady banks where, unlike willows, it often thrives.

Summary

I. Under typical greenhouse conditions, it appears unnecessary to use bottom heat (at 75 °F) or a solution of plant growth regulators similar to Wood's rooting compound to root hardwood cuttings of snowberry, Pacific ninebark, black twinberry or salmonberry.

2. Snowberry, black twinberry, and especially Pacific ninebark can root as well or better from cuttings of 3 year old wood versus younger wood. Results suggests they have high potential as live stakes.

3. Salmonberry roots best from cuttings of 1 year old stems and my not do well as live stakes.

4. All four species appear to have fair to good potential as fascines under favorable conditions, but will not root as fast or as predictably as willows.

5. At least initially, it appears some species may have value over willows for soil bioengineering in certain environments (i.e. salmonberry on moist, shady sites or snowberry on droughty soils).

6. Supplemental use of these four species for soil bioengineering provides further options for increasing habitat diversity.

7. Finally, it should be cautioned that field trial results are still preliminary and may change over time. Results can also be substantially affected by ecotype, site conditions, installation technique, stock quality, and handling.

Future Work

Continued monitoring and additional studies are needed to further define how well these and other native shrubs perform over time under variable soil, moisture, and hydrologic conditions, as well as with other soil bioengineering practices such as brush mattresses and brush layering. Furthermore, anecdotal information suggesting that fall installation of cuttings, live stakes, and fascines may perform as well or better than early spring planting, needs to be validated for select species.

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