Comparison of Deterrents to Reduce Elk Rubbing and Herbivory in a Skagit River Restoration Planting, Washington

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Abstract

Salmon habitat restoration projects have reforested around 800 hectares in the Skagit River watershed from 2008 to 2017 but coincident growth of the North Cascades Elk Herd has complicated these efforts. *Cervus canadensis* (elk) browse terminal and primary lateral branches and wound bark on seedlings, resulting in reduced growth, vigor and survivorship. This impacts restoration success and increases reforestation costs. Few studies have compared the efficacy and shortcomings of methods to reduce *C. canadensis* damage within a restoration setting. This study aimed to 1) compare the efficacy of paper bud caps, companion planting with *Picea sitchensis* (Sitka spruce*),* and Plantskydd® topical repellent in reducing *C. canadensis* browse; and 2) test the efficacy of Plantskydd® topical repellent in reducing bark wounding on seedlings at the Savage Slough Restoration Project site near Concrete, Washington. We found that Companion planting and Plantskydd® application significantly reduced browse damage, whereas paper bud caps had no significant effect. Furthermore, Plantskydd® application did not significantly reduce bark wounding. While Plantskydd® application or companion planting can reduce *C. canadensis* browse in restoration plantings, thereby increasing success rates and decreasing costs, Plantskydd® application is more expensive per hectare than companion planting.

Key words

Introduction

In the last decade salmon habitat restoration projects have reforested around 800 hectares in the Skagit River watershed (Brocksmith 2017). At the same time, the North Cascade Elk Herd has increased in many areas, especially on the Skagit River floodplain near the restoration projects. Elk (*Cervus canadensis*) damage seedlings through browsing—especially *Thuja plicata* (T. plicata*;* Curran and Dunsworth 1987)—and bark wounding (SRSC and SCL 2012). Schaap and DeYoe (1986) measured 40% average browse damage in 50 conifer plantations across western Oregon and Washington. *C. canadensis* consume terminal and primary lateral branches and pull young seedlings (Campbell 1974), resulting in reduced growth, vigor and survivorship; impacted success rates; and increased costs.

The North Cascade Elk Herd ranges over 1,230 km^2 in Whatcom, Skagit, Snohomish and King Counties (McCorquodale et al. 2011). The herd often occupies areas above 500 meters, but selects lower elevation habitat for avoidance of snow in winter (Creel et al. 2005, Unsworth et al. 1998, Jenkins and Starkey 1984), and transitionally in spring and fall (Tressler and Davis 2003). Recent radio telemetry of collared cow *C. canadensis* captured near the Skagit River have shown that groups spend a significant amount of time in the floodplain throughout the year. *C. canadensis* provide ecological, recreational, and economic benefits (Davison 2002); Northwest Native communities rely upon this resource for sustenance and cultural practices. The population peaked at 1,700 in 1984 but declined to 300 *C. canadensis* in the 1990's (McCorquodale et al. 2011). To promote population growth, wildlife co-managers imposed hunting restrictions. In 2003 and 2005, the Washington Department of Fish and Wildlife joined several Point Elliot Treaty Tribes to introduce 98 *C. canadensis* from Mount St. Helens into the area (McCorquodale et al. 2011, WDFW 2017). Population models based on annual aerial population surveys show that the herd increased between 2006 and 2015. Total abundance estimates range from 600 to 639 in 2005, 1,078 to 1,450 in 2013, and 1,200 to over 1,800 in 2015 (McCorquodale et al. 2013, Hoens 2016, WDFW 2017).

Few studies have compared the efficacy and shortcomings of methods to reduce *C. canadensis* damage within a restoration setting. Bud caps reduce browse by enclosing the terminal leader, but animals or wind may remove them (Kopp 2007, Schaap and DeYoe 1986). Repellants deter deer and *C. canadensis* browsing on various forages (Moser 2000, Andelt et al. 1992, Trent et al. 2001) but they can lose effectiveness in rainy climates. Foresters and tree farmers sometimes plant *P. sitchensis* together with *T. plicata* in the same hole (i.e. companion plant)—the spruce protects the cedar with sharp needles and undesirable secondary compounds—but scientific studies of this method are unavailable (Romanovsky 2015). In this study we 1) compare the efficacy of paper bud caps, companion planting *Picea sitchensis* (Sitka spruce) and *T. plicata*, and Plantskydd® topical repellent (Tree World Plant Care Products, Inc., St. Joseph Missouri, USA) in reducing *C. canadensis* browsing damage; and 2) test the efficacy of Plantskydd® topical repellent in reducing bark wounding, on conifer seedlings.

Methods

Study Area

We conducted the study at the Savage Slough Fish and Wildlife Habitat Lands, a property owned by a municipal utility company (Seattle City Light) located seven kilometers west of Concrete, Washington, on the south bank of the Skagit River (Figure 1). Study sites ranged in elevation from 37 to 41 m. Precipitation averages 114 inches per year. Previous owners maintained the site as pasture before the salmon habitat restoration project began with reforestation of portions of the pasture near the river and sloughs. *C. canadensis* frequent the site (confirmed visually, by damage to the plantings, and by scat).

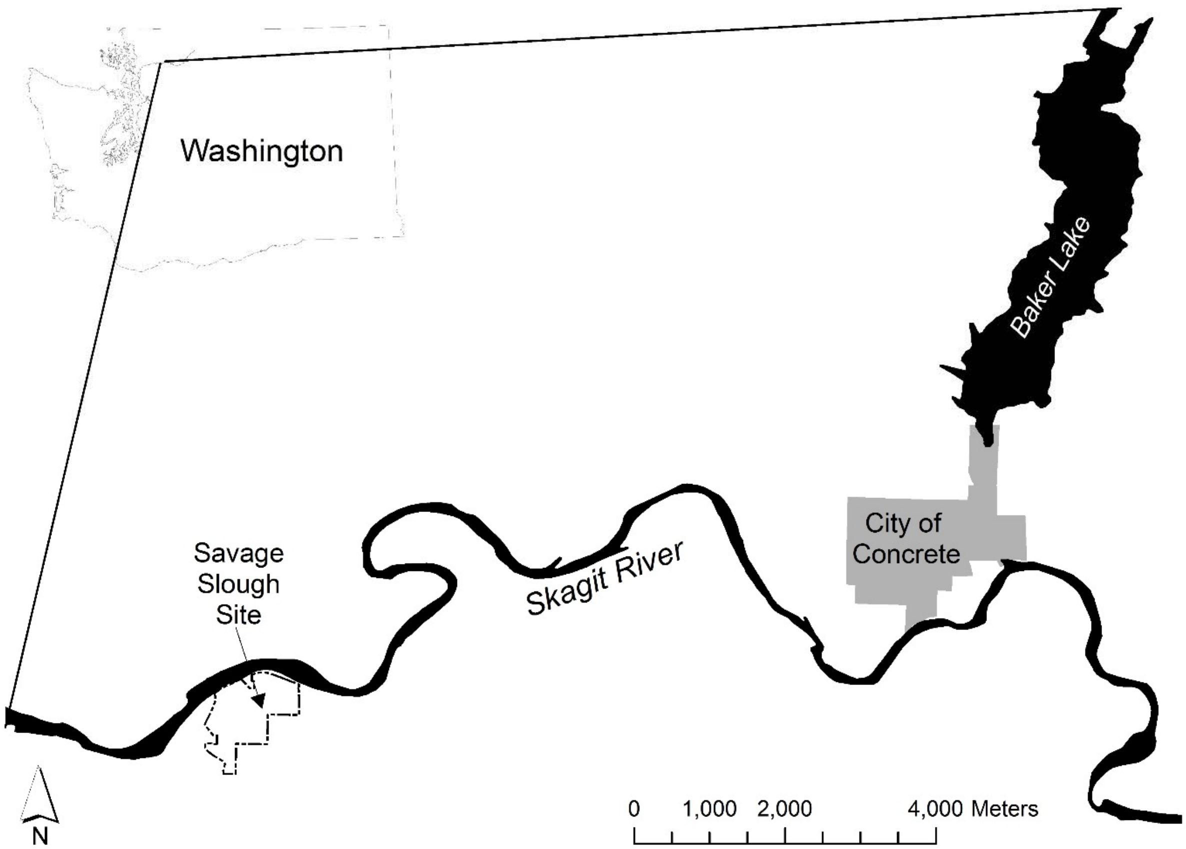

Figure 1. Location of the study site in relation to the Skagit River and the municipality of Concrete, in Washington State.

Study Design

The study used a randomized block design with tree seedlings planted three meters apart and randomly assigned to treatment or control groups. Blocks were randomly located throughout the restoration planting area.

In 2014, we tested the efficacy of bud caps to reduce *C. canadensis* browse on *Pseudotsuga menziesii* (Douglas fir), *Abies grandis* (grand fir), *P. sitchensis* and *T. plicata*. Species were assigned to blocks based on moisture requirements: *P. menziesii* and *A. grandis* in the two drier blocks, and *P. sitchensis* and T. plicata in the two wet blocks. The four blocks consisted of 40 seedlings each, ranging from 30 to 46 cm tall, with ten individuals of each species signed to each treatment (Figure 2; Table 1). Bud caps made from 10 by 15 cm Rite in the Rain® paper were folded over the terminal leaders and stapled along one edge and to a lower branch during planting on February 11, 2014. We recorded *C. canadensis* damage within the four blocks on December 4, 2014.

In 2015 and 2016, we tested the efficacy of Plantskyyd® repellant and companion planting to reduce *C. canadensis* browse on *T. plicata*. We tested newly planted seedlings each year and the studies continued for ten months. In 2015, two blocks consisted of 39 *T. plicata* seedlings each (13 individuals per treatment) and in 2016, three blocks consisted of 36 *T. plicata* seedlings (12 individuals per treatment) each. Seedlings were 15 to 31 cm tall and *P. sitchensis* seedlings were 30 to 46 cm tall. Treatments were applied during planting on March 9, 2015 and March 8, 2016. Companion seedlings were planted with their stems aligned in the same hole. We applied Ready-to-Use Plantskydd® with backpack sprayers as per label instructions. Plantskydd® was reapplied on October 12, 2015 and October 3, 2016. We recorded *C. canadensis* damage within the five blocks on January 11, 2016 and January 11, 2017.

In 2015 and 2016, we also tested the efficacy of Plantskydd® on reducing bark wounding on *P. menziesii*. In 2015, one block consisted of 26 seedlings (13 individuals per treatment) and in 2016, two blocks consisted of 24 seedlings (12 individuals per treatment). The plots were located within 50 meters of one another; the trees in the correct size range was limited to one area within the planting zone. The trees had been planted before the study between April 16 and April 30, 2013 and ranged from 152 to 183 cm during the study. Each year the study continued for ten months: Plantskydd® was applied on March 9, 2015 and March 8, 2016, reapplied on October 12, 2015 and October 3, 2016 and we recorded *C. canadensis* damage within the three blocks on January 11, 2016 and January 11, 2017.

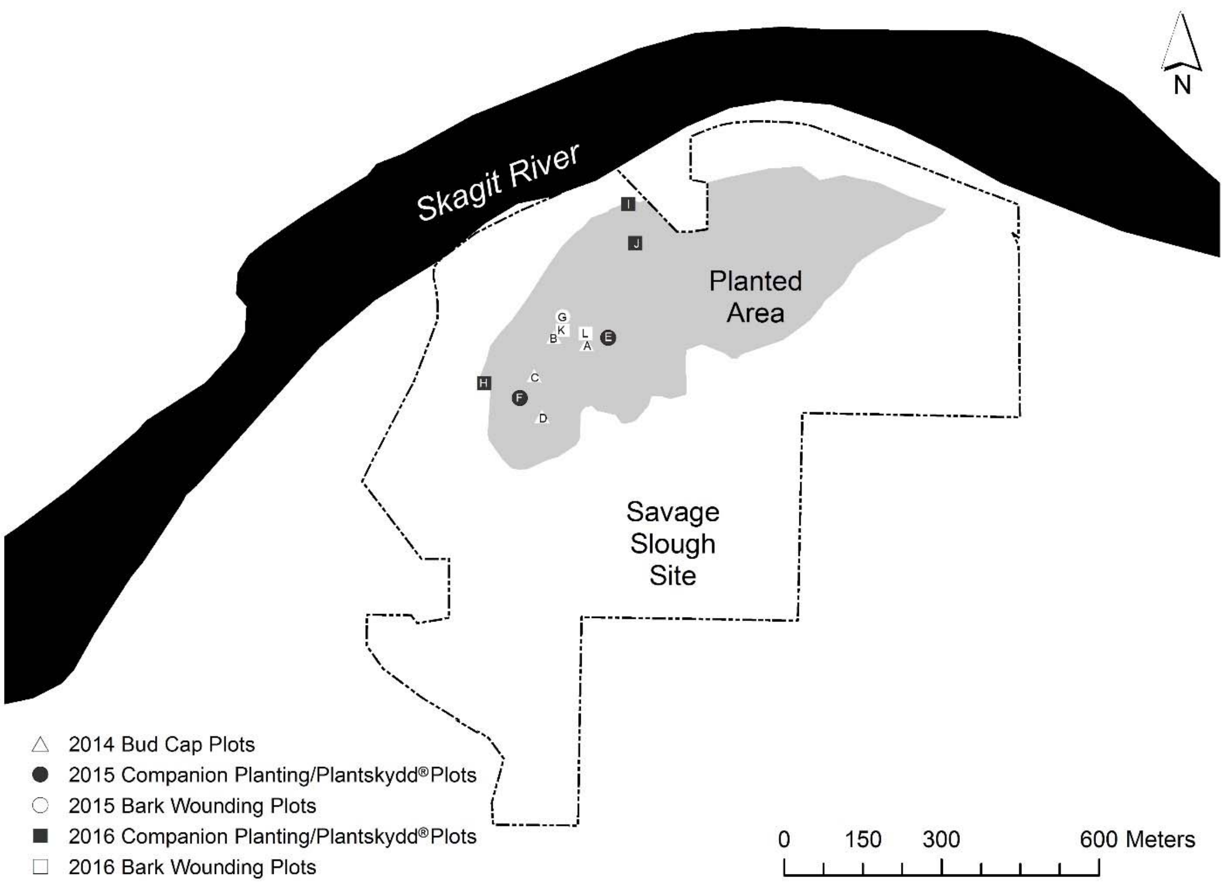

Figure 2. Location of Block Groups (A through L) within the Savage Slough Fish and Wildlife Habitat Lands planting area.

Table 1. Summarization of experimental set-up, including treatments, species and treatments for each block group.

Block Group	Year	Treatment (s)	Species Treated	Seedlings per Treatment	Damage Type
A	2014	Bud caps; control	Pseudotsuga menziesii; Abies grandis; Picea sitchensis; Thuja plicata	20	Browse
B	2014	Bud caps; control	Pseudotsuga menziesii; Abies grandis; Picea sitchensis; Thuja plicata	20	Browse
C	2014	Bud caps; control	Pseudotsuga menziesii; Abies grandis; Picea sitchensis; Thuja plicata	20	Browse
D	2014	Bud caps; control	Pseudotsuga menziesii; Abies grandis; Picea sitchensis; Thuja plicata	20	Browse
E	2015	Companion planting; Plantskydd®; control	Thuja plicata	13	Browse
F	2015	Companion planting; Plantskydd®; control	Thuja plicata	13	Browse
G	2015	Plantskydd®	Pseudotsuga menziesii	13	Bark wounding
H	2016	Companion planting; Plantskydd®; control	Thuja plicata	12	Browse
I	2016	Companion planting; Plantskydd®; control	Thuja plicata	12	Browse
J	2016	Companion planting; Plantskydd®; control	Thuja plicata	12	Browse
K	2016	Plantskydd®	Pseudotsuga menziesii	12	Bark wounding
L	2016	Plantskydd®	Pseudotsuga menziesii	12	Bark wounding

We assessed the effectiveness of treatments by recording 1) the total number of seedlings browsed, and 2) the amount of damage done to each seedling. We rated damage with an index that associated a numerical classification from one to five to each tree, based on the percentage of the tree damaged (Table 1). A single factor ANOVA tested for differences in damage among treatment means. Statistical tests were calculated in Microsoft Excel® with an alpha level of .05.

Table 2. Damage index measured as the percent of damage done to the entire tree

Percent Damage	Rating Index
0	1
1 to 25	2
26 to 50	3
51 to 75	4
76 to 100	5

Cost Calculations

We compared the costs of the effective treatments based on the labor and material costs incurred during this study and experience thinning other reforestation projects. The cost of Plantskydd® was calculated at two applications per year until plants grow above the browsing level (estimated at three years); 1.3 gallons of ready-to-use Plantskydd® cost $64.00 and treated 500 plants. Application time was 2.5 hours (22 seconds per plant). Companion plantings include bareroot *P. sitchensis* ($0.68) and labor to remove *P. sitchensis* after the *T. plicata* grows above the browsing level (1000 trees per person per day) at $20.00 per hour.

Results

Companion planting and Plantskydd® application significantly reduced browse damage; however, Plantskydd® application did not significantly reduce bark wounding. *C. canadensis* browsed control cedars to a significantly greater extent than trees with spruce companion plantings (Table 2; $p = 0.031$) and trees with Plantskydd® applications ($P = 0.004$). On the other hand, bud caps did not reduce browse, when compared to the control ($P=0.236$). Furthermore, Plantskydd® application did not significantly reduce bark wounding ($P = 0.660$).

Table 2. Comparison of mean *C. canadensis* damage values for herbivory and bark wounding studies between treatments.

Year Studied	Damage Type	Treatment	Mean Damage Index Rating	Proportion Damaged (%)
2014	Browse	Control	1.19[a]	12.5[a]
		Bud Cap	1.11[a]	6.2[a]
2015/2016	Browse	Control	1.16[a]	16.1[a]
		Companion Planting	1.03[b]	1.6[b]
		Plantskydd®	1.03[b]	3.2[b]
2015/2016	Bark Wounding	Control	1.02[a]	2.7[a]
		Plantskydd®	1.05[a]	2.7[a]

[ab] Significant difference (single factor ANOVA; $P < 0.05$).

Applying Plantskydd® until plants grow above the browsing level is more expensive than companion planting with *P. sitchensis*, then removing the spruce at a later date (Table 3).

Table 3. Costs of applying Plantskydd® twice a year for three years and companion planting, including eventual spruce removal, to reduce *C. canadensis* browse on cedar.

Treatment	Item	Cost per Tree
Plantskydd® Application	Plantskydd®	$0.84
	Labor (repellent application)	$0.60
	Total	$1.44
Companion Planting	Plant material (bareroot *P. sitchensis*)	$0.68
	Labor (*P. sitchensis* removal)	$0.20
	Total	$0.88

Discussion

We found that companion planting *T. plicata* with *P. sitchensis* and Plantskydd® topical repellant application reduced browsing of conifer seedlings by *C. canadensis*. Moser (2002) also found that Plantskydd® effectively reduced *C. canadensis* browse on conifer seedlings for five to six months. Other studies have found that Plantskydd® reduces conifer browse by deer as well (Nolte 1998, Trent et al. 2001, Kimball and Nolte 2006, Deisenhofer and Rasor 2010).

Bud caps were ineffective at reducing browse; the *C. canadensis* removed 98% of the bud caps within three weeks. Our results differed from other ungulate herbivory studies. Moser (2002) found that Vexar bud caps reduced *C. canadensis* browse overall, even though the *C. canadensis* removed the caps in large areas. Schaap and DeVoe (1986) found that paper bud caps reduced deer browse on conifer seedlings.

Urbanization and roads have fragmented winter and transitional forage areas making restoration sites with their combination of grasses, shrubs and tree seedlings attractive to winter foraging *C. canadensis*. Nutrient availability varies with plant phenology, growth form and location (Rochelle 1980). Nutritional resources generally decline as forests mature (Tressler and Davis 2003): low energy evergreen shrubs and ferns replace high energy deciduous shrubs and forbs as conifer overstories mature (Cook et al. 2016).

C. canadensis select certain forage species over others to avoid harmful secondary compounds. Bryant and Kuropat (1980) found that avoidance of secondary chemical determines the winter forage of browsing vertebrates more than nutrient content. At the Savage Slough restoration site, we observed that *C. canadensis* browse young *T. plicata* and deciduous leaf buds from late fall through winter and opening conifer buds in early spring. *T. plicata* contains low quantities of defense resins (Theis and Lerdau 2003), leaf buds are more digestible than woody stems (Short et al. 1975), and conifers decrease defense metabolite levels after spring bud break (Brooks et al. 1987).

The principle ingredient of Plantskydd® is bloodmeal. Kimball and Nolte (2006) found that hydrolyzed casein is the Plantskydd® compound that minimizes damage to forest trees. Fear-inducing repellents emit sulfurous odors, which herbivores perceive as indicators of predator activity. Prey species use olfactory cues to recognize predators and the literature indicates that fear-inducing repellents repel via olfaction (Sullivan et al. 1985, Andelt et al. 1992, Nolte 1998, Trent et al. 2001). Therefore, it is curious that bark wounding persisted despite Plantskydd® application. Sullivan et al. 1985 suggest that active repellent components can evaporate, and predator scents lost effectiveness over snowshoe hares (*Lepus americanus*) in three to seven days.

This study used proportion of plants browsed, similar to Schaap and Devoe (1986), and a qualitative rating index based on the proportion damaged to measure results. However, measurements based on seedling size, either change in height or size after damage, may have been more repeatable. For example, Baker et al. (1999) assigned the proportion of aspen sprouts and terminal leaders browsed to four categories based on tree size. Other studies have used tree height, height growth, canopy size, and number of bites to measure deer and *C. canadensis* herbivory (Schaap and Devoe 1986, Trent et al. 2001, Schoenecker et al. 2004, Deisenhofer and Rasor 2010).

Implications for Restoration

Plantskydd® application or companion planting can reduce *C. canadensis* browse in restoration plantings, thereby increasing success rates and decreasing costs. Restoration technicians need to apply Plantskydd® twice a year until seedlings grow above the browse level (approximately three years). In high density plantings, growers should remove the *P. sitchensis* in companion plantings to reduce competition for resources. Plantskyyd® application is nearly twice as expensive as companion planting. However, it is still useful when growing conditions are outside of the *P. sitchensis* niche.

However, Plantskydd® showed no effect on bark wounding in this study. Other methods suggested in the literature, such as fencing or hazing *C. canadensis* with loud noises (Campbell 1984, deCalesta and Witmer 1994, VerCauteren et al. 2007), are a poor fit for public access restoration sites. Wire fencing around individual trees offers protection from rubbing (DeCalesta and Witmer 1994), but the cost exceeds the benefit: $37.00 per tree compared to 20.1% of trees wounded with 1.4% mortality in a nearby Skagit River restoration project (SSIT 2009). Some restoration practitioners are experimenting with planting thick stands of red alder around conifers, which could be explored in future studies.

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