Low Elevation Tree Planting Trial in the Cedar River Municipal Watershed

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Introduction

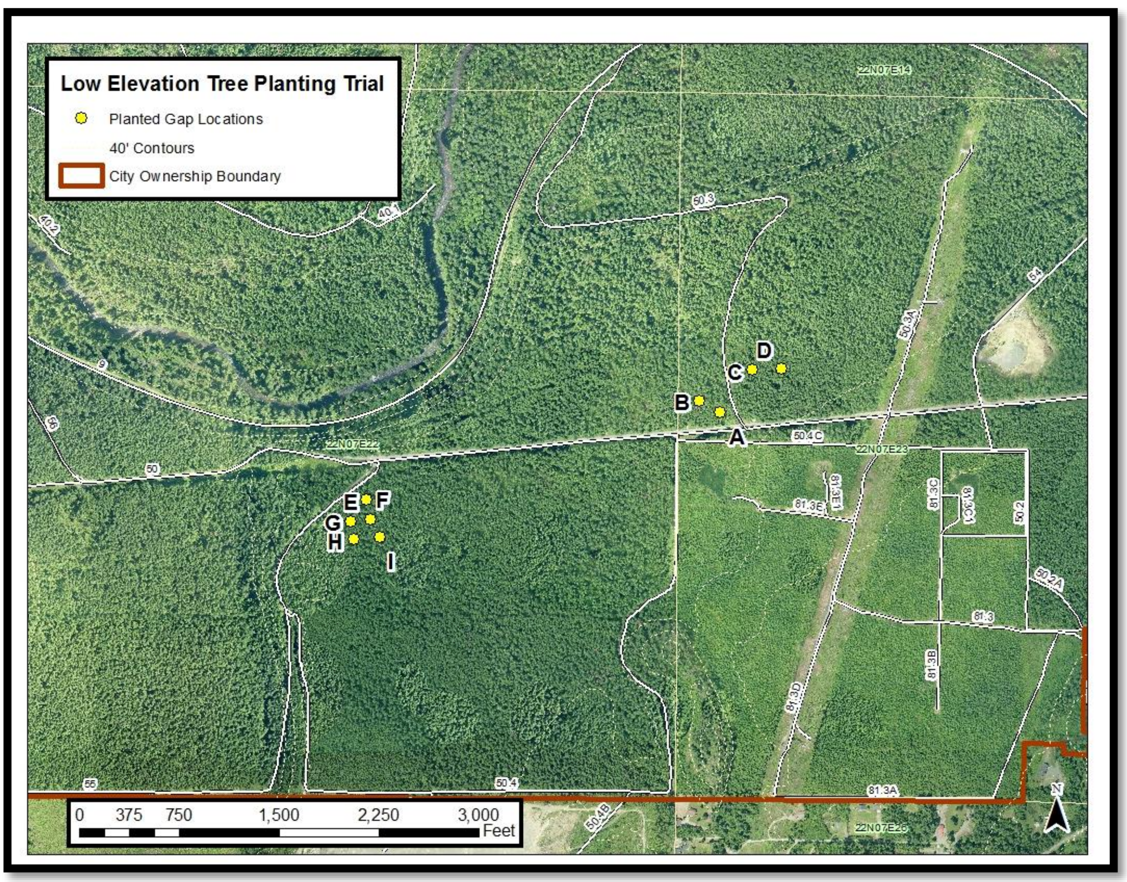
The conservation and restoration of old-growth forest conditions is the primary forest management directive of the Cedar River Watershed Habitat Conservation Plan (HCP), including restoring and enhancing biodiversity. In younger forests that are recovering from previous even-aged management, tree diversity can be relatively low and is often dominated by one species. Augmenting tree diversity through actively planting various tree species is one of the three forest management programs established by the HCP (the other two being thinning programs). Getting seedlings established under a forest canopy, however, is relatively new to forest management in the Pacific Northwest and is fraught with difficulty. Competition with existing plants, both in the overstory and understory, along with ungulate herbivory, makes survival of tree seedlings challenging. This study trial is an attempt to evaluate the efficacy of planting tree seedlings in the understory of a young forest at a relatively low elevation in the watershed.

Methods

Study Site

This study was conducted in the Cedar River Municipal Watershed (CRMW), which is owned and managed by Seattle Public Utilities. The 36,500-hectare CRMW lies on the western slope of the Cascade Mountain Range in Washington State.

Figure 1. Location of nine planting trial gaps.

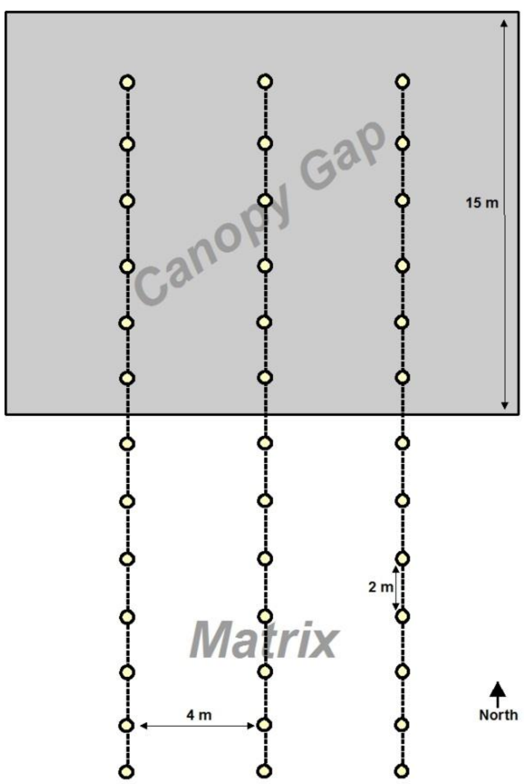


The flat forest area where the study was installed is in the western hemlock (*Tsuga heterophylla*) vegetation zone (Franklin and Dyrness 1973), at roughly 260 m above mean sea level (asl). The relatively low productive site (site class three) is characteristic of the outwash gravel and moraine soils. The forest has regenerated following clearcut timber harvesting in the early-mid 20th century. The overstory is dominated by 30-m tall Douglas fir (*Pseudotsuga menziesii*) that are 60-80 years old. The understory is primarily salal (*Gaultheria shallon*) and vine maple (*Acer circinatum*).

The area has a temperate climate with average monthly temperatures ranging from -0.3°C in January to 24.3°C in July. Of the 145 cm of total annual precipitation, most falls during November to March, while only 8 cm fall during July to August. Precipitation is rain dominated with a 24 cm falling as snow, primarily in January.

This site was chosen for this study because of its relatively low diversity of tree species, its easy installation and sampling access, and to evaluate the efficacy of active biodiversity restoration.

Figure 2. Planting transect design through each of nine gaps.



Planting Design

Three variables were incorporated into the planting design; tree species, overstory shade, and method of site preparation prior to planting. In mid-November, 2005, western hemlock, western redcedar (*Thuja plicata*), and bigleaf maple (*Acer macrophyllum*) were planted in single-species transects through each of nine gaps (15 m on a side) previously cut into the forest canopy (Figure 1). These native species were chosen because of low abundance in the stand and their unique habitat functions. Each transect consisted of at least 13 planted trees, with six in the gap and at least six outside the gap in the forest matrix (Figure 2). Prior to planting, 1-meter planting spots in three of the gaps were cleared of vegetation, 1-meter planting spots in three other gaps were cleared of vegetation and the remaining roots were grubbed out, and the three remaining gaps had no planting preparation. Site preparation was randomly assigned to the gaps.

Sampling
The height (with leader stretched where necessary) and diameter (with caliper just above litter layer) of each tree was measured soon after planting, and again in 2007, 2009, and 2013. The presence of ungulate browse was also noted, though winter sampling made evidence of browse difficult to determine in deciduous bigleaf maple. Available light (e.g., Photosynthetically Active Radiation – PAR) was measured with a Decagon AccuPAR ceptometer along transects through each gap in 2013, and calibrated as a percent of the PAR measured at unobstructed control areas nearby and on the same day. The heights of at least four dominant trees neighboring each gap and the spatial dimensions (e.g., average of three diameters at random angles) of the gaps were also measured to compare gap size and light availability.

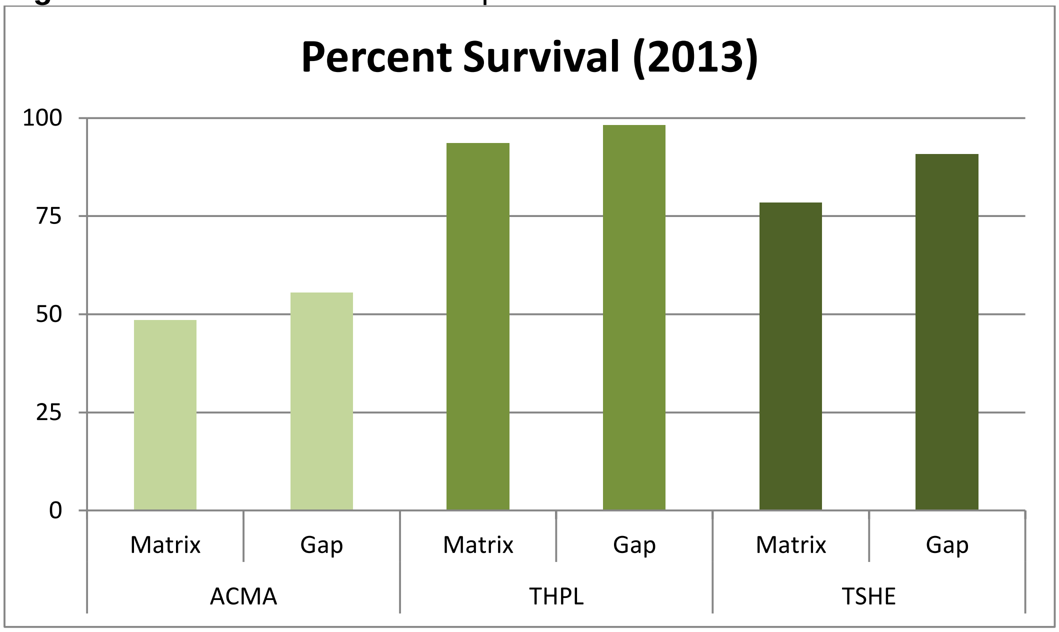
Results
A total of 353 trees were planted in 2005 (Table 1). Survival was significantly different ($p<0.05$) between the species, with 96% of the redcedar, 84% of hemlock, and 52% of maple living in 2013 (Figure 3). There was no difference in survivorship based on being planted in a gap or in a forest, or on planting treatment.

Table 1. Total numbers of trees planted in the trial.

Species	Location	# Planted	Total
ACMA	Gap	54	118
	Matrix	64	
THPL	Gap	54	116
	Matrix	62	
TSHE	Gap	54	119
	Matrix	65	
			353

ACMA = bigleaf maple, THPL = western redcedar, TSHE = western hemlock

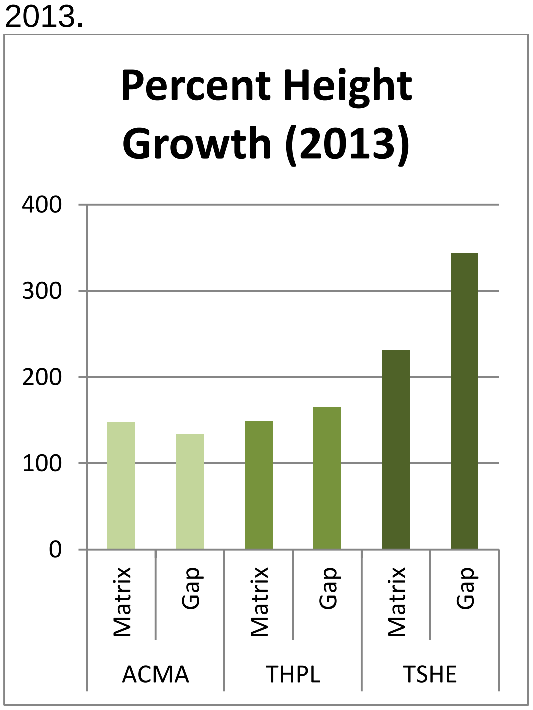
Figure 3. Percent survival of the planted trees from 2005 to 2013.

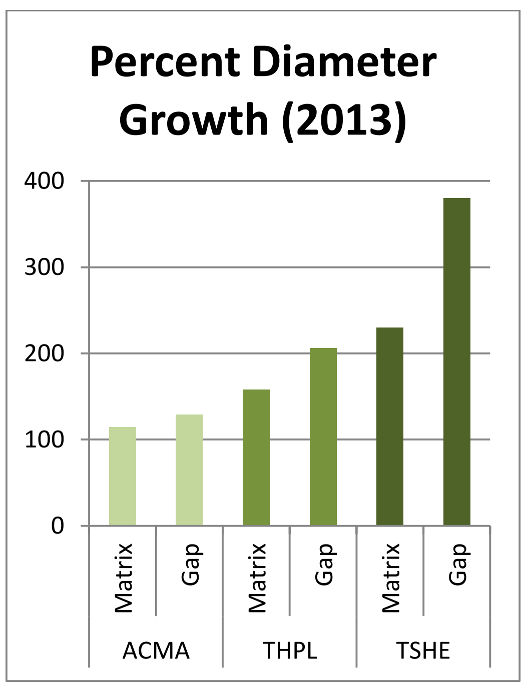


ACMA = bigleaf maple, THPL = western redcedar, TSHE = western hemlock

Height and diameter growth is significantly different (p<0.05) between species, except between the heights of maple and redcedar (p=0.08). Height growth from 2005 to 2013 was 289% for hemlock, 162% for redcedar, and 148% for maple (Figure 4). Diameter growth was 334% for hemlock, 211% for redcedar, and 120% for maple.

Figure 4. Percent height and diameter growth of the planted trees between 2005 and 2013.

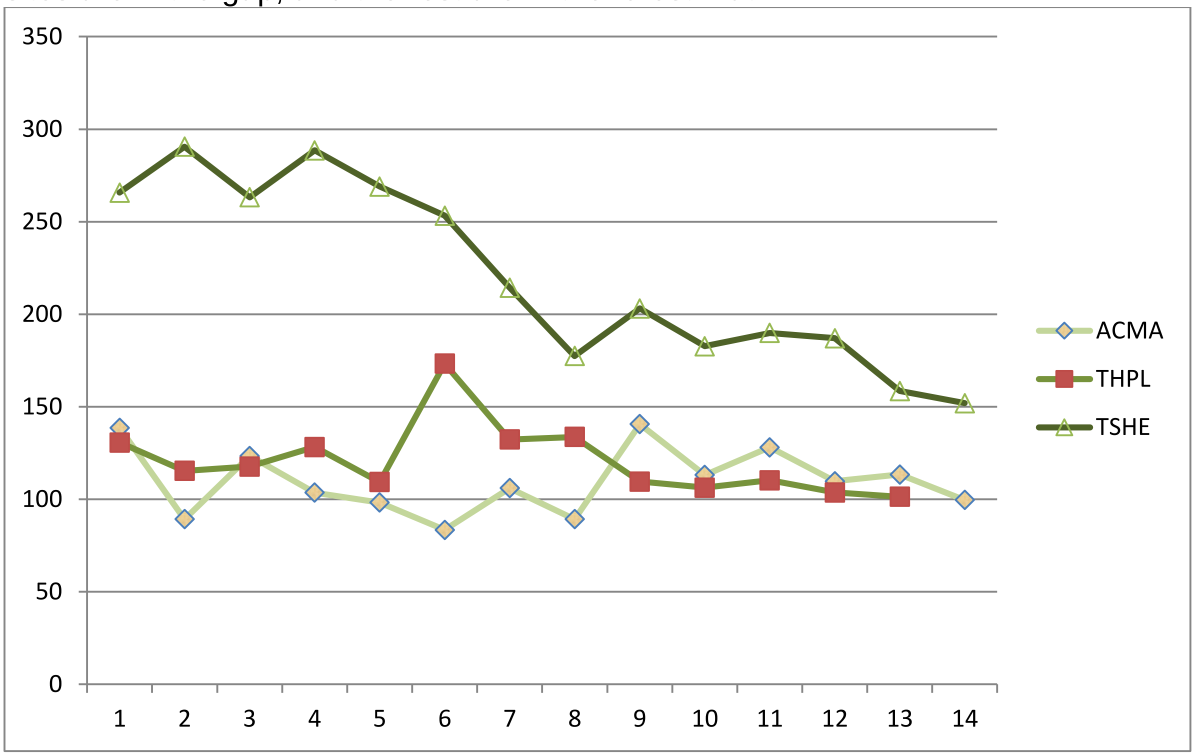




ACMA = bigleaf maple, THPL = western redcedar, TSHE = western hemlock

Hemlock grew significantly ($p<0.05$) larger in height and diameter in gaps compared to in the forest (Figure 5). Redcedar and maple, however, did not grow significantly different in the gaps. Site preparation did not have a significant effect on survival or growth.

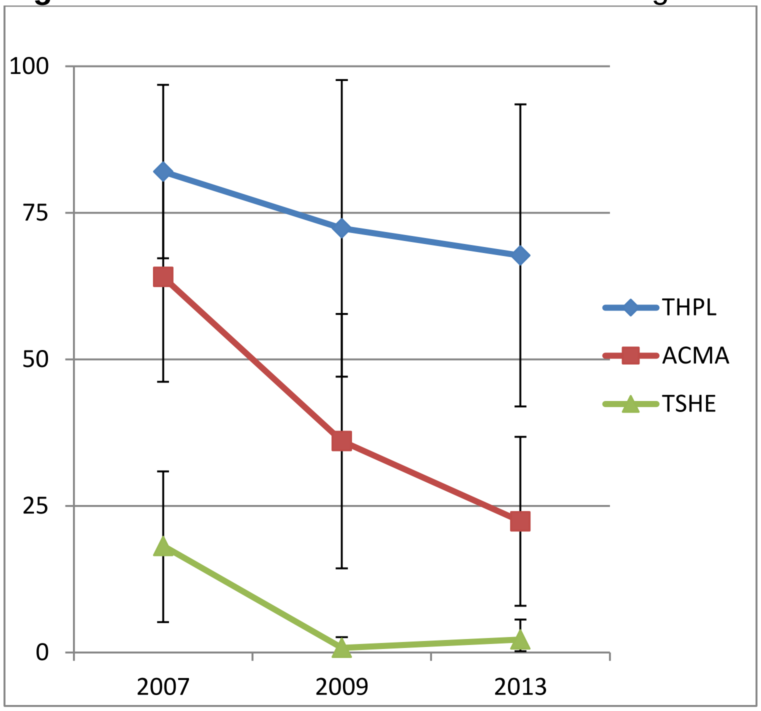
Figure 5. Average height of trees along planting sites on the transect. The first six sites are in the gap, and the rest are in the forest matrix.



ACMA = bigleaf maple, THPL = western redcedar, TSHE = western hemlock

Ungulate browse decreased over time on all three species, and was most significant and consistent over time on redcedar (Figure 6). Hemlocks showed some signs of browse in the years immediately after planting (2007), while antler rubbing had a greater impact as the trees grew (11% of live trees in 2013, while absent in previous years). Dwarf mistletoe (*Arceuthobium tsugense*) had also infected two of the hemlocks by 2013.

Figure 6. Percent of live trees that showed signs of browse by ungulates.



ACMA = bigleaf maple, THPL = western redcedar, TSHE = western hemlock

The light available to the planted seedlings is greatest at the southern end of the gap, and lowest 10 m into the forest matrix (Figure 7). The data shows a general relationship between the size of the gap and light availability (p = 0.23), though not strong (Table 2).

Figure 7. The Photosynthetically Active Radiation (PAR) along the transect as a percentage of control measurements. The first six sites on the transect are in the gaps, and the rest being in the forest matrix.

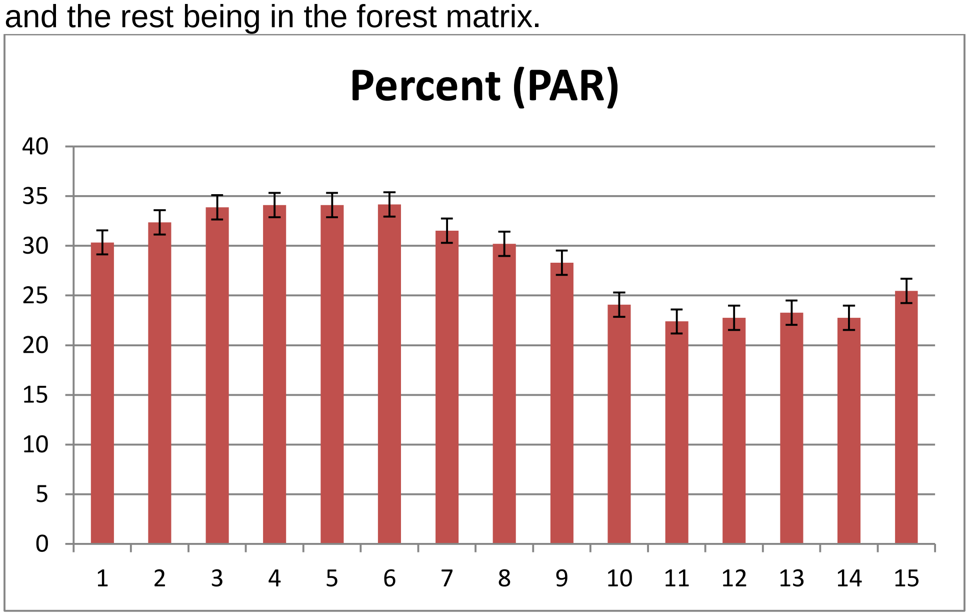


Table 2. Gap diameters and adjacent tree heights.

Gap	Average Gap Width (m)	Average Adjacent Tree Height (m)
A	19.4	35.0
B	18.0	34.2
C	22.4	35.7
D	20.2	35.8
E	20.4	32.5
F	19.6	33.2
G	17.1	31.2
H	19.7	35.3
I	26.6	35.5

Discussion

Western hemlock was the obvious success story of this trial, as expected. Not only does it readily grow in partial shade of the gap and the understory of the forest matrix, but it was shown to be generally unappealing as forage for ungulates. Hemlock growth generally mimics available light, with greater height growth in the gaps.

Western redcedar is quite hearty, at least in its survival, but it takes a beating for being palatable as ungulate forage. As a result it tends to exist in both the gaps and forest understory without much growth. A physical deterrent to the browse to get the trees above browse height is obviously warranted.

Bigleaf maple did not do well in either survival or growth in any of the transects. It is difficult to attribute to any one factor, but forage and light availability in the understory contribute to poor performance.

Site class, gap size, and adjacent tree height did not vary enough to be factors in understory tree growth and survival. Site preparation prior to planting makes little impact to the long-term survival of any of the tree species.

The trial was discontinued in late 2013, when a forest resilience project was installed in the area that included these trial sites. The restoration project included thinning the overstory canopy and planting diverse shrub and tree species. Sampling of this trial is no longer possible.

Acknowledgements

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