2016 PROJECT REPORT

REFORESTATION OF A FORMER BUILDING SITE AT LOMPICO HEADWATERS FOREST

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Submitted by:

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by
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INTRODUCTION

Site and Project History

The Lompico reforestation site is located on the headwaters of Lompico Creek above the small town of Lompico and is located within the San Lorenzo River Watershed. A house, carport, swimming pool, and underground storage tank were demolished in 2000. By 2009 there was still no evidence of the recovery of native forest vegetation and the site was evaluated for its potential as a reforestation project (Singer 2009). At that time the only vegetation present was French Broom (*Genista monspessulana*) and non-native annual grasses and forbes.

The 2009 site investigation found extremely poor soil conditions. All of the original topsoil had been removed by grading and filling, and the remaining substrate consisted of pulverized construction debris and finely-ground rock. The capability of this “soil” to hold water or nutrients for plant use (i.e., available water-holding capacity and cation exchange capacity) was almost nil. Available rooting depth was also limited, with portions of the site having a soil depth of 12 inches or less. Soils this shallow would not support tree establishment and growth.

At the request of the Sempervirens Fund, a reforestation plan using redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii)* was prepared that utilized local ecotype trees and included special measures and innovative techniques to ameliorate the extreme soil conditions. The details of this approach were presented in last year’s report (Singer 2015) and will not be repeated here.

The Lompico reforestation site was planted in the fall of 2010, largely by the volunteer labor of Sempervirens Fund members, with 30 redwood seedlings and 20 Douglas-fir seedlings. Since then it has been irrigated and weeded as necessary through the fall of 2015, after which time irrigation and weeding ceased. Monitoring of tree vigor and growth was done each year through the fall of 2016. This report addresses the 2016 results in context of the previous work.

RESULTS

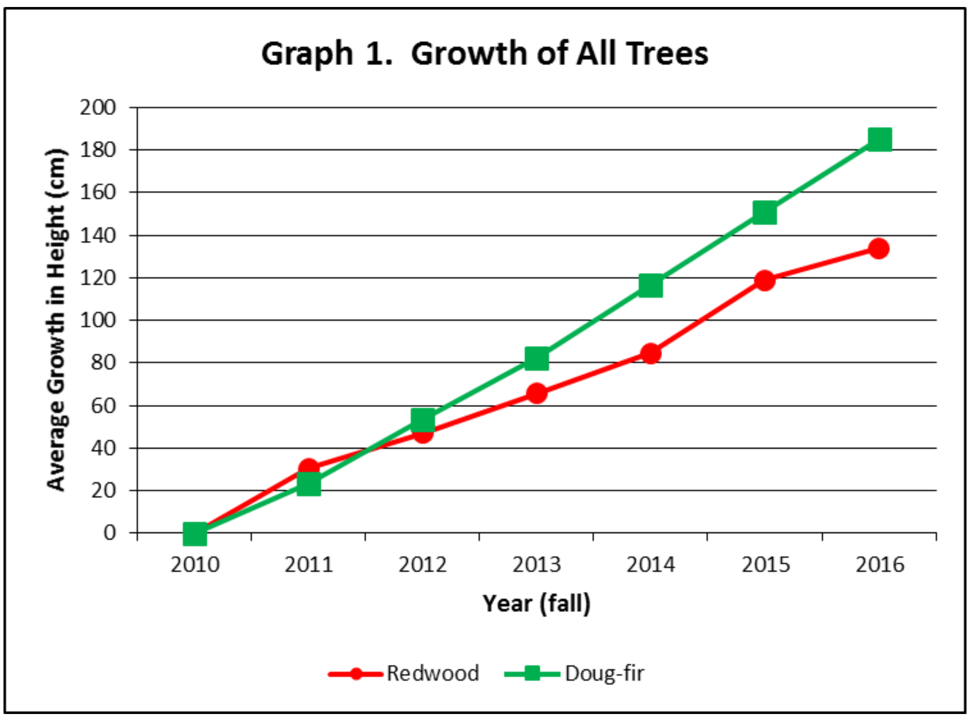
Effects of the Cessation of Irrigation

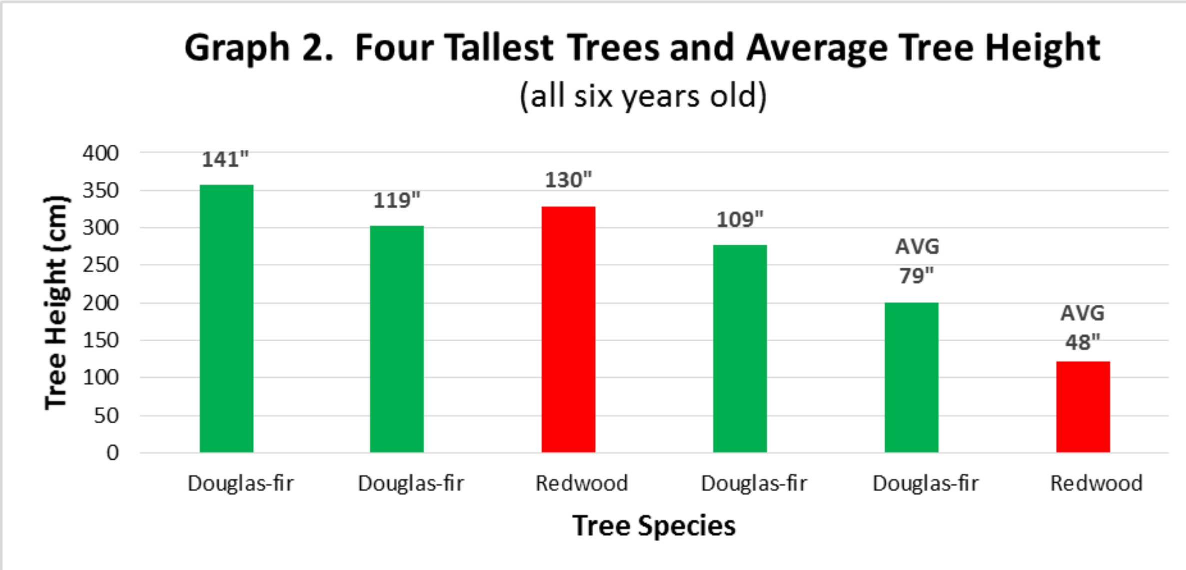
In 2016 the growth rate of redwoods declined slightly while the growth rate of Douglas-firs remained the same. The lack of irrigation had the most effect on redwoods, decreasing their annual growth rate to 15.0 cm (5.9”) which was less than half of what it had been the year before - 34.3 cm, (13.5”). Some trees grew extremely well as can be seen in Graph 2 which shows the four tallest trees. The annual growth rate that 50% or more of the trees achieved in 2015-2016 was 30 cm (11.8") for Douglas-firs and 15 cm (5.9") for redwoods.

Table 1 and Graph 1 show the annual growth rate of all trees over the years.

Table 1. Average Yearly Growth of All Trees at Lompico (cm)

Year	Redwoods	Douglas-firs
0-1	30.5	23.4
1 – 2	16.6	30.2
2 - 3	18.5	28.9
3 - 4	18.9	33.8
4-5	34.3	34.5
Avg. Year 0 Thru Year 5	23.8 (9.3")	30.2 (11.9")
5 - 6	15.0 (5.9")	34.4 (13.5")





Tree Health and Tree Mortality

In the October 2015 inspection of tree health, 7 trees had such poor vigor that it appeared they might die in the summer of 2016. In reality, only 3 trees died, showing that tree vigor can vary tremendously from one year to the next, although two of the 7 trees remain in very poor condition. All 5 of these trees are redwoods, an indication that redwoods are not as well suited to this site as are Douglas-firs. Many of the dead trees showed symptoms of apparent nitrogen deficiency with older needles turning brown, dying, and eventually falling off the tree. This was to be expected given the site soil conditions and the decision not to apply fertilizer after planting. Tree mortalities throughout the duration of the project are presented in Table 2.

Table 2. Individual Tree Mortalities at Lompico

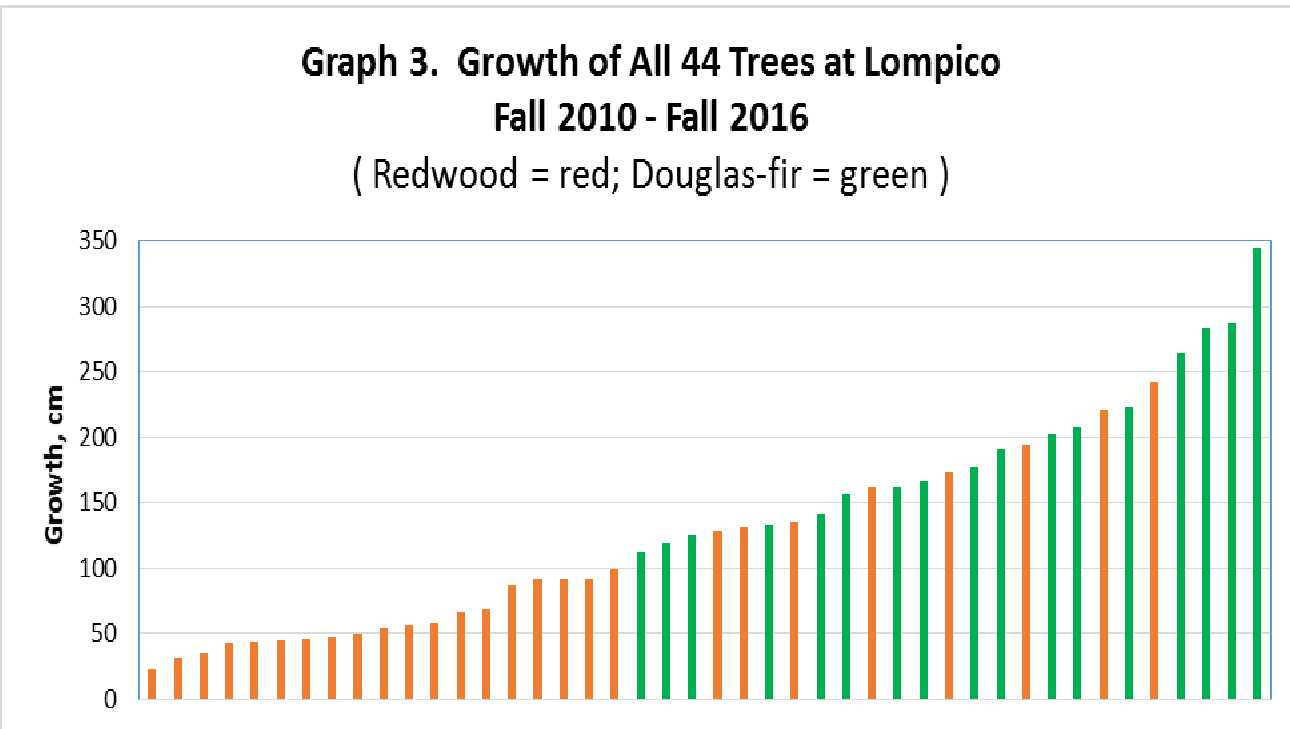
Mortalities Summer 2011	Mortalities Summer 2012	Mortalities Summer 2013	Mortalities Summer 2014	Mortalities Summer 2015	Mortalities Summer 2016
3 redwoods 3 Doug-firs	1 Doug-fir 1 replanted redwood	None	None	None	3 redwoods
Subtotal = 6	Subtotal = 2	Subtotal = 0	Subtotal = 0	Subtotal = 0	Subtotal = 3

Individual Tree Responses to Variations in Planting Site Conditions

Forty-five trees survive at the Lompico site. There is a wide variation in growth rates of the planted trees. In most cases, growth rates for individual trees were not in synchrony with their neighbors, suggesting soil differences at the micro-site level. In some cases the annual growth rate for an individual varied widely from year to year. For example, a redwood in the B planting pod had successive annual growth rates of 39 cm, 18 cm, 42 cm, 20 cm, and 56 cm before dying mysteriously over the following winter. Exceptional annual growth rates were 98 cm (3.2 ft) for a Douglas-fir this last year, and 83 cm (2.7 ft) for a redwood in its first year after planting.

Graph 3 shows cumulative tree growth for each of the 45 trees from 2010 to 2016. It can be seen that Douglas-firs grew better than redwoods, and this is not surprising given the extremely poor soil conditions at the site.

The regular and fairly even progression of individual tree growth rates shown in Graph 3 is striking as is the width of the range, from 23 cm. to 345 cm. This variation is likely due to a combination of an individual tree's genetic makeup and the wide variation in condition of the soil and soil depth at planting micro-sites. Some micro-sites no doubt contained construction debris that was harmful to tree growth. Unfortunately, there was no way of telling in advance where these pockets of "bad" soil were located.



There were also differences in tree response on the macro-site scale. At the time of planting, the site was divided into 5 planting areas, called planting pods, where soil depth was suitable (12" minimum). These were pods A, B, C, D1, and D2 and their locations are shown in Figure 1 in the Appendix.

Table 3. Growth and Survival at Different Planting Pods

Planting Pod	Average Growth All Trees 2010-2016 (cm)	Mortalities - All Trees Fall 2011 to Present[1]
A	141.9 (n = 13)	0
B	162.3[2] (n = 11)	1
C	128.5[3] (n = 6)	4
D1	84.8 (n = 8)	0
D2	179.2 (n = 7)	0

Notes: 1. First year mortalities were excluded since mishandling during planting could have caused a tree to die.
2. Average value would have been higher except for 4 redwoods planted in almost full shade at east edge of the pod which have grown very little.
3. Includes one exceptional value of 221, if removed average would be 112.6.

From Table 3 it can be seen that trees did best in planting pod D2 and did very poorly in planting pods C and D1. Pod D2 was in full sun and its location was over the old swimming pool location. Perhaps the soils were deeper here, and perhaps the bottom of the pool was left in place, allowing it to catch and hold water and nutrients that became accessible to growing tree roots. If this were the case, it might explain the several exceptionally tall trees here, one of which is 329 cm (10.8 ft.) tall. Trees in Pod B, for the most part, did quite well with one tree being 357 cm (11.7 ft.) tall. This tree actually grew 98 cm (3.2 ft.) during this last year. Pod B is not located above the old pool, but is located on the only remaining patch of native soil. Trees have grown well here except at the east end where 4 redwoods were planted in a full shade situation. Over this last year those four trees have only grown 5 – 7 cm, and all are less than 55 cm (1.8 ft.) tall.

The cause of the poor growth in pods C and D1 is unclear. Both plots received a significant amount of sunlight during the day. One possibility is that construction debris with constituents harmful to plant grown was concentrated into this area.

The best macro-sites for planting were those with lots of sunlight, deep soils, and free from harmful soil constituents. Unfortunately, there was no simple way of determining the status of these last two components before we did the planting, other than to determine that soils were at least 12 inches deep, which was done (see Figure 1 in Appendix).

CONCLUSIONS

Due to regular watering and weeding over the first five years and the intensive and innovative planting site enhancement measures implemented the first year (see 2015 report for details), 78% of the initial and replacement tree seedlings have survived.   If we discount the first year losses, the survival rate was 87%. The survival rate for redwoods and Douglas-firs were nearly the same, although as Graph 3 shows, the redwoods haven't grown nearly as much as the Douglas-firs. In the absence of any of the special planting enhancements and irrigation, it is very unlikely that this many trees would have survived. The combination of the multi-year drought, which was on-going at the time, and the excessively-drained nature of the soils (meaning they had little ability to hold water into the summer months) could have easily lead to a complete loss of all trees. Thanks to the irrigation and other care provided, over three-quarters of the plantings have survived and 16 trees are now over 183 cm (6.0 ft.) tall, so it can be said that the Lompico Reforestation Project was very successful.

Here are some lessons that were learned, or if already known, were further affirmed.

1. Redwoods were a poor choice for planting at this site. The sandy nature of the substrate meant that it could not retain the necessary water and nutrient for normal tree growth, especially during the first several years when a root network has not yet been established. Regular irrigation was able to compensate for these excessively well-drained soils, but nutrient shortages (notably Nitrogen) were apparent after the initial soil amendments were exhausted.

The initial application of fertilizer, organic material, and biochar was intended to keep the trees alive long enough for their root systems to expand and find other nutrient sources. This is known to take several years. The applications apparently were successful, as most trees survived and and some, especially the Douglas-firs, did quite well.

Planting a tree species more suitable to the changed and now very harsh conditions of the site, such as Knobcone Pine (*Pinus attenuata*) instead of redwood, would have significantly reduced the needed for planting amendments/enhancements and long-term irrigation. Even though this project was successful, forcing redwoods to grow in places where they don't want to grow, is never a good idea.

2. Given the regular irrigation of the plantings, the environmental factors that had the greatest impact on tree growth were percent available sunlight and soil conditions. The more sunlight available, the better the growth. This was true for both redwoods and Douglas-firs. Other environmental factors played only a minor role in tree growth and survival.

3. Subfreezing temperatures a few months after planting damaged 10 trees, all redwoods. In January 2011, a hard freeze dropped temperatures in the Lompico area to the low-mid 20^{o}s. Most trees exhibited signs of minor frost burn, but three trees had moderate burn, and one of these died. Hard freezes have occurred again in subsequent years, but only produced minor damage with little or no long-term effect. The plantings are most susceptible to frost damage during their first winter and redwoods are much more sensitive than Douglas-firs. A more severe hard freeze (colder temperatures, longer duration, etc.) in the first winter would pose a significant threat to redwood establishment.

4. Gophers were likely responsible for 1 – 2 tree deaths in the first year, when the seedlings were most vulnerable. It doesn't appear to be the case that the gophers were feeding on tree roots. More likely, their diggings disrupted the root-soil connection. A few gopher diggings within the anti-browse cages were present every year, but no additional tree mortalities occurred. The gophers were likely attracted to roots of the weedy grasses that sprang up in a ring around the anti-browse cages due to the regular irrigation of the trees.

Any opportunity for browsing by deer or rabbits on the young trees was prevented by the anti-browse cages. Even after branch tips extending outside of the cage, there was little or no sign of browsing by deer. However, the use of the anti-browse cages is probably worthwhile as they protect the nutrient-rich tree leader which would be more attractive to deer and might be browsed if accessible. Deer browsing of leaders would seriously set-back tree growth.

LITERATURE CITED

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Singer, Steven. 2009. Lompico Reforestation Project. Phase I – Investigation and Analysis of Site Conditions. Unpublished report prepared for the Sempervirens Fund. Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

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<u>Appendix</u>

Figure 1. Disturbed Sites at Lompico Headwaters Property (map).

APPENDIX

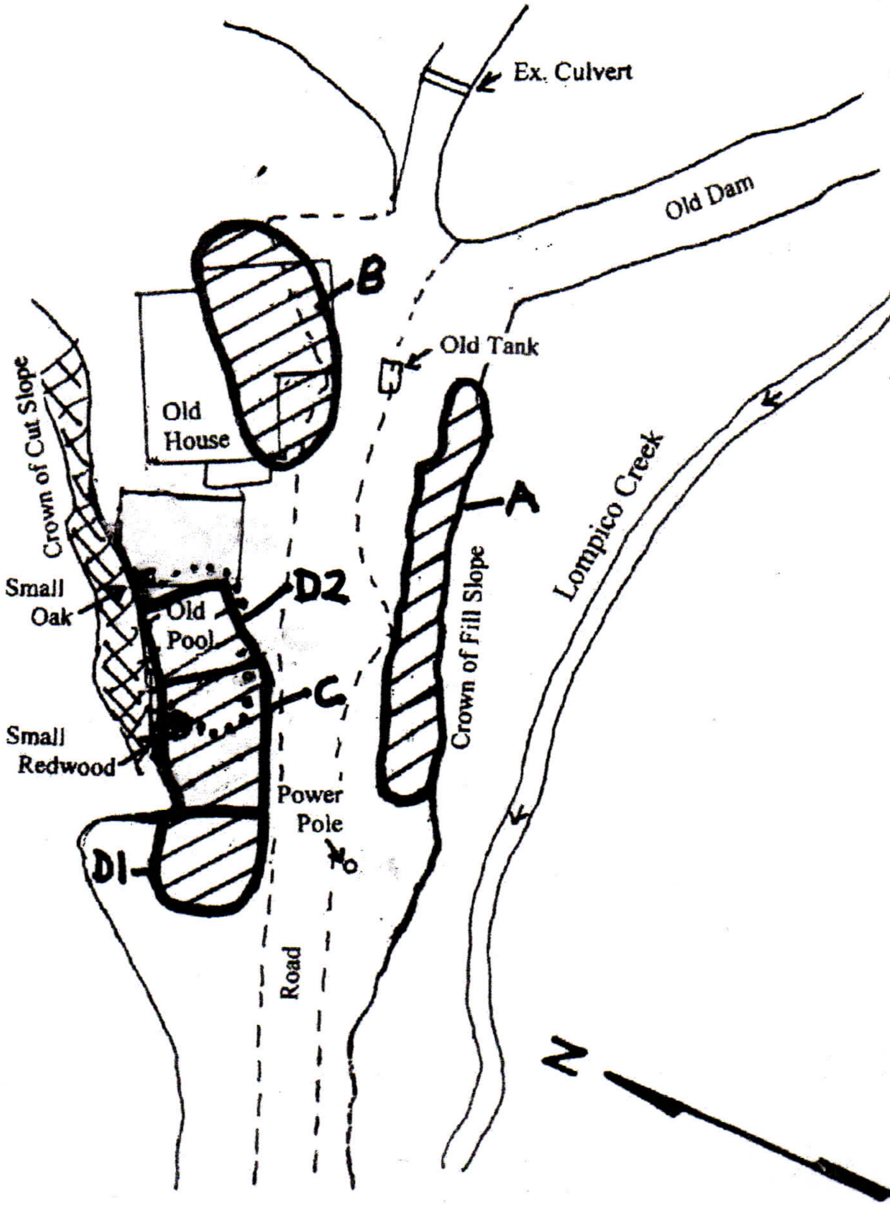

Figure 1. Disturbed Site at Lompico Headwaters Property
Scale: 1 inch = 48 feet (very approx.)
(Map adapted from Krazan & Associates, Inc. 2006)

KEY:

- ·········· = Edge of former swim pool
- [hatched area] = Area with suitable soil depth for planting and containing Planting Pods A – D2.

(Note: Structures, swimming pool, and tank were removed in 2000.)