Sierra Cascade Intensive Forest Management Research Cooperative Proposal 00-05
Timmer/ Jopson Study

Principal Investigators: Vic Timmer and Tom Jopson

TITLE: Improving seedling nutrition in the nursery to increase seedling performance in the field.

Year Funded: 2002

Executive Summary:
Seedlings grown with constant and sufficient internal nutrient concentrations achieved through exponential fertilization are free of nutrient stress. Seedlings can be produced with balanced, high reserves of nutrients superior to those possible through late-season heavy fertilization. Presumably, balanced, surplus reserves of nutrients at planting affords growth that is rapid enough to offset weed competition and soil drought. Questions to be answered are: (1) what techniques are best for western species? (2) how does nutrition favoring rapid growth affect seedling resistance/ susceptibility to drought, pests, and temperature extremes?

At one or more forest nurseries, seedlings will be raised according to various nutrient regimes including conventional fertilization and exponential fertilization. Growth and nutrient status of the seedlings will be assessed at 2-week intervals during the culture period to chart the progress and adjust nutrient supply schedules. At lifting, seedlings will have nutrient contents that vary incrementally from conventional to very hight values, and should identify a treatment optimal for out-planting success. Survival and growth of these seedlings will be followed for at least 5 years, at which time a firm decision can be reached on the best treatment(s) to apply to operational planting.

A trial run using the fertilization rates specified in the proposal was made during 2001 at Cal Forest Nursery in Etna, CA.

Three Co-op members supplied seedlings for the test: Boise Cascade, Fruit Growers Supply Co., and Soper-Wheeler. Three species were grown: Douglas-fir, ponderosa pine, and white fir.

Problems with pH complicated the study while the seedlings were in the nursery. Over all, the constant rate fertilized seedlings outgrew the exponentially fertilized ones. Mortality was excessive with the latter application technique.

The foliar analysis done at Davis showed a range of nitrogen levels in the seedlings, but only in the constant feed application. Timmer believed that nutrient concentrations were too low in the early stages for the exponential treatments, and that seedlings were stunted and not able to catch up to those in the constant feed treatment. A later foliar sample from Scott's Lab showed miner but consistent differences in nitrogen levels among the constant feed treatments. Whole seedling nitrogen concentrations generally increased in proportion to nitrogen concentrations in the constant feed solution.

It was decided to out-plant only the two extreme treatments in the constant feed technique: 50ppm and 300 ppm.

The seedlings were lifted in February. Seedling height and caliper were recorded for each treatment and needles were collected and sent to Scott's Laboratory for analysis.

All plots were established by the last week of March, 2002. Plot corners were marked by metal conduit and planting spots were designated with wire stake flags. All three sites had been planted as of the first week in April. Only ponderosa pine had sufficient numbers of seedlings to be out-planted on the Boise Cascade site. Six replications of the 50 ppm and 300 ppm treatments were out-planted there. Fruit Growers had enough seedlings for 5 replications of each treatment for ponderosa pine and white fir; four replications of Douglas-fir were out-planted. Six replications of each treatment for ponderosa pine and white fir and five replications of Douglas-fir were out-planted on the Soper-Wheeler site.

Measurements for seedling heights and caliper were taken at all three sites in October, 2002. Survival was noted at the time the measurements were being taken.

First year data were analyzed in December, 2002. The experimental design was completely randomized with one-way treatment structure. Two treatments were each replicated 4 to 6 times. To test for treatment effects and significant differences among treatments, one-way analysis of variance of treatment means and Tukey tests were applied. Statistical significance in all tests was the 0.05 level.

Results: Survival at the end of the first growing season was uniformly high for both treatments with all species on the three sites. Survival was always higher for the 50 ppm treatment when compared to the 300 ppm treatment but not statistically higher. For the study as a whole (all three sites), ponderosa pine survival ranged from 97-100 percent; white fir from 91-100 percent; and Douglas-fir from 94-100 percent.

The seedlings are responding early on to the different levels of fertilization. For the most part, the seedlings that received the largest fertilizer rate (300 ppm) were bigger than those seedlings that received the smaller rate (50 ppm). At the time of their lifting in the nursery, white fir and Douglas-fir showed significant differences in height and volume for all seed lots. Those seedlings receiving 300 ppm treatment were always larger than those receiving 50 ppm. Generally speaking, ponderosa pine seedlings did not show these differences.

After their first growing season, seedlings that were fertilized at the 300 ppm rate are always significantly taller and have significantly more volume than do their counterparts that received the 50 ppm rate. With the exception of ponderosa pine, this is also true for caliper. The percentage differences in height and volume that showed up at time of lifting are continuing to show after one year. The difference in volume is actually increasing. Survival is high regardless of treatment.

2003: The seedlings were remeasured for caliper and height at all three sites in the fall of 2003 at the end of their second growing season. Survival was noted at the time the measurements were being taken.

Survival at the end of the second growing season was still uniformly high for both treatments with all species on the three sites. Unlike at the end of the first growing

season, survival was not always higher for the 50 ppm as compared to the 300 ppm. For the study as a whole (all three sites), ponderosa pine survival ranged from 95-99 percent; white fir from 83-99 percent; Douglas-fir from 85-91. These percentages are lower than those reported at the end of the first growing season, but not significantly so.

After their second growing season, seedlings that were fertilized at the 300 ppm rate are always significantly taller than are their counterparts that received 50 ppm. But the differences are less than at the end of the first growing season. Many of the significant differences among treatments in caliper and volume that showed up at the end of the first growing season are no longer there. The 300 ppm treatment always gives the higher values for these two variables but many of the differences among the two treatments are no longer statistically different. Survival continues to be high for all treatments.

2004: Seedlings were remeasured for caliper and height at all three sites in the fall of 2004 at the end of their third growing season. Survival was noted at the time the measurements were being taken.

Survival continues to be high for both treatments with all species on the three sites. Survival for the 50 ppm treatment is slightly higher than that in the 300 ppm treatment in 5 to 7 comparisons. For the study (all three sites), ponderosa pine survival ranged from 96-99 percent, exactly the same as at the end of the second growing season; white fir from 79-89 percent, down slightly from the end of the second growing season; and Douglas-fir from 80-90 percent, also down slightly from the second growing season numbers.

After three years in a plantation, seedlings that were treated at the 300 ppm rate are always taller, have larger caliper, and have more volume than seedlings treated at the 50 ppm rate. But the majority of these differences are no longer significant. Of the 21 comparisons possible (fertilizer rates/species), only 5 show significant differences. In 2003 that number was 11. There seems to be an influence of site quality (most influence on higher sites) but this generalization has problems. As far as tree species, white fir is the most influenced by fertilization rate. The most influenced dependent variable is tree height. Survival continues to be high on all sites for all treatments.

2005: No measurements taken on this study.

2006: After five years in a plantation, seedlings that were fertilized at the 300 ppm rate are always taller, have larger caliper, and have more volumne than their counterparts that were fertilized at the 50 ppm rate. But continuing a trend that started at the end of the second growing season, most of these differences are no longer significant. In fact the only significant difference between treatments on all three sites in the study is found in the white fir planted on the Soper-Wheeler site where the seedlings fertilized at the 300 ppm rate are significately taller than those fertilized at the 50 ppm rate.

Survival has remained high throughout the life of the study for all species. Percent survival ranges at the end of 2006 for all sites combined were: white fir 72-89%, ponderosa pine 95-96%, and Douglas-fir 77-87%. There was very little difference in survival rates between the two treatments except in the white fir where the 50 ppm treatment had a 7% higher survival rate than counterparts in the 300 ppm treatment.

In summary, significant differences in volume, caliper, and height between the two fertilization rates that were evident at time of lifting continued through the end of the first growing season. The difference in volume actually increased from the time of lifting to the end of that first year. But by the end of the second growing season although the 300 ppm seedlings were still larger and taller than the 50 ppm seedlings, many of the differences were no longer significant. This trend continued through the third growing season with even less significant differences by the end of 2004. No remeasurements were scheduled for the fourth growing season (2005). At the end of the fifth growing season in 2006, there was only the single significant difference among all treatments on all plots and sites.

Study results will be presented to the membership at the 2007 annual meeting. At this time, a decision will need to be made concerning the future status of this study as origninal plans were to carry it through the fifth growing season (2006).