Sierra Cascade Intensive Forest Management Research Cooperative Proposal 11-03
Mat 28 Site Preparation and Conifer Tolerance

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Title: Aminocyclopyrochlor Site Preparation and Conifer Tolerance

Year Funded: 2011

Executive Summary:

Aminocyclopyrochlor is a new product to the vegetation management market. It will be registered for use in 2011 for non-crop sites. Currently Dupont is compiling data to expand the registration to other uses, including forestry. Aminocyclopyrochlor is a pre and post emergent herbicide that controls a wide variety of broadleaf weeds and brush. It is a synthetic auxin and has both foliar and soil activity. The residual control is proving to be quite strong and the product is an excellent inhibitor of seed germination. It is also showing some unique properties for brush control when tank mixed with other products. It has very low use rates, with maximum proposed label rates of 9 ounces product per acre. The product is very safe to mammals with oral and dermal LD 50 values greater than 5000 mg/kg body weight. Half life ranges from 37 to 128 days depending on soil type and weather conditions. There is no bio-accumulation or magnification. It is also extremely safe to aquatic organisms including daphnia.

Previous testing has indicated no conifer tolerance for "over the top" applications, but directed applications around trees may be feasible. There is also a strong potential to broaden the spectrum of control when tank mixed with Velpar DF. The major questions surrounding this herbicide in forestry regard conifer tolerance as a site preparation spray, efficacy on forest weeds, and the duration of control by season. Aminocyclopyrochlor may potentially have a fit as a site preparation treatment for some of the chemically intolerant conifers such as sugar pine, cedar, and redwood, although testing has yet to be done.

The stated objective of this study is to evaluate the effect of aminocyclopyrochlor rate and timing on vegetation control and conifer tolerance of ponderosa and Douglas-fir when applied as a pre-plant site preparation spray. This proposal is for a trial that would look at the effect of site, rate, and timing on vegetation control and conifer tolerance of ponderosa pine and Douglas-fir for site preparation treatments with aminocyclopyrochlor alone and in combination with Velpar DF and Accord XRT II compared to Velpar DF as the operational standard. Specific questions to be answered are: Does Mat 28 rate effect vegetation control or conifer tolerance? Can tank mixes of Mat 28 and a low rate of Velpar DF achieve similar vegetation control and coniference tolerance to the operational standard of Velpar DF alone? How does Mat 28 alone compare to the operational standard of Velpar Df regarding vegetation control and conifer tolerance? Does the addition of Accord XRT II to Mat 28 improve vegetation control?

The study will have two sites, one high elevation or east side Cascade site and a low elevation west side Cascade site (only one site was funded in 2011). Each site should be a fresh clear-cut or wildfire that has not had any chemical treatment prior to the trial. All plots will be laid out in the spring or fall of 2011. The plan will be to spray the high elevation site in the fall of 2011 and the low elevation site in the spring of 2012. Both sites will be planted in the spring of 2012.

The study design will be a completely randomized block design with three replications. Plot size will be 12' x 36' (0.01 acre). Plots will be planted with 10 trees each of ponderosa and Douglas-fir in the same plot (two rows of each species). Stock type will be similar to what is operationally planted on the site. Seedlings are to be provided by the cooperator as well as one or two planters to plant the plots. Planting will be supervised by Thunder Road Resources.

Two spray timings will be utilized in this study (October 2011 – high elevation and March of 2012 – low elevation). Treatments will include Mat 28 at 1.125, 2.25, and 4.5 ounces a.i. per acre; Mat 28 at 2.25 ounces a.i. per acre combined with Velpar DF at 1.0 pound a.i. per acre; Mat 28 at 2.25 ounces a.i. per acre combined with Velpar DF at 2.0 pounds a.i. per acre; Velpar DF at 2.5 pounds a.i. per acre; Mat 28 at 2.25 ounces a.i. per acre combined with Accord XRT II at 2.6 pounds a.i. per acre; and a control. Plots will be sprayed with a twelve foot boom sprayer at ten gallons per acre. All plots will be sprayed with one timed pass. The boom will be set with 4-9503 nozzles which provide a similar drop size spectrum to a helicopter set up with D-8 nozzles at a 45 degree angle. All chemical will be provided by Dow AgroSciences.

Seedling caliper and height will be measured initially at time of planting. End of season evaluations, which will take place at the end of the first and second growing seasons after treatment, consist of ocular estimation of vegetation percent cover by species for the weeds and brush, measurement of conifer seedling caliper and height, and an ocular rating of conifer damage. Stem volume will be calculated for analysis. Analysis of variance and multiple procedures for a completely randomized block design will be utilized to analyze data.

2011: The study site was established in October on ground owned and managed by Sierra Pacific Industries near Shingletown, CA. Elevation is approximately 4200 feet. Slope is 0 to 5 percent and of relatively negligible aspect. The site was pre-harvest sprayed with four percent Accord XRT II and two percent MSO, logged, and ripped. No further site preparation activities have been conducted.

The trial was staked and sprayed on October 20th.

2012: The trial was planted on March 24th. The trial was planted with Styro 6 ponderosa pine and Styro 8 Douglas-fir from Cal Forest Nursery of Etna, CA. Ten trees of each species were planted in rows in each plot.

The trial was evaluated on August 12th. Visual assessments of vegetation control and conifer damage were recorded at the time. Initially this trial was slated to

have conifer measurements taken at the end of the first and second growing seasons. The trial site was confounded by severe frost damage to the Douglas-fir. It was decided to not measure conifer seedlings in 2012, but to take visual assessments only. The measurements that were to be taken in 2012 will be put off until 2014. The 2013 measurements will occur as planned.

Data were analyzed using SAS statistical software. Analysis of variance was used to determine significance of the main effects of treatment and orthogonal contrasts were used to make specific comparisons among treatments. Analysis of variance was used to determine if there were any differences in initial seedling size among treatments. If initial seedling size was found to be significantly different among treatments, analysis of co-variance was used to adjust for initial seedling size difference with initial tree size as the co-variate. Vegetation data was analyzed using analysis of variance for the main effects, and multiple comparisons of means were done using Student Neuman Kewls least significant difference procedure. Orthogonal contrasts were used to make specific comparisons among treatments.

The herbicide treatments had significantly less total cover and more bare ground than the controls ($P<=0.05$). The treatments with Mat 28 alone at any rate had significantly more cover than the operational standard of 2.66 pounds of Velpar DF alone (Table 1). The addition of 4.5 ounces of Mat 28 to 2.66 pounds of Velpar DF did not significantly improve vegetation control. The two treatments with a combination of Mat 28 plus Velpar DF and the Mat 28 plus Accord XRT II treatment were not significantly different than Velpar DF alone for either percent bare ground or percent total cover.

Although this site was not pre-treated with imazapyr prior to logging, total cover on the site was generally low and consisted mainly of bull thistle. All herbicide treatments greatly reduced the bull thistle cover compared to the controls.

Ponderosa pine survival was not significantly affected by treatment ($R<=0.05$). Douglas-fir survival was affected by treatment (Table 2). The treatments with Mat 28 alone (except 4.5 ounces/acre Mat 28) and all three of the tank mix treatments with Mat 28 had higher survival than the operational standard of Velpar DF alone. The same treatments were also higher than the control, but were not significant.

The damage ratings for ponderosa pine significantly varied by treatment ($P<=0.05$). The Velpar DF alone treatment and the controls had significantly less damage than any treatment containing Mat 28. Damage in general was severe with Mat 28. Bud swelling, terminal dieback, shortened needles, and twisting were some of the most common symptoms. Douglas-fir damage was severe for all treatments and did significantly differ by treatment. This was a direct result of severe frost damage.

Regardless of the frost damage on the Douglas-fir, it does not appear that Mat 28 will be a suitable pre-plant site preparation chemical due to the severe seedling damage it causes. Analogous trials with the Forest Stewardship

Council Research Group demonstrated the same trends in the spring or fall and across three different conifer species. Like Milestone alone, treatments with Mat 28 alone also provided little vegetation control. Due to its efficacy on brush, Mat 28 may still have a fit as a pre-harvest site preparation treatment. Several trials are underway to test this hypothesis.

2013: The Mat 28 trial was evaluated on September 9th. This trial was heavily impacted by a May 2013 frost event. All the Douglas-fir and white fir were killed. Even the ponderosa pine was severely impacted. Survival was high enough in the pine that these seedlings were measured. This was mainly due to the pine having such severely stunted terminal buds that the trees never broke bud in the spring and were less susceptible to the frost.

The 2013 data were analyzed using the same procedures as those used in 2012.

Ponderosa pine survival varied among treatments, but high variability for two of the treatments resulted in no significant differences among treatments with multiple comparisons (Table 4). However, all seedling parameters (survival, caliper, height, stem volume, and needle and bud damage) indicated a significant negative impact of increasing Mat 28 rate on ponderosa pine ($P<=0.05$). All treatments that included Mat 28 at any rate were significantly shorter and smaller in caliper and stem volume than either the operational standard of 2.66 pounds Velpar DF or the control ($P<=0.05$).

Ponderosa pine vigor and bud and needle damage ratings also showed severe damage from any application including Mat 28. All treatments with Mat 28 had significantly more bud and needle damage and lower vigor than either the operational standard Velpar DF treatment or the controls ($P<=0.05$). All three damage ratings also showed a significant increase in damage with increasing rates of Mat 28 ($P<=0.05$).

All tree factors were only slightly better with the operational standard Velpar DF treatment than the controls, but were not significantly different.

In general, Mat 28 alone provided poor vegetation control at any rate (Table 3). The best vegetation control was achieved with the operational standard of 2.66 pounds of Velpar DF alone or in combination with 4.5 ounces of Mat 28. These two treatments provided significantly less total cover than all other treatments including the control ($P<=0.05$), but were not significantly different from each other.

The only species of vegetation in heavy abundance on this site was bull thistle. The operational standard and the 2.66 pounds of Velpar DF plus 4.5 ounces Mat 28 provided significantly better bull thistle control than all treatments with the exception of the highest rate of Mat 28 alone or the combination of 4.5 ounces of Mat 28 plus 1.33 pounds of Velpar DF ($P<=0.05$). Bull thistle control did show a significant increase in control with increasing rate of Mat 28 alone ($P<=0.05$).

Overall, Mat 28 treatments alone or in combination with other forestry herbicides are not a suitable treatment for forestry site preparation. Conifer damage is high and Mat 28 adds very

little to vegetation control. The effects of Mat 28 on conifer growth appear to be fairly long lasting and it doesn't appear likely that seedlings will outgrow the stunting in the first couple of years after application.

Due to the heavy conifer mortality from frost events, this study is no longer viable and will be terminated. No more field work or evaluations will be done. The complete report and all supporting data are available at the Coop's office in Redding.

APPENDIX 1

CONIFER DAMAGE CODES
0= NO DAMAGE
1= SLIGHT DISCOLORATION
2= SLIGHT CHLOROSIS, NO BUD DAMAGE, NO NEEDLE CURL
3= SLIGHT CHLOROSIS, NO BUD DAMAGE WITH NEEDLE CURL
4= MODERATE CHLOROSIS, NO BUD DAMAGE WITH NEEDLE CURL
5= HEAVY CHLOROSIS, NO BUD DAMAGE WITH NEEDLE CURL
6= MODERATE CHLOROSIS, WITH BUD DAMAGE AND NEEDLE CURL
7= HEAVY CHLOROSIS, WITH BUD DAMAGE AND NEEDLE CURL
8= LESS THAN 50% BROWN WITH BUD DAMAGE
9= GREATER THAN 50% BROWN WITH BUD DAMAGE
10= DEAD

ROOT NUMBER SCALE
0= NO NEW ROOTS
1=1 TO 5 NEW ROOTS
2= 6 TO 10 NEW ROOTS
3= 11 TO 15 NEW ROOTS
4= 16 TO 20 NEW ROOTS
5= 21 TO 25 NEW ROOTS
6= >25 NEW ROOTS

ROOT LENGTH SCALE
0= NO NEW ROOTS
1= 0.1 TO 1 CM
2= 1.1 TO 2 CM
3= 2.1 TO 3 CM
4= 3.1 TO 4 CM
5= 4.1 TO 5 CM
6= 5.1 TO 6 CM
7= 6.1 TO 7 CM
8= 7.1 TO 8 CM
9= 8.1 TO 9 CM
10= >9 CM

Product and Rate	% Bare Ground	% Total Cover	% Cover Bull Thist	% Cover Grass	% Cover Squaw Carp	% Cover Snow Berry	% Cover G.L. Manz
2.25 oz MAT 28	95.0	5.7	1.0	1.3	0.3	0.3	1.0
4.5 oz MAT 28	95.7	5.3	2.7	0.3	0.3	0.3	0.3
9.0 oz MAT 28	93.3	7.0	1.0	0.3	0.0	0.7	0.3
4.5 oz MAT 28 + 1.33 lbs Velp DF	95.7	4.7	1.0	0.0	0.0	1.0	0.0
4.5 oz MAT 28 + 2.66 lbs Velp DF	98.7	1.3	0.0	0.0	0.0	0.3	0.0
2.66 lbs Velp DF	98.0	2.0	2.0	0.0	0.0	0.0	0.0
4.5 oz MAT 28 + 2 qts Acc XRT II	98.0	2.7	1.0	0.3	0.0	0.0	0.0
Control	81.0	21.0	16.7	0.3	0.7	0.7	0.3

Table 1. Total percent cover, percent bare ground and percent cover by species for MAT 28 site prep trial 10 months after treatment. All rates are pounds product per acre. Acc = Accord XRT II, Velp = Velpar DF

Product and Rate	P. Pine % Survival	Doug Fir % Survival	P. Pine Dam Code	Doug Fir Dam Code
2.25 oz MAT 28	100.0	70.0	6.7	8.3
4.5 oz MAT 28	96.7	50.0	7.3	8.7
9.0 oz MAT 28	93.3	60.0	7.3	8.3
4.5 oz MAT 28 + 1.33 lbs Velp DF	93.3	60.0	7.3	8.3
4.5 oz MAT 28 + 2.66 lbs Velp DF	93.3	63.3	7.0	8.3
2.66 lbs Velp DF	96.7	50.0	1.0	8.7
4.5 oz MAT 28 + 2 qts Acc XRT II	96.7	56.7	7.3	8.8
Control	100.0	50.0	1.7	8.7

Table 2. Ponderosa pine and Douglas-fir percent survival and damage ratings for MAT 28 site prep trial 10 months after treatment. Damage codes: 0 = No Damage, 10 = Dead.

TREAT	% BARE GROUND	% TOT COVER	% COV GRASS	% COV SNOW BERRY	% COV G.L. MANZ	% COV BULL THISTLE	% COV TURK MULL	% COV COM MULL	% COV OTHER
2.25 OZ MAT 28	78.2	20.3	5.7	0.0	0.7	11.0	0.3	1.7	1.7
4.5 OZ MAT 28	83.2	15.3	1.0	0.0	0.7	10.3	0.0	1.7	2.0
9 OZ MAT 28	76.5	21.9	1.3	0.0	0.3	4.4	14.7	1.0	1.3
4.5 OZ MAT 28 + 1.33 LBS VELP	83.2	17.5	1.0	0.3	0.7	3.1	1.0	1.7	10.7
4.5 OZ MAT 28 + 2.66 LBS VELP	96.9	3.8	0.3	0.3	0.3	2.2	0.0	0.0	0.7
2.66 LBS VELP	97.2	2.8	0.3	0.0	0.0	2.5	0.0	0.0	0.0
4.5 OZ MAT 28 + 2 QTS ACC XRT II	73.2	25.3	0.3	0.0	0.0	19.7	0.0	1.7	4.0
CONTROL	74.9	24.4	1.0	0.0	0.3	20.4	0.7	0.3	2.0

Table 3. Percent bare ground, percent total cover and percent cover by species for Fall MAT 28 Site Preparation Trial 22 months after treatment.

TREAT	CALIPER mm	HEIGHT cm	STEM VOL CM^3	% SURV	TREE DAMAGE	BUD DAMAGE	NEEDLE DAMAGE
2.25 OZ MAT 28	9.4	25.8	26.6	76.7	5.3	5.3	4.7
4.5 OZ MAT 28	6.8	21.1	10.3	33.3	8.0	7.3	8.0
9 OZ MAT 28	5.9	16.3	6.5	33.3	9.0	8.0	9.0
4.5 OZ MAT 28 + 1.33 LBS VELP	8.2	22.2	20.3	56.7	7.3	6.3	7.3
4.5 OZ MAT 28 + 2.66 LBS VELP	7.0	19.6	10.6	73.3	7.3	6.0	7.0
2.66 LBS VELP	10.1	29.0	34.5	76.7	2.7	2.0	2.0
4.5 OZ MAT 28 + 2 QTS ACC XRT II	6.5	19.4	8.6	40.0	8.7	7.3	8.3
CONTROL	10.1	28.2	32.8	63.3	3.7	2.7	2.7

Table 4. Tree measurements for ponderosa pine for the Fall MAT 28 Site Preparation Trial 22 months after treatment. Needle and bud damage rated on a scale from 0 to 10 with 0 being no damage and 10 is dead. See appendix 1 for tree damage codes.