

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 12-03
Pindar GT Site Preparation

Principal Investigator: Ed Fredrickson

Title: Intolerant Conifer Site Preparation with Pindar GT (Penoxsulam + Oxyflourfen), Dimension EC (Dithiopyr), Goaltender (Oxyflourfen), and Milestone (Aminopyralid)

Year Funded: 2012

Executive Summary:

Mixed conifer plantations are becoming more and more popular in industrial forestry due to better seedling stock and the desire to diversify plantations. Unfortunately, conifer species such as Douglas-fir, white and red fir, incense cedar, and sugar pine have a lower tolerance to the operational standard chemical site preparation herbicide, hexazinone. This poses a significant challenge to foresters who wish to establish a diverse mix of conifer species in their plantations, and often leads to vegetation management treatments that are inferior in control and at a higher cost. With the potential loss of atrazine, foresters currently have no available chemical tool that exhibits a high degree of tolerance to these species of conifers. It is the goal of this trial to evaluate several new herbicides that may provide effective residual control of herbaceous vegetation and conifer safety.

Pindar GT, Dimension EC, Goaltender, and Milestone are four residual herbicides manufactured by Dow AgroSciences. Pindar GT is a liquid formulation that contains 0.083 pounds per gallon of the active ingredient penoxsulam plus 3.93 pounds per gallon of the active ingredient oxyflourfen; Dimension EC is a liquid formulation that contains 4 pounds per gallon of the active ingredient dithiopyr; Goaltender is a liquid formulation containing 4 pounds per gallon of the active ingredient

oxyflourfen; and Milestone is a liquid that contains 2 pounds per gallon of the active ingredient aminopyralid. Currently, all products are registered for a variety of uses in California, however none are registered for forestry site preparation. All products can be applied as either a pre or post emergent herbicide for broadleaf weed control and some grasses.

None of the products have been extensively tested as a forestry site preparation tool under field conditions, with the exception of Milestone. Two of the four active ingredients have demonstrated a high degree of conifer tolerance. Oxyflourfen has long been used in forest nurseries and even the most chemically intolerant conifer species such as coast redwood show a high degree of tolerance. Aminopyralid is currently being tested as a site preparation chemical with ponderosa and Douglas-fir and early results show a high degree of tolerance. Seedling conifer tolerance with penoxsulam and dithiopyr has not been tested, although ornamentally planted conifers have shown tolerance to dithiopyr.

Combinations of Milestone with Pindar GT, Dimension EC, and Goaltender have exhibited long-term residual control of herbaceous vegetation in non-forestry settings. These combinations have been some of the most encouraging

bare ground treatments tested to date. With the known tolerances of several of the active ingredients in this trial, one or more of these combinations may have the potential to replace atrazine as a site preparation treatment for intolerant conifers.

The stated objective of this study is to evaluate the effect of Pindar GT, Dimension EC, Goaltender, and Milestone alone and in combination for vegetation control and conifer tolerance of Douglas-fir and white fir when applied as a pre-plant site preparation spray. This proposal is for a trial that would evaluate vegetation control and conifer tolerance of Douglas-fir and white fir with pre-plant spring applications of Milestone, Pindar GT, Dimension EC, and Goaltender alone and in combination. The specific questions to be addressed are: Do any of the new herbicides alone or in combination with Milestone provide similar vegetation control compared to the operation standard of 3.3 pounds product Velpar DF per acre? Do any of the new herbicides alone or in combination with Milestone provide better conifer tolerance to Douglas-fir or white fir compared to the operational standard of 3.3 pounds product Velpar DF per acre?

This proposal is for a spring application on a low elevation site (below 4000'). This should be a site that would normally be treated with hexazinone in the spring.

The study design will be a completely randomized block design with four replications. Plot size will be 12' x 36' (0.01 acre). Plots will be planted with 10 trees each Douglas-fir and white fir in

the same plot (two rows of each species). Stock type and seed-lot will be the same for all trees of each species in the study. The 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.

Spray timing will be approximately March of 2012 with planting being done shortly after. Treatments will include Milestone at 0.11 pounds a.i. per acre; Pindar GT at 1.5 pounds a.i. per acre; Dimension EC at 0.5 pounds a.i. per acre; Goaltender at 1.5 pounds a.i. per acre; Milestone at 0.11 pounds a.i. per acre combined with Pindar GT at 1.5 pounds a.i. per acre; Milestone at 0.11 pounds a.i. per acre combined with Dimension EC at 0.5 pounds a.i. per acre; Milestone at 0.11 pounds a.i. per acre combined with Goaltender at 1.5 pounds a.i. per acre; Velpar GF at 2.5 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 up 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 planting and at the end of the first growing season. Ocular estimates of percent bare ground, percent cover by species, percent conifer foliar brownout, and terminal bud and needle damage will be made at the end of the first and second growing seasons. Stem volumes will be calculated for analysis as will conifer survival. Analysis of

variance and multiple comparison procedures using orthogonal contrasts will be used to analyze all data.

2012: A trial was established on April 2nd on land owned and managed by Sierra Pacific Industries near Burney, CA in an existing plantation that had poor survival and heavy herbaceous cover. Elevation is approximately 3500 feet with 0 to 5 percent slope. Due to the heavy vegetation at time of treatment, all treatments included one quart per acre of Accord XRT II to brownout the existing cover to allow us to look at the residual activity of the products. An Accord XRT II alone treatment was also included to compare with the other treatments. The site has not been treated with residual chemicals in several years.

Plots were laid out and sprayed on April 2nd. Ten seedlings each of Douglas-fir and white fir were planted into each plot on April 20th. Seedlings were measured at planting for caliper and height. Future seedling measurements will not occur until the end of the second growing season (this is a change from the original proposal).

Ocular evaluations of percent cover by species, percent bare ground, seedling survival, seedling percent brownout, and seedling damage ratings were taken on August 31st (end of first growing season). Similar evaluations will be done at the end of the second growing season.

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 were analyzed using analysis of variance for the main effects, and multiple comparisons of means were done using Student Newman Kewls least significant difference procedure. Orthogonal contrasts were used to make specific comparisons among treatments.

In general, vegetation control was excellent with all products tested with the exception of the Accord XRT II alone treatment which vigorously germinated soon after treatment (Table 1). All treatments were significantly different from the control ($P \leq 0.05$). Even the Milestone plus Accord XRT II increased percent bare ground twofold over the Accord XRT II alone treatment. This shows that once the vegetation is burned down, Milestone has the ability to suppress germination. The addition of Pindar GT, Goaltender, or Dimension 2EW (slightly different formulation from the one listed in the original proposal) to Accord XRT II significantly decreased total cover and increased percent bare ground compared to Accord XRT II alone. While the addition of Milestone to Pindar GT, Goaltender, or Dimension 2EW did decrease total cover and increased bare ground, the results were not significant although the Dimension 2EW comparisons were close.

The addition of 1.33 pounds per acre of Velpar DF to 7 ounces of Milestone per acre with Accord XRT II significantly

decreased total cover compared to the Milestone plus Accord XRT II treatment ($P \leq 0.05$). Neither percent bare ground or total cover were significantly different with the Velpar DF, Milestone plus Accord XRT II treatment compared to the operational standard of Velpar DF alone at 3.33 pounds per acre. However, the 1.33 pounds per acre treatment of Velpar DF plus Accord XRT II was also not significantly different from either the operational standard of Velpar DF alone or the Velpar DF plus Accord XRT II combination with Milestone.

Of all treatments tested, the ones with Velpar DF provided the best control of houndstongue and common mullen. Downy brome was controlled well with all treatments with the exception of the Dimension 2EW plus Accord XRT II and the Accord XRT II alone treatment. It should be noted that control of downy brome was enhanced when 7 ounces of Milestone was added to Dimension 2EW. All treatments except the Accord XRT II alone provided good control of tumble mustard.

Frost severely impacted both white and Douglas-fir, however, treatment effects were still readily apparent. White fir survival was significantly affected by treatment ($P \leq 0.05$). All treatments had significantly greater survival than either the control or the operational standard of 3.33 pounds per acre of Velpar DF alone (Table 2). Survival of the Velpar DF standard was similar to the control (42.5 percent and 47.5 percent, respectively). The remaining treatments ranged from 67 to 90 percent survival and were not significantly different from each other. All treatments with Pindar GT, Goaltender, or Dimension 2EW alone or in combination with Milestone did have

significantly greater white fir survival than the operational standard of Velpar DF alone. White fir percent brownout was also higher for the Velpar DF standard compared to other treatments. The Velpar standard had significantly more brownout compared to the 1.33 pounds Velpar DF plus 7 ounces of Milestone and Accord XRT II treatment. The Dimension 2EW plus Accord XRT II treatment had significantly less brownout compared to the same treatment with Milestone. White fir damage rating did not significantly vary among treatments.

Douglas-fir survival was not affected by treatment other than all herbicide treatments has significantly greater survival than the control ($P \leq 0.05$). Although the main effect of treatment was not significant on Douglas-fir percent brownout or damage rating, one contrast did show that the addition of Milestone to the Dimension 2EW plus Accord XRT II mix significantly increased percent brownout and damage. This was similar to the white fir results for these treatments.

This trial produced several good alternatives to Velpar DF where conifer tolerance is a concern. Excellent conifer tolerance was seen in both Douglas-fir and white fir for Pindar GT, Goaltender, Dimension 2EW, and Milestone. Even though frost damage confounded results, treatment effects were clearly visible. Vegetation control was excellent for most treatments, especially when comparing Pindar GT and Goaltender to the operational standard of Velpar DF alone. Control was comparable with better conifer tolerance, especially with white fir. In this case, the addition of Milestone to any of the products did

show a trend in reducing cover, however the differences were slight and not significant. It was clearly demonstrated however that Milestone when added to Accord XRT II did suppress germination compared to the Accord XRT II alone treatment.

2013: The Pindar GT trial was evaluated on August 14th. Frost severely damaged all seedlings on this site in late May. Douglas-fir survival averaged 9 percent and white fir was 29 percent. Percent brownout was heavy on the white fir that survived rendering any measurement data useless. Therefore, the evaluations in 2013 consisted of all previous vegetation assessments, conifer survival, and percent brownout only (Table 3). No significant differences existed between treatments for percent survival or percent brownout ($P \leq 0.05$).

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

From previous year's data, it was shown that all treatments with Milestone, Pindar GT, GoalTender, and Dimension 2EW alone or in combination had excellent conifer tolerance and survival (Table 2). White fir survival and brownout were worse with the operational standard of Velpar DF at 3.33 pounds per acre. The earlier data showed there were several good alternatives to Velpar DF concerning conifer tolerance and vegetation control (Table 1).

Percent bare ground and total cover did show significant differences by treatment at the end of the second year (Table 4). Orthogonal contrasts indicated that there were some differences that were not reflected in the

multiple comparison tests. This was true for individual species comparisons as well.

By the end of the second growing season, vegetation had recovered in most treatments. Treatments of Pindar GT, Dimension 2EW, and GoalTender with Accord XRT II only were not significantly different from the non-treated controls or the Accord XRT II only treatment ($P \leq 0.05$). This was a marked difference from the previous year data where all treatments provided significantly better vegetation control than either the non-treated control or the Accord XRT II alone treatment.

The addition of 7 ounces of Milestone to Pindar GT did significantly increase the percent bare ground, but did not significantly decrease total cover, though it was close ($P \leq 0.05$). There were no significant differences in vegetation control with the addition of Milestone to either GoalTender or Dimension 2EW. The combination treatments of 7 ounces of Milestone with Pindar GT and GoalTender did significantly increase the percent bare ground compared to the non-treated controls, but not to the Accord XRT II only treatment ($P \leq 0.05$). Percent cover did not show any significant differences for the same comparisons. The combinations of Pindar GT plus Milestone and GoalTender plus Milestone were not significantly different from the operational standard of Velpar DF at 3.33 pounds for either percent bare ground or total cover.

There were some significant differences by species among treatments. Cheat grass control was significantly better with all treatments compared to the non-

treated controls, but multiple comparison tests did not indicate any differences compared to the Accord XRT II only treatment. Orthogonal contrast data showed that the operational standard Velpar DF treatment at 3.33 pounds provided more cheat grass control than the 1.33 pound Velpar DF treatment. The addition of Milestone to Pindar GT, GoalTender, and Dimension 2EW did reduce cheat grass cover compared to treatments without Milestone, but the results were not significant ($P \leq 0.05$). Orthogonal contrasts also indicated that all treatments provided significantly more control of other annual grasses than the non-treated control ($P \leq 0.05$).

Mullein was controlled significantly better with treatments containing Velpar DF. Orthogonal contrast data indicated the addition of 1.33 pounds of Velpar DF to 7 ounces of Milestone significantly improved control. The Velpar DF standard of 3.33 pounds also provided significantly better mullein control when compared to all other treatments.

Houndstongue was best controlled with the operational standard of 3.33 pounds Velpar DF. Contrast data indicated this treatment provided more control when compared to all other treatments combined and also provided significantly more control than the tank mix of 1.33 pounds Velpar DF with 7 ounces of Milestone. Some other contrasts were significant, but this appears to be an anomaly in the data due to variability in houndstongue density among plots.

The combination of 7 ounces of Milestone with 1.33 pounds Velpar DF with Accord XRT II significantly

reduced total cover compared to either Milestone or Velpar DF alone at the same rates. Percent bare ground was not significantly different ($P \leq 0.05$). The Milestone plus Velpar DF combination was also not significantly different from the operational standard of 3.33 pounds Velpar DF for either total cover or percent bare ground. The 3.33 pound Velpar DF treatment did significantly reduce total cover compared to the 1.33 pound treatment of Velpar DF alone, but did not significantly effect percent ground cover. Overall, the operational standard Velpar DF treatment did not provide significantly more bare ground than any treatment other than the controls, but did reduce total cover significantly compared to all treatments with the exception of Pindar GT, GoalTender, or Velpar DF with Milestone ($P \leq 0.05$).

Most treatments evaluated in this trial provided excellent first year control of vegetation. The addition of 7 ounces of Milestone to Pindar GT, GoalTender, and Velpar DF at the low rate enhanced control through the second growing season. Treatments with Pindar GT, GoalTender, and Dimension 2EW by themselves were similar to the Accord XRT II only treatment at the end of the second growing season. Several treatments provided control similar to the operational standard of 3.33 pounds of Velpar DF at the end of the second growing season including the low rate of Velpar DF, Pindar GT, and Dimension 2EW, in combination with 7 ounces of Milestone.

Conifer tolerance was good with all new products tested at the end of the first growing season. The only treatment causing significant damage in the first

season was the operational standard of 3.33 pounds Velpar DF on white fir. It appears that the addition of Milestone aided in control of cheat grass in the second year, and the addition of Velpar DF was needed to reduce mullein cover.

Due to the heavy conifer mortality from the 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 Co-op's office in Redding.

Product & Rate	% Bare Ground	% Total Cover	% Cover Downy Brome	% Cover Tumble Mustard	% Cover Hounds Tongue	% Cover Bull Thistle	% Cover Common Mullen
7 oz MVM	86.2	14.0	3.2	1.0	5.2	0.0	3.0
1.5 qts Pindar GT	88.0	13.0	1.2	0.8	4.0	0.5	3.0
1 qt Dimension 2EW	71.2	33.2	20.8	2.0	3.8	0.5	2.8
1.5 qts Goaltender	82.5	19.2	2.0	0.5	4.0	0.8	9.5
1.5 qts Accord XRT II	41.2	58.2	21.2	8.0	3.2	0.8	5.0
1.5 qts Pind GT + 7 oz MVM	94.0	7.2	1.0	0.0	1.2	0.5	4.2
1 qt Dim 2EW + 7 oz MVM	86.2	13.8	1.5	0.0	5.2	0.2	0.5
1.5 qts GoalT + 7 oz MVM	87.5	12.8	1.2	0.2	3.8	0.0	6.5
1.33 lbs Velp DF + 7 oz MVM	97.8	2.2	0.5	0.0	0.8	0.0	1.0
1.33 lbs Velp DF	95.8	4.8	0.2	0.0	0.8	0.2	0.2
3.33 lbs Velp DF	98.5	1.5	0.2	0.0	0.2	0.2	0.2
Control	23.8	91.2	63.8	9.2	5.5	3.2	2.0

Table 1. Total percent cover, percent bare ground and percent cover by species for Pindar GT site prep trial 4 months after treatment. All rates are pounds product per acre. Acc = Accord XRT II, Velp = Velpar DF, MVM = Milestone, Pind GT = Pindar GT, Dim 2EW = Dimension 2EW, GoalT = Goaltender.

Product & Rate	White Fir % Survival	Douglas-Fir % Survival	White Fir % Brownout	Douglas-Fir % Brownout	White Fir Dam Code	Douglas-Fir Dam Code
7 oz MVM	70.0	77.5	17.5	18.8	4.0	5.2
1.5 qts Pindar GT	77.5	82.5	13.8	11.2	3.0	3.2
1 qt Dimension 2EW	85.0	85.5	5.0	7.5	2.0	2.0
1.5 qts Goaltender	80.0	90.0	17.5	20.0	3.2	4.0
1.5 qts Accord XRT II	80.0	77.5	11.2	12.5	3.2	3.0
1.5 qts Pind GT + 7 oz MVM	90.0	80.0	11.2	18.8	3.2	4.2
1 qt Dim 2EW + 7 oz MVM	67.5	72.5	13.8	21.2	4.2	6.0
1.5 qts GoalT + 7 oz MVM	77.5	82.5	12.5	16.2	3.8	3.5
1.33 lbs Velp DF + 7 oz MVM	72.5	75.0	11.2	15.0	3.2	4.5
1.33 lbs Velp DF	82.5	92.5	15.0	13.8	3.8	3.0
3.33 lbs Velp DF	42.5	80.5	32.5	12.5	5.5	2.5
Control	47.5	57.5	37.5	23.8	5.8	5.5

Table 2. White and Douglas-fir percent survival, percent brownout and damage rating for the Pindar GT site prep trial 4 months after treatment.

TREATMENT	% WF SURVIVAL	% DF SURVIVAL	WF % BROWNOUT	DF % BROWNOUT
7 OZ MILE	22.5	7.5	77.0	94.8
3 PTS PIND GT	45.0	15.0	62.5	89.5
1 QT DIM 2EW	42.5	17.5	75.0	91.2
3 PTS GOAL TENDER	35.0	5.0	72.0	99.5
1.5 QTS ACC XRT II	12.5	5.0	72.5	97.5
7 OZ MILE + 3 PTS PIND GT	50.0	5.0	76.2	99.5
7 OZ MILE + 1 QT DIM 2 EW	12.5	10.0	81.2	89.8
7 OZ MILE + 3 PTS GOAL TENDER	40.0	2.5	72.5	98.8
1.33 LBS VELP + 7 OZ MILE	35.0	7.5	65.0	99.2
1.33 LBS VELP	35.0	17.5	82.5	90.0
3.33 LBS VELP	17.5	17.5	94.8	95.0
CONTROL	10.0	7.5	62.5	94.8

Table 3. Percent survival and percent brownout for white fir and Douglas fir in the Spring Pindar GT Site Preparation Trial 16 months after treatment.

TREAT	% BARE GROUND	% TOT COVER	% COV CHEAT GRASS	% COV TUMBLE MUST	% COV HOUNDS TONGUE	% COV BULL THISTLE	% COV COM MULLEIN	% COV TAR WEED	% COV WILLOW HERB	% COV OTHER GRASS	% COV OTHER HERBS
7 OZ MILE	53.8	47.2	22.5	3.5	6.0	0.0	8.8	0.5	1.2	1.8	3.0
3 PTS PIND GT	43.8	57.5	27.5	2.5	6.2	2.5	9.5	1.8	1.2	0.5	5.8
1 QT DIM 2EW	52.5	67.8	28.0	4.0	2.5	1.8	8.2	1.8	3.2	13.2	5.0
3 PTS GOAL TENDER	56.2	45.8	10.8	3.2	5.8	1.8	18.8	0.2	1.0	0.5	3.8
1.5 QTS ACC XRT II	51.2	43.5	8.2	3.5	4.5	0.8	15.8	1.5	2.0	1.5	5.8
7 OZ MILE + 3 PTS PIND GT	71.2	30.2	10.0	3.2	2.0	0.8	12.0	0.0	0.2	0.2	1.8
7 OZ MILE + 1 QT DIM 2 EW	60.0	42.2	9.2	4.5	5.8	0.8	3.2	1.5	0.8	1.5	15.0
7 OZ MILE + 3 PTS GOAL TENDER	76.2	35.8	11.5	2.8	5.8	0.2	10.8	0.0	1.0	0.0	3.8
1.33 LBS VELP + 7 OZ MILE	80.0	23.0	8.8	1.5	5.8	0.0	1.2	0.2	0.0	1.2	4.2
1.33 LBS VELP	53.8	45.5	26.2	2.2	2.0	1.0	1.5	0.5	0.2	0.5	11.2
3.33 LBS VELP	87.0	12.8	5.5	0.2	0.8	0.0	0.2	0.0	0.0	0.0	6.0
CONTROL	30.0	70.0	38.8	2.2	5.8	3.2	3.8	2.0	2.5	10.0	6.2

Table 4. Percent bare ground, percent total cover and percent cover by species for the Spring Pindar GT Site Preparation Trial 16 months after treatment.