

# Dieback and mortality of ponderosa and lodgepole pines associated with herbicide applications along roads on the Deschutes National Forest

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Bend-Fort Rock District (Deschutes County):

## Cottonwood Rd between Hwy 97 and town of Sunriver

At the request of District staff including Marlo Fisher (District Botanist), Forest Health Protection staff Andris Eglitis (Forest Entomologist), Helen Maffei (Plant Pathologist) and Brent Oblinger (Plant Pathologist) visited sites to assess ponderosa pine mortality levels and potential causes of crown damage in December of 2013. This was after various people started observing dieback and fading crowns next to the road where this damage is typically uncommon. Trees were viewed along a two mile stretch from the HWY 97 Cottonwood Rd Exit to Sunriver.

Tree mortality levels were low at the end of 2013. Only several ponderosa pines (less than five overall) had crowns with 0-5% live crown left and they were all immediately adjacent to the road (Figures 1-2). Bark beetles, other insects and biotic diseases did not appear to be affecting these trees at that time. We were informed that the synthetic auxin (growth regulator type) herbicide Perspective<sup>®</sup> (aminocyclopyrachlor) was applied by the county road department in the right-of-way along the road for vegetation management (e.g., invasive plant control). According to District staff, at least one application occurred in October of 2012 but other applications may have occurred. Other scattered pines had various levels of dieback and were limited to the roadside closest to the right-of-way (Figure 3). At that time, it did not appear to be of great concern since the vast majority of trees along the road still appeared healthy (Figure 3). However, if additional trees were killed, they would become a danger to people using the road and have negative impacts on aesthetics. In late 2013, we recommended monitoring the damage to see if dieback and tree mortality increased, and offered to help with monitoring. Information about the risk of tree damage due to herbicides containing the active ingredient aminocyclopyrachlor (including Perspective<sup>®</sup> and Imprelis) was provided to District staff including the Botanist and Roads Manager (Steve Bigby).

**Figure 1. Several ponderosa pines with very little live crown left along the Cottonwood Rd in December of 2013.**



**Figure 2. Roadside ponderosa pines in April of 2015 at same location in Figure 1.**



**Figure 3. Scattered ponderosa pines with dieback along the Cottonwood Rd in December of 2013.**



In April of 2015, sites were re-visited by Forest Health Protection staff. Dieback (Figures 4-6) and mortality (Figures 7-8) was observed along the same 1.9 mile stretch of this road. After approximately one year and four months, additional trees had died and 10 recently killed trees were recorded compared to around three before. Killed pines were sapling to sawtimber sized and all were growing adjacent to the right-of-way. A few pole to sawtimber sized trees appeared to be recently attacked by bark beetles that were killed. Dieback also appeared to have increased or remained at the same levels on individual trees. Dieback was scattered along this road segment and but not all roadside trees had crown damage in 2015. However, all recently killed trees and those with the most severe dieback were still confined to locations adjacent to the right-of-way and not farther from the road. Symptomatic shoots were collected from young trees and from mature trees using pole pruners.

**Figure 4. Dieback on ponderosa pine along the Cottonwood Rd in April of 2015.**



**Figure 5. Severe dieback on ponderosa pine along the Cottonwood Rd in April of 2015.**



**Figure 6. Dieback on ponderosa pine near the Cottonwood Rd Exit and HWY 97 in April of 2015.**



**Figure 7. Recently killed ponderosa pine along the Cottonwood Rd in April of 2015.**



**Figure 8. Recently killed ponderosa pine along the Cottonwood Rd in April of 2015.**



Also in April of 2015, symptoms of off-target herbicide injury were observed on recently killed trees and trees with dieback along this road segment. Crown symptoms did not appear to be characteristic of damage by de-icing salts (typically confined to foliage and does not result in stem dieback). Symptoms of herbicide injury included characteristic curling or twisting (epinasty) of shoots and tips of branches that are typical of damage caused by growth regulator type (synthetic auxin) herbicides (Freucht 1988). Curling of shoots was observed much more frequently on younger trees (on ponderosa pine and lodgepole pine) than older, less vigorously growing trees (Figures 9-13). Shoot blight did not appear to be caused by insects such as shoot borers or fungal pathogens such as *Diplodia* spp.

**Figure 9. Dieback and curling of shoots on pole sized ponderosa pine along the Cottonwood Rd in April of 2015.**



**Figure 10. Dieback and curling of shoots on ponderosa pine sapling along the Cottonwood Rd in April of 2015.**



**Figure 11. Dieback and curling of shoots on ponderosa pine sapling along the Cottonwood Rd in April of 2015.**



**Figure 12. Dieback and curling of shoots on pole sized lodgepole pine along the Cottonwood Rd near Sunriver in April of 2015.**



**Figure 13. Dieback and curling of shoots on lodgepole pine sapling along the Cottonwood Rd in April of 2015.**



Also on conifers affected by growth regulator type herbicides, affected new growth can turn brown and die, which was commonly observed on pines adjacent to the right-of-way where shoots were dying from the tip back (Figures 14-15).

**Figure 14. Dieback of shoots on ponderosa pine along the Cottonwood Rd near Sunriver in April of 2015.**



**Figure 15. Dieback of shoots on ponderosa pine along the Cottonwood Rd near Sunriver in April of 2015.**



Abnormal swellings on shoots were also commonly observed on young and mature trees with dieback (Figures 16-17). Swellings did not appear to be caused by western gall rust or insects after examining samples back in the lab. Swellings were always toward shoot tips and often immediately distal to killed shoot tips that may have been abnormal callus tissue formed as a result of a response to growth regulator type herbicide damage. In response to growth regulator herbicides, cell proliferation can occur in meristematic tissue of stems and tissue swelling is a common symptom associated with this type of herbicide damage.

**Figure 16. Abnormal swellings and dieback on shoot tip of ponderosa pine collected along the Cottonwood Rd in April of 2015.**



**Figure 17. Abnormal swellings (arrows) and dieback on shoots of ponderosa pine collected along the Cottonwood Rd in April of 2015.**



County Rd 40 / Century Dr between Hwy 97 and town of Sunriver

In 2013 and 2015, Forest Health Protection staff also visited sites along this road to assess levels of ponderosa pine mortality and dieback. During both times, less dieback and mortality were observed on this road overall compared to the Cottonwood Rd. Less than five recently killed young ponderosa pines (sapling to pole size) total were observed and no mature trees appeared recently killed in April of 2015. Dieback and crown thinning also was very isolated along a 0.3 mile stretch on ponderosa pine and young lodgepole pine. Curling of shoots on sapling to pole sized trees (Figures 18-19) and abnormal swellings on young and mature pines (Figures 20-30) with dieback were observed. Symptoms appeared identical to those observed nearby on recently killed trees and trees with dieback along the Cottonwood Rd. We were informed that the herbicide Perspective® was also applied the county road department along this road.

**Figure 18. Curling of shoots and abnormal swellings on shoot tips of recently killed, pole sized ponderosa pine along County Rd 40 in April of 2015.**



**Figure 19. Curling of shoots on young ponderosa pine closest to right-of-way along County Rd 40 in April of 2015.**



**Figure 20. Abnormal swellings on shoot tips of recently killed, young ponderosa pine along County Rd 40 in April of 2015.**



**Figure 21. Abnormal swellings and dieback on shoot tips of pole sized ponderosa pine along County Rd 40 in April of 2015.**



**Figure 22. Abnormal swelling on shoot tip of recently killed, young ponderosa pine collected along County Rd 40 in April of 2015.**



**Figure 23. Abnormal swelling on shoot tip of recently killed, young ponderosa pine collected along County Rd 40 in April of 2015.**



**Figure 24. Abnormal swelling (arrow) and dieback on shoot tip of mature ponderosa pine collected along County Rd 40 in April of 2015.**



**Figure 25. Abnormal swellings (arrow) and dieback on shoot tip of ponderosa pine collected along County Rd 40 in April of 2015.**



Figure 25. Cross sections of abnormal swellings on shoot tip of pine with dieback collected along County Rd 40 in April of 2015.



Figure 26. Cross section of abnormal swelling on shoot tip of pine with dieback collected along County Rd 40 in April of 2015.



**Figure 27. Abnormal swelling on shoot tip of mature ponderosa pine with dieback collected along County Rd 40 in April of 2015.**



**Figure 28. Abnormal swelling on shoot tip of mature ponderosa pine with dieback collected along County Rd 40 in April of 2015.**



**Figure 29. Abnormal swellings and dieback on shoot tip of young lodgepole pine collected along County Rd 40 in April of 2015.**



**Figure 30. Abnormal swellings and dieback on shoot tip of lodgepole pine collected along County Rd 40 in April of 2015; note adventitious buds and shoots elongating (arrows) below killed shoot tip.**



## Other roads in Deschutes County on the Bend-Fort Rock District

Symptoms described above were also observed along portions of other roads such as the Vandever Rd and County Rd 21 / Paulina-East Lake Rd in 2013 and 2015. Again, curling of shoots was most common on young (sapling to pole size) ponderosa and lodgepole pines growing adjacent to the right-of-way. Crown thinning and dieback was also observed on ponderosa pine of all sizes. Low levels of tree mortality were concentrated along these roads adjacent to the right-of-way as of April 2015. We were informed that the herbicide Perspective® was applied along these roads and others in the County not mentioned above.

Sisters District (Deschutes and Jefferson Counties):

### Hwy 20 / Hwy 126 from NF-100 Rd intersection to NF-12 / Jack Lake Rd intersection

At the request of Forest Service staff including Maret Pajutee (District Ecologist) and Sarah Callaghan (the Forest's Invasive Plant Program Manager), Forest Health Protection staff Andris Eglitis and Brent Oblinger visited sites to assess ponderosa pine mortality levels and potential causes of crown damage in March and April of 2015. We were informed that the herbicide Perspective® was applied along the highway in the year before and once in early-2015 by the Jefferson County road department.

The use of de-icing products was considered as a possible cause. However, according to road maintenance crews in Oregon Department of Transportation, nothing out of the ordinary occurred with de-icing salt or cinder applications in recent years, and applications would not have occurred along the entire stretch of road where tree damage was evident.

Symptoms of dieback, abnormal swelling at shoot tips and recent mortality described at previous locations were also observed along portions of this heavily-used highway just northwest of the town of Sisters. Dieback and mortality was recently noticed by Forest Service staff in this area where crown thinning, dieback and mortality are relatively uncommon in ponderosa pine along the road. Severe dieback was initially noted by staff in late-fall of 2014. In 2015, nearly all recently killed trees (Figures 31-33) and trees with dieback (Figure 34-37) were found closest to the road and growing adjacent to the right-of-way. Ponderosa pine was the predominant species with symptoms along this road segment. There was concern that additional large, old ponderosa pines would be killed after several had recently died next to the road. Dead trees also pose a significant danger to people using the road and there is a high frequency of traffic along this highway with thousands of vehicles passing by every day. We mentioned that dead trees at intersections, where there is longer exposure time to hazards, posed the highest risk to public safety along this road based on Forest Service guidelines (Toupin et al 2008).

**Figure 31. Recent ponderosa pine mortality along Hwy 20 in April of 2015.**



**Figure 32. Ponderosa pine recently killed along Hwy 20 in April of 2015.**



**Figure 33. Mature ponderosa pine recently killed along Hwy 20 at the intersection of the Tollgate Rd (Photo by Jeremy Fields, May of 2015).**



**Figure 34. Ponderosa pine with very little live crown along Hwy 20 near the intersection of NF-500 Rd in April of 2015.**



**Figure 35. Ponderosa pine with severe dieback along Hwy 20 in April of 2015.**



**Figure 36. Mature ponderosa pine with crown thinning and dieback along Hwy 20 in April of 2015.**



**Figure 37. Mature ponderosa pine with dieback along Hwy 20 in April of 2015.**



Additional symptoms of herbicide damage consistent with other locations were also observed along Hwy 20. Branches with dieback were collected from young and mature trees and examined back in the lab. Abnormal swellings at shoot tips were found on young and mature ponderosa pine with dieback and those recently killed adjacent to the right-of-way (Figures 38-39).

**Figure 38. Young ponderosa pine with abnormal swellings at shoot tips and severe dieback along Hwy 20 across from the Tollgate Rd intersection in April of 2015.**



**Figure 39. Tops of recently killed, mature ponderosa pines with abnormal swelling at shoot tips along Hwy 20 in April of 2015.**



Identical symptoms described above were also observed on ponderosa pine along the Three Creek Lake Rd just south of the town of Sisters. After meeting with Sisters District staff, we recommended mitigating any danger trees (any killed and especially those dead at intersections) along this heavily used highway, provided information on past reports of damage to trees by herbicides containing aminocyclopyrachlor, shared Dupont's Warning Statement about the risk of damage to trees (including ponderosa pine) by Perspective® and recommended that alternative herbicides be evaluated for use along right-of-ways that are less likely to threaten tree health in areas where valued trees are growing adjacent to roads.

## **Conclusions**

Because of the concentrated pattern of damage adjacent to the road right-of-way, where pines would have root zones extending toward roads, applications of de-icing salts or herbicides were suspected causal agents. The scattered pattern of dieback and symptoms of curling shoots or abnormal swelling at shoot tips are not characteristic of damage by de-icing salts (shoots and buds typically not killed). Symptoms were not typical of drought stress, insect damage, western gall rust or shoot blight due to fungal pathogens either. However, curling of shoots, shoots dying from the tip back and abnormal swelling at shoot tips are characteristic of damage by herbicides containing growth regulators. These symptoms were not observed along roads nearby where Perspective® was not applied.

Herbicides containing the active ingredient aminocyclopyrachlor, including Perspective®, are in a relatively new class of systemic herbicides called pyrimidine carboxylic acids. The active ingredient accumulates in meristematic tissue of shoots and roots after being translocated in the xylem and phloem. Symptoms of herbicide damage on target weeds are similar to those of herbicides in the synthetic auxin family such as 2,4-D, dicamba and clopyralid. These symptoms include twisting of petioles and bending, curling or cupping of leaves.

Off-target damage to trees by herbicides containing the active ingredient aminocyclopyrachlor has been reported within the last five years in various parts of the U.S. Due to reported extensive damage to conifer trees, the EPA issued a stop sale order for the herbicide Imprelis® in 2011. From late-2011 to present, University Extension reports about the risk of herbicide damage to trees from products containing aminocyclopyrachlor have been widespread from colleges such as University of Missouri, University of Wisconsin-Madison, Michigan State University, Purdue University and Penn State University. Photos and descriptions of symptoms associated with Imprelis® damage were similar to those we observed on roadside trees. Reports documented affected new growth on shoots of conifers turning brown and dying. Reports of curling shoots and shoot dieback on pines and other conifers were commonly associated with Imprelis® damage, along with abnormal swellings (e.g., Cregg 2013) at the tips of shoots (Figure 40). Information about damage due to herbicides containing aminocyclopyrachlor and these reports were shared with the Sisters District staff.

**Figure 40. Abnormal swellings on shoot tips of eastern white pine associated with Imprelis® herbicide injury (Cregg 2013).**



In 2012 when Perspective® was still a DuPont product (now a Bayer product), the company issued a Warning Statement that included ponderosa pine and Douglas-fir as conifers susceptible to damage. Warnings were also in the product

label about the risk of damage to trees when applying Perspective® near tree root zones where trees could absorb the herbicide through their roots.

Based on the symptoms and pattern of damage confined to roadside settings where Perspective® was applied, mortality and dieback was likely caused by herbicide injury. The abnormal swellings on tips of shoots and dieback from the tips of shoots back are characteristic of growth regulator type herbicide damage and damage reported by herbicides containing aminocyclopyrachlor. Based on observations along the Cottonwood Rd over several years, it is also likely that additional mortality of trees will occur along Hwy 20 in the next several years. Dead trees along roads with high traffic frequency pose a danger to those using the roads.

As a result of the observed tree damage and the high likelihood that Perspective® application caused the injury, the U.S. Forest Service, Pacific Northwest Region sent letters to Oregon Department of Transportation and Washington Department of Transportation requesting that all use of Perspective® or any other product containing aminocyclopyrachlor be discontinued on right-of-ways within National Forest System lands where trees are present.

## References

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