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# Gouty Pitch Midge Damage to Ponderosa Pines Planted on Fertile and Infertile Soils in the Western Sierra Nevada

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Crown damage caused by gouty pitch midge (GPM) and its effects on tree growth were assessed in two 14-year-old ponderosa pine plantations, one on a shallow, infertile soil derived from serpentine and the other on a deeper, more fertile nonserpentine soil of marine parent material. Seed sources for each plantation were nearby indigenous stands on the same soils. Trees in both plantations had either viscid (resinous) or nonviscid surfaces on spring shoots. Light to moderate GPM damage was found in both plantations. Trees of both seed sources grew much faster in the nonserpentine than in the serpentine plantation. And in the serpentine plantation, the serpentine seed source grew faster than the nonserpentine seed source. But both fast- and slow-growing trees had similar levels of GPM damage. Both direct and inverse relationships between GPM damage and growth of trees within seed sources occurred in both plantations, thus there was little evidence that GPM damage had affected tree growth on either site. In all comparisons, trees with viscid shoot surfaces had more GPM damage than trees with nonviscid shoots, a difference not previously reported for plantations with locally adapted seed sources.

*Retrieval Terms: Cecidomyia pinniopsis, Pinus ponderosa,* injury, growth, site quality, seed source

In California forests, the gouty pitch midge (GPM) (*Cecidomyia pinniopsis* O.S., Diptera: Cecidomyiidae) infests new shoots of ponderosa pines (*Pinus ponderosa* Dougl. ex Laws.) forming gall-like swellings and scars which result in deformed (gouty) shoots and dead needles and twigs. Prolonged, severe infestations usually deform or stunt the crowns and occasionally kill small trees.[1] Trees with spring shoots having viscid (resinous) surfaces are reportedly more prone to injury than those with shoots having nonviscid surfaces.[2] Vigorous, rapidly growing trees are as readily infested as others; however slower growing trees appear to be more adversely affected.[1] While effects of damage have not been considered serious in natural stands, their economic significance in plantations where damage has been prevalent is a concern.

This note reports a study to determine (1) if trees of local seed sources planted on a shallow, infertile soil had more crown damage caused by GPM than trees of the same seed sources planted on a deeper, more fertile soil; (2) if, with these seed sources and sites, damage levels were related to the shoot-type of trees; and (3) whether damage had resulted in reduced stem growth.

Two 14-year-old plantations established on different soils to assess seed source-soil interactions on westside sites of the Sierra Nevada in California were studied. Results indicated that soil, and to some extent seed source, had affected stem growth, but there was little evidence that tree growth had been affected by the light to moderate GPM damage occurring on these two sites. Trees with viscid shoots, however, generally had more damage than trees with nonviscid shoots, a difference not previously reported for plantations with locally adapted seed sources.

## STUDY SITES AND PROCEDURES

The study sites were two plantations established in 1970 as part of an ongoing investigation of edaphic adaptation in ponderosa pine.[3] Except for soil, the site factors for the plantations are similar. They are situated on the western slope of the central Sierra Nevada, California, in the warm, dry, westside-pine phase of mixed-conifer forest dominated by ponderosa pine. Both sites are at 580 m elevation and within 1 km of the hamlet of Garden Valley in Eldorado County. One plantation is on a shallow (ca. 0.3 m), infertile serpentine soil of the Henneke Series. The other plantation is on moderately deep (ca. 1 m), fertile marine soil of a Sites-like Series. The seed sources, hereafter referred to as serpentine and nonserpentine, were local indigenous stands on the same soil types.

Each plantation consists of five randomized complete blocks of 24 trees, each from a different, open-pollinated seed parent. There were 12 seed parents per soil type. Because they are maintained free of brush and damage from large vertebrates, these plantations offered the opportunity to analyze interactions of planting site and seed source with effects of GPM damage in the absence of the confounding effects of other factors affecting tree growth.

In May 1984, the spring shoot surface of each tree was rated as either viscid (resinous) or nonviscid. Three categories of GPM damage (old, new, and dead tips) were estimated as percentages for each tree. Old and new damage were estimated either on 10 branches selected at random (trees < 4 m tall) or on 5 branches selected at random from each of the upper and lower halves of the crown (trees > 4 m tall) using a modified rating system that made rating more objective.[2] Percentages of these branches with two or more GPM scars or swellings on the 1983 internode (new damage) and on older internodes (old damage) were estimated over the entire crown. In addition, the percentage of recently dead or dying branch tips on the entire crown (dead tips) was estimated to the nearest 10 percent. After the 1984 growth was completed, total height (m) and basal diameter (cm, at 5 cm above ground) were measured to assess cumulative stem growth for each tree.

Each category of GPM damage was assessed by analysis of variance.[4] The main effects and interactions of planting site, seed source, and shoot type were considered fixed factors and the blocks within plantations, random. Means representing significant ($p<.05$) factors in analyses of variance were compared by Bonferroni t-tests with an experiment-wide error rate (alpha) not exceeding 0.05.

To assess the effects of GPM damage on tree growth, tree height and diameter were dependent variables in separate analyses of covariance. The model used was the same as when GPM damage was the dependent variable except that the three categories of damage and their interactions with the other factors were included as separate covariables. Because previous results indicated that most, but not all, GPM damage was closely associated with shoot type, shoot type and its interactions were excluded from the model so that the effects of interest would not be obscured. Relationships between the dependent variables and the covariables were interpreted from the signs of their regression coefficients and whether they differed significantly ($p<.05$) from zero (t-test).

Table 1—*Gouty pitch midge damage in relation to planting site and shoot type of ponderosa pines, Garden Valley, California*

| Planting site | Shoot type | N | Percent damage: Old | Percent damage: New | Percent damage: Dead tips |
|---|---|---|---|---|---|
| | | | *Mean (SE)*[1] | | |
| Serpentine | Viscid | 55 | 46.7(2.8) | 45.3(2.4)a | 2.6(0.3)a |
| | Nonviscid | 63 | 9.1(2.6) | 8.6(2.3)b | 0.2(0.3)b |
| Nonserpentine | Viscid | 52 | 52.8(2.9) | 37.5(2.5)c | 0.1(0.3)b |
| | Nonviscid | 68 | 15.8(2.5) | 10.9(2.2)b | 0.1(0.3)b |
| Serpentine | Both | 118 | 27.9(1.9)a | 26.9(1.7) | 1.4(0.2)a |
| Nonserpentine | Both | 120 | 34.3(1.9)b | 24.2(1.7) | 0.1(0.2)b |
| Both | Viscid | 107 | 49.8(2.0)a | 41.4(1.8)a | 1.4(0.2)a |
| Both | Nonviscid | 131 | 12.5(2.0)b | 9.7(1.6)b | 0.2(0.2)b |

[1]Mean percentages of tree's branches with old (pre-1983) or new (1983) damage, or dead tips. Means for factors significant in analysis of variance are followed by letters; means with different letters differ significantly ($p<.05$, Bonferroni t-test).

## RESULTS

### GPM Damage

GPM damage did not appear to be severe in either plantation. Dead and dying needles and distorted, twisted shoots were infrequent. Mean old and new damage were each less than 35 percent, and mean dead tips was less than 2 percent, in both plantations. Plantation, shoot type, their interaction, and blocks within plantations, were generally significant sources of variation for each of the three categories of GPM damage, but seed source and its interactions generally were not significant.

Comparison of means *(table 1)* indicated that differences in damage between plantations were small, but in all comparisons viscid-shooted trees generally had much more damage than trees with nonviscid shoots. Ratios of viscid to nonviscid trees in each plantation and seed source were similar (ca. 0.8:1), but varied widely (0.5:1 - 1.7:1) among blocks. Overall, direct correlations ($r$ ranged between 0.31 and 0.65, $p<.05$, 236 df) were found between the three categories of GPM damage on individual trees.

### Stem Growth

Plantation and its interaction with seed source, as well as interactions between each of these and GPM damage, were significant sources of variation in tree height and diameter. Comparisons of mean height and diameter by plantation and seed source *(table 2)* indicated that trees in the serpentine plantation had grown much more slowly than those in the nonserpentine plantation. Differences between seed sources were evident only in the serpentine plantation where trees of the serpentine source averaged taller, and larger in diameter, than those of the nonserpentine source. Blocks within plantations were also a significant source of variation in tree height and diameter. Regression coefficients for relationships between cumulative (old) GPM damage and tree height or diameter are given in *table 3.* Positive coefficients, indicating direct relationships between GPM damage and tree growth, were significant for the serpentine seed source on the serpentine site. Negative coefficients, indicating inverse relationships between GPM damage and tree growth, were obtained for trees of the nonserpentine seed source in the nonserpentine plantation, but only one of these coefficients—when tree diameter was the dependent variable—differed significantly from zero.

Table 2—*Height and diameter of ponderosa pines in relation to planting sites and seed sources at Garden Valley, California*

| Planting site | Seed source | Trees | Height (m) | Diameter (cm) |
|---|---|---|---|---|
| | | | Mean (SE)[1] | |
| Serpentine | Serpentine | 60 | 3.50(0.11)a | 12.2(0.4)a |
| | Nonserpentine | 58 | 3.05(0.11)b | 10.5(0.4)b |
| Nonserpentine | Serpentine | 60 | 9.00(0.12)c | 24.8(0.5)c |
| | Nonserpentine | 60 | 8.89(0.30)c | 25.7(1.1)c |
| Serpentine | Both | 118 | 3.28(0.08)a | 11.3(0.3)a |
| Nonserpentine | Both | 120 | 8.95(0.16)b | 25.3(0.6)b |
| Both | Serpentine | 120 | 6.25(0.08) | 18.5(0.3) |
| Both | Nonserpentine | 118 | 5.97(0.15) | 18.1(0.6) |

[1]Means representing factors significant in analysis of covariance are followed by letters. Different letters indicate means differed significantly ($p<.05$, Bonferroni t-test). Diameter was measured 5 cm above ground.

## DISCUSSION AND CONCLUSIONS

In all comparisons, trees with viscid shoots had more GPM damage than trees with nonviscid shoots. These results agreed with those from a provenance (seed source) test plantation at nearby Placerville, California, with two exceptions: most of the seed sources for their plantation were not local but came from throughout western North America, and the study did not address the question of variation in susceptibility among seed sources.[2]

Effects of GPM damage on tree growth were difficult to interpret in either plantation. Trees on the serpentine soil grew much more slowly than those on the nonserpentine soil, and trees of the nonserpentine seed source grew more slowly than those of the serpentine source on the serpentine soil. Nevertheless, both slow- and fast-growing trees had similar levels of GPM damage. Both positive and negative relationships were found on both sites between GPM damage and growth of trees within seed sources, so evidence that GPM damage was adversely affecting tree growth was contradictory.

Several factors may have militated against finding pronounced adverse effects. GPM damage did not appear to be severe in either plantation, corresponding on the average to light or moderate injury by the rating scheme of Austin and others.[2] Variation in GPM damage and tree growth was considerable in both plantations; blocks within plantations were a significant source of variation. For the GPM damage, this variation was attributable to the wide variation in the number of trees with viscid shoots among blocks. The variation in tree growth among blocks evidently was not caused by the uneven distribution of GPM damage, but instead possibly reflected planting-spot or micro-site variation. A final factor was the virtual absence of shrub competition as both plantations had been maintained free of brush. Competition from brush can reduce growth of planted ponderosa pines[5,6] and—interacting with other factors such as poor growing site or inappropriate seed source—could result in trees growing so slowly that the GPM damage could be more severe and result in additional growth loss.

The experimental plantations were on soils contrasting strongly in depth, water storage capacity, and fertility, which resulted in large differences in tree growth. Nevertheless, wider inferences regarding the effects of GPM must await investigations of other plantations, including those with varying brush competition and higher levels of GPM damage. Our results indicated, however, that even on sites free of brush and planted with locally adapted seed sources, trees with viscid shoots had more GPM damage than trees with nonviscid shoots. Duffield[7] reported that the viscid shoot trait is heritable and that selection against viscid parents could reduce the frequency of the viscid shoot type in the progeny and perhaps reduce the possibility of GPM damage. Whether selection would be worthwhile, however, awaits determination of whether gouty pitch midge is a serious pest of ponderosa pine.

Table 3—*Regression coefficients relating gouty pitch midge damage to height and diameter of ponderosa pines for planting sites and seed sources at Garden Valley, California*

| Planting site | Seed source | Height | Diameter |
|---|---|---|---|
| | | Coefficient (SE)[1] | |
| Serpentine | Serpentine | 1.77(0.44)* | 0.48(0.17)* |
| | Nonserpentine | 0.33(0.48) | 0.01(0.18) |
| Nonserpentine | Serpentine | 0.54(0.56) | 0.07(0.21) |
| | Nonserpentine | -0.65(0.52) | -0.55(0.20)* |

[1]The damage covariable was old (pre-1983) damage.
*Differed significantly ($p<.05$) from zero by t-test.

## END NOTES AND REFERENCES


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