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COMPARISON OF TWO ROADSIDE SURVEY PROCEDURES FOR DWARF MISTLETOES ON THE SAWTOOTH NATIONAL FOREST, IDAHO

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ABSTRACT.—Two roadside surveys were conducted for dwarf mistletoes parasitizing lodgepole pine and Douglas-fir on the Sawtooth National Forest, Idaho. One survey used variable-radius plots located less than 150 m from roads. The 2nd survey used variable-radius plots established at 200-m intervals along 1600-m transects run perpendicular to the same roads. Estimates of the incidence (percentage of trees infected and percentage of plots infested) and severity (average dwarf mistletoe rating) for both lodgepole pine and Douglas-fir dwarf mistletoes were not significantly different for the 2 survey methods. These findings are further evidence that roadside-plot surveys and transect-plot surveys conducted away from roads provide similar estimates of the incidence of dwarf mistletoes for large forested areas.

Key words: dwarf mistletoes, surveys, lodgepole pine, Douglas-fir.

Dwarf mistletoes (*Arceuthobium* spp.) are damaging disease agents in many western forests (Hawksworth and Wiens 1995). In the Intermountain West lodgepole pine (*Pinus contorta* Dougl. ex Loud.) and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) are the most commonly infected trees (Hawksworth and Wiens 1972, 1995, Hoffman 1979). Each of these hosts is parasitized by a different dwarf mistletoe: lodgepole pine dwarf mistletoe (*A. americanum* Nutt. ex Engelm.) and Douglas-fir dwarf mistletoe (*A. douglasii* Engelm.). Severe infection by these parasites is often associated with tree mortality, reduced growth and cone production, tree deformity, and predisposition to attack by other diseases and/or insects (Hawksworth and Wiens 1995). Therefore, resource managers in many private, state, and federal land-management agencies implement management activities designed to reduce the damage associated with dwarf mistletoes. Because information on the incidence and severity of these pathogens is required by resource managers for making decisions regarding dwarf mistletoe management, surveys are commonly conducted in designated management units (stands) and over larger areas, such as national forests.

Surveys of dwarf mistletoe infection over large areas frequently combine roadside reconnaissance information with data collected using variable-radius or fixed-area plots located near roads (roadside-plot surveys) for estimating the incidence (percent of trees or plots infected) and severity (intensity of infection in individual trees; Hawksworth 1956, 1958, Hawksworth and Lusher 1956, Andrews and Daniels 1960, Graham 1960, 1964, Dooling 1978, Hoffman 1979, Johnson et al. 1980, Johnson et al. 1981, Hoffman and Hobbs 1985, Merrill et al. 1985, Maffei and Beatty 1988). Roadside reconnaissance surveys consist of driving roads at slow speed and recording visual estimates of dwarf mistletoe infection within a short distance from the roadside, usually 20 m. Dwarf mistletoe incidence is estimated by determining the ratio of the number of kilometers surveyed adjacent to infected trees to the total kilometers surveyed adjacent to stands predominated by host trees (Dooling 1978). Roadside-plot surveys involve locating plots near roads at specific intervals and collecting tree data including species, diameter, height, age, and mistletoe severity on each plot. Dwarf mistletoe incidence has typically been represented by the percentage of plots infested with mistletoe, rather than the percentage of trees infected in all plots (Dooling 1978).

Roadside surveys have the benefit of allowing large areas to be surveyed rapidly and

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inexpensively. In addition, roadside surveys concentrate efforts in areas that are accessible and more likely to be considered for management actions. Concerns about the reliability of roadside survey methods are primarily related to the bias that may be encountered by sampling mistletoe incidence and severity near roads because roads are typically constructed according to topographic features (in drainages or along ridgetops) rather than randomly or systematically located throughout the survey area. Since there is evidence that dwarf mistletoe distribution is related to topography (Hawksworth 1959, 1968), these concerns need to be considered when conducting dwarf mistletoe surveys over large forested areas.

Because few surveys have compared data collected from roadside reconnaissance or roadside-plot surveys with data collected from more intensive, random or systematic surveys for dwarf mistletoes over large areas (Hawksworth 1956, 1958, Johnson et al. 1981, Merrill et al. 1985), we initiated this study to compare dwarf mistletoe incidence and severity estimates obtained from roadside-plot surveys with those from transect-plot surveys that sampled areas at greater distances from roads. We surveyed 3 districts of the Sawtooth National Forest, Idaho, because this national forest is representative of forests in the Intermountain West where lodgepole pine and Douglas-fir are the predominant tree species and dwarf mistletoes are common (Hoffman 1979, Hoffman and Hobbs 1985).

METHODS

We used a roadside-plot survey and a transect-plot survey to collect dwarf mistletoe incidence and severity data in 3 adjacent districts (Ketchum Ranger District, Fairfield Ranger District, and Sawtooth National Recreation Area) of the Sawtooth National Forest, Idaho, in 1990. We surveyed each district by arbitrarily selecting a major road system in each township containing ≥10 sections of federally managed land. Townships with no roads or with few roads were not sampled. Road systems were chosen before fieldwork began, and adjustments were made in the field only when selected road systems were closed or impassable.

Roadside-plot Survey

Field crews arbitrarily chose a starting reference point on each selected road system. Starting reference points were landmarks that could easily be relocated such as a bridge, stream crossing, or road junction. Crews drove a distance of 800 m from the starting reference point toward the center of each township. They then selected a compass bearing perpendicular to the right-hand side of the road and located an end point 120 m from the road. Three 20 basal area factor variable-radius plots (point samples; Avery and Burkhart 1983) were established 40 m from this end point at compass bearings of 240°, 120°, and 0° from the compass bearing used to locate the end point. Crews then drove another 800 m down the road and established a 2nd cluster of 3 variable-radius plots using the same procedure. For each plot tree the following information was recorded: plot number, species, diameter at 1.37 m aboveground (nearest 0.25 cm), status (live or dead), and dwarf mistletoe rating (DMR, 6-class system; Hawksworth 1977). If a plot did not contain trees, it was recorded as nonstocked.

Transect-plot Survey

A 1600-m (approximately 1-mi) transect perpendicular to the road was run along the same compass bearing used for establishing the 1st set of roadside plots (800 m from the starting reference point) in each township surveyed. A 20 basal area factor variable-radius plot was located every 200 m along each transect for a total of 8 plots. Information recorded for plot trees was the same as above.

Analyses

The incidence of each species of dwarf mistletoe (percentage of trees infected) was calculated for each set of roadside plots (up to 6 plots) and each set of transect plots (up to 8 plots) for each township. Incidence was calculated on a per-hectare basis by multiplying by per-hectare conversion factors based on 2.54-cm-diameter classes for 20 basal area factor variable-radius plots (Avery and Burkhart 1983). Weighted dwarf mistletoe ratings were calculated by multiplying the DMR of each tree by the per-hectare conversion factors also. These weighted values were used to calculate the mean percentage of trees infected and mean dwarf mistletoe rating for each survey procedure in each township on a per-hectare basis. These values were then used to calculate the percentage of trees infected and a mean DMR for each tree species and survey method.

Data from townships where the surveys did not sample at least 3 Douglas-fir or lodgepole pine for each of the survey procedures were not included in the analyses. Only living trees were used in the analyses for calculating mean DMR because it was not always possible to accurately assign a DMR to dead trees. Incidence values were calculated for 9 townships for lodgepole pine and for 17 townships for Douglas-fir. The roadside-plot survey sampled a total of 206 lodgepole pine and 357 Douglas-fir in 46 and 75 plots, respectively. The transect-plot survey sampled 171 lodgepole pine and 342 Douglas-fir in 42 and 87 plots, respectively. A one-way analysis of variance (ANOVA, $P > 0.05$) was used to determine if the mean values for incidence and severity were significantly different between the 2 survey procedures. Percentages were converted using arcsin transformations before ANOVA analyses were performed (Snedecor and Cochran 1989).

To compare our results with those of other dwarf mistletoe surveys, we determined incidence of both dwarf mistletoes for both survey procedures by calculating the percentage of plots infested. If a plot had at least 1 infected tree, it was considered infested. This method of reporting dwarf mistletoe incidence has been applied in the majority of roadside-plot surveys conducted for dwarf mistletoes in the western United States.

RESULTS AND DISCUSSION

Mean diameters for trees sampled using each survey method were approximately the same for lodgepole pine and Douglas-fir (Table 1). Sampled tree diameters were clearly skewed toward larger trees (Table 1) because both survey methods used variable-radius plots that sample large trees more often than small trees (Avery and Burkhart 1983). Because both survey methods sampled trees in the same way, the survey results should be comparable. However, it is probable that the percentage of infected trees and mean DMR would have been lower for both lodgepole pine and Douglas-fir had more small trees been sampled because small trees are typically less often and less severely infected (Parmeter 1978).

Estimates of incidence for Douglas-fir dwarf mistletoe using the 2 survey methods were within 3% of each other based on the percentage of trees infected (Table 2). Estimates of Douglas-fir dwarf mistletoe severity were similar also. The differences between Douglas-fir dwarf mistletoe incidence and severity for the 2 survey methods were not statistically significant. The differences between estimates of the incidence and severity of lodgepole pine dwarf mistletoe for the 2 survey methods were larger than for Douglas-fir dwarf mistletoe (Table 3). However, the differences were not significant. Therefore, the 2 survey methods

TABLE 1. Distribution of lodgepole pine and Douglas-fir sampled by diameter classes for the roadside-plot and transect-plot surveys on the Sawtooth National Forest, Idaho.

	Lodgepole pine				Douglas-fir			
	Roadside-plot		Transect-plot		Roadside-plot		Transect-plot	
Diameter class (cm)	Mean diameter (cm)	*N*	Mean diameter (cm)	*N*	Mean diameter (cm)	*N*	Mean diameter (cm)	*N*
2–13	9.1	47	8.6	39	10.6	17	9.1	10
14–25	19.6	108	19.8	92	20.6	90	20.1	108
26–38	29.2	39	30.0	34	31.8	98	32.0	99
39–51	41.9	7	42.9	5	43.7	85	44.7	60
52–64	60.7	5	51.1	1	56.6	32	57.4	24
>64	—[a]	—	—	—	96.5	35	89.4	41
TOTAL	20.8	206	20.1	171	39.5	357	40.9	342

[a]No trees sampled in this size class.

TABLE 2. Incidence and severity of Douglas-fir dwarf mistletoe estimated from roadside-plot and transect-plot surveys on the Sawtooth National Forest, Idaho.

	Incidence		Severity	
Survey method	Mean percent infected[a]	95% mean confidence limit	Mean DMR[b]	95% mean confidence limit
Roadside-plot	28.4[c]	11.0–45.8	0.9[c]	0.2–1.5
Transect-plot	25.8	10.0–41.5	0.8	0.2–1.4

[a]Based on the percentage of individual trees infected on a per-hectare basis
[b]Dwarf mistletoe rating (Hawksworth 1977)
[c]Means in this column are not significantly different; one-way ANOVA, $P > 0.05$.

TABLE 3. Incidence and severity of lodgepole pine dwarf mistletoe estimated from roadside-plot and transect-plot surveys on the Sawtooth National Forest, Idaho.

	Incidence		Severity	
Survey method	Mean percent infected[a]	95% mean confidence limit	Mean DMR[b]	95% mean confidence limit
Roadside-plot	48.5[c]	29.4–67.5	1.2[c]	0.6–1.8
Transect-plot	55.7	35.3–76.1	1.6	1.1–2.1

[a]Based on the percentage of individual trees infected on a per-hectare basis
[b]Dwarf mistletoe rating (Hawksworth 1977)
[c]Means in this column are not significantly different; one-way ANOVA, $P > 0.05$.

provided equivalent estimates of dwarf mistletoe incidence, based on the percentage of trees infected, and severity for both dwarf mistletoes.

Dwarf mistletoe incidence based on the percentage of plots infested is presented in Table 4. Both survey methods provided estimates that were within 2% of each other for both dwarf mistletoes. Calculating dwarf mistletoe incidence based on the percentage of plots infested greatly increases the estimates of dwarf mistletoe incidence when compared to the incidence based on the percentage of trees infected because it requires only 1 infected tree for a plot to be treated as infested.

Lodgepole pine dwarf mistletoe is one of the most widely distributed dwarf mistletoes in the western United States (Hawksworth and Wiens 1995). The incidence of this mistletoe, based on the percentage of plots infested, has varied between approximately 40% and 70% for the majority of national forests surveyed, and averages about 50% (Hawksworth 1958, Graham 1960, 1964, Johnson et al. 1980, 1981, Hoffman and Hobbs 1985). The incidence of lodgepole pine dwarf mistletoe, based on the percentage of plots infested estimated from our surveys in the Sawtooth National Forest (approximately 80%), is higher than for most national forests surveyed thus far. An earlier dwarf mistletoe survey of the Sawtooth National Forest (Hoffman and Hobbs 1985) reported the incidence of lodgepole pine dwarf mistletoe as 71%. However, that survey did not include the Sawtooth National Recreation Area, the district in which we detected a very high incidence of lodgepole pine dwarf mistletoe (83%). Therefore, the Sawtooth National Forest probably does have a higher incidence of lodgepole pine dwarf mistletoe than many other western national forests.

An earlier estimate of the incidence of Douglas-fir dwarf mistletoe, based on the percentage of plots infested, for the Sawtooth National Forest was 53% (Hoffman 1979). Although that survey sampled only the southern districts of the Sawtooth National Forest and did not include the districts we surveyed, our estimate for Douglas-fir dwarf mistletoe, based on the percentage of plots infested, is approximately the same (almost 50%).

Our findings provide additional evidence that estimates of incidence and severity of dwarf mistletoes using roadside-plot surveys

TABLE 4. Incidence of Douglas-fir and lodgepole pine dwarf mistletoes based on the percentage of plots infested estimated from roadside-plot and transect-plot surveys on the Sawtooth National Forest, Idaho.

	Douglas-fir dwarf mistletoe		Lodgepole pine dwarf mistletoe	
Survey method	Plots	Percent infested	Plots	Percent infested
Roadside-plot	75	47	46	80
Transect-plot	87	48	42	78

approximate those of similar surveys conducted away from roads. Hawksworth (1956) reported similar results based on a more intensive comparison of roadside-plot and transect-plot surveys for dwarf mistletoes on the Mescalero Apache Indian Reservation, New Mexico. Partridge and Canfield (1980) compared the incidence of several forest pests in southern Idaho estimated using roadside-plot surveys and plots randomly located in areas without roads. They reported no discernible differences between the incidence of the pests detected (including dwarf mistletoes) for the 2 survey procedures. Because this study and others indicate that roadside-plot surveys provide similar estimates of dwarf mistletoe incidence to surveys conducted away from roads, we recommend that resource managers continue to use roadside-plot surveys for estimating dwarf mistletoe incidence for national forests or other large forested areas. However, because these surveys sample only a small fraction of the survey area, they will provide only rough estimates of the incidence and severity of dwarf mistletoes.

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