Road/Plot Survey of Dwarf Mistletoe and Comandra Blister Rust Diseases in Lodgepole Pine on the Bighorn National Forest: 2013
Biological Evaluation R2-15-01
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Abstract
In 2013, a combined road and plot survey of dwarf mistletoe and comandra blister rust diseases was conducted of lodgepole pine stands in the Bighorn National Forest. Variable-radius plots (n=91) were installed at two-mile intervals along roads to evaluate lodgepole pine for these diseases. Plot survey results estimate 42% of lodgepole pine trees and 65% of the plots near roads were infected with dwarf mistletoe; 10% of the trees and 37% of the plots were infected with comandra blister rust; and 5% of the trees and 23% of the plots had both diseases. Road side survey results of 161 miles of road, broken into 0.1 mile sections found 75% of the sections had dwarf mistletoe, 44% had comandra blister rust, and 36% had both diseases. Previous surveys in the forest indicated increasing levels of dwarf mistletoe incidence. The 2013 survey suggests a slight decrease in road, but an increase in plot dwarf mistletoe incidences. Comandra blister rust disease incidence decreased using both methods compared with previous surveys. Emphasis on suppression work for these two diseases will result in reductions in disease incidences and promote improved forest health.

Introduction
Lodgepole pine dwarf mistletoe (*Arceuthobium americanum*) is one of the most important diseases in lodgepole pine (*Pinus contorta*) stands. It is a parasitic plant that requires water, mineral, and carbon nutrients from its hosts. This stresses host trees causing reductions in both growth and cone/seed production. Infections of young host tissues result in stimulation of dormant host buds which causes abnormal-dense clumps of branches called “brooms” or “witches’ brooms.” Other symptoms include branch swellings, host dieback from the top down, and eventual tree mortality. Trees can survive infection for decades. However, in areas with extensive infection tree mortality can be three to four times higher than in uninfected areas (Hawksworth and Wiens 1996).

Comandra blister rust (*Cronartium comandrae*) is also one of the more important diseases of lodgepole pine in the region. This fungal rust disease causes stem deformities, growth reduction, and cankers that girdle branches or stems resulting in top-kill and tree mortality. Trees may survive several decades with spiked-tops. Heavy stand infections can result in high volume losses by affecting tree form, lumber quality, and growth rate.

Past road-plot surveys conducted on the Bighorn National Forest (NF) indicated an increasing incidence of dwarf mistletoe in lodgepole pine. In 1958, Hawksworth (1958) reported 31% of road sections of 146 miles of roads through lodgepole pine stands in the Bighorn NF were infected with dwarf mistletoe. Twenty years later, Johnson et al. (1979) duplicated the methodology used in the road plot studies. The same roads were evaluated as in the Hawksworth survey, including newer roads built through lodgepole pine stands. Johnson et al. (1979) found 36% of 174 miles through lodgepole pine forest types near roads were infected with dwarf mistletoe. After another 20 years (sampled in 1999) Harris (2003) found 79% of the trees along 147 miles were infected with dwarf mistletoe.

Johnson et al. (1979) assessed growth loss and mortality caused by dwarf mistletoe on the Bighorn NF. Their findings were used to promote dwarf mistletoe suppression work on the forest. Dwarf mistletoe suppression work has occurred on the Bighorn NF in past years (Johnson 1987).

The incidence of comandra blister rust disease was also evaluated during the previous surveys. However, Hawksworth (1958) did not note any comandra blister rust disease incidence. Johnson et al. (1979) found 71% of lodgepole pine road sections contained comandra blister rust infected trees. Harris (2003) found this disease to be less common in 1999 with 62% of the road sections containing comandra blister rust.

The objectives were to evaluate incidence and severity of dwarf mistletoe and comandra blister rust diseases on the Bighorn NF. Comparisons with previous years were used to explore changes in these important diseases.

Methods

In 2013, traveling many of the same roads previously described (Harris 2003, Hawksworth 1958, Johnson et al. 1979) a road and plot survey was conducted in the Bighorn NF. Due to road closures and new roads, some road sections were different from those previously surveyed. Plots were evaluated at two-mile intervals throughout the road survey (**Fig. 1**).

Road survey methods. Forest roads with stands of lodgepole pine were traversed at 15 to 20 miles per hour. This slow speed allowed surveyors to observe and record stand conditions of lodgepole pine along the right side of the road about 1 chain (22 yards) deep into the stand. Road sections were surveyed on both sides with a return-trip of road sections. At every 0.1-mile data was recorded. Dwarf mistletoe intensity was recorded for lodgepole pines as: 0 for not observed, 1 for observed on <1/3 of the pines, 2 for observed on 1/3 to 2/3, and 3 for observed >2/3. Occurrence of comandra blister rust infection was recorded (present/absent). Road dwarf mistletoe incidences and road comandra blister rust incidences were calculated as percent of road segments with the diseases.

Other data recorded for the 0.1-mile segments included: forest vegetation types, major tree sizes, and non-disease disturbances. Forest vegetation types were categorized as pure lodgepole pine, lodgepole/conifer mix, or lodgepole/aspen mix. Tree sizes for the majority of trees in the road segment was determined as mature (dbh ≥ 9 in), pole (4 in ≥ dbh <9 in), or sapling/seedling (dbh < 4 in). Easily observed disturbances such as recent cutting (thinning or harvesting) and evidence of recent fire were recorded.

Plot survey methods. Plots were installed 2 chains into stands perpendicular to roads every 2 miles during the road survey (not during return-trip of road sections). Numbers of plots were increased compared to earlier surveys due to reported discrepancies between road and plot surveys (Harris 2003). Variable-radius plots with 20 basal area factor were used to delineate trees as saplings (dbh < 4 in), poles (4 in ≥ dbh < 9 in), or mature trees (dbh > 9 in). A 1/100 acre, fixed-radius plot at plot center was used to evaluate frequencies of seedlings by species (height ≤ 4.5 feet).

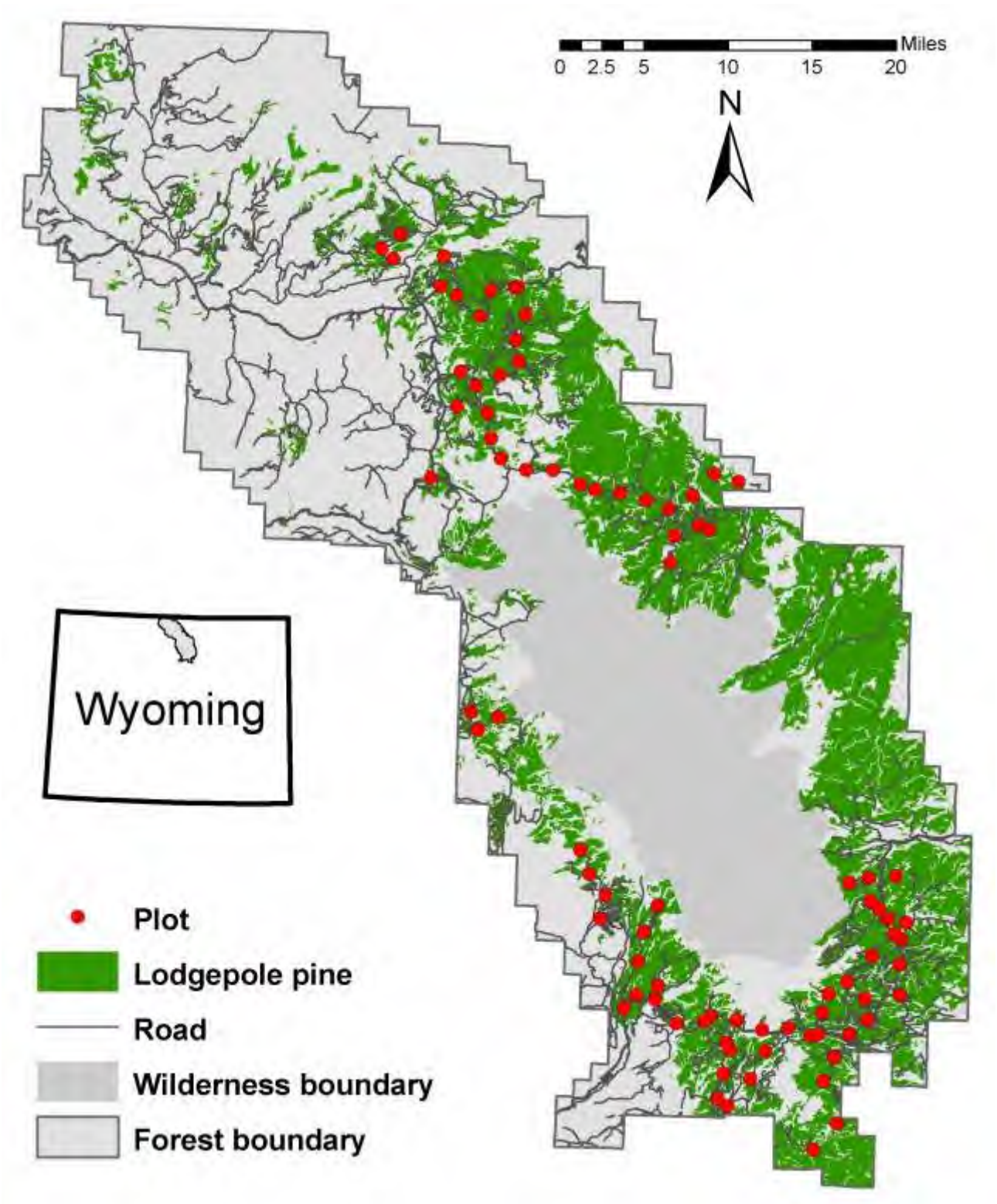

Figure 1. Plots in lodgepole pine stands along roads surveyed in the Bighorn National Forest in 2013. Plots were installed at 2-mile intervals along 161 miles of roads surveyed for dwarf mistletoe and comandra blister rust diseases.

Data collected for live trees in plots included species, dbh, and disease rating. The six-level dwarf mistletoe disease rating system was used (Hawksworth 1977). Disease severity ratings for comandra blister rust were: 0 for no infection, 1 for a branch canker, 2 for a stem canker, 3 for a girdling stem canker causing top kill, and 4 for rust-caused mortality. Plot dwarf mistletoe incidences and plot comandra blister rust incidences were calculated as percent of plots with the diseases. Tree dwarf mistletoe incidences and tree comandra blister rust incidences were calculated as percent of trees within plots with the diseases. Frequencies of other damage agents were recorded.

Results and Discussion

Road survey. We surveyed 161 miles of roads in forested areas containing lodgepole pines. Stands with lodgepole pine totaled 133 miles with 119 miles classified as lodgepole pine stands; 14 miles as lodgepole/conifer mixed forests, and < 1 miles as lodgepole/aspen mixed forests.

Dwarf mistletoe occurred in 75% and comandra blister rust in 44% of the road segments surveyed. Road segments with only dwarf mistletoe disease made up 39% and with only comandra blister rust 8%. At least one of the damage agents occurred in 83% of the lodgepole pine road segments in the Bighorn NF (**Fig. 2**). This is only a slight decrease from the percentage reported by Harris (2003) of 86%.

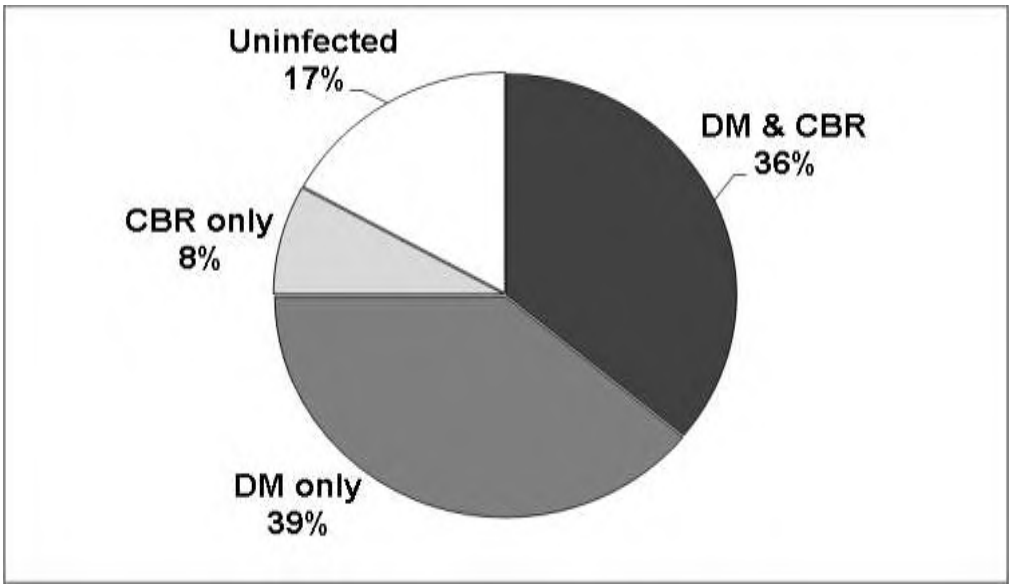

Figure 2. Frequencies of dwarf mistletoe (DM) and comandra blister rust (CBR) infection in lodgepole pine stands along Bighorn National Forest roads in 2013.

Stands with larger trees had more dwarf mistletoe diseases (**Table 1**). This could be due to longer exposure to the pathogens and/or greater disease development within trees (Hawksworth and Johnson 1989). Larger trees also have more branches, increasing the opportunity for infection.

Table 1. Classifications for the road survey of lodgepole pine stands in the Bighorn National Forest by miles and percentages and associated dwarf mistletoe incidence.

Classification	Miles surveyed	Percentage surveyed	DMI[b] (%)
No DMT	33	25	0
DMT intensity level[a] 1	45	34	100
DMT intensity level[a] 2	36	27	100
DMT intensity level[a] 3	19	14	100
Saplings/seedlings	11	8	42
Pole sized trees	11	8	49
Large trees	111	84	81
No disturbance	131	99	75
Fire	1	<1	58
Cutting	1	<1	75
Comandra blister rust present	58	44	82
No comandra blister rust	75	56	69
Total	133	100	75

[a] Dwarf mistletoe intensity was recorded for lodgepole pines as: 1 for observed on <1/3 of the pines, 2 for observed on 1/3 to 2/3, and 3 for observed >2/3.
[b] Road dwarf mistletoe incidence (DMI) was calculated as the percent of road segments with the diseases.

Although infections levels were lower in saplings/seedlings and pole sized tree segments compared with large trees, numbers were higher than expected. Some of those road segments were seed-tree cuts with large, residual trees left to restock the sites. Many of the residual seed-trees were infected with dwarf mistletoe. These trees should have been destroyed when the regenerating pine were small (approximately 5-years old). As a result, seed trees are spreading dwarf mistletoe seed, infecting regeneration. Thus pole sized and saplings/seedling sized stands are infected with dwarf mistletoe (**Table 1**).

Stands with fire had less dwarf mistletoe (**Table 1**). Fire sanitizes forested areas reducing dwarf mistletoe (Hawksworth and Johnson 1989). However, there was little evidence of recent fire during the survey. Dwarf mistletoe incidence and severity can increase due to infrequent fires.

Recent cutting was observed along <1% mile of the road survey. The same dwarf mistletoe incidence was observed between recent cut and uncut stands.

Stands with comandra blister had higher dwarf mistletoe incidence (**Table 1**). The combination of the two diseases will result in reduced growth and seed production, and increased mortality of lodgepole pine in these stands.

Plot survey. We surveyed 91 lodgepole pine plots along roads. These variable-radius plots contained 1,088 trees (all sizes); approximately 87% were lodgepole pine (**Table 2**).

Table 2. Number of trees by species and size class in 91 variable-radius and fixed-radius plots in the Bighorn National Forest.

Size class[a]	Lodgepole pine	Subalpine fir and Engelmann spruce	Aspen	Total
Seedlings	227	99	3	389
Saplings	43	17	0	
Pole trees	245	10	0	699
Mature trees	436	8	0	
Total	951	134	3	1,088

[a] Variable-radius plots with 20 basal area factor were used to delineate trees as saplings (dbh < 4 in), poles (4 in ≥ dbh < 9 in), or mature trees (dbh ≥ 9 in). A 1/100 acre, fixed-radius plot at plot center was used to evaluate seedlings (height ≤ 4.5 feet).

The large number of spruce and fir seedlings, 30% of seedlings and 30% of both seedlings and saplings (**Table 2**), suggests forest successional changes are occurring on some sites (Hawksworth and Johnson 1989). This could be hastened by reduced seed production due to high levels of dwarf mistletoe and/or comandra blister rust in some stands. The observed disease-caused topkill can hindered lodgepole pine seed production and viability (Hawksworth and Johnson 1959).

In mature trees, the incidences of both dwarf mistletoe and comandra blister rust were high, as was the average disease severity ratings of infected trees (**Table 3**). In 1999 the plot dwarf mistletoe incidence was 57% and plot comandra blister rust incidence was 43% (Harris 2003). This suggests a slight increase in dwarf mistletoe and a reduction in comandra blister rust in the Forest. Other damage agents were infrequent in mature trees: 0.002% for mountain pine beetle, 0.005% for pine engraver beetles (*Ips* sp.), and 0.005% for western gall rust.

Table 3. Incidence and mean disease ratings for dwarf mistletoe and comandra blister rust in mature trees[a] in 91 variable-radius plots in the Bighorn National Forest.

Damage agent	Plot incidence	Tree incidence[b]	Mean tree severity rating[c]	Mean infected tree severity rating[c]
Dwarf mistletoe	65%	48%	1.5	3.1
Comandra blister rust	37%	12%	0.3	2.2

[a] Mature trees were ≥ 9 in dbh.
[b] Tree incidence is the percentage of infected mature lodgepole pine.
[c] The six level Hawksworth (1977) system was used to rate dwarf mistletoe infection. Comandra blister rust infections were rated by the most lethal canker on a tree: 1 = branch canker, 2 = stem canker, 3 = girdling stem canker causing topkill, and 4 = rust-caused mortality; and 0 = no canker (not used in last column).

At least one of the damage agents occurred in 79% of the plots (**Fig. 3**). While many of the plots trees were categorized as uninfected, 24% of the trees had a dwarf mistletoe infection ratings above 3; 5% of the trees had a rust stem canker; and 4% had both. In all lodgepole pine trees in the variable-radius plots (saplings to mature trees), over 46% were infected with either dwarf mistletoe, comandra blister rust, or both diseases (**Fig. 3**).

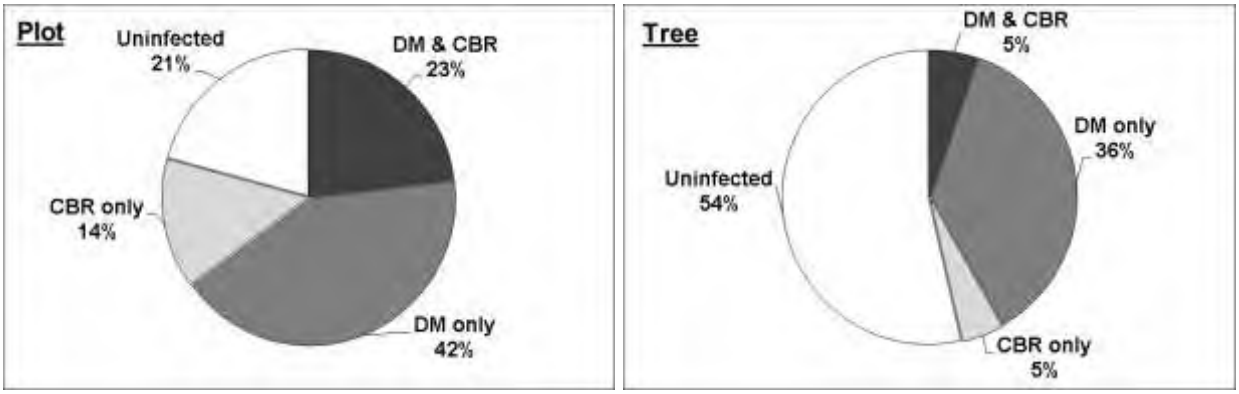

Figure 3. Frequencies of dwarf mistletoe (DM) and comandra blister rust (CBR) infection in plots and in lodgepole pine trees (sapling to mature trees) in 91 variable-radius plots along Bighorn National Forest roads in 2013.

Accuracy check. An accuracy check for road surveys includes a comparison with plot surveys. In this study, road survey dwarf mistletoe incidence was 75% which seemed high when compared to the plot dwarf mistletoe incidence of 65%. However, this discrepancy is not unusual for dwarf mistletoe road-plot survey (Harris 2003, Johnson et al. 1979) including those in other forests (Smith and Hoffman 1998). Lodgepole pines growing near roads or stand edges can have "stimulation brooms." Stimulation brooms are non-mistletoe brooms that can be confused with brooms induced by dwarf mistletoe and are common in lodgepole pine (Hawksworth 1961, Hawksworth and Johnson 1989). Thus, there may be a tendency to overrate dwarf mistletoe incidence during road survey. Dwarf mistletoe intensity level 1 likely was overestimated during road surveys due to these non-mistletoe brooms. Plot dwarf mistletoe incidence values should be more accurate due to ground-level inspections.

Comparisons among study years. Road-survey results suggest an increase in dwarf mistletoe incidence from 1959 to 1999 (**Fig. 4**). Plot results also suggest an increase in dwarf mistletoe incidence from 1979 to 1999, though 1959 dwarf mistletoe incidence plot results do not fit this trend. Harris (2003) speculated the very high 1958 percentage for plot data were due to different method of traversing stand from the road. The 2013 road-survey results suggest a slight reduction and plot results suggest a slight increase in dwarf mistletoe incidence compared to the 1999 survey. Different plot locations and more road segments were surveyed in 2013 which could account for slight differences among years.

The comandra blister rust incidence for both road and plot surveys consistently decreased since 1979 (**Fig. 5**). This trend is likely due to mortality of rust infected lodgepole pine along with low infection rates. Harris (2003) speculated Hawksworth (1958) did not evaluate comandra blister rust disease in the Bighorn NF since levels were very low in 1950's. It is believed that weather conditions of the 1940's promoted *C. comandrae* infection, starting a disease outbreak of the rust disease in Wyoming during the 1950's (Krebill 1965). Symptoms of the disease may not have been apparent during the 1958 survey.

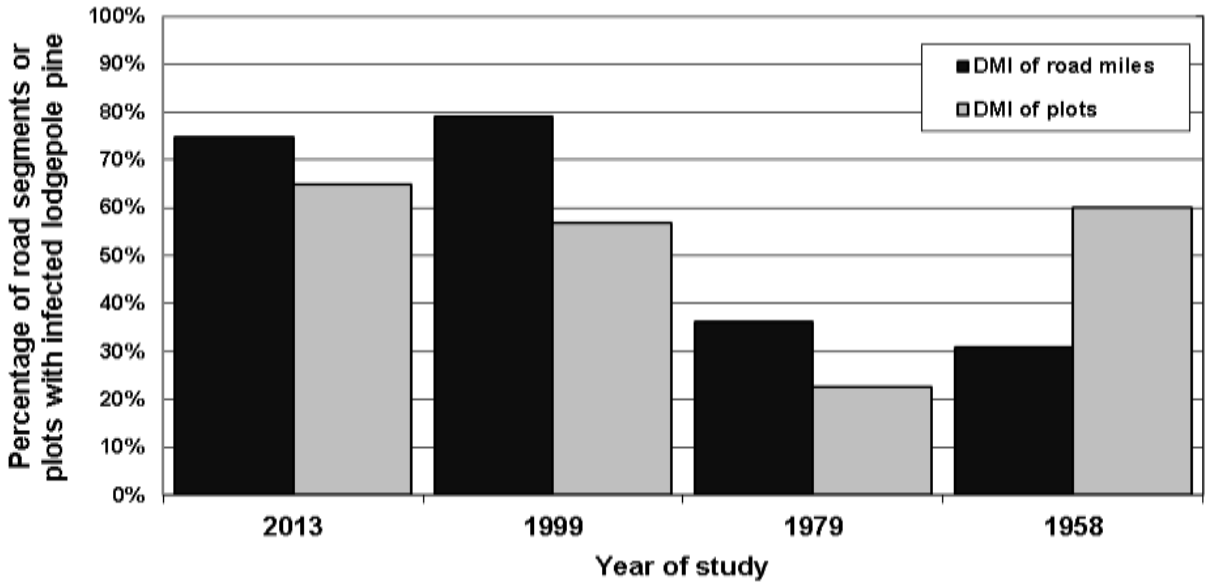

Figure 4. Dwarf mistletoe incidence (DMI) in lodgepole pine road-plot surveys in the Bighorn National Forest from 1958 to 2013. Hawksworth (1958) surveyed 146 miles of road and installed 70 plots. Johnson et al. (1979) evaluated 174 miles of forest roads and 65 plots. Harris (2003) in a 1999 study surveyed 147 miles and 44 plots. In 2013, 161 miles and 91 plots were surveyed.

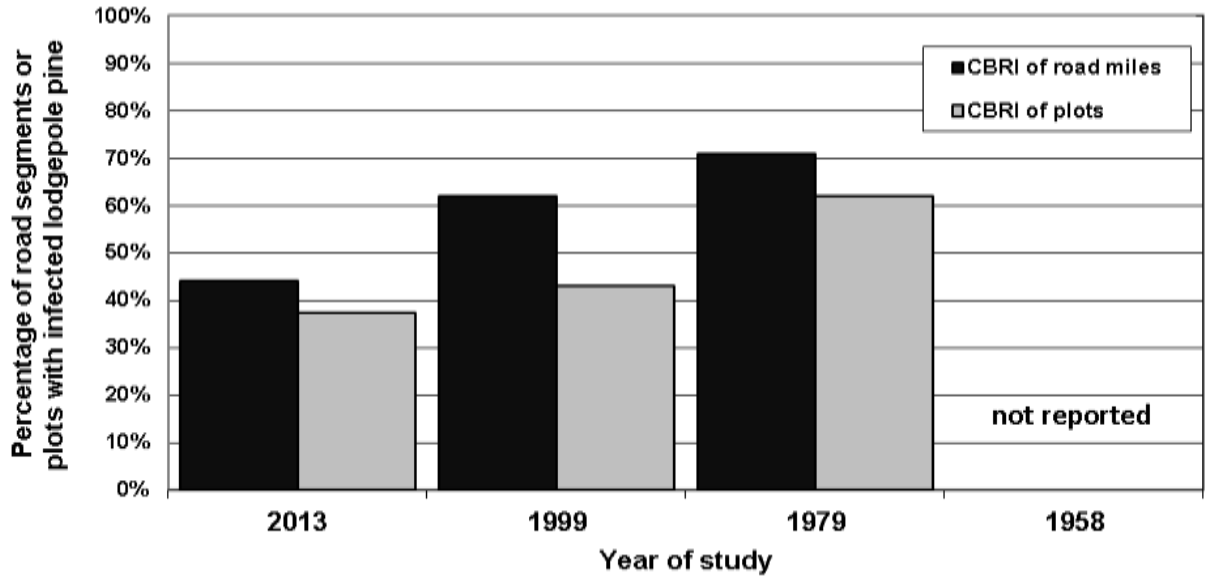

Figure 5. Comandra blister rust incidence (CBRI) in lodgepole pine road-plot surveys in the Bighorn National Forest from 1979 to 2013. Hawksworth (1958) did not survey comandra blister rust diseases. Johnson et al. (1979) evaluated 174 miles of forest roads and 65 plots. Harris (2003) in a 1999 study surveyed 147 miles and 44 plots. In 2013, 161 miles and 91 plots were surveyed.

Summary and Recommendations

- Results suggest dwarf mistletoes levels are increasing in the forest. The more accurate plot dwarf mistletoe incidence suggests a consistent increase in dwarf mistletoes since 1979. Although road-side dwarf mistletoe incidence might suggest a slight reduction in dwarf mistletoes levels from 1999, levels are up from 1979.
- Comandra blister rust levels are still high in the forest, but both plot and road-side comandra blister rust incidences suggest levels are decreasing.
- Some lodgepole pine stands are shifting to subalpine fir and/or Engelmann spruce. This might be due to forest succession and/or reduced pine seed production resulting from dwarf mistletoe and/or comandra blister rust.
- Seed tree cuts were observed during the survey where the residual overstory (seed trees) had dwarf mistletoe infecting regeneration. These residual seed trees should be felled or girdled.
- Several stands are reaching levels where the only management option is stand replacement to improve forest health. These heavily infected mature stands have reduced vigor and volume growth. Stand replacement could result in healthier residual stands.
- Although mean per tree dwarf mistletoe and comandra blister rust disease severity ratings were low, road-side and plot incidences are high for these diseases. The mean tree severity ratings of infected trees are also high. This indicates several stands in the forest would benefit from disease management.
- Options for comandra blister rust management could include removal of infected trees during partial cuts and selecting disease-free trees as leave trees during seed cuts.
- Silvicultural controls to reduce incidence and severity of dwarf mistletoe include:
  - selecting disease-free trees as leave trees during seed cuts, and promptly remove or kill infected seed-trees after regeneration is established,
  - using stand borders adjacent to treated areas that are dwarf mistletoe free,
  - establishing buffer strips around infection centers or around sanitized patches, and promptly removing or kill infected trees along the edge (to create a 52 foot barrier) once regeneration is established,
  - clearing large areas during regeneration cuts to reduce new infections from stand edges,
  - remove or kill infected trees during partial cuts,
  - pruning infected trees when possible,
  - favoring or encourage non-host species that are adapted to the site,
  - Monitor treatments to identify and remove infected trees that were missed or had latent infections.
- More detailed dwarf mistletoe management recommendations can be found in:
  - Hawksworth and Johnson (1989),
  - Dwarf Mistletoes: Ecology and Management in the Rocky Mountain Region: <www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_039584.pdf>.

- Dwarf mistletoe and comandra blister rust suppression work will promote healthier forest stands. Forest Health Protection staff can assist with planning and funding suppression projects for these diseases.

Acknowledgments
Kurt Allen, Alan Dymerski, and Angie Ambourn assisted during the survey.

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