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PONDEROSA PINE CONELET AND CONE MORTALITY IN CENTRAL ARIZONA

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ABSTRACT.—Ponderosa pine conelets in 10 stands on the Coconino and Kaibab national forests were observed periodically from July 1982 until they matured in September 1983. Abortion, ponderosa pine cone beetles (*Conophthorus ponderosae* Hopkins), and ponderosa pine coneworms (*Dioryctria* sp., probably *Auranticella* [Grote]) were the significant mortality factors. Cattle, tip moths, and squirrels rarely destroyed conelets or cones.

Good cone crops in stands of ponderosa pine, *Pinus ponderosa* Lawson, in the Southwest occur on the average of every three to four years (Schubert 1974), with large crops about every five years (Larson and Schubert 1970). Because good cone crops occur infrequently and natural regeneration is difficult to obtain, any factor adversely influencing cone production, and therefore seed production, needs to be identified. Cone mortality is caused by insects, small mammals, and weather factors (Schubert 1974). Cone beetles (*Conophthorus*) have occasionally destroyed 50% of the cone crop in some locales (Pearson 1950). Mice, chipmunks, and ground squirrels may eat seeds but are not important while the cones are attached to the branches. Abert squirrels, *Sciurus aberti* Woodhouse, on the other hand, destroyed an average of 20% of the cone crop over a 10-year period (Larson and Schubert 1970). Freezing temperatures in June have also killed conelets (Schubert 1974).

This paper reports on the conelet and cone mortality caused by different factors during a two-year period.

METHODS

Ten cone-producing areas were selected in ponderosa pine stands on the Coconino and Kaibab national forests in north central Arizona (Fig. 1). For an area to be selected, it had to have 10 trees bearing conelets. In most areas, each tree usually bore more than 30 conelets, but only 30 conelets were randomly selected for study. In one area, Dutch Kid, each tree had less than 15 conelets, so only 10

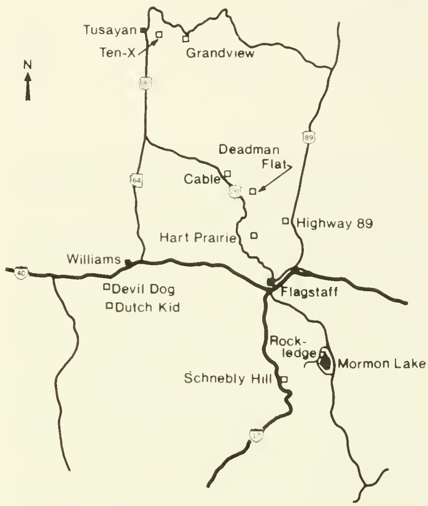

Fig. 1. Location of study areas on the Coconino and Kaibab national forests, Arizona.

were selected. Two other areas, Devil Dog and Ten-X, had individual trees with fewer than 30 available cones, so the desired number of 300 conelets per area was not attained. Table 1 shows the total number of conelets observed per area.

The conelets were generally on the lower crown branches of large-diameter, open-grown trees. The conelets were randomly selected from those within 4 m of ground level because no equipment was available to examine cones above that height. Conelets were present individually and in clusters of two to

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TABLE 1. Number of ponderosa pine cones observed in each area, Arizona 1982–1983.

National forest/Area	Number of cones	Elevation
		m
Coconino National Forest		
Cable	302	2,226
Deadman Flat	301	2,290
Hart Prairie	301	2,561
Highway 89	301	2,195
Rockledge	300	2,195
Schnebly Hill	300	1,980
Kaibab National Forest		
Devil Dog	281	2,012
Dutch Kid	100	2,012
Grandview	301	2,256
Ten-X	291	2,025

five. Their cone cluster class was recorded to determine whether insect damage varied with the number of cones per cluster.

The conelets were selected in July 1982 and were examined about every two weeks thereafter until September 1982. Observations were discontinued during the winter of 1982–1983 but were begun again in March or April 1983, depending on accessibility of the site. In August–September 1983 observations were terminated and the cones collected for additional study. During each observation period, factors causing damage or mortality were identified when possible.

Some of the areas were the same as those used by Schmid et al. (1984) in an earlier study, in which 32 cones were collected from the lower and middle crowns of large-diameter, open-grown trees in September 1982. However, in that study cones were not observed from the time they were conelets.

RESULTS AND DISCUSSION

Abortion, ponderosa pine cone beetles (*Conophthorus ponderosae* Hopkins), and ponderosa pine coneworms (*Dioryctria* sp., probably *D. auranticella* Grote) were the three most important mortality factors, with abortion consistently causing the greatest amount of conelet mortality (Table 2). Abortion, as used herein, encompasses several mortality factors. Conelets died and failed to mature, but the exact cause of their death was undetermined. Many of the conelets died the first summer, which suggests some physiological disfunction, i.e., inadequate pollination or water stress. The 1983 mortality was primarily observed when observations were resumed, which indicates that the mortality occurred during the winter months. Schubert (1974) and the USDA Forest Service (1974) note cold temperatures can be lethal, so much of the 1983 mortality may be attributed to freezing temperatures. In December 1982 and January and February 1983, temperatures dropped below 0 F in Flagstaff, but whether these low temperatures caused overwinter mortality was not determined. And finally, insects like seedbugs (*Leptoglossus occidentalis* Heidemann) could cause conelet mortality, although neither the adults nor damage were observed. In the life of the cone, mortality factors during the first year are the least understood.

Although *Conophthorus*-caused mortality was 10% or less in 7 of the 10 areas, *Conophthorus* beetles generally caused the second greatest amount of mortality, causing up to 62% mortality in one area (table 2). *Conophthorus*-caused mortality changed significantly between 1982 and 1983 in two locations and remained the same in two other areas. In 1982, *Conophthorus*-caused mortality averaged 39% in the Highway 89 area and 2% in the Ten-X area (Schmid et al. 1984). In 1983, the second year of this study, mortality attributable to *Conophthorus* was 1% in Highway 89 and 28% in Ten-X. Whereas the two studies have slightly different sampling designs, which may have created some of the difference in the incidence of mortality, enough difference exists to suggest that *Conophthorus* populations, and therefore *Conophthorus*-caused mortality, exhibit significant variation from year to year.

The frequency of *Conophthorus*-killed cones mirrored the frequency of the cone cluster class for all levels of *Conophthorus*-caused mortality. When two-cone clusters were the most abundant cone cluster, *Conophthorus* damage was greatest in that class. When three-cone clusters predominated, damage was greatest in that class. Thus, even though female beetles can infest more than one cone (Kinzer et al. 1970), multiple cone clusters do not apparently reduce beetle mortality during dispersal and host location nor do they increase the probability of

TABLE 2. Percent mortality* of developing ponderosa pine cones by location and mortality factors, Arizona 1982–1983.

Mortality factor	Coconino National Forest						Kaibab National Forest			
	Cable	Deadman Flat	Hart Prairie	Highway 89	Rockledge	Schnebly Hill	Devil Dog	Dutch Kid	Grandview	Ten-X
Abortion										
1982	13	15	10	6	5	8	13	10	8	21
1983	15	4	7	7	17	22	15	14	8	13
Total	28	19	17	13	22	30	28	24	16	34
Cattle	0	0	0	0	0	1	0	0	1	0
Conophthorus	<1	14	62	1	3	1	2	<1	10	28
Dioryctria	4	7	1	6	0	1	3	0	5	1
Missing	0	2	2	0	<1	2	3	0	0	0
Rhyacionia	0	<1	0	0	0	0	1	0	0	0
Squirrel	0	1	0	2	1	0	<1	0	<1	0

*Mortality will not add up to 100% because not all cones died or disappeared.

Conophthorus infestation. It also suggests that although females can attack more than one cone, they probably do not do so.

Dioryctria-caused damage averaged 7% or less in all areas. *Dioryctria* averaged 0.5% in 1982 and 4% in 1983 for those areas that were also used in 1982 by Schmid et al. (1984). *Dioryctria* damage was thus significantly greater in 1983, which supports the hypothesis of increasing insect damage in areas where good cone crops are produced consecutively for several years.

Conelet and cone mortality caused by cattle, tip moths, and squirrels was generally rare, averaging less than 1% for each factor. Cattle destroyed conelets on two areas by chewing off the tips of the low branches. Cattle were only important here because conelets in the lower crown were being studied; on a whole-tree basis, cattle were insignificant. Similarly, tip moths (probably *Rhyacionia neomexicana* (Dyar)) caused minimal damage on two areas and on a whole-tree basis were insignificant.

Mortality attributable to squirrels (probably the Abert squirrel) averaged less than 1% (Table 2) but was evident in more areas than mortality caused by cattle or tip moths. Squirrels cut few developing conelets prior to maturation and are thus insignificant predators of ponderosa pine conlets during the development stage. Significant cone loss, as noted by Larson and Schubert (1970), occurs when cones mature in September of the second year or about the time our observations were terminated.

Conelet losses attributed to specific mortality factors were identified during specific time periods. Figure 2 depicts survivorship curves for cones on 3 of the 10 areas (Highway 89, Hart Prairie, Ten-X), each of which exemplifies a different situation. The Highway 89 area had the lowest abortion rate and high cone damage caused by *Dioryctria*. Abortions were evenly divided between 1982 and 1983. *Dioryctria* killed 6% of the cones between 15 May and 15 June; losses thereafter were relatively small. The Hart Prairie area had a low abortion rate and substantial losses caused by *Conophthorus*. After abortion losses in the summer of 1982 and losses in the winter months of 1982–1983, conelet mortality was negligible until *Conophthorus* beetles caused a rapid decline in the percentage of surviving cones between 15 June and 15 August. The Ten-X area had high cone mortality attributable to abortion and *Conophthorus*. Abortion losses were greater in 1982 and 15 April to 15 May 1983 in the Ten-X area than in the Hart Prairie. From 15 June to 15 July, the rate of loss to *Conophthorus* was similar in the Ten-X and Hart Prairie areas, but the total loss of conelets was greater in the Hart Prairie area.

MANAGEMENT IMPLICATIONS

This study showed abortion, cone beetles, and coneworms to be the most important factors affecting cone survival. Losses to abortion cannot be reduced until the specific factors responsible can be isolated and identified as to

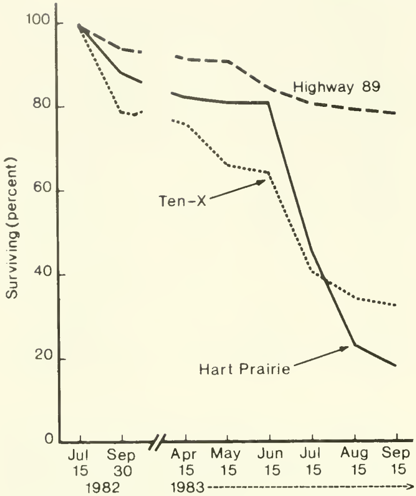

Fig. 2. Ponderosa pine conelet survival for three study areas on the Coconino and Kaibab national forests, Arizona, 1982–1983.

their relative importance. Losses to *Conophthorus* and *Dioryctria* can be drastically reduced using chemical insecticides. If an area produces a good conelet crop and seed is needed from it, a preventive spray might be applied in May or early June of the year the cones mature to keep these cone beetles and coneworms from infesting the cones.

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