CONE AND SEED DAMAGE SURVEY FOR MAINE - 1983

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Abstract.--Maine's major commercial conifer species were surveyed in 1983 to assess seed and cone damage due to insect predators. Balsam fir, tamarack, and hemlock all sustained over 80% seed loss per cone. The spruces (red, white, and black) showed losses in the 60-70% range, while jack, white, and red pines exhibited the least amount of cone damage (21-41% seed loss).

Production of conifer seed is becoming increasingly important in the northeastern United States and Maritime Canada as harvested sites are artifically regenerated. As the demand for forest tree seed grows, the impact of seed-feeding insects becomes of greater concern. Insects are widely considered to be one of the most important causes of conifer seed loss (Miller 1914, Morley 1948, Keen 1958, Hedlin 1960, Mattson 1968,1978, Ebel and Yates 1974, Ebel et al. 1980).

The geographical ranges of many cone and seed insects extend into Maine (Hedlin et al. 1981). Among these are coneworms (Dioryctria spp.), seedworms (Laspeyresia spp.), cone borers (Eucosma spp.), seed chalcids (Megastigmus spp.), cone midges (Cecidomyiidae), cone beetles (Conophthorus spp.) and cone maggots (Lasiomma spp.).

Losses due to insects are a critical factor in seed production; even in years when cones are plentiful, a high percentage of the seed may be destroyed (Mattson, 1971). Although the literature on seed and cone insects in the northwestern and southern U.S. is abundant, there is minimal information available for tree species found in the Northeast. However, some good sources of information for northeastern species are available primarily from the Lake states and Canadian provinces on: white spruce (Picea glauca (Moench) Voss) (Tripp and Hedlin 1956, Bean and Prielipp 1961, and Fogal et al. 1977), white spruce, black spruce (Picea mariana (Mill.) B.S.P.), and balsam fir (Abies balsamea (L.) Mill.) (Fye and Wylie, 1968), red pine (Pinus resinosa Ait.) (Lyons 1957, Mattson 1968, 1971) ana jack pine (Pinus banksiana Lamb.) (Rauf et al. 1985).

We found only one unpublished report by W. H. Klein which dealt with a survey of cone and seed insects in the Northeastern region of the U.S. Forest Service.[3] This survey was conducted in 1964 and resulted in a total of 25

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[3]/ Klein, William H. 1965. Report on a cooperative seed and cone insect survey in the northeastern region, 1963-64. Mimeo. Northern Forest Pest Control Zone, Forest Service, R-7, U.S. Department of Agriculture. February 10, 1965, (not for publication).

collections representing 10 coniferous species from 9 eastern states. Klein recognized the shortcomings of this survey and stated "information as to the distribution of the most important seed and cone insects, and their impact on seed production of the primary northeastern conifers is still lacking ..." ; he also provided several recommendations for future surveys, which we used in designing our study.

Prof. N. R. Brown at the University of New Brunswick, with the assistance of his students, has provided a foundation for seed and cone insect studies in the Northeast. Most of the work has been in the form of Master's theses which deal with a specific tree species and the associated seed and cone insects: Kettela (1967) studied balsam fir; Odera (1968) reported on insects occurring in cones of eastern white pine (Pinus strobus L.); Barkhouse (1970) studied black, red (Picea rubens Sarg.), and white spruce; and Amirault (1984) investigated the cone insects of tamarack (Larix laricina (DuRoi) K. Koch). However, these reports only deal with infestation levels in the one or two years in which they were conducted and provide no basis for comparisons between species within a given time period.

We conducted a statewide survey of cone and seed damage in Maine in 1983 to expand the existing information base of insect impact on conifer seed production in the Northeast; our survey results for ten tree species are reported here. Comparisons of damage levels (seed losses) were evaluated at cone maturity; causes of cone abortion before maturity such as cone beetles, lepidoptera, etc. were not included in our survey results. The survey results provide valuable data about the levels of seed damage being sustained in I Maine's forests, and provide a basis for refining priorities for future research projects.

METHODS AND MATERIALS

Cone Collection Procedures

In August and September 1983, cone collections were received from various forest landowners and agencies throughout the state of Maine. Although not directly measured for each species, the cone production in 1983 was considered "good" or average, in comparison to 1984 which was a bumper cone crop year for most species. The sampling design of the survey called for collecting three current-year cones from each of ten randomly-selected trees per site. Most sites were separated by at least 10 km. Cones were collected from various locations within the tree crowns without regard to presence or absence of visible insect damage; cones were occasionally collected from felled trees. Each sample tree was selected to be representative of the whole site. Cones from each tree were placed in a plastic bag (1 liter), and the bag was closed with a wire tie. The total collection per site was placed in a paper bag (5-10 liter), labeled, and shipped to our laboratory in Orono for assessment.

In the laboratory, the presence of any free-moving, live insects was recorded, and the insects removed and preserved. For each collection, tree species, specific location and township, type of collection site (natural stand, plantation, or seed production area), date of collection, collector, and cooperating agency were recorded. The cones were then refrigerated (1° C,45 RH) until dissection.

Cone Dissection Procedures

The length and width of each cone was measured (mm), and then the whole cone was examined externally for obvious insect damage (e.g. feeding holes from lepidopteran insects , deformities, etc.) prior to dissection. Following external examination, each cone was cut in half longitudinally using a cone chopper, similar to those described by Winjum and Johnson (1960), McLemore (1962) and Wilson (1968). Cones were oriented in the chopper to approximately bisect any external damage. The cut seeds on the surface of the longitudinal slice were immediately examined, and the number of seeds in each of the following categories was recorded: filled or sound, hollow, shrunken megagametophyte/endosperm, insect present in seed, insect-caused and other damage, and aborted seed.

Following the assessment on the cut surface, a subsample of six of the 30 collected cones per site was selected for further intensive examination. One-half of each cone in the subsample was destructively sampled, (i.e. each seed was dissected from the half cone and cut open to determine and record its condition, using the same previously listed categories).

RESULTS

We received over 2000 cones collected from 76 collection sites throughout the State of Maine. The collection sites for each tree species were broadly distributed within the state (Figures 1A-D). The list of tree species sampled, approximate dates of collection, number of collection sites per species, and number of cones examined and dissected is given in Table 1.

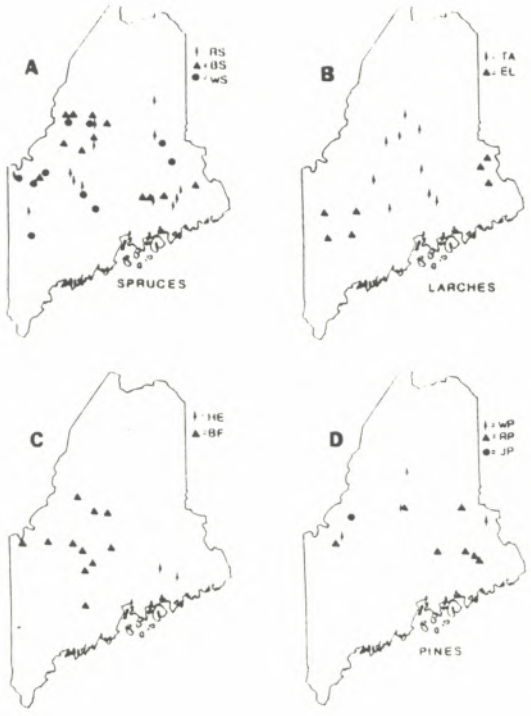

Figure 1. Distribution of cone collections for spruces (A), larches (B), balsam fir and eastern hemlock (C), and pines (D) for the 1983 cone and seed survey in Maine.

Table 1.--Collection data for the 1983 cone and seed survey in Maine.

Tree Species		Collection		Number of Cones Examined		
Common Name	Species Code	Date	Site	External	Cut Surface	Half-cone Dissection
White spruce	WS	mid-late Aug	10	257	256	181
Red spruce	RS	mid Aug to late Sep	13	351	343	90
Black spruce	BS	late Aug to mid Sep	12	306	305	85
Balsam fir	BF	Aug	11	224	216	61
Exotic larches[a/]	EL	mid Aug to early Sep	7	206	206	48
Tamarack	TA	early-late Aug	9	261	258	64
Eastern white pine	WP	late Aug to early Sep	4	107	106	28
Red pine	RP	late Aug to late Sep	7	195	185	48
Jack pine	JP	late Sep	1	30	30	7
Eastern hemlock[b/]	HE	mid Sep	2	57	57	14

[a/] Includes Japanese larch (*Larix leptolepis* (Sieb. & Zucc.) Gord.) and European larch (*Larix decidua* Mill.) and hybrids of both species.

[b/] (*Tsuga canadensis* (L.) Carr.)

Results of the 1983 cone survey (Figure 2) indicate balsam fir, tamarack, and eastern hemlock cones yielded the least filled seeds with over 80% seed loss per cone. Of the spruces sampled, black spruce showed the least amount of seed loss per cone (62.4%), followed by red spruce with 68.5%, and then white spruce with 71.4%. Second-year cones of jack pine, eastern white pine, and red pine exhibited the lowest seed loss per cone, with 21, 29, and 41% respectively.

We compiled a detailed anaylsis of the half-cone dissection data by various categories (Table 2). For example, of the 83.3% total seed damage found in balsam fir, 27.7% was obviously insect damaged, being comprised of: 18.5% internal and external insect damage, plus another 9.2% of the seeds had insect larvae inside the seed (possibly *Megastigmus* sp., a tiny chalcid wasp which oviposits on and develops totally within the seed). An additional 55.3% of the seeds had shrunken endosperms; while only 0.3% of the seeds were found to be hollow.

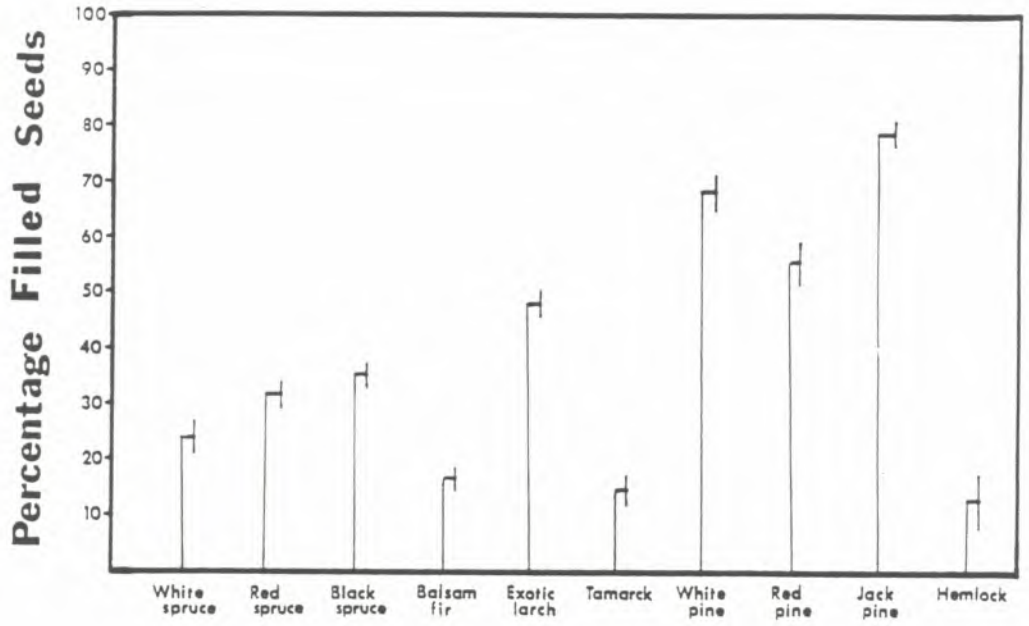

Figure 2. Percentage filled seeds by tree species from the 1983 cone and seed survey in Maine (vertical bar = mean, small vertical bar = SE, according to Tufte, 1983).

Table 2. Mean percentage of seeds from half-cone dissections by tree species for the 1983 cone and seed survey in Maine.

Species Code	Cones (n)	Filled Seeds	Total Damaged Seeds	Dissection Categories				
				Hollow	Shruken	Insect in Seed	Insect Damage	Aborted
WS	(56)	23.6	71.4	4.7	47.2	3.5	15.1	0.9
RS	(74)	31.4	68.5	4.0	48.7	0.5	14.9	0.4
BS	(53)	34.9	62.4	1.3	50.5	0.0	10.6	0.0
BF	(51)	16.6	83.3	0.3	55.3	9.2	18.5	0.0
EL	(42)	47.3	52.4	0.3	47.7	0.0	3.9	0.5
TA	(54)	16.1	83.9	0.2	37.5	0.2	45.2	0.8
WP	(24)	68.5	29.2	1.0	12.5	0.2	4.2	11.3
RP	(42)	56.8	41.0	1.9	12.4	0.3	10.4	16.0
JP	(6)	78.8	21.2	0.0	19.4	0.0	1.8	0.0
HE	(12)	13.8	86.2	0.0	86.2	0.0	0.0	0.0

For total insect damage for a species the data in both insect columns (in seed and damage) should be combined; we have maintained these categories separate (Table 2) so that the seed chalcid damage could be recognized, because these species are notoriously difficult to control in suppression programs.

Tamarack suffered the most insect damage with 45.4%; this percentage is somewhat lower than what we observed (unpub. data) for the 1982 season, which was a poorer cone production year. In contrast, insect damage ranged between 10-19% for several other species (white, red, and black spruce, and red pine), while balsam fir sustained 27.7% insect damage. Exotic larches, eastern white pine, jack pine, and eastern hemlock exhibited less than 5% insect damage.

Shrunken seed accounted for a high proportion of the total seed examined in many species. The cause of the shrunken seed remains unknown, but it is possible that these seeds have been fed upon by true plant bugs (Hemiptera) which suck the juices from the seed leaving little evidence (either internal or external) of their presence. Seed orchards in the southern U.S. are plagued by these seed-feeding plant bugs and, from all reports, the characteristics of the damaged seeds match the shrunken seed in balsam fir and other species (Hedlin, 1981). However, because there are other possible causes for the shrunken category, seeds with shrunken endosperm were not included in the insect damage column.

The data from the external examination of the cones were summarized in two ways: as a percentage of all collected cones that exhibited any external damage (Table 3), and percentage of the cone surface damaged if any external damage was present (Table 4). Except for the pine species, damage from lepidopteran feeding was generally caused by the spruce budworm, Choristoneura fumiferana (Clemens); however, other species of lepidopteran larvae were observed, especially in the samples of balsam fir and tamarack.

Table 3. Percentage of all cones with external damage by tree species in the 1983 Maine cone and seed survey.

		External Damage (% of seed cones)		
Species Code	Cones (n)	Lepidop. Feeding	Insect Exit Holes	Other Damage
WS	257	36.2	24.1	22.2
RS	351	48.1	15.1	11.7
BS	306	50.0	14.1	5.2
BF	224	26.3	27.2	16.5
EL	206	32.0	4.9	10.2
TA	261	3.4	1.1	0.4
WP	107	5.6	2.8	33.6
RP	195	2.1	2.1	3.1
JP	30	0.0	10.0	0.0
HE	57	0.0	0.0	1.8

External lepidopteran damage was highest for red and black spruce (9.2%), while white spruce, balsam fir and exotic larches ranged from 5.2 to 5.7% (Table 4). Eastern white pine exhibited the greatest amount (10.5%) of other insect damage. Low numbers of insect exit holes per cone were recorded for the tree species we examined (Table 3).

Table 4. Mean percentage (+ SE) of cone surface damaged and mean cone size for each tree species in the 1983 Maine cone and seed survey.

Species Code	Cones (n)	Percent Surface Damage		Cone Size (mm)	
		Lepidop. feeding	Other Damage	Length	Width
WS	257	5.7 (±0.8)	4.7 (±0.9)	43.9 (±0.6)	12.2 (±0.1)
RS	351	9.2 (±0.8)	2.0 (±0.4)	33.1 (±0.3)	15.0 (±0.1)
BS	306	9.2 (±0.8)	0.6 (±0.2)	24.7 (±0.3)	13.6 (±0.1)
BF	224	5.2 (±0.9)	2.6 (±0.6)	59.1 (±0.7)	21.0 (±0.2)
EL	206	5.5 (±0.8)	0.9 (±0.3)	28.4 (±0.4)	18.3 (±0.3)
TA	261	0.7 (±0.3)	0.02 (±0.02)	15.6 (±0.4)	9.2 (±0.1)
WP	107	0.5 (±0.2)	10.5 (±2.0)	119.7 (±1.8)	20.8 (±0.2)
RP	195	0.3 (±0.2)	0.4 (±0.2)	41.5 (±0.4)	25.4 (±0.2)
JP	30	0.0 ---	0.0 ---	48.3 (±1.5)	21.3 (±0.4)
HE	57	0.0 ---	0.2 (±0.2)	15.7 (±0.3)	8.2 (±0.2)

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