Fig. 1. This green ash "brood" tree has been infested by the carpenterworm for many years. (U.S. Forest Service Photo).

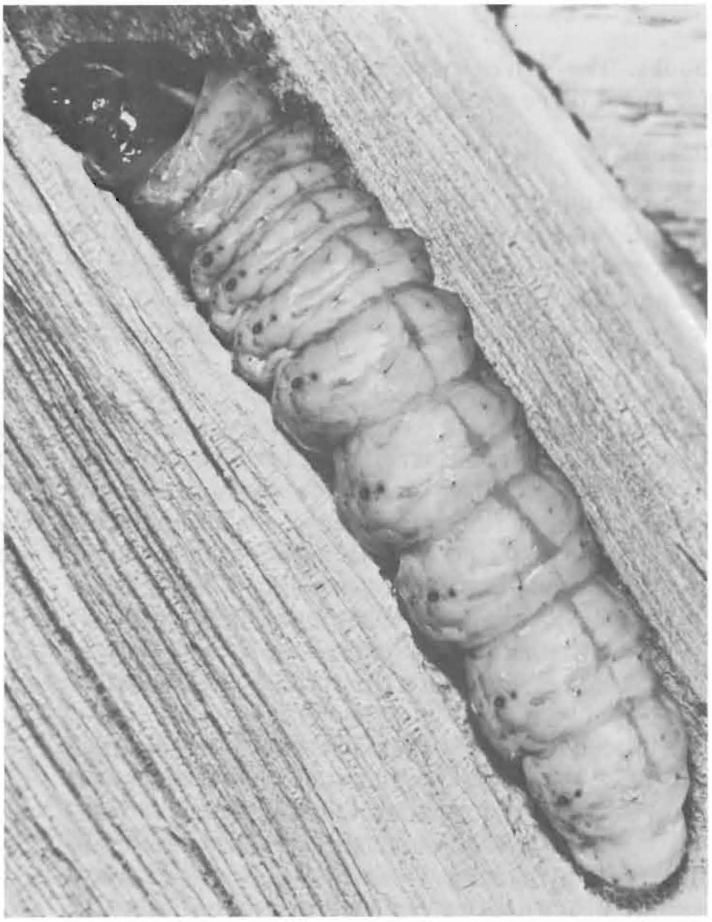

Fig. 2. Full-grown carpenterworm larvae are two to three inches long, light green, with dark brown heads. (U.S. Forest Service Photo).

The Borer Problem in Green Ash In North Dakota Shelterbelts

M. E. McKnight and Scott Tunnock

Introduction

Green ash has been widely planted on the Great Plains, and has proved to be a highly desirable tree in urban areas and rural plantings. However, it and other tree species used in ornamental plantings and windbreaks are sometimes attacked by various species of boring insects. The likelihood of damage by borers is now so great that it limits the use of green ash in field and farmstead windbreaks in parts of North Dakota, South Dakota and Montana.

Borers in green ash are usually the carpenterworm, **Prionoxystus robiniae** (Peck), and the ash borer, **Podosesia syringae** Harris, also known as the lilac borer. These native insects have probably become more abundant as supplies of host material have increased, largely in the form of field and farmstead windbreaks.

The Insects

Life histories of the carpenterworm and the ash borer are well known on the northern Great

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Fig. 3. New attacks by the ash borer (arrows) are difficult to detect. (U.S. Forest Service Photo).

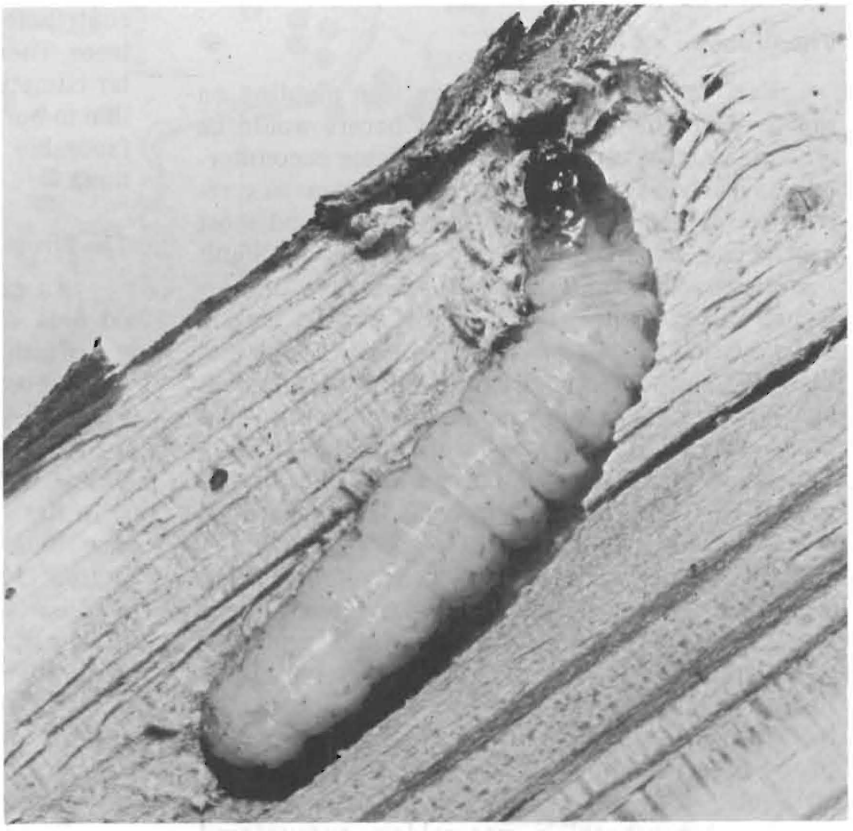

Fig. 4. Full-grown ash borer larvae are about one inch long, creamy white, with reddish brown heads. (U.S. Forest Service Photo).

Plains (6, 7, 9). Moths of the carpenterworm and the ash borer may be present from late May to early August. Eggs are laid in cracks and crevices of rough bark on trunks and branches, and in wounds resulting from cultivation, pruning, hail, frost or snow. Old burrow openings are favorable sites for egg deposition, and therefore infested trees tend to remain infested year after year and become "brood" trees (Figure 1). Open-grown trees in sunny situations seem to be preferred. A female carpenterworm moth may deposit as many as 800 eggs (11).

Newly hatched carpenterworm larvae begin their burrows in cracks, crevices and wounds in the bark. Young larvae are present on infested trees throughout the summer months. The borers are well established in burrows at the end of the first summer, and the burrows are extended and enlarged the second and third summers. Borer larvae feed on the cambium tissue around the burrow opening; galleries in the heartwood are mainly for protection (12). Carpenterworm larvae (Figure 2) become pupae in May of the fourth summer and the moths emerge in June. Habits of ash borer larvae (Figures 3, 4) are essentially the same except that they become pupae in May of the third summer; the moths also emerge in June.

The Problem

Early advocates of extensive tree planting on the Great Plains anticipated that borers would be among the most serious insect problems encountered. As early as 1936 the carpenterworm was recognized as the most widely distributed and most destructive of several species of borers in South Dakota attacking green ash, Russian-olive, honeylocust, black walnut, black locust, poplar, cottonwood, willow, elm, soft maple, pear, cherry and lilac (17). Severe damage resulted in wind breakage, lower wood value and death of trees. Trees that survived borer attacks were usually stunted. Damage caused by the ash borer was similar to that caused by the carpenterworm, but it was confined more to green ash and lilac.

George (2), who observed nearly 4,700 plantings made between 1916 and 1942, reported that green ash with heavy infestations of the carpenterworm and the ash borer suffered severe topkilling. In many plantings, especially in South Dakota, the trees broke down at ground level or died out entirely. Siberian elm was also subject to borer infestation.

The borer problem was seldom encountered in general surveys of shelterbelt insects and diseases in the eastern portions of North Dakota and South Dakota in 1960 (18) and 1964-1966 (3).

Green ash was present in 80 of 107 shelterbelts selected for a study to determine the influence of climate and host age on insect distribution and abundance in North Dakota shelterbelts (5). In 1964, observers detected the ash borer or the carpenterworm in 18 (22.5 per cent) of the plantings with green ash. No infested shelterbelts were recorded in the northeastern quarter of the state. Since 1969, 58 of the plantings with green ash have been re-examined and 30 (52 per cent) contained borers. The ash borer was found in 18 (31 per cent) and the carpenterworm in 12 (21 per cent). The ash borer appeared to be most prevalent in the eastern half of the state, especially the southeastern quarter; the carpenterworm in the western half of the state, especially the southwestern quarter.

Several observers have reported an abundance of borer injury during drought conditions. Infested trees probably were unable to tolerate borer injury as well as they could when moisture supplies were normal, but undoubtedly many uninfested trees died from inadequate moisture supply, also. Wygant (19) concluded that the carpenterworm and a roundheaded borer (**Tylonotus bimaculatus** Haldeman) were not the primary cause of decadence in plantings in Nebraska, although they may have contributed, with drought, to the deaths of some trees. There is now no information on what particular climatic regime makes individual trees susceptible to borer attack, or creates conditions especially favorable for sudden increases in borer populations.

The Situation in 1972

An extensive, statewide survey to obtain needed data on the damage caused by the borers in green ash in windbreaks was initiated in 1972 by the Forest Service, Division of State and Private Forestry, Northern Region, Missoula, and the Shelterbelt Insect Research project, Rocky Mountain Forest and Range Experiment Station, Bottineau, with the cooperation of the Soil Conservation Service. Ninety-six plantings (Figure 5) were sampled in four land resource areas, defined on the basis of land use, soils and climate (1). Four age classes of plantings were recognized: up to 6 years; 7 to 15; 16 to 30; and 31 years and older. Within plantings, a systematic sampling method was used to select trees to be examined for borers, the number varying according to the number of green ash trees in the planting.

Of the nearly 4,100 trees examined in the survey, 7.2 per cent were damaged by carpenterworms

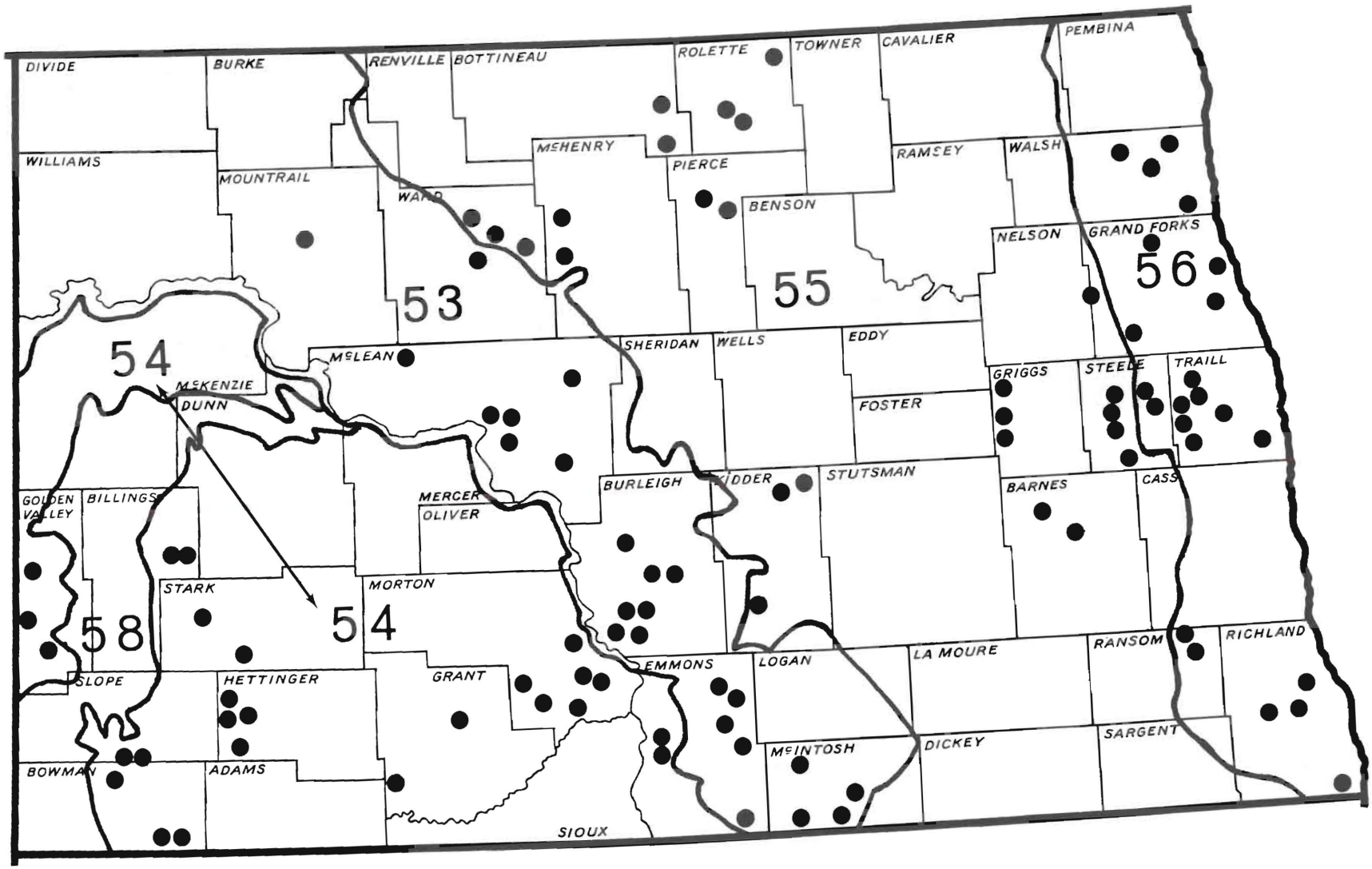

Fig. 5. More than 4,000 trees were examined in 96 windbreaks (black dots) to determine the incidence of the ash borer, the carpenter worm and other borers in land resource areas 53, 54, 55 and 56 in North Dakota in 1972.

Table 1. Incidence of green ash trees with borer damage in windbreaks in 4 age classes in North Dakota, 1972.

Age class, years	Trees examined	Windbreaks examined	Carpenterworm		Ash borer		Other borers	
			Trees	Windbreaks	Trees	Windbreaks	Trees	Windbreaks
	No.		Per cent					
0-6	1009	24	0.5	12.5	4.7	58.3	0.1	4.2
7-15	954	24	3.0	29.2	5.8	58.3	.2	8.3
16-30	1045	26	14.1	34.6	3.0	50.0	.5	15.4
31+	1088	22	10.4	36.4	1.1	36.4	4.0	54.5
All	4096	96	7.2	28.1	3.5	51.0	1.2	19.8

and 3.5 per cent by ash borers. About 28 per cent of the plantings had damage by the carpenterworm, and 51 per cent had damage by the ash borer. "Damage" included old infestations as well as current presence of the insect.

Both borers were present in all age classes (Table 1). The ash borer predominated in plantings less than 16 years old, the carpenterworm in plantings more than 15 years old. Both the ash borer and the carpenterworm were found in all land resource areas (Table 2), but the greatest percentage of infested trees was found in area 54. There the carpenterworm predominated over the ash borer by a ratio of more than 3 to 1. The percentage of windbreaks with ash borer damage was more than 30 per cent in all areas, but was highest in area 54.

The significance of these data depends upon whether one is concerned about the percentage of trees damaged or the percentage of windbreaks infested. Even if damage by borers were equated to mortality and loss of wind barrier effectiveness, 7 per cent damage of trees by the carpenterworm may be tolerable. However, the presence of the ash borer in 51 per cent of the plantings should be considered a real threat.

Damage by borers other than carpenterworm and ash borer was noted in all land resource areas sampled (Table 2) and was encountered most frequently in area 54. The "other borers" were especially abundant in windbreaks over 30 years of age (Table 1). The identity of the "other borers" is not known in all instances, but adults and larvae of a round-headed wood-boring beetle, **Tylonotus bimaculatus,** were found in living, apparently healthy windbreak trees in areas 53, 54 and 55. The presence of this borer in drier areas of the state and in the oldest trees is significant. Wygant (19) also found this borer, as well as the carpenterworm, in Nebraska in old trees suffering from lack of moisture.

Within the sampled plantings, trees were measured for height and diameter (at the base). For windbreaks with two or more infested trees, the mean heights and diameters of infested and uninfested trees were compared. Statistical tests were of doubtful validity because in most cases only a few infested trees, often only two, were compared with many uninfested trees, often 25 to 40. The borer-infested trees were not necessarily shorter or smaller in diameter, however. In fact, infested trees under 16 years old were usually taller and larger than trees without borers.

The plantings examined during the survey represented all degrees of "care". Cultivation between and within the tree rows ranged from clean cultivation to completely sod-bound. However, the incidence of borer infestation was more closely related to geographical location and age of trees than to indications of care.

Table 2. Incidence of green ash trees with borer damage in windbreaks in 4 land resource areas, North Dakota, 1972.

Land resource area	Trees examined	Windbreaks examined	Carpenterworm		Ash borer		Other borers	
			Trees	Windbreaks	Trees	Windbreaks	Trees	Windbreaks
	No.		Per cent					
53	952	23	2.0	43.5	2.1	34.8	1.6	17.4
54	1117	26	23.4	53.8	7.2	84.6	1.4	26.9
55	1044	24	.5	8.3	2.5	50.0	1.0	20.8
56	983	23	.9	4.3	1.8	30.4	.9	13.0
All	4096	96	7.2	28.1	3.5	51.0	1.2	19.8

Control

Chemical insecticides. At present, only carbon disulfide, used as a burrow fumigant, is registered for use against the carpenterworm. Endosulfan and lindane are registered as trunk sprays against the ash borer. Young borer larvae are especially vulnerable to long residual insecticides applied as sprays to the rough bark of branches and trunks of infested trees. Dursban® is reported to have a long residual on wood surfaces (4), and it, too, may be useful for borer control, but it is not yet registered for this use. Spraying the "brood" trees or trees with evidence of past or current infestation for three or four consecutive years should eventually eliminate the borer infestation.

Natural enemies. A wasp, **Macrocentrus marginator** (Nees)[1] was found as a parasite of the ash borer at several locations in North Dakota in 1972. The carpenterworm has few insect parasites, and none have been found in recent surveys on the northern Great Plains. Spiders are probably important predators of young borer larvae (Solomon, personal communication). Woodpeckers and other arboreal birds are known to prey heavily on the carpenterworm (7, 13).

In one instance, carpenterworm larvae were killed in their galleries in green ash by a fungus, **Beauvaria bassiana,** a well-known insect pathogen and widely distributed in nature. However, it was unusual to find it in the interior of a tree, a relatively uncontaminated environment.

Autocidal control. Male carpenterworm moths are attracted to female carpenterworm moths over distances greater than two miles (15). A successful control strategy may utilize a synthetic attractant (14) and a sterilant (10) for the male moths. Sex attraction of the ash borer also has been demonstrated (8).

Cultural control. Development of borer-resistant varieties may be one solution to the borer problem. In 1954, seeds were taken from a green ash tree apparently resistant to borers, in a farmstead windbreak near Carlyle, Montana. This tree showed no evidence of borer injury although all other green ash trees in the planting had been injured severely. The seeds (Accession No. 12002) were planted in 1955, and four of the resulting seedlings were planted at the Great Plains Research Center, Mandan, N. D., in 1957. Carpenterworm larvae caged on two of these trees in July, 1970, were still alive in September, 1972. In August, 1971, the parent tree from which the seeds were taken in 1954 was examined and found to be infested by carpenterworm. Considerable green ash material traceable to this selection has been planted in North Dakota and South Dakota. These plantings should be watched carefully to detect borer incidence lower than in plantings originating from other sources.

[1]*Identified by P. M. Marsh, USDA-ARS, Systematic Entomology Laboratory, U. S. National Museum of Natural History, Smithsonian Institution, Washington, D. C.*

Reducing Impact of Borers

The value of green ash warrants measures to reduce the likelihood of serious damage by borers. We have sufficient experience with the problem and knowledge of the habits of the insects to suggest methods of effective pest control: surveillance, detection and suppression.

Surveillance. All plantings of green ash—from a single tree in a lawn for ornamental purposes to mile-long rows in field windbreaks—should be examined frequently and thoroughly for past and current evidence of borers. In field plantings, inspection annually for at least the first five or 10 years would assure early detection and control of a borer problem. If suppression is required, surveillance should continue after control to determine if the control effort was adequate.

Detection. Carpenterworm infestations older than one year can be detected by the volume of chewed wood, bark bits, frass and webbing. Close examination of the bole from ground level up is necessary to detect recent attacks of both borers. Sunken and discolored areas, cracks and other wounds must be examined closely. In field and farmstead windbreaks, a systematic sampling method may be used to estimate the percentage of infested trees within specified error limits. It may not always be possible to distinguish which borer is present by the damage, but the insects themselves are easily separated. For example, pupal cases of the two species are easily distinguished by size and shape. They are left in the burrow openings when the moths emerge.

Suppression. Several alternatives are available for dealing with active borer infestations.

1. Infested trees may be cut and removed. The cut should be as close to the ground as possible because the borers are sometimes below ground level. The functions of multi-row plantings are not likely to be impaired by the removal of as high as 50 per cent of the green ash trees, and the vigor of the remaining trees may be improved by the thinning (16). Sprouts are produced profusely from green ash stumps. The density of the windbreak may be improved by the sprouting; thinning sprouts to single stems may soon produce replacement trees.

Infested trees removed must be destroyed by burning or deep burial at least before the following May.

2. Insecticides with at least three months residual should be used to kill newly hatched larvae seeking sites to start burrows. The rough bark of branches and trunks of infested trees must be thoroughly sprayed annually for at least three or four consecutive years to kill each new brood of larvae which may be present. Get the recommendations of your local county agent or State Extension Entomologist to select insecticides for use.

3. Cutting and spraying methods may be combined in severely infested plantings where complete removal would reduce windbreak effectiveness.

4. Burrow fumigation would be effective and practical for small infestations. Inject the material into the burrows with an oil can and seal the openings with mud, putty, or similar material. Again, local recommendations should be sought.

The costliest item in borer suppression will be labor. In field trials in 1971, insecticide costs were about $0.12 per tree. Finding, marking and spraying infested trees required about 0.1 man-hour per infested tree with a two-man crew. Borer control projects might make good use of tree-planting crews after planting is completed in the spring.

The usual methods of maintaining tree vigor may prevent borer problems. Trunk wrappings with or without trunk sprays may protect high-value ornamentals. Avoid pruning; larvae sometimes become established around branch stubs. In some areas snow and ice damage is common; broken branches and stems should be removed. Take special care to prevent injury during cultivation or other maintenance. Trees in lawns and boulevards are especially vulnerable to wounds from lawn mowers.

Summary

In the past 10 years, fear of infestation by wood borers has limited the use of green ash as a major component of windbreaks on the northern Great Plains. A 1972 survey confirmed and quantified the extent of the borer problem in North Dakota. The ash borer was found in about half of the plantings sampled, and the carpenterworm was found in 28 per cent. Borers were more common in the southwestern quarter of the state. The ash borer predominated in plantings less than 16 years old; the carpenterworm in plantings more than 15 years old. Other borers, probably **T. bimaculatus,** were especially abundant in plantings more than 30 years old.

The borer problem should not prevent planting green ash wherever it is needed, but management practices should include pest control with recommended insecticides or alternative methods to provide adequate protection and development of the most effective wind barriers.

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