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A Report to the 1975 Eastern Plant Board

THE RED PINE SCALE IN NORTH AMERICA

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Members of the 1974 Eastern Plant Board appointed a four-man committee to make an in-depth evaluation of the present and future status of the red pine scale, *Matsucoccus resinosae* B. & G., in North America. Herewith is our report.

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THE RED PINE SCALE IN NORTH AMERICA

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The red pine scale was initially found in 1946 in red pine plantations in western Connecticut (Plumb 1950). The infestation was extensive, indicating that the insect had been present for several years prior to its recognition. It was recognized as an undescribed species of *Matsucoccus* and subsequently described and named *Matsucoccus resinosae* by Bean and Godwin (1955). It now occurs in Connecticut, New York, and New Jersey. This species is presently established south of the natural range of red pine, but it is moving north and westward and may, in time, infest natural stands. Inasmuch as there are no suitable procedures for coping with this pest, which kills its host, this insect must be considered the most serious pest of red pine.

TAXONOMY

Red Pine

(Harlow and Harrar 1958, Critchfield and Little 1966).

Order	•	Coniferales
Family	•	Pinaceae
Genus	•	Pinus
Subgenus	•	Pinus
Section	•	Pinus
Subsection	•	Sylvestres
Species	•	resinosa Ait.

Red Pine Scale

(Bean and Godwin 1955)

Order	•	Homoptera
Superfamily	•	Coccoidea
Family	•	Margarodidae
Tribe	•	Matsucoccini
Genus	•	Matsucoccus
Species	•	resinosae B. & G.

BIONOMICS

Red Pine

The silvics of red pine have been discussed by Fowells (1965). It ranges through southern Canada from Newfoundland to southeastern Manitoba and south through the Lake states and northeastern U.S., with outliers in Illinois and West Virginia. The natural stands of red pine are generally confined to sandy soils of low fertility, although it is often found in small groups near swamps and on rocky cliffs. Heavy cutting in the early 1800s depleted many natural stands, which did not reproduce because of competition from more aggressive species such as hemlock, white pine, and hardwoods. The largest stands now occur in Quebec, Ontario, New York, Minnesota, Michigan, and Wisconsin (Table 1).

Red Pine Scale

Life Cycle. The life cycle has been discussed in detail by Bean and Godwin (1955) and Duda (1961). The stages include the egg, first stage larva, intermediate stage, and adult.

(a) Egg. These hatch in 15-20 days in the laboratory. Adults of the overwintering generation lay eggs from May until the first week of July. Adults of the summer generation lay eggs from about the middle of August until the last of October. Eggs are laid in ovisacs in cracks or crevices in the bark and axils of branches, under loose bark scales, and on needles.

(b) First stage larva. This is the overwintering stage. Duration varies from 45-50 days for the summer generation and from 235-260 days for the overwintering generation. The newly hatched larvae are active and may crawl considerable distances before settling down to feed. Suitable feeding sites are under loose bark scales or in cracks and crevices where

the crawlers have access to the succulent inner bark. Sessile or motile forms of this stage may be found throughout the year.

(c) Intermediate stage. This is a sessile feeding stage. It remains in the same location selected by the first stage larva. Intermediate stages of the overwintering generation occur in the latter part of April into early July. Those of the summer generation occur from mid July into October.

(d) Adult. The male forms that emerge from the cast skins of the intermediate stages are not true adults but pre-adults. Almost immediately after emergence, these pre-adult males spin a loose, fluffy, spindleshaped cocoon of waxy threads whereupon transformation to the true-adult stage occurs. Females, which do not pupate, are wingless and resemble the pre-adult males but are much larger. They crawl over the bark in search of suitable oviposition sites. Males are winged and locate females via a pheromone (Doane 1966). Females lay an average of 262 eggs.

(e) Generations. There are two generations per year and sometimes there is a partial third generation (Bean, personal communication).

Dispersal. Dispersal mechanisms are not thoroughly understood. Females are wingless, accounting in part for the slow spread of this insect (Doane 1959a). Also, red pine is sparsely scattered throughout much of the infested area (McIntyre 1956). Presumably, natural dispersal occurs only during the motile stages; i.e. first stage larva and female. First stage larvae may become air-borne and have been recorded to travel a quarter of a mile (Bean and Godwin 1955). Birds and mammals may also transport the motile stages (Duda 1961). Motor vehicles are also known to transport these insects, and this means of transport may account, in part, for infestations occurring initially along roadsides (Duda 1961). All stages may be carried on nursery stock and timber and other red pine products that are transported out of infested areas. Wind, however, is probably the natural and most important means of dispersal.

Table 1. Red Pine Roundwood Resource in North America

Location	Acres of Plantations[1]	million cubic foot volume (all stands)[2]
USA		
Connecticut	9,900	58.7
Maine	15,700	42.5
Massachusetts	7,400	23.3
Minnesota	199,000	199.5
Michigan	723,500	289.6
Ohio	33,900	16.3
Pennsylvania	32,200	NA[4]
Rhode Island	600	11.8
New Hampshire	16,000	49.1
New Jersey	9,500[6]	NSV[5]
New York	95,900	327.3
Vermont	15,200	32.9
Wisconsin	239,400	241.1
West Virginia	200	NSV
Indiana	1,300	NSV
Iowa	1,800	NSV
Canada[3]		
New Brunswick		45.0
Nova Scotia		26.0
Ontario		750.0
Quebec		222.0
	TOTAL	2335.1

[1]Data obtained from Kingsley and Mayer (1972).
[2]Data obtained from the most recent forest survey by the U.S. Forest Service.
[3]Data obtained from Horton and Bedell (1960).
[4]NA – Not available.
[5]NSV – No significant volume.
[6]Data from John D. Kegg.

Natural mortality factors. Life table studies suggest that the primary mortality factor is the degeneration of phloem cells following repeated attacks on trees (Duda 1961). This effect on the host prevents the establishment of first stage larvae. Predators are also considered important, but obviously, these biological agents are not sufficient to protect plantations from being heavily infested. Predators include *Xenotracheliella inimica* Drake and Harris (Hemiptera: Anthocoridae), a cecidomyid that preyed upon eggs, *Chrysopa* sp. nr. *carnea, Hemerobius stigmatus* Fitch, *Mulsantina picta* (Rand), *Crematogaster cerasi* Fitch, and mites belonging to the genus *Anystis*, along with several species of spiders and nuthatches (Duda 1961, Bean and Godwin 1955, Plumb 1950). No insect pathogens or parasitoids have been reported.

Hartzell (1957) reported that first stage larvae were highly susceptible to temperatures of −10°F. Few survived two exposures of −10° for four hours. This susceptibility may, in part, explain the slow northward spread of this insect.

Hosts. Aside from red pine, *M. resinosae* has been reported infesting three species of exotic pines in North America. Infestations have been reported on Chinese pine (*P. tabulaeformis* Carr.), Japanese red pine (*P. densiflora* Sieb. and Zucc.) and Japanese black pine (*P. thunbergiana* Franco) (Hartzell 1957, Duda 1962, 1964b).

Red pine scale was reported not to attack any of the following eighteen species of pine (Hartzell 1957):

Pinus aristata Engelm.
P. armandi Franch.
P. ayacahuite Ehrenb. (*P. hamata* Roezl.)
P. bungeana Zucc.
P. cembra L. var. *sibirica* Loud.
P. flexilis James
P. griffithii McClelland (*P. excelsa* Wall.)

P. heldreichii Christ. var. *leucodermis* (Ant.) Markgraf ex Fitschen.
P. koraiensis Sieb. & Zucc.
P. lambertiana Dougl.
P. monticola Dougl.
P. mugo Turra var. *rostrata* Hoopes (*P. montana* Mill., *P. uncinata* Ramond.)
P. nigra poiretiana (Ant.) Aschers. & Graebn. (*P. laricio* Poir. var. *calabrica* Loud.)
P. parviflora Sieb. & Zucc. (*P. pentaphylla* Mayr.)
P. peuce Griseb.
P. ponderosa Dougl.
P. rigida Mill.
P. sylvestris L. var. *rigensis* Loud.

Survival in cut logs. Infested trees have been and are continuing to be salvaged and are often shipped outside of infested areas. These salvage operations are often carried out during the winter, and the question arises as to whether the first stage larvae can survive to adulthood the following spring on cut logs. Data by Duda (1964a) suggest that survival does occur and that logs could carry this species unless they are debarked or otherwise utilized in such a fashion that would destroy the overwintering larvae.

Geographical distribution. Red pine scale occurs in Connecticut, New York, and New Jersey. The infested areas within these states are shown in Figure 1. In Connecticut, infestations have been moving north and eastward at a rate of about 1 or 2 miles per year, though in recent years the spread may be more rapid. This scale presently occurs throughout much of Fairfield and New Haven Counties, southern Litchfield County, southern portions of Hartford County, a western portion of Middlesex County, and one location in New London County.

The initial infestation in New Jersey was found near the Wanaque Reservoir in Passaic County. All infestations to date have occurred within 10 miles of the initial infestation. Infestations also occur in Bergen County.

In New York, red pine scale was initially found in 1950 in East Norwich, Long Island, and in lower Westchester County. Spread has been at 1 to 5 miles per year. The scale now occurs in all but the northwestern part of Westchester County, on most of Long Island, in southeastern Putnam County, the extreme southeastern tip of Orange County and the extreme southwestern tip of Rockland County.

RELATED SPECIES AND THEIR GEOGRAPHICAL DISTRIBUTION

Red Pine

The following species all belong to the subsection Sylvestres and are closely related to *P. resinosae* (Critchfield and Little 1966):

P. tropicalis Morelet, Tropical pine. Isle of Pines and western Cuba.

P. nigra Arnold, Austrian pine. Ranges widely through southern Europe from Spain to Austria and throughout much of the Balkan Peninsula east to southern Russia and south to Turkey, on the islands of Cyprus, Sicily, and Corsica, with outliers in Algeria and Morocco.

P. heldreichii Krist, Heldreich pine. Balkan Peninsula and southern Italy.

P. mugo Turra, Swiss mountain pine. Central and southern Europe, ranging east to the USSR, south to Rumania, Bulgaria and central Italy, north to Germany and Poland, and west to eastern Spain.

P. pinaster Ait., Maritime pine. Ranges from the Iberian Peninsula to southern France, to the west coast of Italy, in northern Africa from Morocco to Tunisia, and to the islands of Corsica and Sardinia.

P. halepensis Mill., Aleppo pine. Widely distributed in the Mediterranean region.

P. brutia Ten. The eastern Aegean region, Turkey, the Levant, on the Mediterranean islands of Crete and Cyprus, and in the Black Sea region.

P. sylvestris L., Scotch pine. This is the most widely distributed species of pine and grows throughout northern Eurasia, from Scotland, southern Spain, northern Greece and northern Turkey to northern Manchuria, and the Sea of Okhotsk.

P. densiflora Sieb. & Zucc., Japanese red pine. Japan, Korea, to eastern Manchuria and adjacent USSR, and the Shantung Peninsula of China. Its distribution on the mainland of Asia is uncertain.

P. thunbergiana Franco, Japanese black pine. Japan and southern Korea.

P. massoniana Lamb., Masson pine. Widely distributed in China.

P. taiwanensis Hayata, Taiwan red pine. Taiwan.

P. luchuensis Mayr, Luchu pine. Ryukyu Islands between Japan and Taiwan.

P. hwangshanensis Hsia, Hwangshan pine. Central China.

P. tabulaeformis Carr., Chinese pine. Occupies a broad discontinuous belt in China.

P. yunnanensis Franch., Yunnan pine. Confined to Yunnan, southern Szechuan, and the western parts of Kwangsi and Kweichow.

P. insularis Endl., Khasi pine. Southeast Asia.

P. merkusii Jungh and deVriese, Merkus pine. Ranges from eastern Burma, northern Laos, northern Viet Nam and the island of Hainan, south to Cambodia, southern Viet Nam and the island of Sumatra, and east to the Philippine Islands.

Red Pine Scale

The following species also belong to the genus *Matsucoccus* (Bean and Godwin 1955, Duda 1961):

Species of *Matsucoccus*	Host	Distribution
	Nearctic	
acalyptus Herbert	*Pinus edulis* Engelm.	California, Arizona, New Mexico, Utah,
	P. monophylla T. & F.	Colorado, and Idaho
	P. balfouriana G. & B.	
	P. aristata Engelm.	
alabamae Morr.	*Pinus* sp.	Alabama
bisetosus Morr.	*P. ponderosa* Laws.	California, Oregon, and Arizona
	P. jeffreyi G. & B.	

Species of *Matsucoccus*	Host	Distribution
	Nearctic (cont.)	
	P. sabiniana Dougl.	
	P. radiata D. Don.	
	P. contorta Dougl.	
californicus Morr.	*P. ponderosa*	California and Arizona
	P. jeffreyi	
degeneratus Morr.	*P. ponderosa*	Arizona
eduli Morr.	*P. edulis*	Arizona
fasciulensis Herbert	*P. ponderosa*	California and Oregon
	P. jeffreyi	
	P. sabiniana	
gallicolus Morr.	*P. rigida* Mill.	New England west to Ohio and Missouri and south to Florida and Georgia
	P. echinata Mill.	
	P. ponderosa	
	P. taeda L.	
	P. virginiana Mill.	
	P. glabra Walt.	
	P. serotina Michx.	
monophyllae McK.	*P. monophylla*	California
	P. edulis	
paucicicatrices Morr.	*P. lambertiana* Doug.	California, Oregon, Montana, and Wyoming
	P. monticola Doug.	
	P. flexilis James	
secretus Morr.	*P. ponderosa*	California, Nevada, Arizona. New Mexico, and Colorado
subdegeneratus Morr.	*P. occidentalis* (*cubensis*) Griseb.	Dominican Republic
vexillorum Morr.	*P. ponderosa*	California, Nevada, Arizona, New Mexico, and Colorado
macrocicatrices Richards	*P. strobus* L.	Ontario, Quebec, New Brunswick, Nova Scotia, and New Hampshire
	Palearctic & Oriental	
M. boratynskii Borkhsenius	*Pinus* sp.	Russia
M. feytaudi Ducasse	*P. maritima* Mill.	France
M. josephi Bodenheimer & Harpaz	*P. halepensis* Mill.	Israel
M. pini (Green)	*P. sylvestris* L.	England
M. matsumurae (Kuwana)	*P. thunbergiana* Franco	Japan
M. sinensis Chen	*P. yunnanensis* Franch.	China
M. yunnanensis Ferris	*P. yunnanensis* Franch.	China

ORIGIN OF RED PINE SCALE

The origin is unknown. The suggestion was made that it was brought into this country on pines planted on the grounds of the World Fair in 1937 and then carried to Connecticut (Doane 1959b).

Although its origin is unknown, the evidence suggests that it is indeed an imported pest from Eurasia. Red Pine is the only species of the typically Eurasian group of pines in the subsection Sylvestres that is native to North America (Critchfield and Little 1966). The host range of *M. resinosae* is unknown, but aside from red pine, it does attack three species of pine, *P. densiflora, thunbergiana,* and *tabulaeformis* that are native to Asia. It is not known to infest species of pine that occur naturally in Europe. These data suggest that red pine scale may have originated on a species of pine native to Asia.

EFFECT ON HOST

Infested red pine, including mature trees, eventually die from the feeding of the scale (Bean and Godwin 1955, Duda 1961, Doane 1959b). Trees often die quickly with little stunting or change in form (Duda 1961). The progressive morphological and histological effects on the tree have been described (Bean and Godwin 1955, Duda 1961). Plumb (1950) suggested that death may, in part, be caused by a toxin produced by the scale.

Japanese red pine has succumbed to scale attack in New York.

CHEMICAL CONTROL

No methods are available to protect plantations from succumbing to scale attack. Ornamental pines may be protected by spraying repeatedly with a 2% oil emulsion (Bean and Godwin 1955). Weekly applications of Cygon and malathion against motile first stage larvae are also effective, though neither of these two insecticides is registered for this use (Duda, personal communication).

POTENTIAL IMPACT OF RED PINE SCALE

M. resinosae is attacking trees outside the natural range of red pine. Should the scale extend into the natural range of its host, red pine would become a rare, rather than an uncommon species. It is suspected that the red pine in stands would be killed, but some, if not many, isolated trees might survive. Reproduction of natural stands would be unlikely because of unsatisfactory seedbed and sunlight.

Red pine is a relatively unimportant species in terms of the total forest of North America. It supplies a very small fraction of the timber harvested when compared to white pine, southern pines, Douglas fir, and Ponderosa pine. The chief value of red pine lies

in its adaptability to reforest on dry sites, its aesthetic aspects, and its use as pulp, posts and poles. The popularity of red pine for reforestation is evident by the many plantations (Table 1) (Kingsley and Mayer 1972).

Potential losses of red pine are in the millions of cubic feet of both natural and planted stock. The total red pine round wood that is threatened is shown in Table 1.

Damage to red pine cannot be measured in saw timber or pulpwood values alone. The impact on aesthetic values is illustrated in New Jersey where in a single year 156 ornamental red pines were cut and burned because they were infested (Kegg 1974). If these trees were replaced, the cost would average $150 per tree.

PRESENT STATE POLICIES

Connecticut guidelines are as follows:

(1) Shippers of red pine timber are encouraged to move their products during the cold months.

(2) Movement of red pine at any time within Connecticut from one uninfested location to another is permissible.

(3) Movement of red pine at any time during the year from one location to another within the infested area is permissible.

(4) Nurserymen within infested areas are encouraged to destroy their plantings.

The New Jersey State Board of Agriculture declared the red pine scale a "dangerously injurious insect" in 1961, and efforts were initiated to remove and destroy all known infestations. This policy continues to the present. The purpose of destroying infested trees is to reduce spreading the insect to pines in other areas of the state. To date, 331.5 acres of plantation and over 1,000 ornamental red pines have been cut and destroyed.

New York has no quarantine on the red pine scale. Some eradication was attempted to 1969, but this policy has been discontinued.

CONCLUSIONS

(1) Biological control. Scale insects have been the targets of numerous successful biological control attempts (DeBach et al. 1971). In fact, the proportion of success has been higher in the coccoideae than in any other group of pests.

***M. resinosae* may be found in Eurasia. Biological control agents could then be shipped to the United States for colonization. Efforts could also be expended to colonize on *M. resinosae* natural enemies isolated from other *Matsucoccus* species in North America and Eurasia.** Several successful biological controls, using enemies of allied species, have been reported (Pimentel 1963). This latter approach would of necessity require a thorough study of the bionomics of the genus *Matsucoccus.*

(2) Regulatory measures. **Regulations that could be used to limit the spread of this insect need examination.** A quarantine was rejected by the Eastern Plant Board in 1965 because the scale had already spread considerably. Nevertheless, the State of New Jersey does quarantine and it would seem that some regulatory measures might impede the progress of this insect at least until satisfactory methods of coping with it have been developed. Two suggestions follow:

a. **Determine the feasibility of removing major scale infestations around parking lots, picnic and recreational areas and along major highways.**

b. **Determine the feasibility of establishing a barrier zone with the assistance of federal funds.**

(3) Dispersal. **Intensive experiments on dispersal mechanisms of the red pine scale seem worthwhile.**

(4) Weather. **The role of low winter temperatures in limiting the spread of this species into the natural red pine growing areas of North America needs re-examination.**

(5) Host. **The mechanisms by which the scale ultimately kills the tree need investigation.**

(6) Chemical control. **Methods of controlling scales on ornamental trees with chemicals need to be re-examined and thoroughly studied.**

(7) Early detection. **Methods of early detection of infestations need to be developed.**

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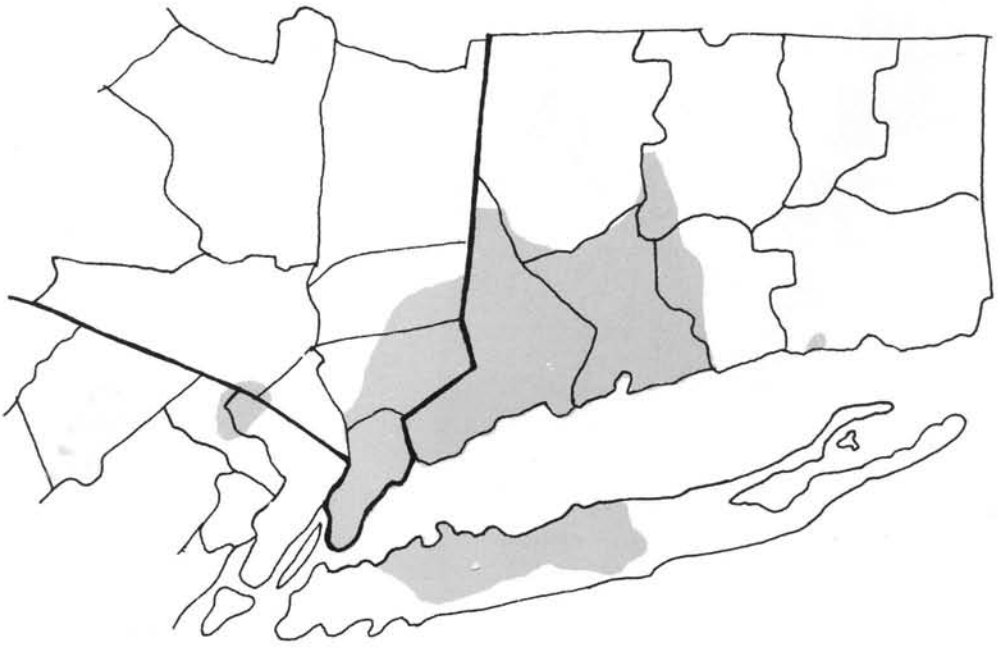

Figure 1. Shaded areas show infested areas of red pine scale in Connecticut, New York, New Jersey and Long Island.