KNOWN AND POTENTIAL INSECT PESTS

of

BRISTLECONE PINE (Pinus aristata)

M. R. GARDNER

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ABSTRACT

The recorded and potential insect pests of a unique and long lived pine, Pinus aristata (Bristlecone pine) are given. The importance of this pine to science and the general public is discussed. The taxanomic position of the pine is reviewed in relation to other pines of the genus found growing in association with the Bristlecone. Some possible mechanisms of insect resistance evolved by the Bristlecone are suggested. Listings of potential insect pest are developed by examining the ecological associations of Bristlecone pine with other tree species and further examining these species for documented insect pests. Insects exhibiting host non-specificity and concurrent geographic distribution are suggested appropriate candidates for further screening. Two pine beetles, Dendroctonus species and a scale insect, Matsucoccus species appear to warrant immediate investigation. Insects attacking cones and seedlings are also of high priority. It is suggested that a contigency plan be developed with hazardous potential pests in mind particularly in light of the increasing public usage of the Bristlecone Pine Forest.

INTRODUCTION

The purpose of this paper is to briefly examine the known and potential insect pests of an interesting high altitude pine of very limited range yet great antiquity; Pinus aristata, commonly called Bristlecone pine. The common name is apparently derived from the needle sharp hooked spines on the cone scales giving the cones an overall bristly appearance.

For the purpose of this paper known insect pests have been directly searched in the literature while the potential pest listings have been prepared by determining those

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1 Graduate Student, Department of Biological Sciences, Simon Fraser University

tree species which occupy an ecological habitat and range with Bristlecone pine, and documenting those species of insect which are a recorded pest of two or more of the tree species. While this in no way substantiates that a particular pest will attack Bristlecone pine it provides a benchmark for more intense investigation of host specificity, geographic and altitudinal range of these insects and of the probable defense mechanisim unique to Pinus aristata.

The importance of Bristlecone pine,also sometimes called Hickory pine,is not that of a timber species but rather one of scientific and aesthetic values unparalleled in the Botannical Kingdom. Specimens of these unique trees are the oldest known living things (1) attaining ages well over 4,000 years. This now discounts the long held belief (2) that Sequoia gigantea was the oldest living thing. The late Dr. Edmund Schulman,a Dendrochologist, Laboratory of Tree Ring Research at the University of Arizona,first discovered the antiquity of the Bristlecone in 1953 while looking for tree species with a combination of considerable age and high sensitivity to rainfall. Such species become a key to unlocking fluctuations in the world's climate over centuries and dating ancient artifacts (3) (4) (5) (6) (7) (8).

First indications of the importance of this discovery of pines with great longevity was published in 1954 (9). However, it was not until 1956 when sufficient field mapping and core sample analysis had been completed that trees almost 5,000 years old were discovered (10) (1).

Scientific considerations apart the tree itself merits great awe as seen in the attached photograph, the sculpturing of the elements causing the white twisted lines to contrast strikingly with the deep green bushy foliage. It can also be well seen how the bristlecone's close relation to the Foxtail pine P. balfouriana also came by its common name. P. aristata is a tree of high mountain ridges; sites of extreme exposure. It appears to have a preference for dolomitic soils (11) and despite this mountain habitat a moisture requirement below ten inches per annum mainly from snow melt,all that is available in the range shadow of the Sierra Nevada Range. It is rarely found below 9,000 feet yet despite the arid and exposed conditions it must endure. It does not exhibit the sprawling many-stemed 'Krummholz' of other timberline conifers. Despite all adversity it clings to an upright habit. Its growing season rarely exceeds two months. Drought resistance is considerable and the tree has a deep spreading root system. One researcher has noted that aristata has one of the most highly developed mycorrhizal associations of any conifer (12), it is also exceedingly wind firm. Where it grows in stands as in the Inyo National Forest (brochure attached) it has wide spacing measured in the hundreds rather than tens of feet. Preston (13) notes that P. aristata will not exceed 60 feet in height and 3 feet in diameter, although this writer has seen specimens exceeding both measurements.

Little if any mention is made by Schulman or other paleoclimatologists regarding longevity in the context of resistance that the bristlecone have to insect pests. Mention is made that high altitude may assist and account for minimal decay (14). Further, Clapper (15) indicates that P. aristata may be somewhat more resistant to Cronartium ribicola and thus serve as an important member of the gene pool for breeding disease resistant white pines.

In fact information regarding insect pests of P. aristata seemed extremely scarce and really current. A number of workers have suggested that the highly resinous nature of the wood could have assisted in protection (1) (8) (15b) (16) while Cornell (17) has noted that the wood is extremely dense and difficult to cut. Preston (13) also notes that the lower or ventral surfaces of needles have numerous rows of stomata usually showing conspicuous exudation of resin. Spiral growth common in high altitude conifers (14), spacing, wood chemistry (18) (19) (20) and the often striplike bark growth (1) (14) may also assist the plant and account for its so successful growing record.

Despite the obvious hardiness and upright habit of the bristlecone little attempt seems to have been made to emulate the spectacular relocation of another poor timber pine from the United States, P. radiata now growing successfully in Chile. However, record has been made in the liturature of P. aristata planted and growing in Iceland (21). Unfortunately no English translation is available but it would appear that the species has shown itself to be both frost and insect resistant.

TAXANOMIC ASSOCIATIONS

There are several concentrations in the northern hemispherical distribution of the 94 recognized species of pine. The region of western North America including Mexico and Central America has 44 species (22); California has 19 of the 23 species of Pinus probably the greatest concentration of the genus. It would appear that three species are endemic to California, P. balfouriana, P. sabiniana and P. torreyana. Balfouriana is the only high altitude five-needled pine of this group. The closely related P. aristata, unlike P. balfouriana, seems to grow only on the east of the Sierra Nevada Range and is found in the States of Nevada, Arizona, New Mexico, Utah and Colorado. P. balfouriana presently found only in California may just enter southeastern Oregon. Little (22) suggests that altitude, climate and edaphic conditions may have accellerated speciation. Certainly altitude remains a highly determinative factor in the present distribution of the bristlecone and foxtail pines. Bristlecone pine was first described by George Englemman in 1862 (23). It is a five-needle pine and closely related to balfouriana first described by Balfour in 1853 (24). Full taxanomic description and classification was given by Rehder in 1942 (25) and this has been adopted by Little in his 1969 revue of the Subdivisions of Pinus species (22). Rehder introduced a 3-rank system of Subgenus, section and series. In the case of bristlecone pine Subgenus is given as Strobus, section as Parrya and series as balfouriana. The series contains only the two pines P. aristata and P. balfouriana. However, a more recent worker Bailey (23b) has suggested that Pinus aristata should be further subdivided into two new series, aristata and longaeva. In 1924, Shaw (26) included the Vietnamese species Pinus krempfii in the balfouriana series; however, Little and Critchfield separated this species into a new subsection in 1966 (27).

Species in the group balfouriana are characterized by very small seeds with long detachable rings. Needles are entire, short (2 to 4 centimeters long), slightly appressed with five to a fascicle. Needles are noted as being extremely long-lived (8). Distribution of these pines is shown in the attached map from Little and Critchfield (22).

A number of species are discussed in the section on Ecological Associations. Their Taxanomic Associations are reviewed briefly here. The Truga Juniperous are not closely related synomically to Bristlecone pine; however, four of the pines, monticola, flexilis,monophylla and albicaulis all belong to the same subgenus, Strobus, as P. aristata. P. monofilia belongs to the same section, Parrya,as aristata though in the Subsection Cembroides while P. flexilis, monticola and albicaulis belong to a different Section, Strobus. P. flexilis and monticola belong to the one Subsection, Strobi while albicaulis is in the Subsection Cembrae. None of course belong to the same Subsection Balfouriana as Bristlecone and Foxtail pine. P. contorta,another ecological associate of Bristlecone pine belongs to a separate subgenus Pinus, subsection Contorae and as a two-needled pine is somewhat removed taxanomically from those above.

ECOLOGICAL ASSOCIATIONS

Of importance in considering potential pests of Bristlecone pine are those non-specific insects which are known to attack related species and species of similar habitat, or insects which have the potential to change host and enlarge their known range. In order to examine this a brief review has been made of trees with similar growth requirements and range as P. aristata. More detailed information on ecological conditions in the Bristlecone pine forest are given by Curry (32), Loope (33), Billings (34) and St enhoff (35).

As noted before, climatic, eda ic and altitudinal factors primarily limit the range of Bristlecone pine. These factors also form the basis for a zonal categorization commonly used in formal ecological associations. As early as 1898 Merriam (28) suggested the life zone concept and Peterson writing in 1975 has still used these zones as broadly descriptive in his book Native Trees of the Sierra Nevada (29). Of interest in this paper is: Canadian Boreal and Hudsonian zones. Of more specific use however, are the biotic communities recognized by Smith (30). Communities of the High Sierra Sub-Alpine Forest, the Bristlecone Pine Forest, and the Pinyon-Juniper woodland encompassing those tree species found in association with Bristlecone pine. The Western Sierra, Juniperus occidentalis grows in each of the communities previously mentioned and can be found on wind swept ridges up to 11,000 feet in the Sierra Nevada (14). It is a picturesque tree up to 60 feet tall but at the higher altitudes it tends to be knarled and grotesque. It is readily recognized by its shreddy cinnimon brown trunk. At present no insects associated with Juniper appear to attack the Bristlecone pine and it will not be dealt with further.

Often growing in association with this Juniper is the unique one leaf Pinyon or Nut Pine, P. monophylla. At the limits of its altitudinal range, just below the timberline at 9,000 to 10,000 feet it is an extremely slow growing yet symmetrical tree usually not more than 30 feet tall (29) it may grow for as many as 200 years but rarely longer. Yosemite National Park appears to be its most northerly range (14). Because of the limited tree growth of the region this widely distributed pine is given a value greatly in excess of that accorded a tree of similar form in a timberland region (31).

Tsuga mertenesiana, the Mountain Hemlock, is an upright-growing high mountain tree readily attaining heights of 100 feet and is easily identifiable by its open pyramidal grown terminating in a long drooping leader. It is found in the Sierra Nevada as scattered individuals or stands and near the timberline at 11,000 feet, and may be reduced to no more than a wind sheared alpine shrub. The larger specimens in sheltered corries with graceful drooping branches have been considered since the time of Muir (36) to be as picturesque as any high country tree. Preston (29) suggests that it will grow for upwards of 1,000 years. As with the Juniper it would not appear that this specimen has any insect associations which would be a potential hazard to Bristlecone pine and is therefore not dealt with further.

Lodgepole pine P. contorta latifolia also known as Tamarack pine has a widespread range at elevations up to 11,000 feet. This tall and slender tree even at high altitudes and in stands can reach heights of 75 to 100 feet (29). Though rarely intermingled with P. arastata both the altitudinal and geographic ranges of these species overlap.

Two White pines and one Stone pine also have similar ranges; P. albicaulis or white bark pine has an extensive range from Nevada to B. C. and Alberta and at altitudes up to 12,000 feet (13) (29). At high altitudes it seems to adopt a spreading shrub-like habit. It is often found in association with limber and lodgepole pines.

P. flexilis or limber pine so named for its unusually sinuous branches is normally a low thick trunked and much branched tree 25 to 50 feet tall but may reach 80 feet in the mountains of Arizona. Its crown consists of long drooping branches often slender and pendulus at the end. It is typically found scattered with other conifers and only occasionally in pure stands. Range is from Canada to the Mexican boarder at altitudes up to 12,000 feet (14). It is often found in association with Bristlecone pine though has a considerably shorter lifespan in the order of 300 to 500 years.

Western White Pine P. monticola also known as Silver Pine and occasionally a Little Sugar Pine is the Western representative of the White Pines and may reach 150 feet in close stands on favourable sights. It occurs extensively in fewer stands at lower elevations but is found scattered with Lodgepole pine at higher elevations up to maximum of 10,500 feet (29). This Western pine has a general range throughout the Rocky Mountains from Canada and Montana to Southern California and westward to the Pacific Coast (14). The impact of blisterust has of course severely reduced the population of this pine. Left undisturbed Western White pine can obtain a life span of up to 500 years.

INSECT ASSOCIATIONS

It is not within the scope of this paper to examine in detail the life history, actual present distribution, frequency of intensity of attack, or 'economic' impact of the insects noted below. Predisposition to fatal injury after attack of one insect, for example leaf miner, and subsequent mountain pine beetle debilitation is also not discussed. Whenever an insect is conclusively known to have a range outside the distribution of Bristlecone pine it is not included in the suggested potential pests. Actual recorded pests are given for both P. arastata and P. balfouriana. As noted in the introduction potential pests are suggested by examining host non-specificity of insects known to attack ecologically associated conifers. Where the literature substantiates that an insect will attack two or more tree species it is listed.

Cat gories used for separation are fairly arbitrary and although taxonomic association of pests may be preferable for some workers, type of attack has been used here to differentiate between pests. This simple separation of insects has been used as it is assumed that the initial list would be used to assist field staff with limited entomological training to monitor discrete areas close to or overlapping Bristlecone pine habitats. Unclear identitication would be referred to an entomological unit for verification.

The method used here is seen as a very preliminary start to the eventual preparation of a dynamic strat gy plan for protection of the unique Bristlecone resource once the outward boundaries of the important insect complexes have been determined. The summary deals in more detail with this concept. Unless otherwise stated, work by Davidson (37) Bright (38) (39) (40) and Keen (41) (42) has provided much of the source data for the potential pest cross-reference analysis. This information is presented in eight separate tables.

PLANT PART ATTACKED	INSECT NAME
Cones	None recorded. This is of interest as the author has collected cones from below the Bristle Cone Pine forest in the White Mountains showing insect exit holes.
Needles	None recorded
Small Twigs and Branches	Carphoborus declivis Pityophthorus aristatae P. artifex P. murray anae P. pracaltus P. opimus
Under bark	Ips latidens Pityogenes fossifrons Dendroctonus ponderosae
Bode and Stump	Hylastes gracilis (may attach seedings)

TABLE I Recorded insect pest of Pinus aristata

PLANT PART ATTACKED	INSECT NAME
Cones	None recorded
Needles	Matsucoccus acalyptus (43)
Small twigs and branches	Carphoborus tuberculatus Pityophthorus inyoensis P. sierraensis P. tuberculatus
Under bark	Dendroctonus ponderosae D. monticolae D. valens Ips. confusus
Bark and Stump	Hylurgops pinifex (may attack seedlings) H. porosus H. rugipennis Gnathotrichus sulcatus

TABLE 2 Recorded insect pest of Pinus balfouriana

PEST TYPE	INSECT NAME	HOST SPECIES
Cone Beetle	Conophthorus flexilis	Pinus flexilis P. monophylla
Cone Moth	Dioryctria abietella	P. flexilis P. contorta P. monticola

TABLE 3 Potential Insect Pests - Cones

PEST TYPE	INSECT NAME	HOST SPECIES
Bud moths	Argyrotaenia pinatabana	Pinus contorta P. albicaulis
	Choristoneura fumi ferana	P. monticola P. contorta
Miner	Recurvaria milleri	P. contorta P. monticola
	Exoteleia pinifoliella	P. contorta P. monticola

TABLE 4 Potential Insect Pests - Needles

PEST TYPE	INSECT NAME	HOST SPECIES
Twig moths	Dioryctria abietella	Pinus contorta P. monticola P. flexilis
Chermes	Pineus coloradensis	P. contorta P. monophylla P. monticola
Flathead looners	Chrysophana placida	P. contorta P. monophylla P. monticola
Beetles	Pityophthorus tuberculatus	P. contorta P. monophylla
	P. confertus	P. contorta P. monophylla P. monticola
Twig beetles	Myeloborus spp	P. flexilis P. contorta
	Pityophthorus nitidulus	P. flexilis P. monticola P. albicaulis
	P. complex	P. flexilis P. contorta P. monophylla P. albicaules

TABLE 5 Potential Insect Pests - Twigs and Branches

PEST TYPE	INSECT NAME	HOST SPECIES
Bark Beetles	Dendroctonus monticolae	P. flexilis P. contorta P. albicaulis P. monticola
	D. ponderosae	P. flexilis P. contorta P. albicaulis
	D. valens	P. flexilis P. albicaulis P. monticola P. contorta
	Dryocoetes confusus	P. contortus P. albicaulis
	Hylurgops porosus	P. flexilis P. monticola P. contorta
	Ips emarginatus	P. monticola P. contorta P. albicaulis
	I. latidens	P. monticola P. contorta
	I. vancouveri	P. monticola P. contorta
	I. radiatae	P. contorta P. albicaulis
	I. plastographus	P. albicaulis P. monticola P. contorta P. flexilis
	I. guildi	P. flexilis P. albicaulus
	I. integer	P. monticola P. flexilis P. contorta

Table continued ...

PEST TYPE	INSECT NAME	HOST SPECIES
Bark Beetles	Pityogenes fossifrons	P. flexilis P. contorta P. monticola P. albicaulus
	P. knechteli	P. flexilis P. contorta
	Polygraphus rufipennis	P. flexilis P. contorta
Bark Weevils	Pissodes webbi	P. flexilis P. contorta

TABLE 6 Potential Insect Pest - Sap Wood

PEST TYPE	INSECT NAMES	HOST SPECIES
Ambrosia Beetles	Gnathotrichus retusus	P. contorta P. monticola
	Trypodendron bivittatump	P. contorta P. monticola
Flathead borers	Buprestis aurulenta	P. contorta P. monticola
	B. nuttalli	P. contorta P. monophylla
	Chrysobothris breviloba	P. flexilis P. contorta

TABLE 7 Potential Insect Pests - Heartwood

PEST TYPE	INSECT NAME	HOST SPECIES
Aphids	Cinera spp	P. flexilis P. contorta
	Pineus strobi	P. flexilis P. monticola
Scales	Matsucoccus pavcicicatrices	P. flexilis P. monticola
	Pitycococcus ferrisi	P. flexilis P. monticola

TABLE 8 Potential Insect Pest - non-specific

CONCLUSIONS

Time constraints have been a study limitation in this work. In particular the orders Homomptera, Hemiptera, Lepidoptera and Hymenoptera require further investigation. In general the literature before 1940 has not been searched and in fact information is disappointingly sparse prior to 1953 when Schulman first popularized the antiquity of the Bristlecone pine. Examination of more detailed records, where they exist, is required to accurately predict potential insect pests.

Sequential field sampling by U. S. Forest Service personnel over a number of seasons and areas would substantially improve our knowledge of the insect pests of these remarkeable trees. Wherever possible nondestructive sampling should be emphasized. Primary and secondary invaders as well as their parasite complexes should be eventually collected, identified and catagorized by relative hazard, or in a case of parasites effectiveness. In this way a protection plan could be drawn outlining an intolerable attack incidence (IAI), control methods, materials, equipment and staff, mobilization stratagy, public awareness and full funding sources. Further, such a plan should recognize the potential modes of introduction for new pests into the area now that the Inyo National Park and the Bristlecone Pine Forest are enjoying an ever increasing public visitation rate (8). Safeguards, perhaps similar to those already in force to protect California in general against the introduction of undesireable insect pests, might be suggested.

From the table provided it would seem most important to concentrate first on determining the possibility of attack from Dendroctonus species especially Mountain and Black Hills pine beetle. In addition the scale Matsucoccus acalyptus already found to cause serious damage to Pinyon pine and found in Foxtail should be more fully investigated. From this point and in view of the extremely slow rate of regeneration in Bristlecone pine, insects attacking cones and seedlings would appear to warrant further study.

The Bristlecone pine is a unique and important resource, the present level of concern regarding insect pests does not appear comparable despite clear indications that some insect pests may be potentially devastating if allowed to establish. Further work would appear justified to establish the substance of such concern and to prepare stratagy plans if necessary. In the words of the old cliche "to be forwarned is to be forarmed".

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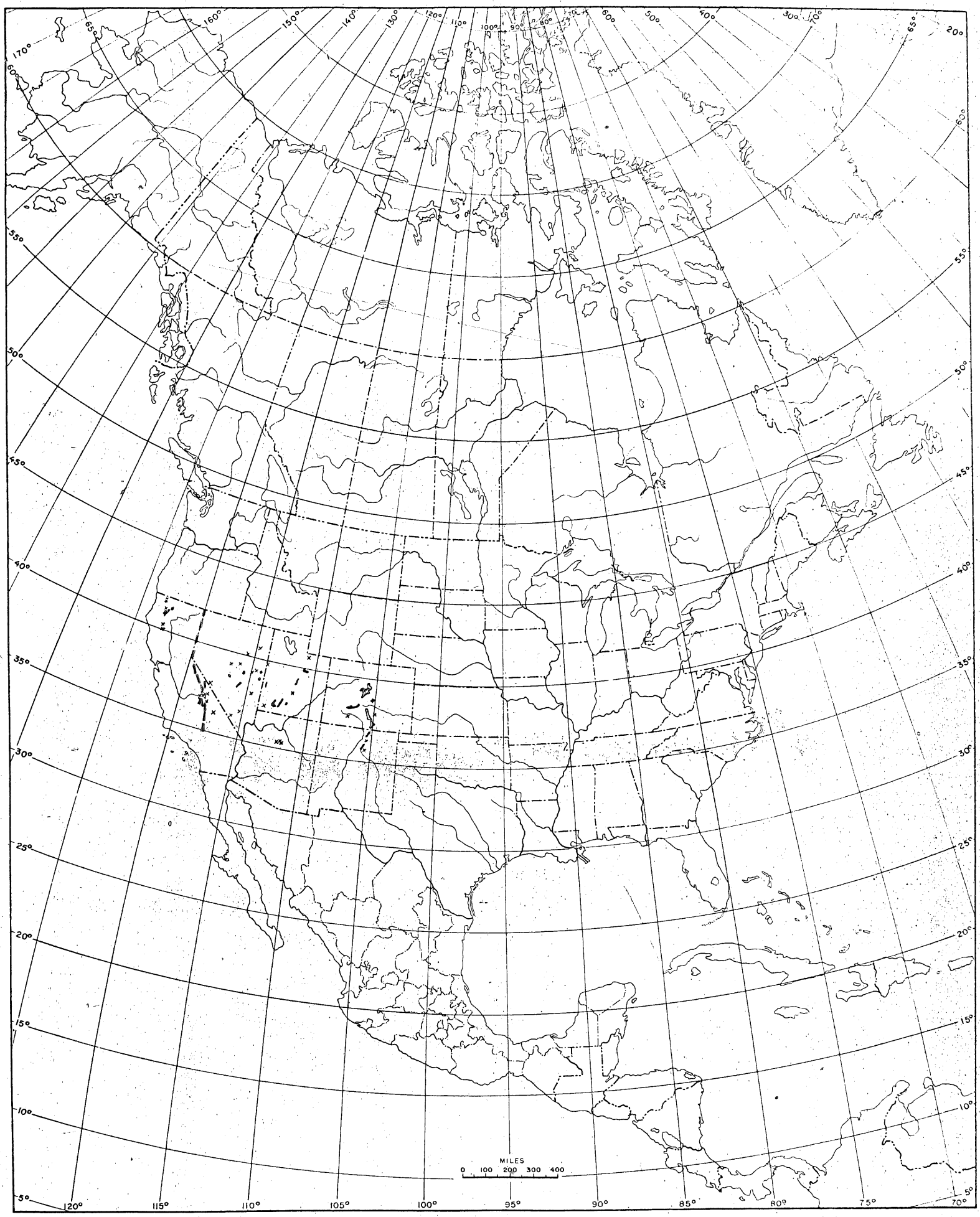

Map 15. ***Pinus*** **subsect.** ***Balfourianae*** **(2 species).** ***P. balfouriana*** **(California, west of broken line),** ***P. aristata*** **(east of broken line).**