



FOREST RESEARCH INSTITUTE
FRI BULLETIN No.124

INTRODUCED
FOREST TREES IN NEW ZEALAND:
RECOGNITION, ROLE, AND SEED SOURCE



7. The silver firs – Abies spp.

J. T. MILLER and F. B. KNOWLES

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7. THE SILVER FIRS — *Abies* spp.

J.T. Miller and F.B. Knowles

This FRI Bulletin series was compiled for people with an interest in the introduced trees of New Zealand, such as foresters, farm foresters, nurserymen, and students.



MINISTRY OF FORESTRY, FOREST RESEARCH INSTITUTE,
PRIVATE BAG 3020, ROTORUA, NEW ZEALAND

1989

ISSN 0111-8129
ODC 174.7 Abies(931):232



Abies grandis aged 26 years growing well at Gwavas Forest, Hawke's Bay, N.Z.

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ABSTRACT

This booklet, the seventh in the Bulletin No. 124 series, provides an account of the silver firs (*Abies*) in New Zealand, referring to: their introduction, history, and role as exotic forest species; their recognition in the field; and the location and quality of current local seed sources.

KEYWORDS: *Abies*, *Abies concolor*, *Abies grandis*, *Abies pinsapo*, *Abies procera*, seed sources, taxonomy, provenance trials, New Zealand

INTRODUCTION AND HISTORY

Natural Distribution

The silver firs (*Abies*) are a large evergreen coniferous genus of about 50 species. They are indigenous to four extensive regions in the northern hemisphere:

- North Africa, southern and central Europe, and parts of western Asia (Asia Minor, Caucasia, Syria, and Lebanon)
- The Himalayas, eastern U.S.S.R., Siberia, China, and Japan
- North America
- Mexico and Guatemala.

The approximate natural ranges of eight species of significance in New Zealand are shown in Figures 1 and 2.

Characteristically the silver firs occupy relatively cool, moist sites at middle to high elevations in mountainous areas. In northerly latitudes firs may occur down to sea level but elsewhere they may reach high elevations (1000–4000 m). They are found both as pure stands and in mixed forests. In parts of the western United States, from whence come the most significant of the fir species grown in New Zealand, they are widely associated with the coniferous genera *Picea*, *Tsuga*, *Thuja*, *Juniperus*, and *Pinus*.

Worldwide, natural stands of silver firs often provide important timber resources. For example, in North America *Abies grandis* (grand fir), *A. concolor* (white fir), *A. procera* (noble fir), and *A. amabilis* (Pacific silver fir) are prominent producers of sawn timber and pulp, and *A. alba* (European silver fir) has a similar role in Europe. In general, firs are not hard to establish in comparable climates outside their natural ranges; consequently, many have become familiar exotic species in both hemispheres, often valued for their ornamental qualities. However, they have been used less extensively as afforestation species than some other conifers, such as pines.

Introduction into New Zealand

In the 1860s several species of silver fir were introduced into Canterbury by the Deans brothers of Riccarton, J.B.A. Acland of Mount Peel, and T.N. Adams of Greendale, settlers noted for their extensive planting of a range of trees and shrubs. The occurrence of *A. alba*, *A. cephalonica*, and *A. spectabilis* was reported in 1865 and that of *A. concolor*, *A. nordmanniana*, *A. pindrow*, and *A. pinsapo* by 1866. The seed of these species had probably been supplied from either Veitch's nursery in England or Shepherd's nursery, Sydney. Thirty years later, in 1896, ten further species were recorded growing at "The Gums", Taita: *A. amabilis*, *A. balsamea*, *A. bracteata*, *A. firma*, *A. fraseri*, *A. grandis*, *A. homolepis*, *A. lasiocarpa*, *A. procera* (as *A. nobilis*), and *A. veitchii*.

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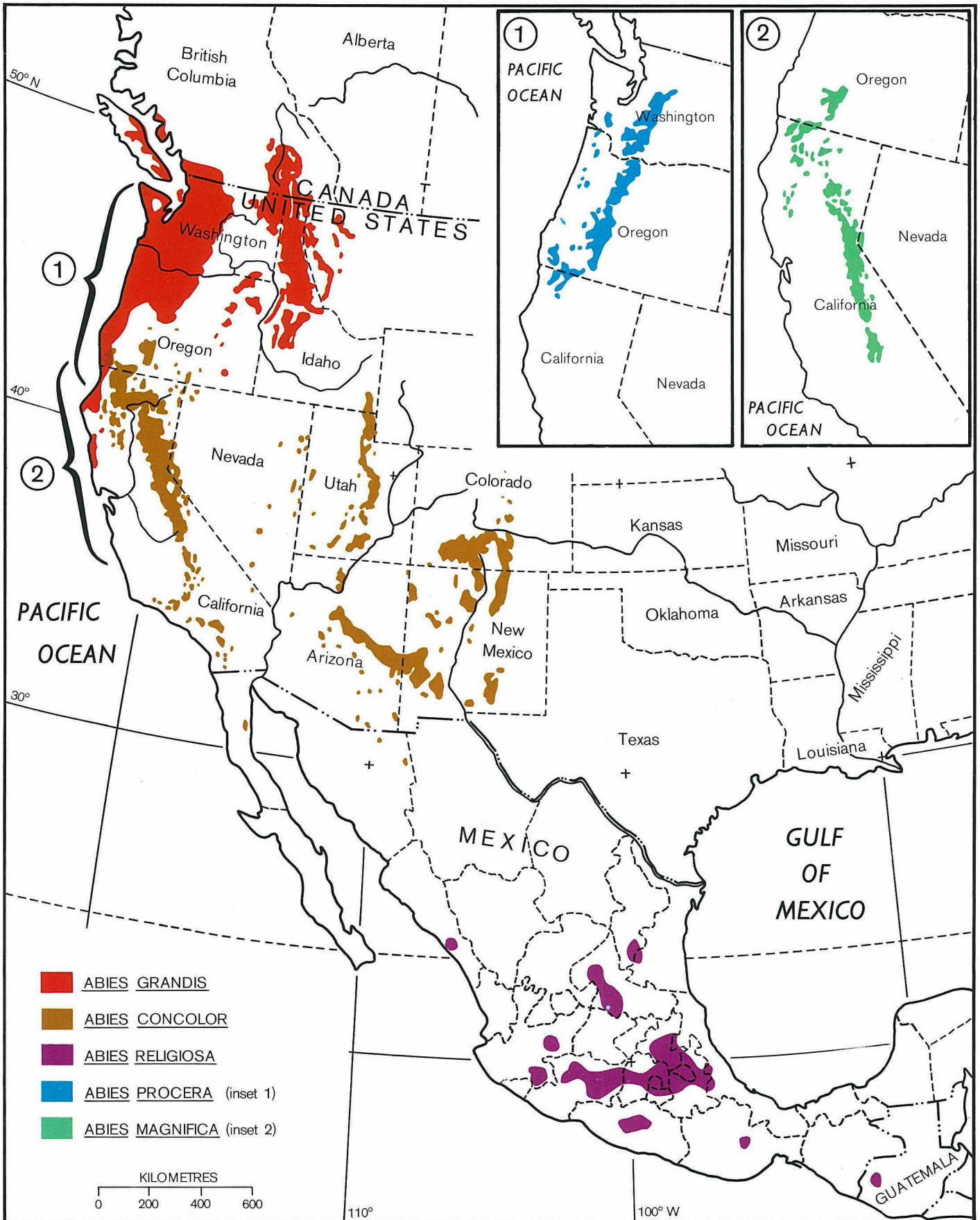


Fig. 1 — Natural distribution of *Abies grandis*, *A. concolor*, *A. religiosa*, *A. procera*, and *A. magnifica* (based on Liu 1971).

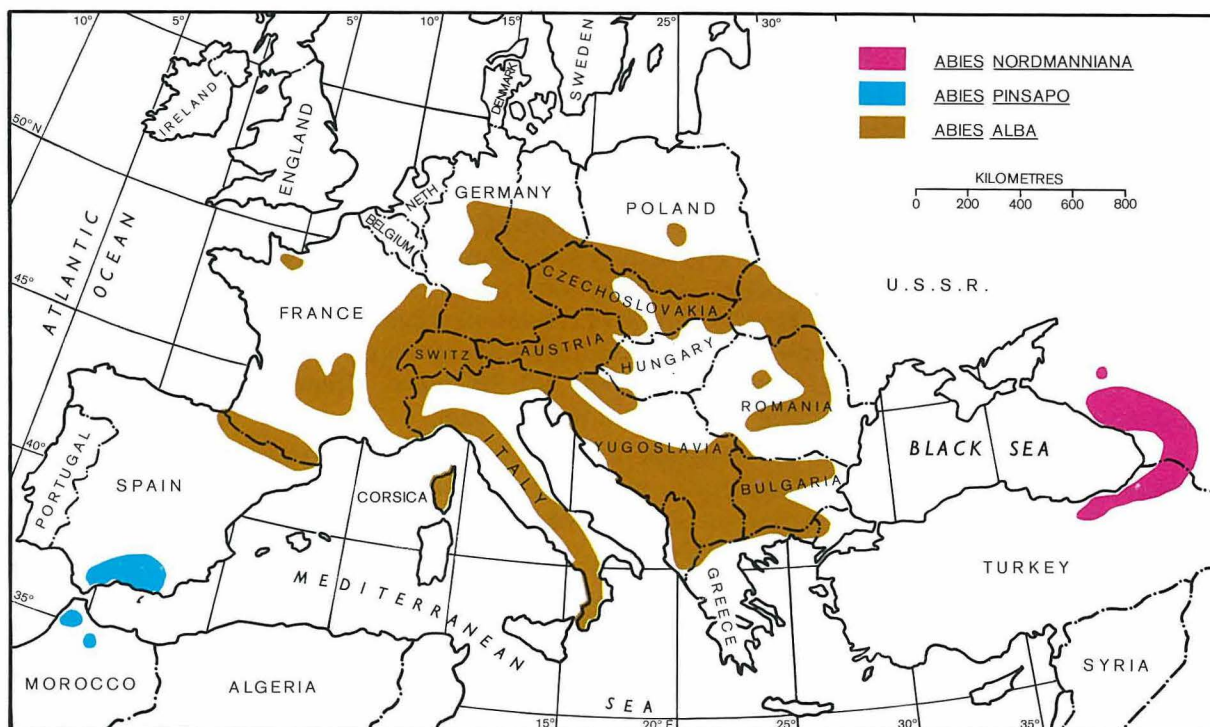


Fig. 2 — Natural distribution of *Abies nordmanniana*, *A. pinsapo*, and *A. alba* (based on Liu 1971).

Between 1875 and 1879 seed imports were made of *A. grandis* (9 kg), *A. amabilis* (10 kg) and *A. procera* (9 kg). During the 60-year period between 1927 and 1987, the New Zealand Forest Service was the main seed importer, receiving experimental seedlots of *A. cephalonica*, *A. cilicica*, *A. numidica*, *A. religiosa*, *A. firma*, and *A. vejari*, and larger amounts of *A. alba* (15 kg), *A. procera* (13 kg), *A. magnifica* (11 kg), *A. amabilis* (10 kg), *A. grandis* (8 kg), *A. concolor* (c. 2 kg), and *A. lasiocarpa*. In recent years small amounts of seed of most of the remaining species in the genus have been imported by private collectors.

Occurrence in New Zealand

Despite the continuous and varied imports of seed, plantations of silver fir species in New Zealand are largely confined to species trials in former State forests. However, *A. nordmanniana* occurs in mixture with *Cedrus deodara* both in a 67-year-old plantation of 0.4 ha at Ross Creek in Dunedin City Council reserves and an 80-year-old shelterbelt between Becks and Wedderburn in central Otago. A group of *A. grandis* occupying 0.2 ha and aged about 90 years is a prominent feature at Conical Hill Reserve on the outskirts of Hanmer Springs township in North Canterbury (see Fig. 5). Since 1959 *A. grandis* has been established on 6.3 ha of State forests and 16.5 ha has been underplanted with it in mixture with *Larix*, *Cedrus deodara*, or *Pseudotsuga menziesii*. *Abies pinsapo* has been used as a shelterbelt species in mid Canterbury and northern Otago, where it is quite common. Apart from these examples it is unusual to find groups of more than ten trees of any one fir species in New Zealand.

At least 30 species of *Abies* are now represented in New Zealand but many of these are confined to arboreta and private collections such as the McKean Pinetum, near Taihape, and the Eastwoodhill Arboretum, Gisborne. A few other species occur throughout the country as specimen trees, singly or in small groups, near areas of settlement (usually in parks, gardens, and churchyards). Those occurring most frequently are *A. nordmanniana*, *A. grandis*, *A. pinsapo*, *A. concolor*, *A. magnifica*, *A. procera*, and *A. alba*, while *A. bracteata*, *A. amabilis*, and *A. veitchii* are represented by some large and attractive trees. Other species occurring in scattered localities include *A. religiosa* and *A. firma* (both introduced from seed imported by the Forest Research Institute), *A. cephalonica*, *A. homolepis*, *A. balsamea*, and *A. lasiocarpa*.

Provenance and Species Trials

Between 1959 and 1968 trials of 6–10 provenance lots broadly spanning the natural ranges of *A. grandis*, *A. concolor*, *A. procera*, and *A. magnifica*, together with single lots of *A. nordmanniana*, *A. firma*, *A. bracteata*, *A. religiosa*, and *A. vejari*, were planted by the Forest Research Institute, Rotorua. The main trials in the series were sited at Gwavas and Hanmer Forests. Smaller trials, consisting mostly of a few plots of one to four species, were established at 22 other sites, some on private land. The early growth of most species at most sites was erratic, with some of the trees going into check. At many sites invasion by gorse or swamping of trees by rank grass growth occurred. By 1976 most of the small trials had been abandoned, either because of poor survival and growth or for administrative reasons. At Gwavas and Hanmer, growth continued to improve, however. At age 20–29 years, these trials provide broad comparisons of performance among the original test species.

Unfortunately, because of an irregular start to growth in the trials, the full effects of provenance variation are still unclear, but *A. grandis* and *A. concolor* have generally survived and grown well. *Abies religiosa* was planted at only two sites, and at one of them it has proved to be the fastest growing species so far (Table 1).

TABLE 1: Diameter at breast height (d.b.h.) and height of better trees of species in *Abies* provenance trials¹

Species	Location					
	Whakarewarewa		Gwavas		Hanmer	
	d.b.h. (cm)	Height (m)	d.b.h. (cm)	Height (m)	d.b.h. (cm)	Height (m)
<i>Abies grandis</i>	39.7	22.9	36.3	19.4	23.1	13.8
<i>Abies religiosa</i>	45.3	25.8				
<i>Abies concolor</i>	24.0	14.3	22.3	13.1	23.0	11.3
<i>Abies procera</i>	22.0	10.8	14.7	12.0	20.2	11.4
<i>Abies magnifica</i>	15.4	6.9	17.3	9.5	23.3	9.5
<i>Abies nordmanniana</i>					9.8	7.3
<i>Abies firma</i>					19.3	9.8
<i>Pseudotsuga menziesii</i> ²			36.0	22.6		

¹ Trials planted 1959–1962; results adjusted in proportion to age 28 years. Average values of samples of 10 trees (Whakarewarewa, Hanmer) and 30 trees (Gwavas)

² Adjoining stand to *A. grandis*. Same age and treatment. Seed from Berteleda, California, a very fast growing provenance of Douglas fir in New Zealand

Pests and Diseases

Little information is available on pathogens because of the minor role of the silver firs in forestry in New Zealand. However, given suitable growing conditions, most species remain generally healthy.

Armillaria root-rot has occasionally led to death in *Abies grandis*, *A. procera*, *A. concolor*, *A. bracteata*, and *A. magnifica*, and other *Abies* species are potentially susceptible. Similarly *Ganoderma applanatum* (formerly *Fomes*), which has been isolated from dying *A. procera* and *A. concolor*, may eventually become more widespread. Otherwise, the fungi recorded have been confined to trees in the nursery stage, including damping-off agents *Cylindrocladium floridanum*, *C. scoparium*, and root-rot-causing fungi *Phytophthora cinnamomi* and *Pythium* sp.

The only insect pathogen of importance is the fir adelgid *Adelges nordmannianae*, an aphid-like insect which usually attacks the leaves of *Abies nordmanniana* but has also been recorded on *A. alba*. This pest appears at its worst in coastal Otago and Southland, where many trees are severely defoliated and some have been killed. The caterpillars of the common forest looper moth, *Pseudocoremia suavis*, and the bagmoth, *Liothula omnivora*, have caused very minor damage to foliage of some *Abies* species. Larvae of the lemon tree borer, *Oemona hirta*, have been found in dead branches of *Abies*, an unusual occurrence since this longhorn beetle normally confines its attack to broadleaved trees. Larvae of another longhorn beetle, *Stenopotes pallidus*, have been found in the wood of *A. religiosa*. There is one record of spinning mite, *Oligonychus ununguis*, occurring on *Abies*.

RECOGNITION

General Description of *Abies*

Habit: Evergreen, conical or pyramidal when young, developing an oval, rounded or flattened crown with age, trunk rarely forked, branches more or less in whorls.

Bark: In young trees usually smooth or covered with resin blisters, in older trees becoming thicker and often deeply furrowed at the base.

Foliage: Leaves narrow, linear; spirally arranged; often twisted at the base; rounded, pointed or notched at the tip; usually flattened, occasionally four-sided; two white or greyish bands of stomata on the lower surface, sometimes with stomata on the upper surface especially on uppermost shoots. On lower branches and lateral shoots either in two ranks with a distinct parting between (pectinate), spreading all round the shoot, or overlapping and directed forwards. On leading shoots, usually widely spreading and on coning shoots directed upwards. Leaves have a strongly resinous odour when bruised.

Branchlets: Usually smooth or occasionally grooved, with or without hairs. Circular flat scars are left by fallen leaves (Fig. 3).

Winter buds: Usually resinous, sometimes non-resinous, variable in size and shape.

Cones: Erect; often confined to the upper part of the crown; cylindrical to barrel-shaped; at first green or red, becoming greenish brown, brown, or bluish purple; often encrusted with resin; consisting of closely overlapping, flat, fan-like scales and hidden or protruding bracts; breaking up on the tree as soon as the seeds are ripe, leaving a narrowly conical spike or rachis (Fig. 4).

Seeds: Ovoid or oblong, containing resin vesicles; wing large and thin with the lower part enclosing the seed on one side. Seed ripening during the first autumn.

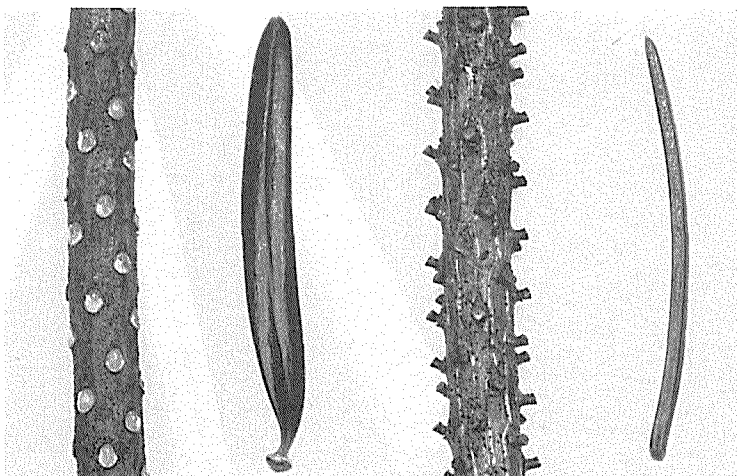


Fig. 3 — Typical *Abies* branchlet (left) showing flattened, rounded leaf scars left by base of fallen leaves. In *Picea* (spruce; right) fallen needles leave peg-like projections on the branchlets.



Fig. 4 — Disintegrating cone of *Abies procera* shedding cone scales and ripe seeds. Note erect central rachis which remains on the tree for some time.

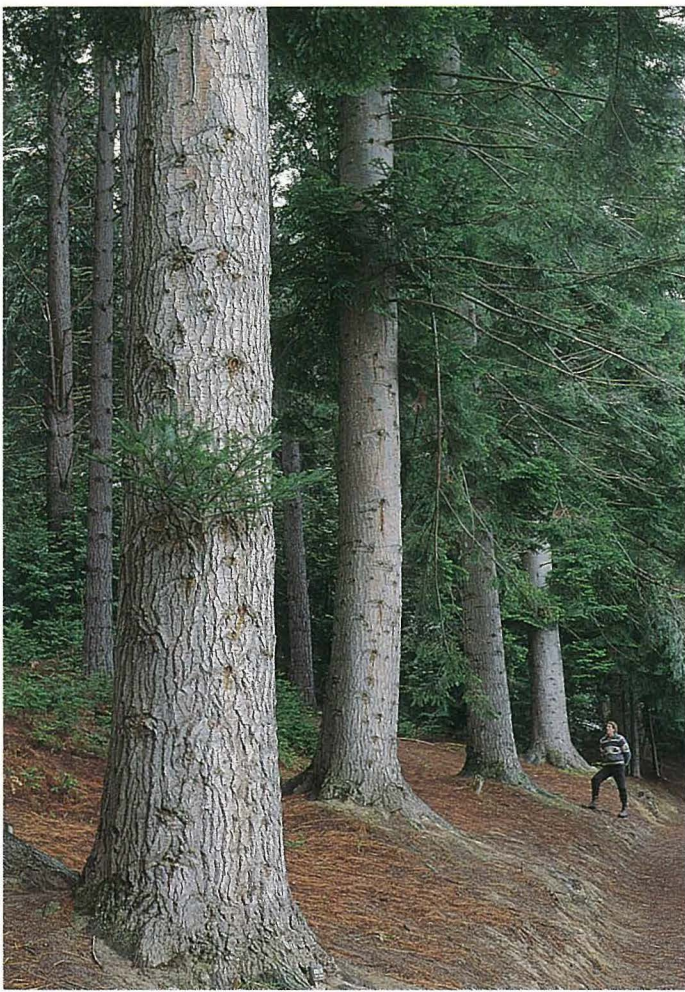


Fig. 5 — *Abies grandis* at Conical Hill, Hanmer Springs, Canterbury, aged c. 90 years.

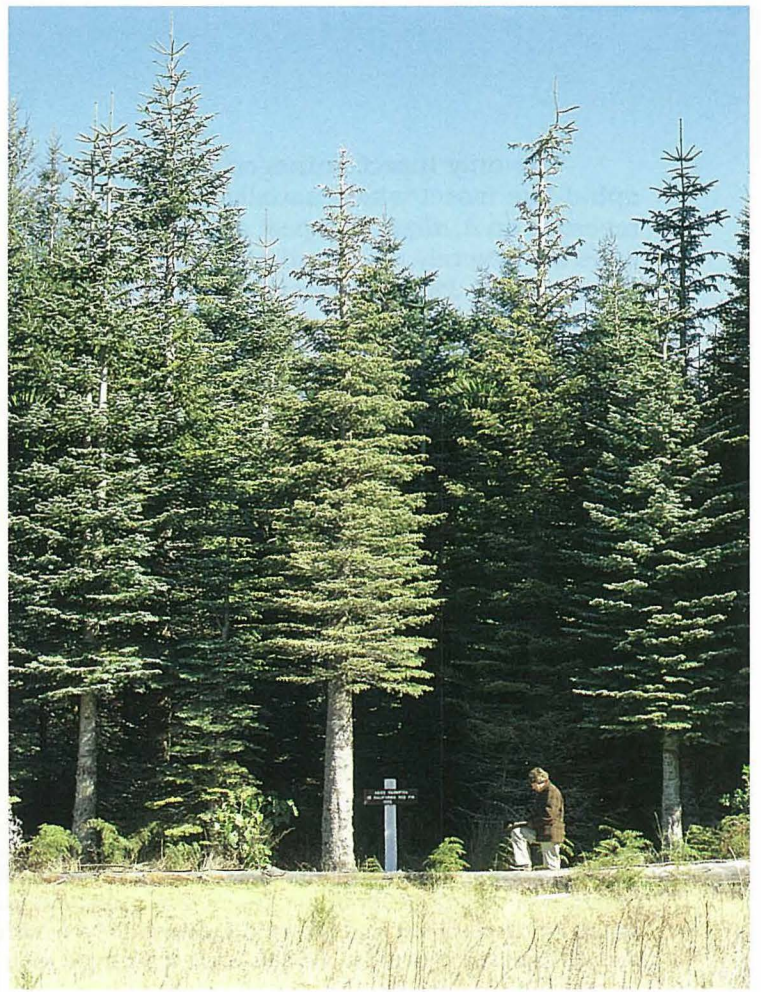


Fig. 6 — *Abies magnifica* provenance trial aged 30 years, Gwavas Forest, Hawke's Bay.



Fig. 7 — *Abies grandis* (left) and *A. religiosa* (right) provenance trials aged 27 years, Long Mile, Rotorua.



Fig. 8 — Framing timber (100 x 50 mm) of *A. concolor*.

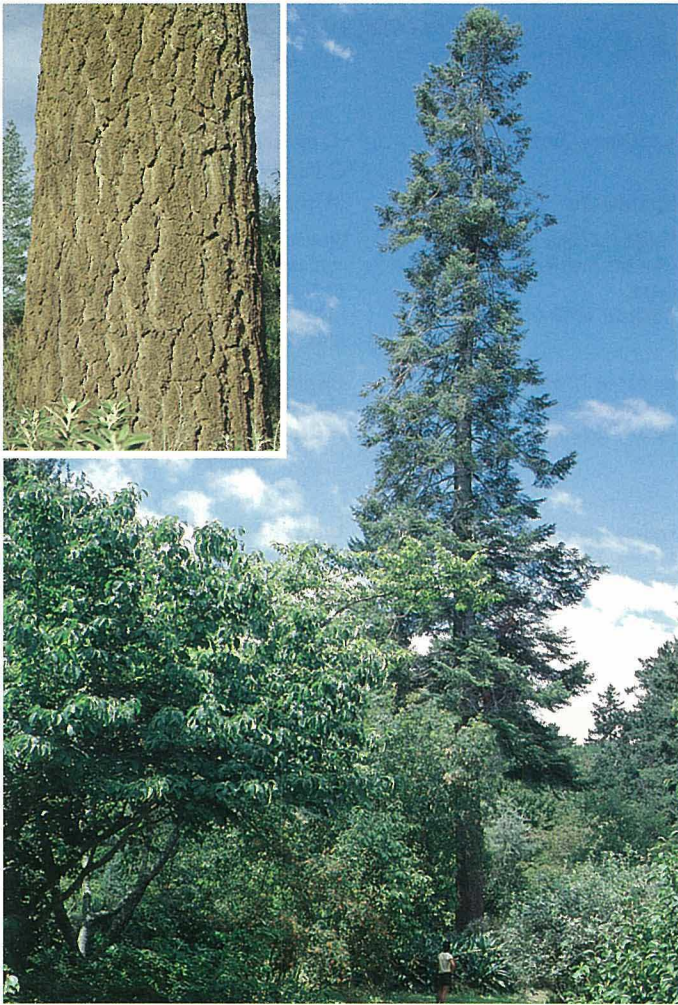


Fig. 9 — *Abies concolor*, over 40 m high, at Gwavas Stn, Hawke's Bay. Inset: thick deeply fissured bark typical of the species.



Fig. 10 — *Abies pinsapo* near Gwavas Forest, Hawke's Bay.

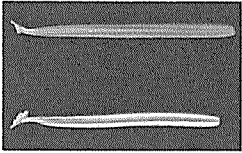
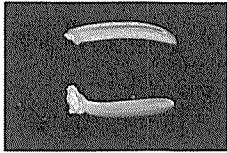
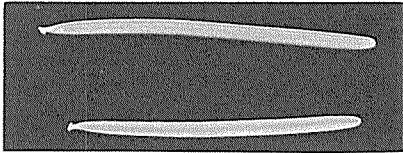
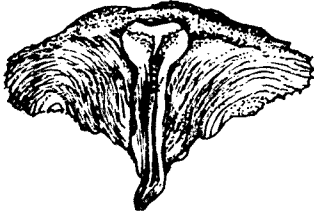
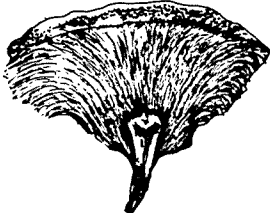
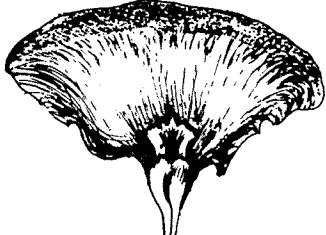
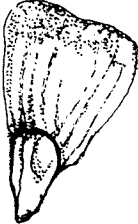
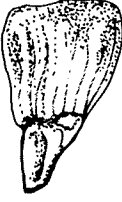



Fig. 11 — *Abies procera* at Mataroa near Taihape.



Fig. 12 — *Abies nordmanniana*, Taihape.

Recognition of *Abies* species

	<i>A. nordmanniana</i> (Steven) Spach. Caucasian fir	<i>A. pinsapo</i> Boiss. Spanish fir	<i>A. concolor</i> (Gordon et Glend.) Hildebr. White fir
Distribution	Caucasus of southwestern U.S.S.R., northern Asia Minor, Turkey. Limited distribution: 46°E to 38°E and 44°N to 40°N. Altitude: 900–2200 m.	Southern Spain: Malaga and Granada provinces. Very limited range. Altitude: 1000–2000 m.	Western United States and northern Mexico. Extensive range: 30°N to 44°42'N, and 105°W to 124°W. Altitude: 610–3350 m.
Habit	Height to over 50 m. Dense foliage, pyramidal crown. Regular branching.	Height to 30 m. Broadly pyramidal, lower branches usually drooping.	Height to 80 m. Narrow spire-like crown, becoming irregular with age.
Foliage*	Leaves 2–3.5 cm x 1.8–2.5 mm; shiny dark green above, two pale bands below; rounded and notched at tip. Leaves directed forwards on top part of shoot, densely covering shoot.	Leaves relatively short: 0.8–2 cm x 1.5–2.5 mm; dark to dull bluish green on both surfaces; tip pointed or rounded; <i>stiff and leathery; set out at right angles all round shoot.</i>	Leaves 3.5–7 cm x 2.5–3 mm; <i>pale blue-green on both surfaces</i> ; pointed or occasionally notched tip; mostly spreading and curving upwards; <i>strongly twisted at base</i> , usually keeled above.
			
Young branchlets	Grey or light brown, covered in short erect hairs.	Red-brown to light brown, without hairs.	<i>Shiny pale yellow-green or olive-green</i> , few reddish hairs or without hairs.
Winter buds	Ovoid, <i>not resinous</i> , light brown to red-brown.	Ovoid, very resinous.	Globose, resinous, purplish to brownish.
Cones	10.5–16.5 cm x 4–4.5 cm. Greenish when young, becoming dark brown or reddish brown and resin-covered at maturity.	10–15 cm x 3.5–4.5 cm. Greenish brown when young, becoming darkish brown at maturity.	7–15 cm x 3–4.5 cm, <i>ash coloured, yellow or purplish</i> when young, becoming brown at maturity.
Cone scales	 Bracts exerted and reflexed.	 Bract scales hidden.	 Bract scales hidden.
Seed	Wings greyish to purplish brown, shiny. Seeds yellowish brown. 	Wings pale reddish brown. Seed yellowish brown. 	Wings clear, lustrous, slightly pinkish. Seeds yellow-brown. 
Comments	Forward-directed leaves on top of shoot, and non-resinous buds, are a distinctive combination in <i>A. nordmanniana</i> .	Very distinctive with short stiff leaves regularly spaced at right angles all around branchlet. <i>Abies cephalonica</i> has similar leaf arrangement but longer and sharper leaves that are shiny green on the upper surface.	The irregularly arranged, long, wide, thick, leathery, blue-green leaves curving outwards and upwards are distinctive. <i>Abies concolor</i> var. <i>lowiana</i> is intermediate between <i>A. grandis</i> and <i>A. concolor</i> , and is probably a natural hybrid between the two.

* Foliage descriptions refer to typical, lower, unshaded branchlets. Foliage characteristics, particularly arrangement of leaves on the shoot, can vary considerably according to position on the tree and exposure to light.

commonly found in New Zealand

A. grandis (D. Don) Lindley

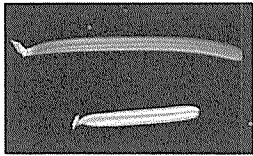
Grand fir

Western North America: British Columbia, Washington, Oregon, California, Idaho, and Montana. Altitude: 0–1800 m.

Height to 100 m – tallest of the *Abies* species.

Narrow oblong crown at first, fanning out with age.

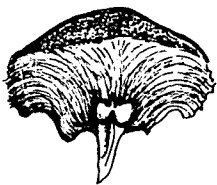
Leaves 1–6 cm x 1.5–3 mm; *shiny green above*, two broad silvery bands below; *deeply grooved upper surface*; comb-like arrangement of alternate long and short leaves on either side of shoot.



Slender, yellow-green or olive-brown to dark purplish red, short greyish brown hairs.

Very small, globose, purplish, slightly to very resinous.

5–12 cm x 3–4 cm, bright yellowish green or greenish purple at maturity.



Bract scales hidden.

Wings lustrous light brown or purplish. Seeds pale brown.



The flat comb-like leaf arrangement with alternating longer and much shorter leaves that are flattened, grooved, and shiny green above, is distinctive.

A. magnifica Andr. Murray

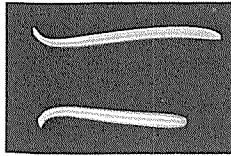
Californian red fir

Western North America: mountains of southern Oregon, northern California, and western Nevada. Range: 43° 35'N to 35°40' N. Altitude: 1400–3000 m.

Height to 70 m.

Regular narrow conic crown; *short slender branches* in regular whorls; middle and lower branches drooping.

Leaves 2–4 cm x 1.5–2 mm; *grey-green to blue-green* with a blunt tip; *hockey stick-shaped with bases pressed against branchlet*; *ribbed (not grooved)* on both sides; directed upwards.



Light yellow-green, densely covered with short red-brown hairs.

Small, globose to ovoid, very resinous, hidden by small leaves.

14–20 cm x 7–10 cm, purple at first, becoming brown at maturity.



Bract scales hidden.

Wings lustrous, purple or rose. Seeds dark red-brown.



Very closely related to *A. procera* both botanically and geographically. Ranges overlap and intermediate forms suggesting hybridism occur. Bark red-brown, fissured, ridged, and thicker than bark of *A. procera* which is greyish.

A. procera Rehder

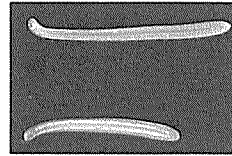
Noble fir

Western North America: Pacific Coast, Cascade Mtns of Washington and Oregon, Siskiyou Mtns of California. From 41°N to 48°30'N. Altitude: 70–2680 m.

Height to 80 m.

Young trees regularly conic, developing a rounded or flat top with age. Lower branches often drooping when open grown.

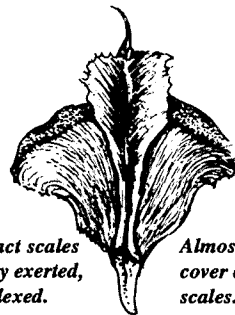
Leaves 1.5–3.5 cm x 1.5–1.8 mm; grey-green to blue-green, especially in first year; *deeply grooved above*, with a blunt tip; *hockey stick-shaped leaves pressed against top side of shoot, completely obscuring it*.



Slender, dark orange-brown to reddish brown, covered with short red-brown hairs.

Small, ovoid to globose, usually resinous, dark purplish brown, hidden by leaves.

10–22 cm x 5–8 cm. Green or reddish at first, becoming purplish brown at maturity, often produced very profusely.



Bract scales very exerted, reflexed. Almost cover cone scales.

Wings light yellowish brown, lustrous. Seeds reddish-yellowish brown.



Hockey stick-shaped leaves distinguish *A. procera* from other firs except *A. magnifica*. Closely arranged leaves, obscuring upper shoot; grooved or partly grooved leaf surface; and exerted and reflexed cone scales distinguish it from *A. magnifica*.

A. alba Miller

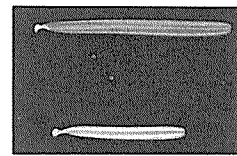
European silver fir

Central and southern Europe. Extensive range, chiefly in mountainous regions. From 52°N to 38°N, and from 3°W to 27°E. Altitude: 300–1950 m.

Height to 60 m.

Pyramidal at first, crown becoming rounded; often branch-free for much of trunk in forest situations.

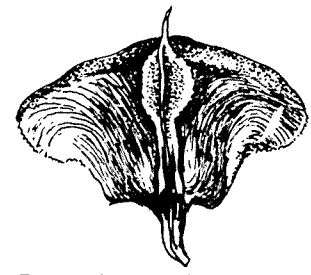
Leaves 1.5–3.5 cm x 1.6–2.6 mm; shiny dark green above, two silvery bands below; tip rounded or slightly notched. *Leaf arrangement comb-like* with a distinct parting between the two opposite sets.



Grey or pale brown with scattered, short, erect, light brown hairs.

Rather small, ovoid or conical, *without resin*, chestnut brown.

10–25 cm x 3–5 cm. Greenish to greenish purple when young, becoming reddish brown when mature.



Bract scales exerted.

Wings reddish or greyish yellow. Seeds yellowish.



Leaf arrangement of *A. alba* similar to that of *A. balsamea* but *A. alba* has non-resinous buds. Sometimes confused with *A. nordmanniana* but comb-like leaf arrangement of *A. alba* is distinctive.



Fig. 13 — Foliage (upper) and cones (lower) of *A. nordmanniana*.

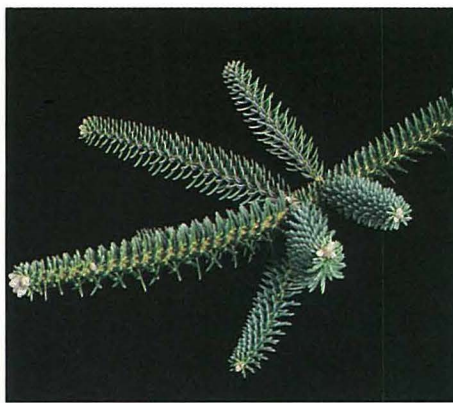


Fig. 14 — Foliage (upper) and cones (lower) of *A. pinsapo*.



Fig. 15 — Foliage (upper) and cones (lower) of *A. concolor*.



Fig. 16 — Foliage (upper) and cone (lower) of *A. grandis*.



Fig. 17 — Foliage (upper) and cone (lower) of *A. procera*.



Fig. 18 — Foliage (upper) and cone (lower) of *A. alba*.

Fig. 19 — Foliage of *A. magnifica*.



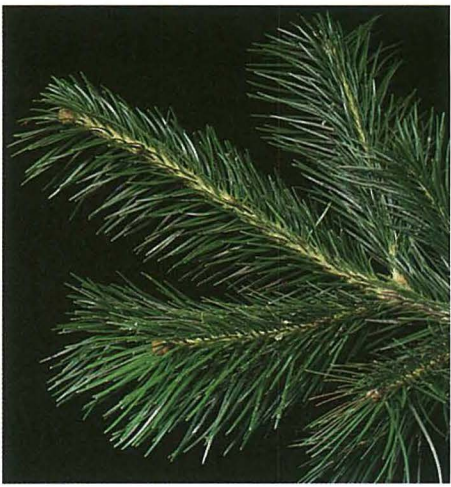


Fig. 20 — Foliage of *A. pindrow*.



Fig. 21 — Foliage of *A. amabilis*.



Fig. 22 — Foliage of *A. veitchii*.



Fig. 23 — Foliage (left) and cones (right) of *A. cephalonica*.



Fig. 24 — Foliage of *A. firma*.



Fig. 25 — Foliage (left) and cones (right) of *A. homolepis*.



Fig. 26 — Foliage of *A. balsamea*.

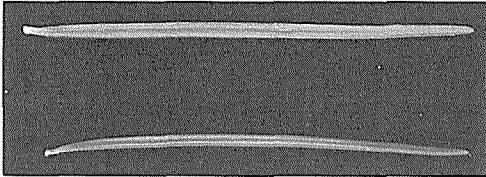
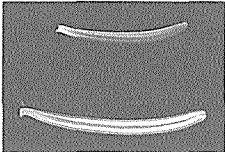
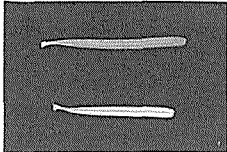
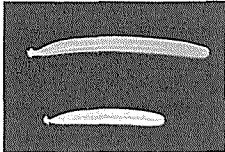
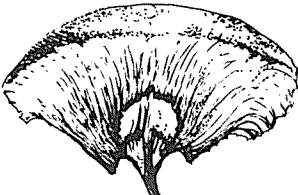
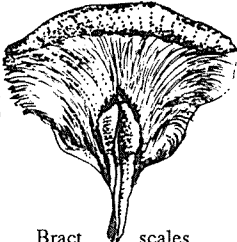

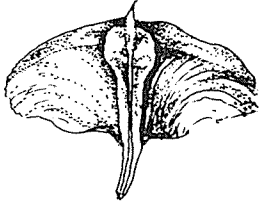
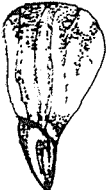





Fig. 27 — Foliage (left) and cone (right) of *A. religiosa*.



Fig. 28 — Foliage of *A. bracteata*.

Recognition of *Abies* species less

	<i>A. pindrow</i> (Lamb.) Royle	<i>A. amabilis</i> Forbes	<i>A. veitchii</i> Lindley	<i>A. firma</i> Siebold et Zucc.
Distribution	West Himalayan fir Himalayas: Chitral to Nepal and northern Afghanistan. Altitude: 2000–3700 m.	Pacific silver fir Western North America: from southern Alaska to northern California. 41°N to 56°50'N. Altitude: 250–1830 m.	Veitch fir Japan: subalpine area of Honshu, from 37°46'N to 34°6'N. Altitude: 1200–2800 m	Momi-fir Japan; wide distribution, from 30°N to 39°5'N. Altitude: 50–1900 m.
Habit	Height to at least 65 m. Narrow pyramidal crown.	Height to 85 m. Pyramidal, in open situations densely clothed to ground with short gracefully curving branches.	Height to 30 m. Conical tree with narrow top, short slender rather sparsely spreading branches.	Height to 50 m. Young trees pyramidal, broadening with age.
Foliage*	Leaves 2–9 cm x 1.3–2.0 mm; shiny green above, two pale bands below; tip notched with two sharp unequal points; leaves on upper side of shoot directed forwards, shorter than those on lower side.	Leaves 1.3–3.5 cm x 1.5–2 mm; dark green above, two silvery white bands below; curved; tip rounded or notched; pointing forward; more or less covering the branchlet.	Leaves 1–3 cm x c. 2 mm; shiny dark green above, two conspicuous pale bands below; blunt or notched; leaves crowded; pointed forward on top of shoot.	Leaves 1.5–4 cm x 2–4 mm; shiny dark green above, two greyish bands below fading with age; rounded or notched at tip; spreading out and up in two ranks with a V-shaped depression between.
				
Young branchlets	Pale, whitish to yellowish brown, prominently ridged, without hairs.	Light orange-brown to reddish purple, covered with fine hairs.	Brown with a dense covering of brownish hairs.	Brownish grey, grooved, short hairs in the grooves on young trees.
Winter buds	Large, ovoid, very resinous.	Small, nearly globose, very resinous.	Small, ovate to rounded, red-brown to purplish, very resinous.	Largish, ovoid, grey-brown, little or no resin.
Cones	10–14 cm x 5.5–7.5 cm; violet-purple at first, changing to dark red-brown at maturity.	9–15 cm x 5–6.5 cm; usually dark purple or red when young, purplish brown at maturity.	4–6 cm x 2–2.5 cm, dark bluish purple when young, becoming brown at maturity.	8–15 cm x 3–5 cm, green at first, becoming greyish or greyish green when mature.
Cone scales	 Bracts scales hidden; very short.	 Bract scales hidden, very short.	 Bract scales not or only slightly exerted.	 Bracts slightly exerted and reflexed or may be hidden.
Seed	Seed shiny blackish brown. 	Wing pale brown, lustrous. Seed light yellow-brown. 	Wing tinged blue or purple. Seed greyish. 	Wing purplish at first, becoming yellow-brown. 
Comments	Unequally notched leaves in combination with large ovoid resinous buds, are distinctive. <i>Abies spectabilis</i> is similar but has blunter leaves and hairy shoots.	Young shoot has a peculiar citrus fruit odour when bruised. Leaf arrangement as in <i>A. nordmanniana</i> but <i>A. amabilis</i> has resinous buds.	Combination of smooth pale grey or white bark, small purplish resinous buds, small cones, and blunt-tipped leaves very white below is distinctive.	Glossy leaves, often deeply notched at tip, wide in middle, narrowing at both ends, and in two opposite ranks, are distinctive.

* Foliage descriptions refer to typical, lower, unshaded branchlets. Foliage characteristics, particularly arrangement of leaves on the shoot, can vary considerably according to position on the tree and exposure to light.

commonly found in New Zealand

A. cephalonica Loudon

Grecian fir

Greece.

Altitude: 760–2000 m.

Height to 30 m.

Pyramidal. Long widely spreading branches.

Leaves 1.5–3.5 cm x 2–2.5 mm, upper surface dark shining green *often with some stomata*, two pale bands below; *sharp-pointed; arranged radially*; pointed forwards.

A. homolepis Siebold et. Zucc.

Nikko fir

Japan: central Honshu and Shikoku, between 37°N and 33°28'N.

Altitude: 700–2200 m.

Height to 40 m.

Crown rounded, wide and cedar-like in open situations.

Leaves 1.5–3.5 cm x 2–3.5 mm; shiny dark green above, two conspicuous white bands below; tip rounded or slightly notched (pointed in young trees); more or less *comb-like* in arrangement; *upper leaves shorter*.

A. balsamea (L.) Miller

Balsam fir

North America between 38°50'N and 59°N, and from 53°W to 117°W.

Altitude: 0–1700 m.

Height to 25 m.

Symmetrical, pyramidal crown. Branches in regular remote whorls.

Leaves 0.8–2.5 cm x c. 2 mm; dark shiny green, often with *stomata above*, two silvery white bands below; rounded or slightly notched at the tip, mostly *comb-like* in arrangement.

A. religiosa (Kunth) Schldl. et Cham.

Sacred fir

Mexico and Northern Guatemala. Widely distributed over high mountains.

Between 15°N and 24°N.

Altitude: 1200–4100 m.

Height to 60 m.

Conical or pyramidal crown. Relatively slender branches spreading slightly upwards. Dense foliage.

Leaves 1.5–3.5 cm x 1.2–1.6 mm; shiny green upper surface, two silvery white bands below; tip sharp, blunt, or notched; leaf narrow, *tapering, deeply grooved on upper surface*; foliage pointing upwards and forwards.

A. bracteata (D. Don) Poit.

Bristlecone fir

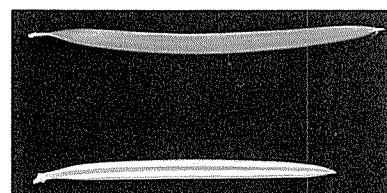
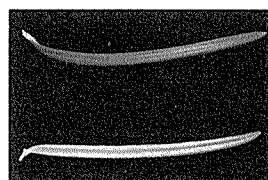
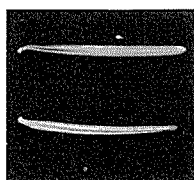
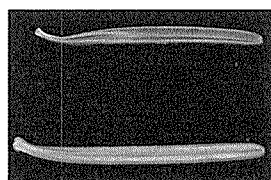
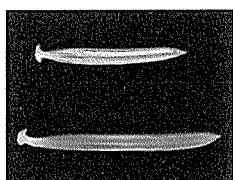
North America: California between 36°N and 37°N.

Altitude: 600–900 m.

Height to 50 m.

Usually broadly conical with a thin tapering top.

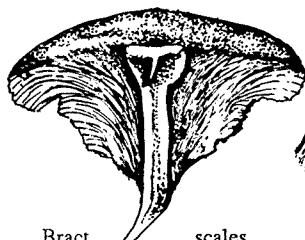
Leaves **3–6 cm x 3 mm**; shiny yellow-green with two silvery white bands below; sharply pointed; arranged in two opposite sets or with some more or less erect leaves between.



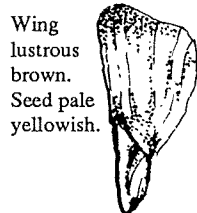
Red-brown, shiny, without hairs, prominent raised striations.

Conical or ovoid, more or less resinous.

10–16 cm x 3.5–4.5 cm, greenish brown when young, brown when mature. Often covered with yellow-brown resin.



Bract scales exerted and reflexed.



Wing lustrous brown. Seed pale yellowish.

Sharp-pointed, radially arranged leaves, and shiny red-brown striated branches are distinctive. Intermediate forms exist between this species and *A. alba* and *A. pinsapo*.

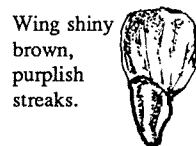
Yellow to light brown, shiny, without hairs, deeply grooved with prominent ridges.

Large, ovoid, resinous.

7–12 cm x 3–4 cm; *violet-purple* when young, becoming *purplish brown* at maturity.



Bract scales hidden.



Wing shiny brown, purplish streaks.

More or less comb-like leaf arrangement, shiny and deeply grooved shoots, in combination with violet-purple young cones with hidden bracts, are distinctive.

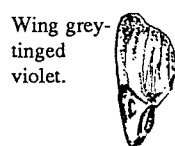
Pale yellow-green at first becoming light brown, covered with short dark grey hairs.

Ovate to globose, resinous.

5–8 cm x 2–3 cm, green-tinged purple when young, brown or brownish purple when mature.



Bract scales hidden or tip may be exerted and reflexed.



Wing grey-tinged violet.

Leaf arrangement similar to *A. alba*, but *A. balsamea* has resinous buds and much smaller cones usually with hidden bracts.

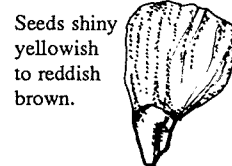
Olive-green to red-brown covered with minute erect hairs when young, becoming hairless.

Roundish, very resinous, shining red-brown or purplish.

10–16 cm x 4–6 cm; *dark violet-blue* at first, becoming dark brown when mature.



Bract scales exerted and reflexed.



Seeds shiny yellowish to reddish brown.

Leaves arranged as in *A. nordmanniana* but much fewer on upper side of shoot. Narrow tapering leaves deeply grooved on top near base and violet-blue young cones are distinctive.

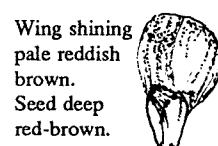
Stout purple-green to red-brown, without hairs.

Narrow ovate to spindle-shaped, large (up to 2.5 cm long) and *prominent, not resinous*.

7–10 cm x 4–5 cm, pale purplish brown, cone scale tips bristly appearance. *very long* giving a



Bract scales with very long exerted spine-like tip.



Wing shining pale reddish brown. Seed deep red-brown.

Very distinctive fir with stiff, sharp-pointed, long, wide, shiny leaves (longest and widest of the firs), pale non-resinous spindle-shaped buds, and bristly cones.

ROLE OF THE SPECIES

Growth and Siting

Most silver firs reach large sizes in natural stands, with heights of 50–60 m or more and diameters up to 5 m occurring in some species. A century after planting, many trees in New Zealand are large and often still growing vigorously. Records by Burstall (Burstall & Sale 1984) include: an *A. concolor* 95 cm in diameter and 41 m high, and an *A. veitchii* 98 cm x 38 m at Gwavas Station, Hawke's Bay; an *A. grandis* 126 cm x 38 m at Wanaka Station, Otago; an *A. nordmanniana* 132 cm x 33 m at Tarata, Taranaki; and an *A. alba* 95 cm x 26 m at Te Anau, Southland. A 90-year-old stand of *A. grandis* at Hammer Springs, Canterbury, has reached a mean top height of 38.5 m and a mean diameter at breast height of 90.6 cm.

The average annual height growth over 28 years, of seven *Abies* species planted in provenance trials, ranged from 0.2 m to 0.9 m. Height growth recommenced soon after planting in *A. grandis*, *A. concolor*, and *A. religiosa* but was delayed for several years in the other species. On good sites, the growth rate of *A. grandis* in New Zealand appears to be comparable with that of Douglas fir (*Pseudotsuga menziesii*); see Table 1.

At the McKean Pinetum, near Taihape, trees up to 28 years old of over 30 fir species are growing on a fertile, sheltered site (Table 2).

TABLE 2: Growth of 24 *Abies* species at McKean Pinetum*

Species	Age (yr)	Height range (m)	Species	Age (yr)	Height range (m)
<i>Abies magnifica</i>	27	7	<i>Abies cilicica</i>	14	4
<i>Abies grandis</i>	17–28	10–20	<i>Abies sachalinensis</i>	12–14	2–5
<i>Abies religiosa</i>	20–27	8–20	<i>Abies koreana</i>	11–14	3
<i>Abies concolor</i>	6–26	6–11	<i>Abies nebrodenis</i>	9–14	5–7
<i>Abies procera</i>	9–25	3–6	<i>Abies x pardei</i>	13	5–6
<i>Abies lasiocarpa</i>	7–23	2–3	<i>Abies x bornmuelleriana</i>	13	3
<i>Abies fraseri</i>	6–21	2–7	<i>Abies pindrow</i>	7–11	2–3
<i>Abies bracteata</i>	13–19	8–9	<i>Abies balsamea</i>	8–11	3
<i>Abies cephalonica</i>	15	6	<i>Abies alba</i>	7–10	3–4
<i>Abies delavayi</i> var. <i>smithii</i>	15	6	<i>Abies nordmanniana</i>	2–10	2
<i>Abies veitchii</i>	14	4–6	<i>Abies homolepis</i>	3–8	2–3
<i>Abies pinsapo</i>	14	5	<i>Abies holophylla</i>	7	1.5

*1–5 trees per species

Collectively, these results suggest that most of the silver firs tried are well suited to New Zealand environments. *Abies grandis* and *A. concolor* are generally the most vigorous, but some trees of *A. religiosa* are the fastest growing of all. Results at the Pinetum demonstrate the ability of most species to reach heights of about 5 m in 14 years.

Few good specimens of firs exist in the warmest parts of New Zealand (e.g., Northland), although the limits of sacred fir, *A. religiosa*, which demands a mild climate, have not been fully determined. At the other extreme, the growth of most species is sharply reduced in severe mountain climates. Several firs were included in species tests at Hut Creek (800 m a.s.l.) in the Craigieburn Range, Canterbury. Most suffered from spring frosts, but later recovered. Like spruces in the same area they preferred sheltered moist slopes with intact soils, but all grew very slowly. Unfortunately, possibly appropriate species such as *A. grandis*, *A. procera*, and *A. magnifica* were not planted at Craigieburn. *Abies concolor* has proved to be the best of those represented (Table 3).

TABLE 3: Growth of silver firs at Craigieburn

Species	Age (yr)	Height (m)
<i>Abies concolor</i>	26	4.5
<i>Abies nordmanniana</i>	22	3.0
<i>Abies spectabilis</i>	18	0.4
<i>Abies alba</i>	8-12	(10-15 cm annually)
<i>Abies cephalonica</i>		
<i>Abies pinsapo</i> ¹		

¹ Some severe frosting and initial mortality

Between climatic extremes there are probably many sheltered sites at middle elevations (300–500 m) in moist, cooler regions suitable for growing firs. Present knowledge is limited because of the lack of representative plantations in many areas but indications are that some fir species eventually may produce large trees or, in plantations, high basal areas and volumes.

Establishment and Silviculture

In nature firs tend to be climax species ecologically, conditioned to regenerating within an existing forest structure. They do not show the fast early growth characteristic of fire-succession species or pioneers. Firs are best planted on sites which have recently carried forest, or on cut-over areas. When planted on new ground, releasing from grass and other competing weeds is required until trees have formed strong leaders. Young trees are especially responsive to nitrogen, and have been observed to benefit from nearby nitrogen-fixing plants such as tutu (*Coriaria arborea* Lindsay) or gorse (*Ulex europaeus* L.). The application of nitrogenous fertiliser at planting time is recommended.

On suitable sites, some firs such as *A. grandis*, *A. concolor*, *A. alba*, and *A. nordmanniana* have regenerated sporadically under parent stands, but as yet have not shown any tendency to spread more widely.

Silvicultural regimes have not been standardised for firs in New Zealand. Because of similarities in growth rate, grand fir may be treated rather like Douglas fir. A suggested schedule would be:

- Plant at 3 m x 2 m spacing, to give 1667 stems/ha
- Low prune at least (for access), although the growth rate of grand fir encourages the option of higher pruning
- Thin at a top height of 14 m (about age 17) to 500 stems/ha
- Rotation length: 40 years or more.

Timber Properties

The timbers of silver firs grown in New Zealand have not been tested, but they are expected to resemble those of firs grown overseas, whose properties are summarised as follows.

Generally, fir timbers are soft, whitish in colour (see Fig. 8), and easily worked to a good finish, taking paint and varnish well. Nailing qualities are good. Air-dry densities fall within the range: 300 g/cc to 480 g/cc. The wood normally kiln-seasons well without checking or collapse, but requires care to prevent warping. Fir timbers are not naturally resistant to decay, but as roundwood they will absorb fluid preservatives applied under pressure, or using a hot and cold impregnation method. Common uses of fir timbers include general finishing in buildings, roof and wall linings, joinery, and built-in furniture, as well as packing cases and crates. Treated in the round they make serviceable posts and poles. Wide-scale natural stands of fir are an importance source of pulpwood.

Silver firs as Amenity Species

The provision of recreational resources is often an important objective of forest management. *Abies* species, with their symmetrical, conical crowns, enhanced by sometimes stratified branching and varied colour, provide valuable landscape and amenity subjects. In particular silver fir trees may be used to set off the autumnal colours or rounded shapes of hardwoods. In New Zealand these objectives are promoted by the longevity and good health of the majority of fir species over most of the country. Silver firs are moderately tolerant of urban atmospheric pollutants, such as sulphur dioxide.

A Utilitarian Role for *Abies*?

Commercial forestry in New Zealand rests almost entirely on the success of radiata pine as a general-purpose timber tree; only a few other species are grown for their special timber properties. Other species capable of producing general-purpose timber tend to be invidiously compared with radiata pine because they grow much more slowly. Nevertheless, they are the only alternatives to radiata pine should disease or any other factor threaten the prevailing monoculture. A good alternative, or "contingency" species must have good health, wide site tolerance, and the capacity to provide general-purpose timber in New Zealand. Several species of *Abies* meet these requirements to some degree. However, contingency species cannot be introduced effectively unless seed sources from the best provenances have been developed already.

SUGGESTED SPECIES

***Abies grandis* (grand fir)** : Suitable for growing either as a woodlot or as an amenity species. As with most firs in New Zealand, tolerates only moderate exposure. Will grow in drier climates (750 mm rainfall annually) but prefers higher, well distributed rainfalls of 1000–1200 mm or more. Prefers deep, moist (e.g., alluvial) well drained soils. Intolerant of podzols or calcareous soils. Fast growing (comparable with Douglas fir), moderately shade tolerant. *Abies grandis* is slow growing in dense shade, but may be used successfully to underplant light crops, or to suppress low scrub. Rarely attacked by *Adelges*.

***Abies concolor* (white fir)** : Less tolerant of exposure than grand fir, but prefers similar soils. Moderately fast growing and potentially a woodlot species. Shade tolerant (more so than grand fir). Rarely attacked by *Adelges*. Its glaucous foliage, especially in some cultivated varieties, contrasts effectively with darker coloured trees, making it an attractive landscape subject.

***Abies procera* (noble fir)** : Suitable for planting as an amenity species at middle elevations (e.g., up to 600 m). Tolerates a wide range of light non-calcareous soils provided they are sufficiently moist. Suitable rainfall 750–1200 mm or more. Intermediate growth rate. Less shade tolerant than either grand fir or white fir (definitely intolerant of deep shade). Has been attacked occasionally by *Adelges*. Noble fir forms a characteristically symmetrical crown and has a stout stem and short, sturdy branches. *Abies procera* 'Glaucous' is a particularly attractive glaucous form.

***Abies magnifica* (Californian red fir)** : Naturally a montane species: in New Zealand suitable for planting at middle elevations, up to 600 m. Could probably be planted higher on sheltered sites with moist, free-draining soils. The species appears disadvantaged on warm lowland sites. Slow growing at first, but like noble fir produces a striking spire-like crown with short, stratified branches. Glaucous foliage, particularly pronounced in some cultivars.

***Abies pinsapo* (Spanish fir)** : A low- to mid-elevation species which, in contrast to most other firs, tolerates drier sites, periodic strong winds, and calcareous soils. Intermediate in growth rate but in New Zealand generally very healthy. Tends to retain fully foliated lower branches increasing its value as a shelter or shade tree. The cultivar 'Glauca' is very attractive and is reputed to be more tolerant of adverse conditions than is the species.

***Abies religiosa* (sacred fir)** : The fastest growing of the firs in New Zealand. Suited to mild low-elevation sites. The species is frost-tender and has succeeded only in the North Island. Generally has poorer stem form and more straggling branches than grand fir. Moderately shade tolerant (has been used as an interplant in open mixed shelterwood of larch and redwood, and has been successfully established under a nurse crop of manuka). Typically the upper crown of *A. religiosa* is dense and narrowly spired. The species has been damaged occasionally by possums.

***Abies nordmanniana* (Caucasian fir)** : In coastal areas of Otago has been heavily attacked by *Adelges* and many older trees appear unhealthy. In inland areas of both islands trees are usually healthy, well formed, and moderately vigorous. Appears to tolerate a wide range of sites but grows best on deep moist soils in sheltered situations.

The following species have features which could interest the grower if seed or plants can be obtained:

***Abies bracteata* (bristlecone fir)** : Attractive long spiny leaves. A rare and beautiful fir suited to mild climates.

***Abies lasiocarpa* (alpine fir)** : Hardy, with rather slow growth rate. Glaucous or blue-green foliage.

***Abies amabilis* (Pacific silver fir)** : Slow-growing. Fine, spire-like form. This fir is slow to develop in the nursery and requires careful treatment until properly established.

***Abies balsamea* (balsam fir)** : One of the smaller firs which will grow on heavy or on podzolic soils. Shade tolerant when young but needs full light later.

***Abies koreana* (Korean fir)** : Small tree suitable for garden planting. Silvery-grey young shoots are distinctive.

***Abies pindrow* (West Himalayan fir)** : An attractive fir with smooth bark and bright green leaves. Slow growing when young. Needs moist soil conditions.

***Abies cephalonica* (Grecian fir)** : Closely allied to *A. pinsapo* but prefers moist soils.

SEED SOURCES

By age 20–30 years most silver firs have produced viable seed in New Zealand. However, low germination capacity (between 20% and 40%) often associated with a variable proportion of empty seeds is characteristic of most species. Sources of seed of good genetic quality need to be developed for all the principal fir species in New Zealand.

Small quantities of seed have been collected in the past from scattered specimen trees, a process which eventually must lead to a preponderance of selfed or inbred stock. Also, where closely related species are growing side by side, as in parks or gardens, hybridisation is likely to affect seed quality. Species between which natural hybrids have been recorded overseas include *A. grandis* and *A. concolor*, *A. concolor* and *A. religiosa*, *A. procera* and *A. magnifica*, and *A. pinsapo* and *A. nordmanniana*. The range of hybrids which can be made artificially is more

extensive (Critchfield 1988) but, generally, hybrids among the firs are less easily produced than once was thought. Nevertheless, some New Zealand seedlots of *A. pinsapo* appear to have hybridised with *A. nordmanniana*. Both species are probably descended from quite small seed imports made before 1900. Reintroduction of these two species in the form of broadly based seedlots is probably desirable.

Provenance trials now aged 19–27 years strengthen prospects for developing better seed sources in the short term. Light seed crops have already been produced from *A. grandis*, *A. concolor*, and *A. procera* in these trials, and similar crops are expected from *A. religiosa* and *A. magnifica* within the next few years. As each species in the trials is represented by 6–10 different provenances, and as each provenance lot is based upon seed collections within natural stands of up to 10 trees, the genetic quality of resulting seed is expected to be much higher than that of seed collected from isolated trees.

The establishment of small grafted seed orchards using the best available material of each species would simplify collection procedures, reduce lead times to seed production and provide control over possible hybridisation in the principal firs. Grafts of *A. grandis*, *A. concolor*, and *A. magnifica* have already been made at the Forest Research Institute. In the meantime supplies of seed of the less common firs grown for interest or ornament may be met either from imports or from collection from specimen trees or arboreta.

Silver firs constitute a large group of healthy species of which many fine specimens exist in New Zealand. Their attractive form, and variety of colour are particularly suited to amenity and landscape planting. Some species have good growth rates and could produce a general-purpose softwood. Development of local seed sources is needed if their use is to be increased.

SEED USERS' GUIDE

A. Nursery practice

Sow in seed beds as soon as ground conditions permit. Cover seed to 1 cm with grit. Cover beds with screens and retain them through hot summer weather. *Abies grandis* will sometimes grow to plantable size in one year; however, most *Abies* are grown as 2/0 plants, and then transplanted as necessary. As *Abies* seedlings soon develop large spreading roots, regular wrenching is needed to produce convenient balanced planting stock. Firs are difficult to propagate as cuttings, but respond to whip or cleft grafting (of leader or erect upper shoots) on established bare-rooted or potted seedlings raised from the same parent tree.

B. Recommended seed sources

Seed of several species of *Abies* is available through Proseed New Zealand, P.O. Box 1946, Rotorua. Seed of New Zealand origin that has been collected from groups of several trees of one species is preferable to that from single individuals.

C. Collection and extraction of *Abies* seed

	<i>A. grandis</i>	<i>A. concolor</i>	<i>A. procera</i>	<i>A. magnifica</i>	<i>A. pinesapo</i>	<i>A. religiosa</i>	<i>A. nordmanniana</i>
Age of first flowering (years)	20* (*Hanmer provenance trials)	25*	12-15*	35-45	25	12-15	30-40
Seed available in quantity (years)	30	35	25	55	35	25	50
Pollen production.	November-December						
Cone maturation period	2-3 months						
Cone collection	Jan-March	Feb-March	Feb-March	Feb	Feb	Feb-March	Feb-April
	Short period not exceeding 4 weeks in any species. Cones disintegrate on ripening.						
Periodicity of crop	2-5 years						
Harvesting	Climbing and branch hooks. Brittle branches require care in climbing. Trees very gummy. Cones usually borne high in crown.						
Mature cone recognition	Cones and seed wings change from green or purple to brown. Seeds detach from scales.						
Seed extraction	Expose and air dry cones promptly. Kiln dry at 6-8 hours at 30-35°C; or air dry for 1-3 weeks at 20-30°C. <i>Abies</i> seed is fragile and can be damaged in de-winging.						
Seed per hectolitre of cones	1.5 to 3 kg (3 kg = good year)						
Number of seeds per kg	18 000	24 000	13 500	16 500	14 500	—	15 700
Storage conditions	Air-sealed container at 3°C						
Storage duration	Maximum recommended storage period 5-6 years. Deteriorates fairly rapidly during storage.						
Stratification	4 weeks of cool moist stratification recommended.						
Expected germination	30-40%						

FURTHER READING

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The authors are grateful to C.G.R. Chavasse, C.E. Ecroyd, R.J.D. McKean, and S.E.A. Hayes for helpful comments on the text, and to J.H. Barran (Frontispiece and Figs. 3, 4, 5, 7, 9, 13, 15-19, 22, 23, 27, 28), D. Blake (Figs. 8, 14, 18 (foliage), 20, 21, 24-26 and photographs in recognition tables), C. Ecroyd (Figs. 6, 9 (inset), 10-12), and S. Burgess for the illustrations.