

Taxon: Pinus radiata	Family: Pinaceae
Common Name(s): Monterey pine radiata pine	Synonym(s): Pinus adunca Bosc. ex Poir. Pinus californica Loisel. Pinus insignis Douglas ex Loudon

Assessor: Chuck Chimera	Status: Assessor Approved	End Date: 9 Mar 2015
WRA Score: 9.0	Designation: H(HPWRA)	Rating: High Risk

Keywords: Environmental Weed, Fire Hazard, Dense Stands, Wind-Dispersed, Serotinous

Qsn #	Question	Answer Option	Answer
101	Is the species highly domesticated?	y=-3, n=0	n
102	Has the species become naturalized where grown?		
103	Does the species have weedy races?		
201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	(0-low; 1-intermediate; 2-high) (See Appendix 2)	Intermediate
202	Quality of climate match data	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
203	Broad climate suitability (environmental versatility)	y=1, n=0	y
204	Native or naturalized in regions with tropical or subtropical climates	y=1, n=0	y
205	Does the species have a history of repeated introductions outside its natural range?	y=-2, ?=-1, n=0	y
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n= question 205	y
302	Garden/amenity/disturbance weed	n=0, y = 1*multiplier (see Appendix 2)	n
303	Agricultural/forestry/horticultural weed	n=0, y = 2*multiplier (see Appendix 2)	n
304	Environmental weed	n=0, y = 2*multiplier (see Appendix 2)	y
305	Congeneric weed	n=0, y = 1*multiplier (see Appendix 2)	y
401	Produces spines, thorns or burrs	y=1, n=0	n
402	Allelopathic		
403	Parasitic	y=1, n=0	n
404	Unpalatable to grazing animals	y=1, n=-1	n
405	Toxic to animals	y=1, n=0	n
406	Host for recognized pests and pathogens		
407	Causes allergies or is otherwise toxic to humans		
408	Creates a fire hazard in natural ecosystems	y=1, n=0	y
409	Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y

Qsn #	Question	Answer Option	Answer
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	y
411	Climbing or smothering growth habit	y=1, n=0	n
412	Forms dense thickets	y=1, n=0	y
501	Aquatic	y=5, n=0	n
502	Grass	y=1, n=0	n
503	Nitrogen fixing woody plant	y=1, n=0	n
504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	n
601	Evidence of substantial reproductive failure in native habitat	y=1, n=0	y
602	Produces viable seed	y=1, n=-1	y
603	Hybridizes naturally	y=1, n=-1	y
604	Self-compatible or apomictic	y=1, n=-1	y
605	Requires specialist pollinators	y=-1, n=0	n
606	Reproduction by vegetative fragmentation	y=1, n=-1	n
607	Minimum generative time (years)	1 year = 1, 2 or 3 years = 0, 4+ years = -1	>3
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	n
702	Propagules dispersed intentionally by people	y=1, n=-1	y
703	Propagules likely to disperse as a produce contaminant	y=1, n=-1	n
704	Propagules adapted to wind dispersal	y=1, n=-1	y
705	Propagules water dispersed	y=1, n=-1	n
706	Propagules bird dispersed		
707	Propagules dispersed by other animals (externally)	y=1, n=-1	n
708	Propagules survive passage through the gut	y=1, n=-1	n
801	Prolific seed production (>1000/m ²)	y=1, n=-1	n
802	Evidence that a persistent propagule bank is formed (>1 yr)	y=1, n=-1	y
803	Well controlled by herbicides	y=-1, n=1	y
804	Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	y
805	Effective natural enemies present locally (e.g. introduced biocontrol agents)	y=-1, n=1	n

Supporting Data:

Qsn #	Question	Answer
101	Is the species highly domesticated?	n
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[No evidence in the Hawaiian Islands] "Domesticated stocks differ appreciably from their progenitor stocks, although this is only in part attributable to responses to natural and silvicultural selection in adoptive environments."

102	Has the species become naturalized where grown?	
	Source(s)	Notes
	WRA Specialist. 2015. Personal Communication	NA

103	Does the species have weedy races?	
	Source(s)	Notes
	WRA Specialist. 2015. Personal Communication	NA

201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	Intermediate
	Source(s)	Notes
	Flora of North America Editorial Committee. 1993. Flora of North America: Volume 2: Pteridophytes and Gymnosperms. Oxford University Press, Oxford, UK	"Pinus radiata has an extremely narrow natural range: three coastal areas in California (one in San Mateo and Santa Cruz counties, one in Monterey County, and one in San Luis Obispo County) and off the coast of Baja California, Mexico (Guadalupe Island and debatably also on Cedros Island). Some natural populations of the species are under protection. Along the California coast it has escaped from cultivation, and from there into southern coastal Oregon it shows signs of naturalizing."

202	Quality of climate match data	High
	Source(s)	Notes
	Flora of North America Editorial Committee. 1993. Flora of North America: Volume 2: Pteridophytes and Gymnosperms. Oxford University Press, Oxford, UK	

203	Broad climate suitability (environmental versatility)	y
	Source(s)	Notes

Qsn #	Question	Answer
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Climatic amplitude (estimates) - Altitude range: 0 - 4000 m - Mean annual rainfall: 350 - 2500 mm - Rainfall regime: winter; uniform - Dry season duration: 0 - 6 months - Mean annual temperature: 8 - 17°C - Mean maximum temperature of hottest month: 13 - 29°C - Mean minimum temperature of coldest month: -3 - 10°C - Absolute minimum temperature: > -17°C"
	Little Jr., E.L. & Skolmen, R.G. 1989. Common forest trees of Hawaii: (native and introduced). USDA Agriculture Handbook No. 679. USDA Forest Service, Washington, D.C.	[Elevation range in the Hawaiian Islands exceeds 1000 m, demonstrating environmental versatility] "...the tree grows better over a wider elevational range than any other pine planted in Hawaii, 1500–7500 ft (457–2286 m)."

204	Native or naturalized in regions with tropical or subtropical climates	y
	Source(s)	Notes
	Little Jr., E.L. & Skolmen, R.G. 1989. Common forest trees of Hawaii: (native and introduced). USDA Agriculture Handbook No. 679. USDA Forest Service, Washington, D.C.	"This subtropical Pine has been used in many forest plantations on all the islands of Hawaii except Oahu."
	Medeiros, A.C., Loope, L.L. & Chimera, C.G. 1998. Flowering Plants and Gymnosperms of Haleakala National Park. Technical Report 120. Pacific Cooperative Studies Unit, Honolulu, HI	[Higher elevations] "This is one of three naturalized species of pine in the Park that readily establish seedlings at 6800 8000 ft, often distant from parent trees."

Qsn #	Question	Answer
205	Does the species have a history of repeated introductions outside its natural range?	y
	Source(s)	Notes
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"Monterey pine (<i>Pinus radiata</i>) is the most widely planted pine in the world (9). Rapid growth and desirable lumber and pulp qualities cause it to be the leading introduced species in Australia, New Zealand, and Spain (34), and a major species in plantations of Argentina, Chile, Uruguay, Kenya, and the Republic of South Africa. In these countries, Monterey pine is a mainstay of the forest economy, serving internal markets, generating valuable foreign exchange reserves as an export, and reducing cutting pressure on native forests."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	" <i>P. radiata</i> , although quite an obscure conifer in its native California, is more extensively grown as an exotic than any other forest tree." ... "The main growing countries are Chile and New Zealand, followed by Australia, then Spain and then South Africa."
	Little Jr., E.L. & Skolmen, R.G. 1989. Common forest trees of Hawaii: (native and introduced). USDA Agriculture Handbook No. 679. USDA Forest Service, Washington, D.C.	"This subtropical Pine has been used in many forest plantations on all the islands of Hawaii except Oahu. Planted at 5200 ft (1585 m) at Kulani Honor Camp southwest of Hilo, Hawaii, it has done quite poorly because of frequent defoliation from volcanic sulfur fumes. Near Waikii, Hawaii, it is doing well except for occasional damage by the Eurasian pine adelgid. At the Kula Forest Reserve at 6000 ft (1829 m) on Maui, it is presently doing well after being set back by the Eurasian pine adelgid, which is now believed to be controlled by an introduced insect parasite."

301	Naturalized beyond native range	y
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The species has become naturalised in several countries, notably New Zealand, Chile, Australia and South Africa, often regenerating naturally within plantations and often invading surrounding land."
	Medeiros, A.C., Loope, L.L. & Chimera, C.G. 1998. Flowering Plants and Gymnosperms of Haleakala National Park. Technical Report 120. Pacific Cooperative Studies Unit, Honolulu, HI	"This is one of three naturalized species of pine in the Park that readily establish seedlings at 6800-8000 ft, often distant from parent trees. See also <i>P. patula</i> and <i>P. pinaster</i> . It is an aggressive species that if uncontrolled could invade and outcompete native species in moist native shrubland. This species can be identified by its stout woody cones, broadened asymmetrically at the base."

302	Garden/amenity/disturbance weed	n
	Source(s)	Notes
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	No evidence. Negative impacts on "Biodiversity (generally) ... Environment (generally) ... Native fauna ... Native flora ... Rare/protected species" [See 3.04]

303	Agricultural/forestry/horticultural weed	n
	Source(s)	Notes

Qsn #	Question	Answer
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	Animal/plant products - Impact = None Crop production - Impact = None Fisheries / aquaculture - Impact = None Forestry production - Impact = None Livestock production - Impact = None

304	Environmental weed	y
	Source(s)	Notes
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	"It can invade plant communities of considerable conservation value, and in the course of that can reduce catchment water yields, and was noted as a habitat transformer species by Henderson (2001). On the other hand, <i>P. radiata</i> can often act as an effective nurse crop for re establishment of natural vegetation. Hydrological impacts have been reviewed by Lewis and Ferguson (1993), Maclaren (1996) and Burdon (2000), and plantations often cause major reductions in catchment water yields through a combination of interception and transpiration losses, although flood peaks tend to be greatly reduced. "
	Weber, E. 2003. Invasive Plant Species of the World. A Reference Guide to Environmental Weeds. CAB International, Wallingford, UK	"It establishes well in burned areas and forms dense stands that may cover large areas. The native vegetation is eliminated and transformed into species poor woodland. A thick litter layer accumulates beneath stands of this tree, preventing establishment of native plants."
	Loope, L.L., Nagata, R.J. & Medeiros, A.C. 1992, Alien plants in Haleakala National Park Pp. 551-576 in Stone et al (eds) Alien plant invasions in native ecosystems of Hawaii. Coop. Nat. Park Resources Studies Unit, University of Hawaii, Honolulu, HI	" <i>Pinus radiata</i> from California, <i>Pinus patula</i> from Mexico, and <i>Pinus pinaster</i> from southern Europe are the only conifers (of many planted species in the Hosmer Grove area) to aggressively establish seedlings in native shrubland of the Park along the boundary adjacent to an experimental watershed improvement project on rangeland. On favorable sites these species can grow in height at a rate of about 12 in./yr (30 cm/year) and start to produce cones after 8 to 10 years."
	Medeiros, A.C., Loope, L.L. & Chimera, C.G. 1998. Flowering Plants and Gymnosperms of Haleakala National Park. Technical Report 120. Pacific Cooperative Studies Unit, Honolulu, HI	"The most serious weeds of the subalpine zone appear to be <i>Cortaderia jubata</i> (Andean pampas grass), <i>Eucalyptus globulus</i> (blue gum), <i>Pinus radiata</i> (Monterey pine), <i>Pinus pinaster</i> (maritime pine), <i>Pinus patula</i> (Mexican weeping pine), and <i>Leucaena leucocarpa</i> (gorse); however, all these are effectively controlled currently in the subalpine zone of the park by resource management personnel." ... "It is an aggressive species that if uncontrolled could invade and outcompete native species in moist native shrubland. This species can be identified by its stout woody cones, broadened asymmetrically at the base."

305	Congeneric weed	y
	Source(s)	Notes
	Medeiros, A.C., Loope, L.L. & Chimera, C.G. 1998. Flowering Plants and Gymnosperms of Haleakala National Park. Technical Report 120. Pacific Cooperative Studies Unit, Honolulu, HI	"The most serious weeds of the subalpine zone appear to be <i>Cortaderia jubata</i> (Andean pampas grass), <i>Eucalyptus globulus</i> (blue gum), <i>Pinus radiata</i> (Monterey pine), <i>Pinus pinaster</i> (maritime pine), <i>Pinus patula</i> (Mexican weeping pine), and <i>Leucaena leucocarpa</i> (gorse); ..."

Qsn #	Question	Answer
	Richardson, D. M., & Rejmánek, M. 2004. Conifers as invasive aliens: a global survey and predictive framework. <i>Diversity and Distributions</i> , 10(5-6): 321-331	"We summarize information on naturalized and invasive conifers (class Pinopsida) worldwide (data from 40 countries, some with remote states/territories), and contrast these findings with patterns for other gymnosperms (classes Cycadopsida, Gnetopsida and Ginkgoopsida) and for woody angiosperms." ... "Twenty-eight of the known invasive conifers belong to one family (Pinaceae) and 21 of these are in one genus (Pinus)."
	Richardson, D. M., Williams, P. A., & Hobbs, R. J. (1994). Pine invasions in the Southern Hemisphere: determinants of spread and invadability. <i>Journal of Biogeography</i> 21(5): 511-527	<i>Pinus banksiana</i> is invasive in New Zealand in scrub and open places on and near forest margins, shrublands, tussock grassland. At least 16 <i>Pinus</i> species are invasive in the Southern hemisphere: <i>P. banksia</i> , <i>P. canariensis</i> , <i>P. contorta</i> , <i>P. elliottii</i> , <i>P. halepensis</i> , <i>P. muricata</i> , <i>P. nigra</i> , <i>P. patula</i> , <i>P. pinaster</i> , <i>P. pinea</i> , <i>P. ponderosa</i> , <i>P. radiata</i> , <i>P. roxburghii</i> , <i>P. strobus</i> , <i>P. sylvestris</i> , <i>P. taeda</i> .

401	Produces spines, thorns or burrs	n
	Source(s)	Notes
	CAB International, 2005. <i>Forestry Compendium</i> . CAB International, Wallingford, UK	[No evidence] "Tree, evergreen, with dense crown, with foliage an unusually deep, vivid green. Crown habit: in young trees pointed, usually somewhat irregular in outline reflecting complex branching pattern, varying from narrow and spire-like on many infertile sites to broad and coarse under high fertility; in old trees rounded or even flattened at top. Persistent, usually large, cones are generally a conspicuous feature."

402	Allelopathic	
	Source(s)	Notes
	Mahboubi, P., Gordon, A. M., Stoskopf, N., & Voroney, R. P (1997). Agroforestry in the Bolivian Altiplano: evaluation of tree species and greenhouse growth of wheat on soils treated with tree leaves. <i>Agroforestry Systems</i> , 37(1): 59-77	"AB: Severe environmental problems encountered in the highlands of Bolivia may be remedied through the adoption of agroforestry systems, which have never before studied adequately in this region. As a first step, 7 tree species were tested for growth, survival and health at 2 altitudes (2700 and 4200 m) in the Bolivian altiplano. Species responded variably, with <i>Buddleja coriacea</i> , <i>Pinus radiata</i> and <i>Eucalyptus globulus</i> (at the higher altitude) and <i>E. globulus</i> , <i>Baccharis</i> sp., <i>Robinia pseudoacacia</i> and <i>B. coriacea</i> (at the lower altitude), displaying high survival, growth and health, and the 2 other species (<i>Alnus nepalensis</i> , <i>Caragana arborescens</i>) not surviving or intolerant to the test sites. In a related greenhouse study, grain yields of wheat planted in soils amended with incorporated foliage of <i>B. coriacea</i> , <i>P. radiata</i> and <i>E. globulus</i> increased 3-fold (approx equal to 0.3 to >1.0 g/plant) over grain yields in unamended soils, in the order <i>B. coriacea</i> > <i>P. radiata</i> = <i>E. globulus</i> . Grain nitrogen (mg/plant) increased equally in soils amended with <i>P. radiata</i> and <i>B. coriacea</i> foliage (approx equal to 18 to 20 mg/plant) but decreased in soils amended with foliage of <i>E. globulus</i> (approx equal to 18 to 9 g/plant)." [No allelopathy documented]

Qsn #	Question	Answer
	Lill, R. E., McWha, J. A., & Cole, A. L. J. (1979). The influence of volatile substances from incubated litter of <i>Pinus radiata</i> on seed germination. <i>Annals of Botany</i> , 43 (1), 81-85	"AB: Vapour from incubated <i>Pinus radiata</i> litter caused a depression in the germination of <i>Lolium perenne</i> seeds and responses varying from stimulation to depression in germination of <i>Trifolium repens</i> seeds. These effects could be attributed to ethylene and carbon dioxide. Experiments using ethylene and carbon dioxide supported this conclusion." [Possible mechanism for allelopathy]
	Ballester, A., Arias, A. M., Cobián, B., Calvo, E. L., & Vieitez, E. (1982). Estudio de potenciales alelopáticos originados por <i>Eucalyptus globulus</i> Labill., <i>Pinus pinaster</i> Ait. y <i>Pinus radiata</i> D. <i>Pastos</i> , 12(2): 239-254	"For laboratory trials, eucalyptus leaves and pine needles were gathered and tested immediately or frozen for extract trials. Dry leaves and needles were collected in April. The allelopathic effects of aqueous solutions, direct contact, volatile components and chromatographic fractions of aqueous solutions were tested on seedling growth of 4 legume and 5 grass spp. It was concluded that the activity of aqueous extracts was in the order <i>E. globulus</i> > <i>P. pinaster</i> > <i>P. radiata</i> . Extracts of materials collected in April were more inhibitory than those of material collected in Jan. Seedlings of <i>Festuca</i> spp. were the most affected, other spp. being scarcely affected. Chromatographic separation showed that the majority of the compounds present were phenolic. Inhibition by contact was greater than for aqueous extracts. Several volatile toxins, probably terpenes, were found in the 3 spp" (=lab allelopathy) .
	Guerrero, P. C., & Bustamante, R. O. (2007). Can native tree species regenerate in <i>Pinus radiata</i> plantations in Chile?: Evidence from field and laboratory experiments. <i>Forest Ecology and Management</i> , 253(1): 97-102	[Possibly. May inhibit germination but not seedling survival] "Our laboratory experiment showed a reduction in seed germination of <i>C. alba</i> seeds watered with an extract of leachate from <i>P. radiata</i> plantations compared to pure water, which suggests allelopathic effects of <i>P. radiata</i> plantation litter (Souto et al., 2001). However this negative effect is not severe and is equivalent to that detected for the native forest litter. The presence of allelopathic biochemicals in some native species, as in <i>Kageneckia angustifolia</i> , may explain the equivalent inhibitory results on seed germination of native forest and <i>P. radiata</i> plantation litter extract (Fuentes et al., 1987; Mongelli et al., 1997; Cavieres et al., 2007). However, we did not detect effects of <i>P. radiata</i> plantation or native forest litter extract on the survival and growth of <i>C. alba</i> seedlings, suggesting that germination is more sensitive than later stages to allelopathic inhibitors."
	WRA Specialist. 2015. Personal Communication	Results of laboratory experiments are inconclusive. Some demonstrate <i>Pinus radiata</i> 's allelopathic potential. Others do not

403	Parasitic	n
	Source(s)	Notes
	CAB International, 2005. <i>Forestry Compendium</i> . CAB International, Wallingford, UK	"Tree, evergreen, with dense crown, with foliage an unusually deep, vivid green." [Pinaceae]

404	Unpalatable to grazing animals	n
	Source(s)	Notes

Qsn #	Question	Answer
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 6 Mar 2015]	"Goats, black-tailed deer, and porcupine browse Monterey pine. Porcupine also eat the bark [27,30,35]. Birds and small mammals consume the seeds [35]."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The brushtail possum, <i>Trichosurus vulpecula</i> , browses stands of <i>P. radiata</i> in New Zealand. Damage involves needle clipping and damage to lateral branches, though is not normally severe (Jacometti et al., 1997)."

405	Toxic to animals	n
	Source(s)	Notes
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 9 Mar 2015]	[No evidence] "Goats, black-tailed deer, and porcupine browse Monterey pine. Porcupine also eat the bark [27,30,35]. Birds and small mammals consume the seeds [35]."
	Cornell University. 2015. Plants Poisonous to Livestock and other Animals. http://www.ansci.cornell.edu/plants/index.html . [Accessed 9 Mar 2015]	No evidence

406	Host for recognized pests and pathogens	
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"A number of pathogens, parasitic plants and insects affect <i>P. radiata</i> within its limited natural geographic range. Moreover, because this pine has been widely planted in many parts of the world, a large number of damaging agents have found it to be a suitable host and have developed into important pests. Agents that damage <i>P. radiata</i> are reviewed by Scott (1960), McDonald and Laacke (1990) and Lavery and Mead (1998)."
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 9 Mar 2015]	"Monterey pine is affected by many pests such as western dwarf mistletoe, western gall rust, various needle blights, and moths [2,35,44]."
	WRA Specialist. 2015. Personal Communication	A large number of pests & pathogens affect <i>P. radiata</i> , which may also impact other <i>Pinus</i> species. This would be a concern for commercial pine cultivation, but not for native flora of the Hawaiian Islands.

407	Causes allergies or is otherwise toxic to humans	
	Source(s)	Notes

Qsn #	Question	Answer
	Fountain, D. W., & Cornford, C. A. (1991). Aerobiology and allergenicity of <i>Pinus radiata</i> pollen in New Zealand. <i>Grana</i> , 30(1), 71-75	"The results presented here for <i>Pinus radiata</i> suggest that the status of <i>Pinus</i> as an allergen source might well be re-assessed. We have found preliminary evidence of allergenic proteins, possibly cross-reactive with ryegrass pollen allergens. In addition <i>P. radiata</i> pollen leaches low molecular weight compounds into solution, at least two of which are pharmacologically active. The clinical significance is as yet unknown but they may represent another way by which human health is affected by pollen."
	DermNet NZ. 2015. Radiata pine. http://www.dermnetnz.org/dermatitis/plants/radiata.html . [Accessed 9 Mar 2015]	[Susceptible individuals may be allergic to pollen, & exposure to sawdust may cause dermatitis] "Allergens: Allergic contact dermatitis. Five allergenic proteins have been detected in pine pollen: 82 kD, 67 kD, 54 kD, 44 kD, and 38 kD. The pollen grain is large, and therefore allergy is thought to be uncommon. However, a recent study from Spain suggests that <i>Pinus radiata</i> pollen may be a significant aeroallergen. Colophony (abietic acid), derived from Pine trees, is a complex mixture of over 100 compounds. Colophony is one of the top 10 causes of contact dermatitis and one of the most common causes of occupational asthma. Other allergens associated with pine trees include Woodcutter's eczema caused by lichens and/or liverworts (<i>Frullania</i>) living on the bark. Allergic reactions to the caterpillar (<i>Thaumetopoea pityocampa</i>) has also been documented among visitors to Pine forests. Dermatitis and ocular lesions may occur by an IgE, mechanic or toxic mechanism. Allergy: Asthma, allergic rhinitis and allergic conjunctivitis. Allergic contact dermatitis (colophony). Several studies suggest that 1-5% of pollen allergic subjects are pine pollen positive Forestry and wood workers show a much higher frequency of IgE sensitisation to the extract of Pine wood dust. Airborne allergic contact dermatitis from Pine dust has been documented. "

408	Creates a fire hazard in natural ecosystems	y
	Source(s)	Notes
	Fonda, R. W., Belanger, L. A., & Burley, L. L. (1998). Burning characteristics of western conifer needles. <i>Northwest Science</i> 7 (1): 1-9	"AB: The needles from thirteen species of western conifers were burned to compare flammability of nonwoody fuels. The following burning characteristics were measured: maximum flame height, flame time, ember time, burn time, percent combusted, and mean rate of weight loss. The burning characteristics tested in this study address important aspects of nonwoody fuel flammability in coniferous forests. Ponderosa pine (<i>Pinus ponderosa</i>), Jeffrey pine (<i>P. jeffreyi</i>), Monterey pine (<i>P. radiata</i>), coast redwood (<i>Sequoia sempervirens</i>), knobcone pine (<i>P. attenuata</i>), giant sequoia (<i>Sequoiadendron giganteum</i>), and sugar pine (<i>P. lambertiana</i>) ranked in the upper half of most of the burn categories. These highly flammable species are prominent in communities for which fire return intervals are two to four decades. Lodgepole pine (<i>P. contorta</i>), western redcedar (<i>Thuja plicata</i>), Douglas-fir (<i>Pseudotsuga menziesii</i>), Pacific silver fir (<i>Abies amabilis</i>), subalpine fir (<i>A. lasiocarpa</i>), and western hemlock (<i>Tsuga heterophylla</i>) seldom ranked in the upper half of any of the burn categories. The needles of these species are less flammable than the upper group of seven. The fire return intervals for the communities in which they grow are commonly two or more centuries. "

Qsn #	Question	Answer
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"Fire is a major influence affecting the extent and makeup of Monterey pine stands. Fire is frequent, sometimes of natural causes, often accidental, and sometimes deliberately set." [Increases fire risk in the Hawaiian Islands, where fire was not a common driving factor prior to human arrival & modification of ecosystems]

409	Is a shade tolerant plant at some stage of its life cycle	y
	Source(s)	Notes
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 6 Mar 2015]	"Monterey pine has intermediate shade tolerance [6,35]. As it matures it becomes even less tolerant of shade, and shows optimal growth in full sunlight [5]."
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"Pines also become established in grassland vegetation and beneath live oaks, the latter providing shade during the critical establishment period. In most instances, the pines eventually grow through the oak canopy and dominate (23). Some pines reproduce naturally under the canopies of older trees." ... "Because Monterey pine exists both as an overstory and an understory tree, it is classed as intermediate in tolerance to shade (4)- that is, at least as tolerant as any other pine in western North America. Age and site quality, however, affect this assessment. As a sapling or seedling, the species tolerates shade but becomes less tolerant in the pole stage and is intolerant when mature (19)."

Qsn #	Question	Answer
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y
	Source(s)	Notes
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"In spite of a small and narrow natural range, Monterey pine grows on soils that are derived from a variety of parent materials."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Like most of the genus, <i>P. radiata</i> is relatively undemanding in its soil requirements, maintaining its performance well over microsite variations. However, it tends to require higher soil fertility than many pines, in accordance with its high growth potential and coastal origin." "Soil descriptors - Soil texture: light; medium; heavy - Soil drainage: free; impeded - Soil reaction: acid; neutral - Special soil tolerances: shallow; infertile - Soil types: acid soils; alfisols; alluvial soils; arenosols; vertisols; cambisols; chernozems; clay soils; colluvial soils; fluvisols; gleysols; granite soils; grassland soils; gravelly soils; loess soils; ferralsols; palaeosols; podzoluvisols; luvisols; pseudogleys; sandstone soils; sandy soils; silty soils; subtropical soils; volcanic soils"

411	Climbing or smothering growth habit	n
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Tree, evergreen, with dense crown, with foliage an unusually deep, vivid green."

412	Forms dense thickets	y
	Source(s)	Notes
	Weber, E. 2003. Invasive Plant Species of the World. A Reference Guide to Environmental Weeds. CABI Publishing, Wallingford, UK	"It establishes well in burned areas and forms dense stands that may cover large areas. The native vegetation is eliminated and transformed into species poor woodland. A thick litter layer accumulates beneath stands of this tree, preventing establishment of native plants."

501	Aquatic	n
	Source(s)	Notes
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	Terrestrial tree

502	Grass	n
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Qsn #	Question	Answer
	Source(s)	Notes
	Flora of North America Editorial Committee. 1993. Flora of North America: Volume 2: Pteridophytes and Gymnosperms. Oxford University Press, Oxford, UK	"Trees to 30m; trunk to 0.9m diam." [Pinaceae]
503	Nitrogen fixing woody plant	n
	Source(s)	Notes
	Flora of North America Editorial Committee. 1993. Flora of North America: Volume 2: Pteridophytes and Gymnosperms. Oxford University Press, Oxford, UK	"Pinaceae"
504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	n
	Source(s)	Notes
	Flora of North America Editorial Committee. 1993. Flora of North America: Volume 2: Pteridophytes and Gymnosperms. Oxford University Press, Oxford, UK	"Trees to 30m; trunk to 0.9m diam., contorted to straight; crown broadly conic, becoming rounded to flattened. Bark gray, deeply V-furrowed, furrow bases red, ridges irregularly elongate rectangular, their flattened surfaces scaly. Branches level to downcurved or ascending, poorly self pruning; twigs slender, red-brown, sometimes glaucous, aging gray, rough."
601	Evidence of substantial reproductive failure in native habitat	y
	Source(s)	Notes
	Farjon, A. 2013. <i>Pinus radiata</i> . The IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org	"Based on the assessments of the two varieties, it is considered that although the large subpopulation on Cedros Island (var. <i>binata</i>) appears stable, the situation on the mainland (var. <i>radiata</i>) is more severe and in total the population is in continuing decline. There are no more than five locations and the population is severely fragmented. With a combined area of occupancy of less than 30 km ² the species meets B2 for Endangered." ... "Subpopulations exist on the mainland coast of California (three) and on two islands off the coast of Mexico (two to three); only one of these is healthy and regenerating well. "
602	Produces viable seed	y
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Commercial propagation is still mainly from seed."
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 9 Mar 2015]	"Monterey pine cones are serotinous; seeds are released when cones are exposed to heat such as fire or high air temperature [19,31,37,53]. Fire is particularly effective for opening cones and releasing seeds. It also creates a favorable seedbed. Reproduction rates are greatest after surface fire in which the parent trees survive [52]."

Qsn #	Question	Answer
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"Seed Production and Dissemination- Fertile cones are produced as early as 5 to 10 years, but substantial crops are not yielded until age 15 or 20 if the trees are open-grown, and considerably later if the stands are dense." ... "Although cones and seeds are produced almost every year, seedfall varies. A relatively small number of seeds dribble out of the cones each year. In warm and dry years, seedfall can be heavy. Fire is particularly effective for opening cones and releasing large quantities of stored seeds."

603	Hybridizes naturally	y
	Source(s)	Notes
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 9 Mar 2015]	"Monterey pine hybridizes with knobcone pine (<i>Pinus attenuata</i>) and bishop pine (<i>Pinus muricata</i>) [12,32,25]."
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"No evidence of widespread introgression from knobcone or bishop pine has been found, although hybridization is occurring locally between Monterey and knobcone pines at Año Nuevo (11). The hybrid is designated <i>Pinus attenuata</i> x <i>radiata</i> Stockwell & Righter. The two-needled pine found on Guadalupe and Cedros Islands is currently named <i>P. radiata</i> var. <i>binata</i> ."

604	Self-compatible or apomictic	y
	Source(s)	Notes
	Cronk, Q.C.B. & Fuller, J.L. 1995. Plant invaders: the threat to natural ecosystems. Chapman and Hall, London, UK	" <i>Pinus radiata</i> is self-compatible (although there is considerable variation in self-fertility) and thus isolated individuals can produce viable seed."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Reproductive behaviour of <i>P. radiata</i> is covered by Burdon and Miller (1992). Like pines in general it is a hermaphrodite, but is incompletely self-fertile (Griffin and Lindgren, 1985) and shows inbreeding depression (Wilcox, 1983)."

605	Requires specialist pollinators	n
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"It is wind-pollinated. Pollen production begins on all trees at an early age, generally around 5-6 years, depending somewhat on site and provenance."

Qsn #	Question	Answer
606	Reproduction by vegetative fragmentation	n
	Source(s)	Notes
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"Vegetative Reproduction- Monterey pine does not reproduce naturally from sprouts, and no record of sprouting in natural stands is known."

607	Minimum generative time (years)	>3
	Source(s)	Notes
	Weber, E. 2003. Invasive Plant Species of the World. A Reference Guide to Environmental Weeds. CABI Publishing, Wallingford, UK	"A fast growing tree with a juvenile period of c. 5 years..."
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	"Fertile cones are produced as early as 5 to 10 years, but substantial crops are not yielded until age 15 or 20 if the trees are open-grown, and considerably later if the stands are dense."
	Loope, L.L., Nagata, R.J. & Medeiros, A.C. 1992, Alien plants in Haleakala National Park Pp. 551-576 in Stone et al (eds) Alien plant invasions in native ecosystems of Hawaii. Coop. Nat. Park Resources Studies Unit, University of Hawaii, Honolulu, HI	"On favorable sites these species can grow in height at a rate of about 12 in./yr (30 cm/year) and start to produce cones after sk to eight years."

701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	n
	Source(s)	Notes
	Cronk, Q.C.B. & Fuller, J.L. 1995. Plant invaders: the threat to natural ecosystems. Chapman and Hall, London, UK	[No evidence] "small, light, winged seeds easily dispersed long-distances by wind"

702	Propagules dispersed intentionally by people	y
	Source(s)	Notes
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"P. radiata has been planted on a massive scale in New Zealand and south-central Chile (ca. 1.5 million ha each), southern Australia (>700,000 ha) and northern Spain (ca. 220,000 ha) (after Burdon, 2000: cf. Lewis and Ferguson, 1993; Lavery and Mead, 1998). Significant areas of plantation exist in western Cape Province of South Africa (ca. 55,000 ha) and Argentina, Italy (Sardinia), Ecuador, Kenya, Colombia and Peru, with lesser plantings in various Mediterranean countries, France and the British Isles, and some African and South American countries (op. cit.)."
	Little Jr., E.L. & Skolmen, R.G. 1989. Common forest trees of Hawaii: (native and introduced). USDA Agriculture Handbook No. 679. USDA Forest Service, Washington, D.C.	"The most common pine in forest plantations through the southern hemisphere for pulpwood and lumber, particularly in Australia, New Zealand, and South Africa. Grown also for shade and ornament."

703	Propagules likely to disperse as a produce contaminant	n
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Qsn #	Question	Answer
	Source(s)	Notes
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	[No evidence] "The seeds are winged and are dispersed by the wind. Pryor (1991) records that dispersal is typically within 2-3 times the height of the tree but may occasionally be moved over several kilometres. Intentional introduction is the prime cause of long-distant dispersal. <i>P. radiata</i> is more extensively grown as an exotic than any other forest tree, occupying some 4 million ha as fast-growing plantations, of which over 90% are located in the Southern Hemisphere."

704	Propagules adapted to wind dispersal	y
	Source(s)	Notes
	van Wilgen, B. W. & Siegfried, W. R. (1986) Seed dispersal properties of three pine species as a determinant of invasive potential. <i>South African Journal of Botany</i> 52(6): 546-548	"AB: Data are presented on the seed morphology of 3 pine species found in SW Cape Province, South Africa, <i>Pinus pinea</i> , <i>P. pinaster</i> and <i>P. radiata</i> . The seeds of both <i>P. pinaster</i> and <i>P. radiata</i> are relatively small (50 and 20 mg respectively) and have relatively large wings (190 and 110 mm ² respectively), while <i>P. pinea</i> seeds are larger (700 mg) with smaller wings (24 mm ²). Data on the rate of fall of samaras of all 3 species determined in the laboratory and field data on the dispersal of <i>P. pinaster</i> and <i>P. pinea</i> showed that <i>P. pinea</i> samaras drop straight to the ground and seedlings of this species occur only under parent trees, whereas the samaras of <i>P. pinaster</i> and <i>P. radiata</i> are adapted for long-range dispersal."
	Haby, N., Herpich, M. & Tunn, Y. 2009. Detection of <i>Pinus radiata</i> wildings in remnant vegetation in the lower SE of South Australia, and far SW of Victoria: a Pilot Study. <i>Land & Water Australia</i> , Canberra	" <i>Pinus radiata</i> produces seeds equipped with a large wing for long-range dispersal (Wilgen & Siegfried 1986). Long distance dispersal of a wind dispersed pine seed is facilitated by 'uplifting' (Buckley et al 2005)."
	Williams, M. C., & Wardle, G. M. (2005). The invasion of two native Eucalypt forests by <i>Pinus radiata</i> in the Blue Mountains, New South Wales, Australia. <i>Biological Conservation</i> , 125(1): 55-64	"The seeds of many pine species are highly adapted for wind dispersal." ... "Regional, dominant north westerly winds during drier periods of the year may be responsible for the dispersal of larger quantities of seed to the south east of the plantation. This pattern of dispersal and subsequent invasion of <i>P. radiata</i> has also been observed during aerial surveys across the Blue Mountains region (C. BanVy, pers. commun.). It is clear that wind exhibits a large influence on the spatial distribution of invading pines and is an important parameter in the prediction of invasion events."

705	Propagules water dispersed	n
	Source(s)	Notes
	Haby, N., Herpich, M. & Tunn, Y. 2009. Detection of <i>Pinus radiata</i> wildings in remnant vegetation in the lower SE of South Australia, and far SW of Victoria: a Pilot Study. <i>Land & Water Australia</i> , Canberra	"Dispersal of <i>P. radiata</i> seeds is mainly by wind and less frequently by birds."
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	[No evidence] "The seeds are winged and are dispersed by the wind. Pryor (1991) records that dispersal is typically within 2-3 times the height of the tree but may occasionally be moved over several kilometres. Intentional introduction is the prime cause of long-distant dispersal."

Qsn #	Question	Answer
706	Propagules bird dispersed	
	Source(s)	Notes
	Haby, N., Herpich, M. & Tunn, Y. 2009. Detection of <i>Pinus radiata</i> wildlings in remnant vegetation in the lower SE of South Australia, and far SW of Victoria: a Pilot Study. Land & Water Australia, Canberra	"Dispersal of <i>P. radiata</i> seeds is mainly by wind and less frequently by birds. Only 3 % of seed disperses further than 20 m from the parent tree and most seed will fall within 400 m of a plantation."
	Burns, R.M. & Honkala, B.H. 1990. Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC	[Birds act primarily as seed predators, but see Williams & Wardle (2005)] "Several species of birds and small mammals depend in part for sustenance on the seeds of Monterey pine. Principal bird species are the scrub jay, Stellar jay, and common crow. Important small mammals are deer mice, chipmunks, and ground squirrels (7). Numerous other creatures eat the seeds of this pine, but their effect usually is insignificant."
	Williams, M. C., & Wardle, G. M. (2005). The invasion of two native Eucalypt forests by <i>Pinus radiata</i> in the Blue Mountains, New South Wales, Australia. Biological Conservation, 125(1): 55-64	[Birds may disperse seeds on a limited basis] "The presence of isolated trees suggests that wind may not be the only dispersal mechanism operating. The occurrence of pines at long distances from plantations has previously been attributed to dispersal by birds (Burdon and Chilvers, 1977). Yellow-tailed black Cockatoos, <i>Calyptorhynchus funereus</i> , have been known to feed on cones and carry seed away (Buchanan, 1989; Gill and Williams, 1996) and were observed feeding on plantation trees at both study sites. Seed dispersal by these birds may act to increase the rate of invasion as wildlings mature and produce their own seed at long distances away from the plantation."

707	Propagules dispersed by other animals (externally)	n
	Source(s)	Notes
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	"The seeds are winged and are dispersed by the wind. Pryor (1991) records that dispersal is typically within 2-3 times the height of the tree but may occasionally be moved over several kilometres."

708	Propagules survive passage through the gut	n
	Source(s)	Notes
	CABI, 2015. <i>Pinus radiata</i> . In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc	"The seeds are winged and are dispersed by the wind. Pryor (1991) records that dispersal is typically within 2-3 times the height of the tree but may occasionally be moved over several kilometres."

Qsn #	Question	Answer
801	Prolific seed production (>1000/m²)	n
	Source(s)	Notes
	Burns, R.M. & Honkala, B.H. 1990. <i>Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654.</i> U.S. Department of Agriculture, Forest Service, Washington, DC	"Although cones and seeds are produced almost every year, seedfall varies. A relatively small number of seeds dribble out of the cones each year. In warm and dry years, seedfall can be heavy."
	Williams, M. C., & Wardle, G. M. (2007). <i>Pinus radiata</i> invasion in Australia: identifying key knowledge gaps and research directions. <i>Austral Ecology</i> , 32(7), 721-739	"The canopy-held seed bank of <i>P. radiata</i> in plantations in South Australia has been estimated at between 3.6 and 8.3 million seeds per hectare with annual seed release in a 40-year-old plantation at one site estimated at approximately 1–3 seeds per m ² (Van der Sommen 1978 sourcing unpublished data in Virtue & Melland 2003)."

802	Evidence that a persistent propagule bank is formed (>1 yr)	y
	Source(s)	Notes
	Cope, A. B. 1993. <i>Pinus radiata</i> . In: <i>Fire Effects Information System</i> , [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/ . [Accessed 6 Mar 2015]	"Monterey pine cones are serotinous; seeds are released when cones are exposed to heat such as fire or high air temperature [19,31,37,53]. Fire is particularly effective for opening cones and releasing seeds. It also creates a favorable seedbed. Reproduction rates are greatest after surface fire in which the parent trees survive [52]."
	Farooqui, U. M., Dixit, R. K., Patra, A. K., Rayal, S. P., Khan, A., & Tiwari, S. K. (2000). Effectiveness of different seed extraction methods on seed value from the cones of <i>Pinus radiata</i> . <i>Indian Forester</i> , 126(9): 936-942	"The cones of radiata pine or <i>Pinus radiata</i> are serotinous. The cone scales are stuck together by resin, making natural seed release impossible for many years."
	Burns, R.M. & Honkala, B.H. 1990. <i>Silvics of North America. Volume 1: Conifers. Agriculture Handbook 654.</i> U.S. Department of Agriculture, Forest Service, Washington, DC	"Seed bank" persists in the cones on the tree] "Cones remain attached to the trees for many years and open and close several times, depending on temperature and humidity. Because the habitat of the species is typically cool and moist, cone opening is infrequent and of short duration, so that seeds are often retained and then disseminated over a longer period than in warmer and drier climates."

803	Well controlled by herbicides	y
	Source(s)	Notes

Qsn #	Question	Answer
	Williams, M. C., & Wardle, G. M. (2007). <i>Pinus radiata</i> invasion in Australia: identifying key knowledge gaps and research directions. <i>Austral Ecology</i> , 32(7), 721-739	"A range of chemicals are also capable of controlling young <i>P. radiata</i> individuals (Minko 1985). Spraying of low concentrations of amitrole plus ammonium thiocyanate, dicamba, fosamine ammonium, glyphosate or paraquet result in the death of pines. In New Zealand, metsulphuron (100–120 g ha ⁻¹) is mixed with a surfactant and either glyphosate (5 kg ha ⁻¹) or paraquet (5.6 L ha ⁻¹) to spray and kill wildings less than 3 m tall (Ledgard 2004). Chemical treatment involves injecting wildlings with herbicide and may be preferred to mechanical removal as it requires less physical effort. Sodium chlorate is used to kill stumps of wildling pines when it is not possible to remove all live foliage (Ledgard 2004). In Australia, treatments involving mechanical cutting combined with herbicide application have enjoyed 100% success rates (N.Westman & C. Banffy, pers. comm. 2005)."
	Kingdom, D. 2014. The challenges of controlling an extensive <i>radiata</i> pine (<i>Pinus radiata</i>) infestation in native bushland. Pp. 365 368 in Baker, M. (ed.). <i>Proceedings of the 19th Australasian Weeds Conference</i> . 1-4 September 2014, Hobart, Tasmania. Tasmanian Weed Society	"Primary control of the <i>radiata</i> pine infestation was achieved by combining two methods: felling of small individuals below the first branch, and drill and kill of larger individuals using undiluted glyphosate 540 g a.i. L ⁻¹ . Using a drill and kill technique developed in New Zealand, the number of holes required per tree to achieve a complete kill was approximately one hole per 35 cm of tree circumference, with 10 mL of herbicide injected into each hole."

804	Tolerates, or benefits from, mutilation, cultivation, or fire	y
	Source(s)	Notes
	CAB International, 2005. <i>Forestry Compendium</i> . CAB International, Wallingford, UK	[Tolerates & benefits from fire at certain growth stages] "Ground fires are tolerated by old trees, and by pole-stage trees if intensity is low. Crown fires, however, can occur readily in hot, dry conditions, and kill. That will release abundant seed from unopened cones, often leading to dense natural regeneration. Similar regeneration can follow clearfelling. Fire is part of the species' natural ecology." ... "Fire can be damaging to dense <i>P. radiata</i> plantations, especially young plantations with thin bark. Dense plantations, where persistent lower limbs contain dead needles, are especially susceptible to fire damage (McDonald and Laacke, 1990). This pine has several adaptations to fire including serotinous cones and thick bark on older trees (Keeley and Zedler, 1998)."

805	Effective natural enemies present locally (e.g. introduced biocontrol agents)	n
	Source(s)	Notes
	Cronk, Q.C.B. & Fuller, J.L. 1995. <i>Plant invaders: the threat to natural ecosystems</i> . Chapman and Hall, London, UK	"Biological Control. As <i>Pinus radiata</i> is such an economically important species and <i>Pinus</i> such an important genus, biological control methods have never been sought."
	CABI, 2015. <i>Pinus radiata</i> . In: <i>Invasive Species Compendium</i> . Wallingford, UK: CAB International. www.cabi.org/isc	No evidence

Summary of Risk Traits:

High Risk / Undesirable Traits

- Elevation range exceeds 1000 m, demonstrating environmental versatility
- Widely naturalized
- An environmental weed in Australia, South Africa and Hawaii
- Other *Pinus* species have become invasive
- Exposure to pollen or sawdust may cause allergies or dermatitis
- Increases fire risk
- Seedling and saplings are shade tolerant
- Tolerates many soil types
- Able to form dense stands
- Reproduces by seeds
- Able to hybridize with other *Pinus* species
- Self-compatible
- Seeds dispersed by wind, rarely by birds & intentionally by people
- Serotinous cones “store” seeds for years until exposed to fire or high temperatures
- Older trees tolerate ground fires, pole-stage trees tolerate low intensity fires

Low Risk Traits

- Valuable commercial tree (pulp, timber, Christmas trees, landscaping)
- Unarmed (no spines, thorns or burrs)
- Palatable to a number of browsing animals
- Not reported to spread vegetatively
- Reaches maturity in 5+ years
- Herbicides may provide effective control