

Advice on Replanting Sites Affected by *Phytophthora ramorum*

The most significant plant species in the life cycle of *Phytophthora ramorum* are those that support spore production; these spores are mainly, if not exclusively, produced on infected leaves or green shoots. In Britain, the key plant species which act as these 'sporulating hosts' and produce abundant spores from infected foliage are rhododendron and larch, especially Japanese larch. A few other tree species, most notably holm oak, ash and sweet chestnut, also have foliage that is moderately or very susceptible to infection by *P. ramorum* and can generate significant numbers of spores once infected. Even so, the spore quantities produced by infected oak and ash leaves are usually much lower than the number produced from Japanese larch and rhododendron, although emerging evidence suggests that sweet chestnut is also a significant sporulator, intermediate between larch and rhododendron.

Once these major sporulating hosts are removed from an infected site, residual spores of *P. ramorum* are likely to remain in the leaf litter and soil for 2-4 years, but the quantity will gradually diminish over time. Available scientific evidence (based on monitoring sites after the removal of infected rhododendron) suggests this residual inoculum is unlikely to pose an infection risk to species planted on cleared sites, unless they have susceptible foliage, which may be readily infected by whatever spores remain. Also, if the infected foliage then generates high numbers of spores, it creates the potential for a new epidemic of *P. ramorum* to build up on a site and start to affect other trees with susceptible bark, thus becoming the more damaging and lethal form of the disease. There may be an additional risk when replanting some tree species with very susceptible bark if they are planted on sites where infected larch has been cleared, but considerable amounts of brash remain, potentially bringing infected larch material into close contact with the bark on stems of young trees. Field observations suggest that bark on stems and branches of young trees of Douglas fir and western hemlock may be especially susceptible to infection by *P. ramorum*.

Species choice

Consideration of what and when to plant on affected but cleared sites is critical. For ornamental shrubs in parks and gardens, replanting with a *P. ramorum*-susceptible host species is not recommended for 3 years after infected plants have been cleared from an area. However, this might not be realistic when restocking with tree species in woodlands and forests. *Phytophthora ramorum* has a wide host range, and many tree species have at least some susceptibility to the pathogen, although species of low or moderate susceptibility are only likely to succumb to infection when close (within 100m) to the heaviest 'sporulator' hosts.

Replanting recommendations

Therefore, advice on what tree species to replant with needs to take account of their bark and foliar susceptibility, the potential to act as a sporulating host should the foliage become infected, as well as the levels of residual contamination remaining on sites after removal of sporulating plants. This information for both conifer and broadleaf species, along with advice on whether to replant, is presented in Tables 1 and 2 below. The data on susceptibility comes from various sources, but primarily from:

- field assessments and laboratory tests undertaken by pathologists at Forest Research; and
- the EU FP6 project Risk Assessment of *Phytophthora ramorum*, which provided North American and European records of naturally infected hosts, as well as host susceptibility testing on hundreds of plant species.

Replanting recommendations

Table 1: Planting recommendations for conifers on *Phytophthora ramorum*-affected sites

Tree species	Known to be a natural host of <i>Phytophthora ramorum</i>		Laboratory host of <i>Phytophthora ramorum</i>		Sporulation on foliage	Planting recommendation
	Bark	Leaves/shoots	Bark	Leaves/shoots		
<i>Abies grandis</i>	Yes (+)	Yes (+)	Yes (+)	Yes (++)	Low	Plant with caution
<i>Chamaecyparis lawsoniana</i>	Yes ¹	No	Yes (+)	No data	No data	Can be planted
<i>Larix decidua</i>	Yes (++)	Yes (+)	Yes (++)	Yes (++)	Moderate	Avoid planting
<i>Larix kaempferi</i>	Yes (+++)	Yes (++)	Yes (+++)	Yes (++)	Very high	Avoid planting
<i>Larix hybrid</i>	Yes (++)	Yes (+)	Yes (+++)	Yes (++)	Moderate	Avoid planting
<i>Picea abies</i>	No	No	Yes (++)	Yes (+)	No data	Can be planted
<i>Picea sitchensis</i>	Yes ¹	Yes ¹	Yes (++)	Yes (+)	Very low	Can be planted
<i>Pinus sylvestris</i>	No	No	Resistant	Resistant	No data	Can be planted
<i>Pinus contorta</i>	No	No	Yes (+)	Resistant	No data	Can be planted
<i>Pinus nigra var larici</i>	No	No	Resistant	Resistant	No data	Can be planted
<i>Pseudotsuga mensiezii</i>	Yes (++)	Yes	Yes (++)	Yes (+++)	Very low, none	Plant with caution
<i>Taxus baccata</i>	No	Yes (+)	Yes (+)	Yes (+)	Low	Can be planted
<i>Thuja plicata</i>	No	No	Yes (+)	Resistant	No data	Can be planted
<i>Tsuga heterophylla</i>	Yes	Yes	Yes (++)	Yes (+)	Low	Plant with caution

¹ Indicates very uncommon; + very low/low level of susceptibility; ++ moderate susceptibility; +++ high susceptibility

Replanting recommendations

Table 2: Planting recommendations for broadleaf species on *Phytophthora ramorum*-affected sites

Tree species	Natural host of <i>Phytophthora ramorum</i>		Laboratory host of <i>Phytophthora ramorum</i>		Sporulation on foliage	Planting recommendation
	Bark	Leaves/shoots	Bark	Leaves/shoots		
<i>Acer campestre</i>	No	No	Yes (+++)	Resistant	No data	Can be planted
<i>Acer pseudoplatanus</i>	Yes ¹	No	Yes (+)	Yes (+)	Moderate	Can be planted
<i>Aesculus hippocastanum</i>	Yes ¹	Yes	Yes (+)	Yes (++)	Low-moderate	Can be planted
<i>Alnus glutinosa</i>	No	No	Yes (+)	Yes (+)	No data	Can be planted
<i>Betula pendula</i>	Yes (+)	No	Yes (+)	Yes (+)	No data	Can be planted
<i>Betula pubescens</i>	No	No	Yes (+)	No data	No data	Can be planted
<i>Catanea sativa</i>	Yes (++)	Yes (+++)	Yes (++)	Yes (++)	Moderate -high	Plant with caution
<i>Carpinus betulus</i>	No	No	Resistant	Yes (+)	No data	Can be planted
<i>Corylus avellana</i>	No	No	Yes (+)	Resistant	Low	Can be planted
<i>Fagus sylvatica</i>	Yes (+++)	Yes (+)	Yes (+++)	Resistant	None	Plant with caution
<i>Fraxinus excelsior</i>	No	Yes (++) ¹	Resistant	Yes (+++)	Moderate	Plant with caution
<i>Ilex aquifolium</i>	No	Yes	Yes (+)	Yes (+)	No data	Can be planted
<i>Nothofagus obliqua</i>	Yes (+++)	Yes (++)	Yes (+++)	No data	No data	Plant with caution
<i>Nothofagus procera</i>	No	No	Yes	No data	No data	Plant with caution
<i>Prunus avium</i>	No	No	Yes (+)	Resistant	No data	Can be planted

Replanting recommendations

<i>Quercus cerris</i>	Yes (+)	Yes (+)	Yes (++)	Yes (++)	Moderate	Plant with caution
<i>Quercus ilex</i>	No	Yes (++)	Yes (++)	Yes (++++)	Moderate	Plant with caution
<i>Quercus petraea</i>	Yes (+)	No	Yes (+)	Yes (++)	Moderate	Can be planted
<i>Quercus robur</i>	Yes (+)	No	Yes (+)	Yes (+)	Moderate	Can be planted
<i>Salix alba</i>	No	No	Yes (+)	Yes (++++)	No data	Can be planted
<i>Salix caprea</i>	No	Yes (+)	No data	Yes (+)	No data	Can be planted
<i>Tilia cordata</i>	No	No	Resistant	Yes (++)	No data	Can be planted

¹ Indicates very uncommon; + very low/low level of susceptibility; ++ moderate susceptibility; +++ high susceptibility