Birch dieback in new native woodlands in Scotland

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INTRODUCTION

Birch (*Betula* spp.) is a major component of native woodlands throughout Scotland, and is valued increasingly as a resource for conservation, habitat and landscape purposes. There has also been recent interest in the potential of silver birch as a timber species in the UK (Malcolm and Worrell, 2001). Silver birch and downy birch are two of the more important broadleaved species in recent native woodland afforestation schemes in Scotland. The area of native woodland is projected to increase further with the continued take-up of the Scottish Forestry Grant Scheme. As a result, there are now large numbers of young birch trees on a wide variety of site types across Scotland. During the past few years, extensive dieback of birch has been reported in more than 20 native woodland planting schemes in Scotland. Affected trees appear to grow well initially, but approximately 5–10 years after planting begin to exhibit crown dieback. Symptoms include sunken cankers and fissures on stems and branches, and discrete lesions and tip dieback on young shoots. Although factors such as unsuitable provenance (area of origin) and site selection, poor silvicultural management and frost damage may contribute to this dieback, these symptoms suggest that attack by fungal pathogens may be important. A number of fungal pathogens have been found to cause shoot and stem lesions on birch in Finland and Canada, resulting in dieback or crown thinning (Arnold, 1967; Paavolainen *et al.*, 2001). However, very little is known about the fungi associated with shoots of birch in the UK, or whether pathogenic shoot fungi are partly or wholly responsible for the symptoms of crown dieback. In 2002, FR initiated a study to investigate the fungal pathogens causing dieback of birch in Scotland; this article provides a brief overview of results from research conducted to date and is based on a recently published Information Note (Green, 2005).

Field surveys and pathogenicity tests

In May and September 2002, 30 diseased and 30 healthy young birch shoots were collected from each of five Woodland Grant Scheme (WGS) plantings in Scotland (Figure 1), making a total of 600 collected shoots. The fungi inhabiting these shoots were identified through a combination of isolation and incubation techniques. The most frequently occurring fungi were then inoculated onto birch seedlings in 2002 and 2003 to test their ability to cause disease on birch over subsequent growing seasons.

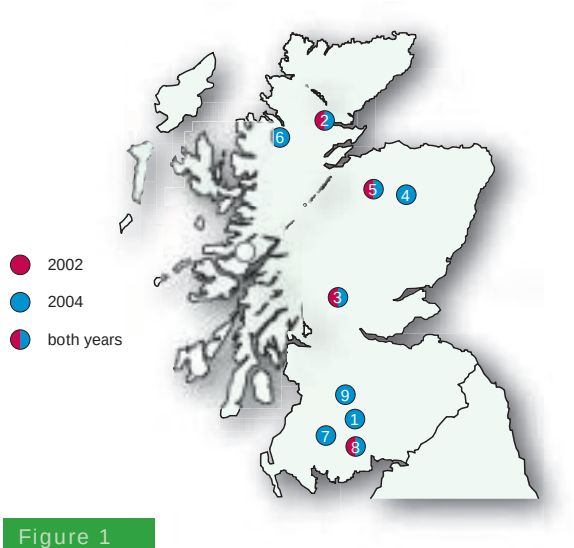

Figure 1

Map of Scotland indicating location of sites for the birch surveys in 2002 and 2004.

In 2004, 100 birch trees at each of nine WGS plantings in Scotland (Figure 1) were surveyed to evaluate the frequency of occurrence and severity of crown dieback, to record the incidence and severity of two fungi, *Anisogramma virgultorum* and *Marssonina betulae*, which were found to be pathogenic, and to determine whether a relationship exists between incidence of *M. betulae* foliar disease and incidence of other (non-*Anisogramma*) shoot/stem cankers. Eight of the sites were planted between 1989 and 1995 with some areas of more recent beating-up, and one site comprised late-1980s naturally regenerated downy birch of local origin.

Pathogenic fungi associated with birch shoots

At least 35 different fungal species were identified on young shoots of birch in the 2002 survey (Green, 2004). The majority of these fungi were non-pathogenic saprophytes or endophytes. Of the most frequently occurring fungal species from the 2002 survey which were inoculated onto birch in pathogenicity tests, three species caused significant disease and dieback: *Anisogramma virgultorum, Marssonina betulae* and *Discula betulina*.

Anisogramma virgultorum

Anisogramma virgultorum was first recorded on birch in the UK by Massee (1914), and has also been reported from other European countries and North America. This fungus was abundant on birch at four of the five WGS sites surveyed in Scotland in 2002. Inoculation studies conducted with *A. virgultorum* in Scotland have demonstrated that it is a primary pathogen on birch, with sexual spores, known as ascospores, infecting young, flushing shoots early in the growing season, stromatal cankers developing late in the growing season (Figure 2), and a large proportion of infected shoots dying back within the

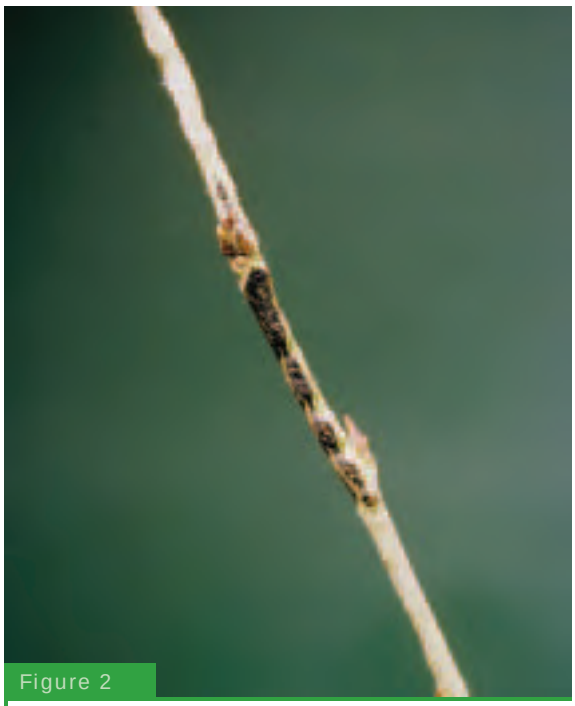

Figure 2

Stromatal canker of *Anisogramma virgultorum* on a young shoot of downy birch.

year following infection (Green and De Silva, unpublished). Currently, little is known about the biology of this fungus. From observations, the fungal fruiting structures, known as perithecia, develop within the black, strip-like, stromatal cankers on current shoots by the autumn following spring infections, and mature ascospores are released, probably via rainsplash, over the subsequent winter and spring. Once ascospores have been discharged, the stromatal tissues dry up and drop out of the cankers, leaving deep fissures in shoots and branches (Figure 3), which are indicative of older infections by *A. virgultorum.*

Marssonina betulae

Marssonina betulae is a common foliar pathogen on birch throughout Europe, causing leaf spots as well as lesions on young shoots. The fungus infects leaves and young shoots in spring and summer via asexual spores called conidia, which are likely spread by rainsplash from overwintering infected leaf material. Previously, damage caused by this fungus was thought to be limited to leaves and young, small shoots, and its degree of aggressiveness was considered to be weak (Peace, 1962; Bäucker & Eisenhauer 2001). In this study, *M. betulae* was found inhabiting diseased shoots at all five WGS sites sampled in 2002, causing necrotic lesions on 63 % of diseased 4 to 5-month-old shoots collected in September (Green, 2004). Also, inoculation of silver birch seedlings with *M. betulae* resulted in the development of secondary stem cankers (Figure 4), which continued to expand months after initial infection, causing extensive shoot dieback and the death of some seedlings (Green, unpublished). These results indicate that *M. betulae* is more damaging to birch than the literature currently suggests.

Figure 3

Elongated fissures in dead shoots of silver birch indicative of an old infection by *Anisogramma virgultorum*.

Figure 4

Secondary cankers on a silver birch seedling inoculated with *Marssonina betulae*, taken 19 months after inoculation.

Discula betulina

Discula betulina is another common leaf spot fungus on birch (Bennell and Millar, 1984). The means by which this fungus initiates new infections in the spring is unknown, but once established, it is thought that conidia produced on leaf spots are spread via rainsplash to perpetuate the cycle of leaf infections during the summer. *Discula betulina* has not been reported previously on birch shoots. However, *D. betulina* was found on both diseased and healthy shoots of birch from all five sites surveyed in Scotland in 2002, indicating that it has an endophytic, or asymptomatic, phase in its host (Green, 2004). When seedlings were inoculated with this fungus, dieback of young shoots occurred, but it did not cause progressive disease and all inoculated seedlings subsequently recovered from infection (Green, unpublished). Although not considered to be a major cause of birch dieback, *D. betulina* may contribute to the problem as severe leaf infections can cause premature defoliation (Phillips and Burdekin, 1982) and this fungus may cause death of small shoots in combination with other stress factors.

Impact of pathogenic fungi on young birch surveyed in Scotland in 2004

Eight of the nine WGS sites surveyed in 2004 (Figure 1) were exposed sites with moderately wet acidic soils and seven of the sites lay above 250 m elevation. In terms of exposure and wetness the most extreme sites were numbers 4, 6 and 7, whereas number 8 was the only sheltered, brown earth site in the survey (Table 1, Figure 1). At six of the nine sites, at least half of all birch trees surveyed had 40 % or greater crown dieback (Table 1). In total, 61 % of silver birch (n = 291) and 41 % of downy birch (*n* = 608) had 40 % or greater crown dieback.

Overall, 57 % of the 900 trees surveyed had *A. virgultorum* and 28 % had *M. betulae*, with incidences of infection varying quite widely from site to site (Table 1). *Anisogramma virgultorum* occurred more frequently on downy birch (64 % infected) than on silver birch (40 % infected), whereas *M. betulae* occurred more frequently on silver birch (50 % infected) than on downy birch (17 % infected). The incidence of other (non-*Anisogramma*)

Table 1

The percentage of trees with 40 % or greater crown dieback, infected by *Anisogramma virgultorum* and infected by *Marssonina betulae* (*n* = 100 for all variables) at each of nine WGS sites in Scotland.

		% incidence	
Site number	≥ 40 % dieback	*Anisogramma*	*Marssonina*
1	27	82	5
2	33	60	35
3	63	19	46
4	50	32	47
5	58	50	60
6	57	72	28
7	62	43	8
8	53	96	8
9	24	56	15
Overall mean	51	57	28

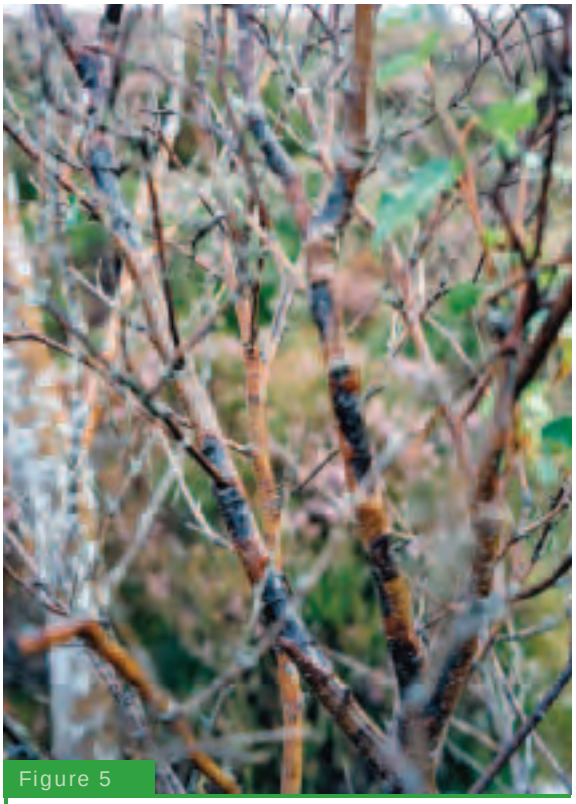

Figure 5

'Other cankers' (non-*Anisogramma*), thought to be caused by *Marssonina betulae* on silver birch.

shoot/stem cankers (Figure 5) was also greater on silver birch (63 % affected) than on downy birch (30 % affected). There was a significant correlation ($P < 0.0001$) between the incidence of *M. betulae* foliar disease and incidence of other (non-*Anisogramma*) shoot/stem cankers, with 82 % of *M. betulae*-infected trees having these other cankers (Figure 5). This provides further evidence that *M. betulae* causes the sunken cankers on shoots and stems which are commonly seen on young birch in the field, resulting in shoot dieback. The severity of *A. virgultorum* and other cankers both correlated highly ($P < 0.0001$ for both disease variables) with severity of crown dieback, indicating that *A. virgultorum* and *M. betulae* are important causal agents of crown dieback of birch at these WGS sites in Scotland. *Discula betulina* was also commonly found causing leaf spots on silver and downy birch at all nine sites.

Other site factors and disease

Birch trees planted on particularly poor, exposed sites might generally be regarded as having increased susceptibility to fungal infection. However, the 2004 field survey indicated that the poorest site conditions do not necessarily result in the highest levels of disease. For example, the greatest incidence of *A. virgultorum* was at site number 8 (Table 1), the only sheltered, brown earth site in the survey. Both *A. virgultorum* and *M. betulae* are present in native populations of birch in Scotland. Therefore, variations in the frequency of these diseases from site to site could be partially explained by varying degrees of exposure to natural inoculum from surrounding areas together with local climatic variables, these being two important factors influencing the establishment and spread of disease on a site.

Birch provenance may also be an important factor determining susceptibility to these diseases, and responsible for some of the site by site variation in disease incidence. The exact provenance of the planting stock could not be determined accurately for the majority of sites surveyed, and it is possible that birch of non-local origin was used in a number of these WGS plantings. At some sites pockets of naturally regenerated downy birch were healthy despite the prevalence of disease at these sites. It cannot be assumed, however, that all naturally regenerated stock is more resistant since site number 9 is largely comprised of naturally regenerated downy birch of local origin, yet many trees were heavily diseased. A certain form of planted birch present at a number of sites appeared to be healthy despite having the same growth conditions as adjacent, heavily diseased birch trees. These were usually scattered individual trees (either silver or downy birch) with particularly dense, bushy growth form, small, round leaves and glabrous shoots. Such trees were phenotypically distinct from heavily diseased trees.

Future work towards managing birch dieback

This study has identified two pathogenic fungi, *A. virgultorum* and *M. betulae*, both of which play an important role in the dieback of young birch in Scotland. Only limited information is currently available on the inoculum source, life cycle and infection biology of these fungi, and further studies need to be undertaken in this area of work before management recommendations for reducing the establishment and spread of disease can be developed. We have already shown that *M. betulae* occurs much more frequently on silver birch than on downy birch and that the reverse appears to be true for *A. virgultorum*. Observations from the 2004 field survey indicated that further genetic variability within each birch species could influence disease expression. An investigation into the role of birch provenance and phenotype in determining susceptibility to *A. virgultorum* and *M. betulae* is now under way in order to try and identify less disease-susceptible stock for use in future planting schemes in Scotland.

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