

INFORMATION NOTE

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SUMMARY

Birch dieback is a problem in many new native woodland planting schemes in Scotland. Affected trees show a steady deterioration in crown health, starting about 5–10 years after planting, and specific symptoms strongly implicate pathogenic fungi as a cause of crown dieback. A study commenced in 2002 with the aim of identifying the fungal pathogens of birch, determining their impact, and developing recommendations for effective management. A survey of five native woodland schemes in Scotland was undertaken to characterise the fungi inhabiting young shoots of birch. Pathogenicity tests identified three fungi which can cause dieback: *Anisogramma virgultorum*, *Marssonina betulae* and *Discula betulina*. A second survey, carried out in 2004, assessed crown health, and the frequency of occurrence and impact of *A. virgultorum* and *M. betulae* on birch at nine native woodland planting schemes in Scotland. This survey demonstrated the widespread distribution of these two pathogens and confirmed their importance as causal agents of crown dieback at these sites. Future work is aimed at investigating susceptibility among native birch provenances and the infection biology of these fungi as factors influencing the establishment, severity and spread of disease, so that new management strategies can be developed for birch.

INTRODUCTION

Birch (*Betula* spp.) is a major component of native woodlands throughout Scotland, and is increasingly valued as a resource for biodiversity, conservation, habitat and landscape. 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 important broadleaved species in recent native woodland planting schemes in Scotland, the area of which is projected to increase further with continued applications under 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 there have been reports to the Disease Diagnostic Advisory Service of Forest Research of widespread dieback of young, planted birch in Scotland, with over 20 native woodland planting schemes reported as affected to date. Affected trees appear to grow well initially, but approximately 5–10 years after planting begin to exhibit shoot die back from the lower crown upwards and from the outer crown inwards (Figure 1). 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 and site selection, poor silvicultural management and climatic damage may contribute to this dieback, the

Figure 1

Dieback of silver birch.



disease symptoms suggest that attack by fungal pathogens may be an important element in the demise of the trees. 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 to what degree pathogenic shoot fungi might be responsible for the observed crown dieback.

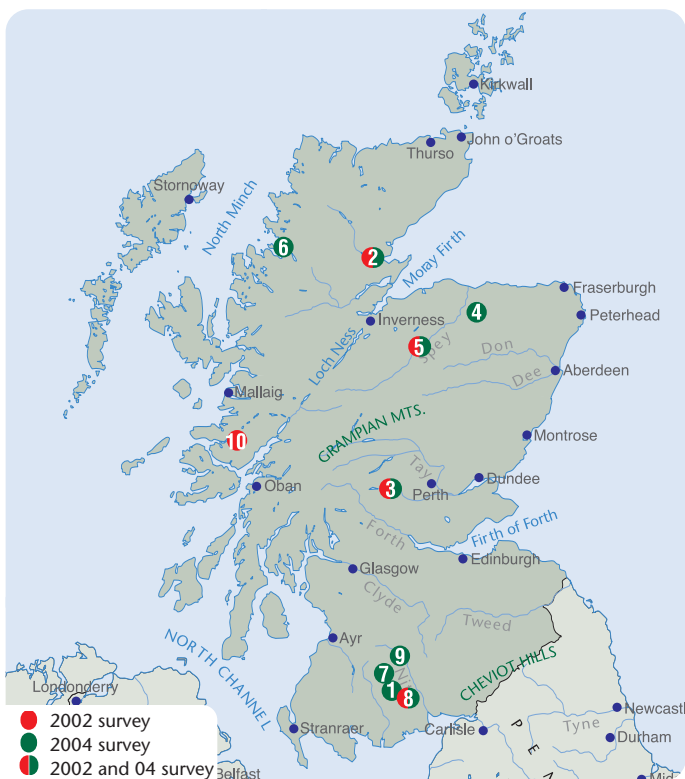
A study was initiated in 2002 to examine the fungal pathology of birch dieback in Scotland. The main objectives of this project are to investigate the fungi infecting birch shoots in Scotland, identify the primary pathogens with the ability to infect healthy trees, determine the impact of these fungi on the national woodland resource, and to develop recommendations for their management. This Note provides an update of information gained so far during the study.

METHODOLOGY

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 2), making a total of 600 collected shoots.

Figure 2

The location (numbered circles) of the 2002 and 2004 birch surveys.



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.

In 2004, 100 birch trees at each of nine WGS plantings in Scotland (Figure 2) were surveyed to evaluate the frequency and severity of crown dieback, to record the incidence and severity of two fungal pathogens, *Anisogramma virgultorum* and *Marssonina betulae*, 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) but the majority of these were non-pathogenic and unable to cause disease. Of the most frequently occurring fungal species which were inoculated onto birch in controlled pathogenicity tests, three species caused disease and dieback: *Anisogramma virgultorum*, *Marssonina betulae* and *Discula betulina*.

Anisogramma virgultorum

Anisogramma virgultorum was first recorded on birch in the UK by Masee (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 2002. Inoculation studies 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 develop late in the growing season (Figure 3) and a large proportion of infected shoots die back within the year following infection (Green and De Silva, unpublished). Currently, little is known about the biology of this fungus. From our observations, the fungal fruiting structures, known as perithecia (Figure 4), develop within the black, strip-like, stromatal cankers on the current year's 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 stomatal tissues dry up and drop out of the cankers, leaving deep fissures in shoots and branches (Figure 5), which are indicative of older infections by *A. virgultorum*.

Figure 3

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

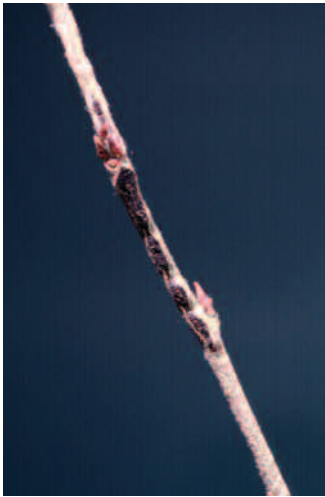


Figure 4

Perithecia of *A. virgultorum* developing within a stromatal canker on downy birch.

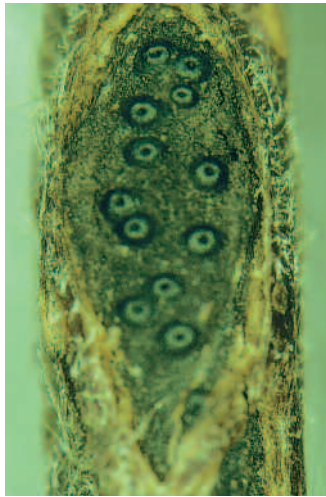


Figure 5

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



Marssonina betulae

Marssonina betulae is a common foliar pathogen on birch throughout Europe, causing characteristic leaf spots (Figure 6) 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 and 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 4–5 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 7), 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 6

Lesions on leaves and young shoots of silver birch caused by *Marssonina betulae*.

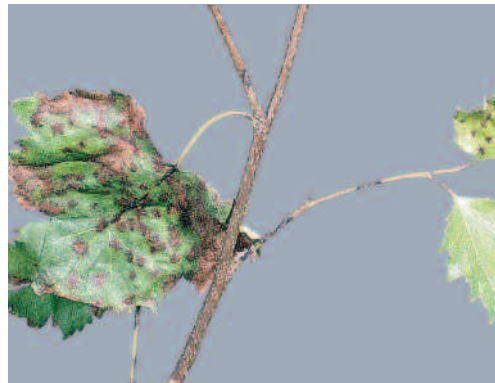
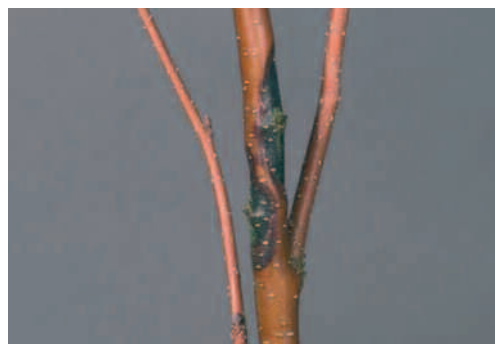


Figure 7

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



Discula betulina

Discula betulina is another common fungus on birch, causing necrotic leaf spots on leaves (Bennell and Millar, 1984). It is currently not known how this fungus starts new infections in spring, 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. While *D. betulina* has not been reported previously on birch shoots, it 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 it may cause death of small shoots in combination with other stress factors.

THE IMPACT OF PATHOGENIC FUNGI ON YOUNG BIRCH SURVEYED IN 2004

Eight of the nine WGS sites surveyed in 2004 (Figure 2) were exposed sites with moderately wet acidic soils and seven of the sites lay above 250 m elevation. The most extreme sites in terms of exposure and wetness were site numbers 4, 6 and 7, whereas site number 8 was the only sheltered, brown earth site in the survey (Table 1, Figure 2). 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).

A. 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*) shoot/stem cankers (Figure 8) 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

Table 1

Percentage of trees with 40% or greater crown dieback, infected by *A. virgultorum* and *M. betulae* ($n = 100$ for all variables) at each of nine Woodland Grant Scheme sites in Scotland.

Site	% incidence		
	≥40% dieback	<i>A. virgultorum</i>	<i>M. betulae</i>
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 8

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



other (non-*Anisogramma*) shoot/stem cankers, with 82% of *M. betulae*-infected trees having these other cankers (Figure 8). This provides further evidence that *M. betulae* also 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. *D. 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 poor quality, 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. The field survey will be repeated in 2006 and more detailed site information gathered in an attempt to investigate the relationships between disease, dieback and site-based characteristics. 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 to infection 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 (both silver and downy birch) with a 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 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 also indicated that 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 underway in order to try and identify less disease-susceptible stock for use in future planting schemes in Scotland.

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