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Aspen in Scotland: biodiversity and management

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Neil MacKenzie

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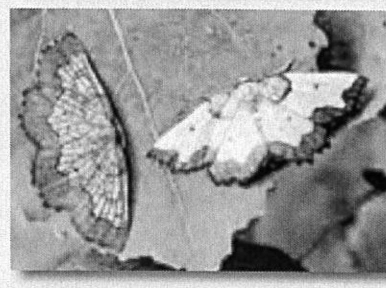
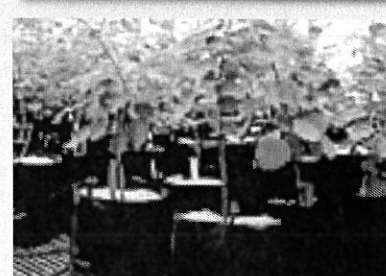
Proceedings of a Conference held in Boat of Garten, October 2008





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Proceedings of a Conference held in Boat of Garten, Scotland
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Preface

The proceedings of this, the second conference to focus on Aspen *Populus tremula* in Scotland, includes material from a wide spectrum of disciplines and interests. Over 100 delegates from all over Scotland, from Galloway to Shetland, attended the conference, while Jari Kouki of Finland provided a European perspective of aspen in the boreal forest.

Aspen plays host to a remarkably diverse flora and fauna, and many of the papers present current research findings on some of the taxa that depend on aspen, particularly mosses, lichens, fungi, moths and flies. Lichen epiphyte diversity on aspen for example may be declining as a consequence of the loss and fragmentation of native woodland since the 19th century. Meanwhile some invertebrate populations are affected by the lack of structural diversity in aspen stands, especially the dead wood component and young regeneration. It therefore becomes vitally important to map the remnant aspen at a landscape level in order to develop future habitat networks, improve connectivity and regenerate depleted stands. Projects to map the aspen using high-resolution aerial photography and manage stands for the benefit of the rare and endangered Dark Bordered Beauty moth and Aspen Hoverfly are currently under way in Strathspey.

There is also a growing interest in aspen among foresters. With its fast growth rates, and attractive appearance in all seasons, it has tremendous potential to complement conifers in productive forestry. Information from North America, parts of Scandinavia and the Baltic states reveal that aspen produces high quality pulp, which is particularly suited to paper making. In the Lake States, aspen is the main species used in the manufacture of oriented strand board (OSB), which is widely used in construction in North America. In Scotland the aspen resource is too limited in extent to provide a sustainable supply of timber but there are moves to increase the resource by increasing the supply of root cuttings and developing an aspen seed orchard.

There are many unanswered questions relating to the ecology of aspen that require further research. Aspen flowers and sets seed rather infrequently in Scotland but, paradoxically, it is among our most widespread native trees. There are only a handful of ten kilometre squares on either the Scottish mainland or islands where it is not recorded.

In fact, aspen is full of paradoxes.

Its individual stems are relatively short-lived, but (at least elsewhere in its range) aspen clones are known to survive thousands of years. Is it the oldest tree in Scotland? With clones sometimes comprising hundreds of stems, is it our largest living organism? Why, despite being one of our most palatable trees, is aspen most frequent in Strathspey on grazed farmland?

Many individual enthusiasts, NGOs, agencies and academic institutions have been working to gain a better understanding of aspen ecology and management, and the requirements of its dependent species.

It is time to harness their collective expertise and energy and to join in an ambitious project to restore aspen to its rightful place in the Scottish landscape. With its biodiversity, aesthetic appeal and potential productivity, aspen could make an important contribution to today's multi-purpose forests.

Part of this challenge requires us to raise wider awareness of aspen's potential. We hope that this conference has contributed to this process. ■

John Parrott & Neil MacKenzie

March 2009

Aspen and forest biodiversity in North European boreal forests

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Introduction

The northern boreal forests are often regarded as rather homogeneous and species-poor ecosystems where conifers dominate the landscape. While it is true that tree species diversity in northern latitudes is far behind those reported from temperate and tropical forests (Currie & Paquin, 1987), the biodiversity in northern forests can nevertheless be remarkably high (Esseen *et al.*, 1992; Kouki, 1994; Hanski & Hammond, 1995; Esseen *et al.*, 1997). Two important factors seem to be of particular importance for boreal forest biodiversity. First, repeated disturbance at the landscape and forest stand levels create and maintain ever-changing mosaics of variable habitats where tree species composition, forest age and several other structural characteristics vary, providing a diverse resource, habitat and substrate base for forest-dwelling organisms (*e.g.* Bonan & Shugart, 1989). Second, although dominated by just a handful of conifer species, boreal forests also harbour a group of broad-leaved deciduous trees that seem to be very valuable in terms of biodiversity (Esseen *et al.*, 1997). In particular, aspen (*Populus tremula* L.) has been regarded as a biodiversity hotspot in Northern Europe.

This paper presents a short overview of the importance of aspen for forest biodiversity in boreal northern Europe. I will first present some figures of the number of species associated with aspen. Next, I will explain a few highlights related to the occurrence and dynamics of aspen trees in boreal landscapes. Finally, I will present some aspects on the possibilities to maintain and restore aspen and its associated biota.

Aspen - the hotspot of boreal forest biodiversity

Aspen trees typically occur as scattered patches, often formed by a single clone, in the midst of the conifer-dominated landscape. Aspen may form large, more continuous stands after a severe disturbance event, but eventually the old trees are typically very patchy in their distribution. Aspen provides habitats and resources in two different ways: some species live on or in aspen trees, taking direct advantage of the resources that aspen provides. Other species, in turn, seem to be favoured by the changes that aspen trees create and maintain in their immediate surroundings. In particular, the leaf litter produced is less acid than the more common needle-litter. The aspen litter seems to be a preferred habitat for several litter-dwellers (*e.g.* Koivula *et al.*, 1999).

The animal species that use aspen directly are typically either herbivorous or saproxylics, and their species richness in Finland alone are counted in hundreds. Furthermore, some species use aspen trees primarily as nesting sites. These include several woodpecker species (in the genera *Dendrocopos* and *Dryocopus*) and the Siberian flying squirrel (*Pteromys volans*). Additionally, several species of polypore fungi, epiphytic lichens and bryophytes thrive on aspen. Figure 1 shows estimated numbers of species that are associated with aspen in North European (Finland) boreal forests. As is evident from these data, several dozens of species in many taxonomic and ecological groups are associated with aspen, and many of these are also specialist species, not found in any other tree besides aspen.

Furthermore, roughly 50 species associated with aspen are classified as threatened in Finland (Rassi *et al.*, 2001). Ecologically they are a conifers. In the Fennoscandian forests, aspen seems to be most common in spruce-dominated forests. And in the absence of a major large-scale disturbance, aspen can persist and probably also reproduce successfully. However, the evidence on long-term persistence of aspen in old-growth forests is still relatively scarce. Lilja *et al.* (2006) analyzed a chronosequence of spruce-dominated forests in the age range 130-340 years since a major disturbance. In economic terms, all these age classes are old-growth or over-mature. Although aspen and other deciduous trees were able to maintain small populations in older forests, their proportion clearly diminished as forests got older. In particular, no living aspen trees were observed in forests that were over 280 years old (measured as the time since the last large-scale disturbance). On the other hand, Vehmas *et al.* (2008) tracked historical records of a single region for the occurrence of aspen trees. They were able to show that aspen seemed to be able to maintain its population at least over a 100-year period in old-growth conditions. These observations suggest that aspen is also capable of long-term persistence in old-growth conditions, *i.e.* in the absence of large-scale catastrophic disturbances, for extended periods. The regeneration may, however, be complicated and influenced by several external factors, such as soil type, topography, or browsing pressure by herbivores.

Large-diameter, old and dying aspens are nowadays restricted almost entirely to protected areas in Fennoscandia (Kouki *et al.*, 2004; Latva-Karjanmaa *et al.*, 2007). Although studies have indicated that long-term continuity of large aspen trees may be possible, regeneration nevertheless seems to be rare in practice. Studies that have analyzed the demography of aspen populations in old-growth protected areas indicate that there are no young trees that would successfully be recruited. For example, both Kouki *et al.* (2004) and Latva-Karjanmaa *et al.* (2007) analyzed aspen demography based on size (or age) classes. Both studies found relatively high current amounts of aspen in the study areas, including both living and dead trees. However, the saplings and seedlings seemed not to be able to establish successfully, although the number of seedlings was rather high. Both studies indicated that exceptionally large current elk populations could effectively browse the young seedlings and saplings so heavily that recruitment is impossible. Elk populations are known to have increased dramatically since the 1970s, due to changes in hunting policy and the lack of large carnivorous predators in the regions studied (see Fig. 5 in Kouki *et al.*, 2004). However, this causal relationship is not always clearly observed in exclosure experiments (Zakrisson *et al.*, 2007; den Herder *et al.*, 2009). For example, Zakrisson *et al.* (2007) observed high variability in recruitment between different localities which were not obviously related to browsing pressure or other ecological differences. The recruitment seemed to be related only to the ramet density of aspens: the higher the density, the more successful was recruitment. Taken together, these results suggest, that if browsing has an important role in preventing the recruitment, that effect must be spatially variable. It would therefore be advisable to try to promote aspen in those areas where ramet density is high enough for successful reproduction. The ability to produce ramets may vary between different aspen clones, and this should be studied before using different clones to re-introduce aspen. This is particularly important if browsing pressure in the restoration area is high.

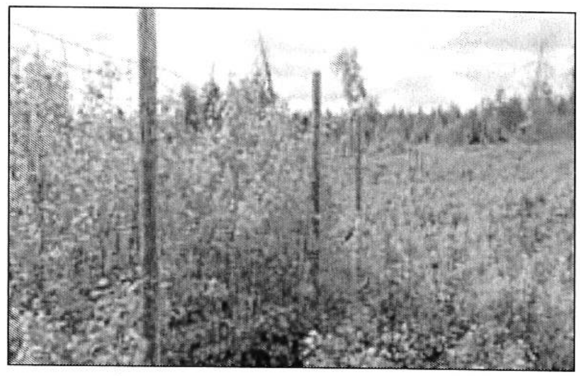

Figure 2. This 5 year-old exclosure in Finnish Karelia demonstrates the impact of elk browsing on Aspen suckers

Aspen-associated species in dynamic patch network

Species associated with aspen face serious challenges in the current managed forest landscape. These are mostly related to the very patchy and also dynamic occurrence of suitable aspen trees. The most valuable substrate, large-diameter aspens (*e.g.* Kuusinen, 1994; Hedenås & Ericson, 2000) are often restricted to only forests to a more "natural" or "pristine" state, there are several challenges and difficulties in implementing them in ecologically justified ways.

For example, the evidence of the importance of herbivores is still somewhat contradictory, and the effects of large herbivores on recruitment have not always been found. Besides elk and deer, smaller mammals such as voles and hares may also be effective browsers of aspen seedlings, but management of these mammals seems impossible. Furthermore, the use of fire and prescribed burnings require careful planning and can produce undesirable results if applied in protected areas. The protected areas are currently very small, isolated and cover only a small fraction of the landscape (in southern Finland, for example, protected areas cover only 1-3 % of all the forests). Several species are dependent on these areas, with highly varying habitat requirements (Tikkanen *et al.*, 2006), and some of the populations may be negatively affected if fire is extensively and intensively introduced to protected areas. Although the use of fire clearly has a positive effect on some species (Hyvärinen *et al.*, 2006), this is not always the case (Junninen *et al.*, 2008). Only if the protected areas are large enough does large-scale disturbance seem a safe choice. A more promising option might also be to enhance the structural characteristics important for aspen-associated species in managed forests. Above all, this would imply promotion of aspen trees as admixture species in managed forests.

Some promising observations have also been made from aspens that grow in sun-exposed habitats. Although several species seem to be associated with shady old-growth conditions, some species, including some of the threatened species, also survive on aspens that are left in clear-cut areas (Martikainen, 2001; Sverdrup-Thygeson & Ims, 2002; Hedenås & Ericson, 2003; Junninen, *et al.*, 2007). Thus, the future survival of aspen-associated species may not be dependent only on aspens that grow in the scattered old-growth forests. Some species may also survive in retention trees left in clear-cut areas. Unfortunately, it is likely that retention levels would be rather high, perhaps over 10% of the original stocking density, to obtain real positive effects of retention trees on their associated species (for a recent review on retention trees and their ecological effects, see Rosenvald & Lohmus, 2008). ■

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Composition and diversity of lichen epiphytes on Aspen

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Historical background

Aspen *Populus tremula* L. was 'discovered' by British lichenologists around the turn of the new millennium. Consistent with the belated recognition of aspen as the 'Cinderella species' of Scottish conservation, the first detailed survey of aspen lichen epiphytes was undertaken in 2001, by Dr Brian Coppins of the Royal Botanic Garden Edinburgh (RBGE) and Les and Sheila Street (RSPB). Subsequently, Coppins *et al.* (2001) and Street & Street (2001) provided a species inventory and analysis for six aspen stands in Strathspey. Their reports included the discovery of species new to Britain (e.g. *Arthonia patellulata*, *Bacidia igniarii* and *Caloplaca ahtii*), the rediscovery of a species previously thought extinct (i.e. *Lecanora populicola*, last recorded from East Norfolk over 150 years ago), and viable populations of species that are rare and/or threatened in the British Isles (e.g. *Bacidia vermifera*, *Biatoridium delitescens*, *Catinaria neuschildii* and *Fuscopannaria ignobilis*). This exciting work on lichens supported the wider recognition of aspen as a previously neglected habitat-feature which is of special importance to native woodland biodiversity (Cosgrove & Amphlett 2002).

This paper reports advances in our understanding of the aspen lichen flora which have emerged since the previous aspen conference in 2001. Results are presented here as two key findings, separated according to scale.

Landscape-scale processes:

Species richness is controlled by historic woodland extent

To examine the relationship between the richness of species and spatial area of habitat, the richness of lichen epiphytes in 93 sampled aspen stands was compared not only to the extent/fragmentation of present-day woodland, but also the extent and fragmentation of historic woodland (using the Ordnance Survey's 19th Century 1st one-inch mapping series). An observed relationship between lichen epiphyte species richness and woodland extent/fragmentation was statistically significant, though relatively weak (Fig. 1). Nevertheless, the significant relationship confirms a fundamental expectation (the species-area relationship) and 'noise' in the data is attributable to environmental variation when comparing aspen stands which were surveyed from a variety of settings. Importantly, when comparing lichen epiphyte richness to woodland extent/fragmentation, richness was found to be significantly related to the extent and fragmentation of woodland in the *historic* 19th Century landscape, though was not related to woodland extent/fragmentation in the *present-day* landscape (Ellis & Coppins,

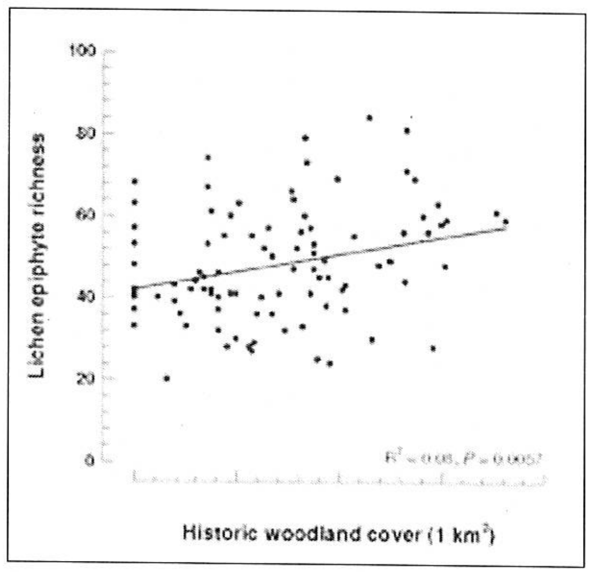

Figure 1. Positive relationship between historic woodland extent (at a 1 km^2 scale) and the species richness of lichen epiphytes in aspen stands

different community structure.

However, the details of species composition (nested within the broad classification of trait groups) may be determined by specific micro-habitat factors. There was a clear transition in bark rugosity from the lower bole (rougher) to a smoother portion which comprised most of the upper bole (over c. 2.5 metres in height). In addition, bark pH increased upwards, from c. pH 3.75 at the lower bole, to c. pH 5.5 at heights > 10 m. Accordingly, this change in bark pH was accompanied by a shift in species, from those which occur on more acid barked trees (e.g. *Hypogymnia physodes*, *Ochrolechia androgyna*) to those more typical of eutrophic bark conditions (e.g. *Caloplaca pyracea*, *Physcia aipolia*). This transition included species of specific conservation interest which occurred higher on the tree bole than would normally be searched during a lichen field survey: *Arthonia patellulata*, at 6.7m; *Bacidia subincompta*, at 3.2m; *Caloplaca ahtii*, > 5m; *Lecania dubitans*, at 5.6 & 6.9m.

● **Climatic setting:** the pattern of change with respect to species' ecological traits observed for trees within a single stand appears to be offset along a climatic gradient from the relatively drier and more continental climate of north-east Scotland, towards the wetter climate of oceanic western Scotland. Thus, with a shift towards a wetter climatic regime, sexually-reproducing crusts appear to be out-competed relatively earlier during the development of the epiphyte community by foliose lichens and especially bryophytes: i.e. younger trees under a more oceanic regime appear to be similar to relatively older trees in a more continental climatic setting (Ellis & Coppins 2006; cf. Fig. 3). With increasing oceanicity there is also a shift from colonisation by green-algal foliose lichens, towards an increasing abundance of foliose cyanolichens (Fig. 3). In the hyper-oceanic climate of western Scotland foliose cyanolichens are frequently abundant on relatively young aspen trees (< 50 yr), though are found only rarely and typically on old and mossy aspen trees in more continental eastern Scotland, particularly in old-growth woodlands (cf. Ellis & Coppins 2006; Ellis & Coppins 2007c). Ellis & Coppins (2006) hypothesised a facilitation effect for cyanolichens along the climatic gradient from relative wetness to dryness, by which the presence of mosses on older trees might create a humid micro-climate suitable to the establishment of cyanolichens under a sub-optimal climatic regime. (See figure 3 overleaf).

Recommendations for conservation

The description of epiphyte community change with respect to aspen habitat dynamics provides a model sequence along important ecological gradients: e.g. climatic setting, tree age, and height on the tree bole. This template of community change is relevant to aspen dynamics and is limited by sampling targeted towards a series of idealised scenarios (upright trees, without wounding, and with uniform shading). The analysis of traits and subsequent generalisations provide a useful template with which to develop an ecological framework towards the protection of epiphyte species diversity. The idealised dynamic portrayed here will be subject to the distortions of unpredictable and localised effects, and caution should be used to ensure the framework is not applied too literally. However, based on our preliminary analysis of aspen epiphytes, three recommendations are highlighted:

1. Aspen stands from sites across a range of climatic settings should be integrated into woodland management. This will protect different epiphyte species and communities which occur across steep climatic gradients within Scotland.

2. Importantly, aspen may provide suitable habitat for old-growth indicator species (e.g. species in the '*Lobarion*'-community) in localities with a sub-optimal climatic setting. However, where these old-growth species occur in remnant aspen stands they may be subject to an extinction debt. Species-rich aspen stands should be protected by regenerating a network of native woodland. This network would buffer stands from long-term species loss through the reestablishment of effective meta-population dynamics following past periods of habitat loss/fragmentation. As an additional benefit, it is likely that woodland regeneration will also provide a buffer against the impacts/uncertainties of climate change (Ellis & Coppins 2007c, Ellis *et al.* 2009).

3. Stand-scale management should aim to ensure the periodic regeneration of aspen stands, and a range of cohorts comprising trees of different age.

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This document is accompanied by a supplementary scientific report, available as a pdf from the author, or as a download from the following website:

http://rbg-web2.rbge.org.uk/lichen/

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Chris Ellis works as a lichenologist and ecologist at the Royal Botanic Garden Edinburgh. A community ecologist, his research aims to describe and explain patterns in species composition and richness, with a special emphasis on the lichen response to habitat dynamics.

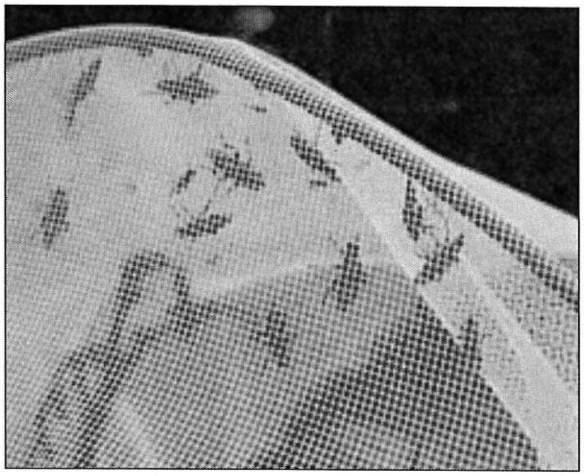

Figure 1. Newly emerged *H. ferruginea* within emergence trap

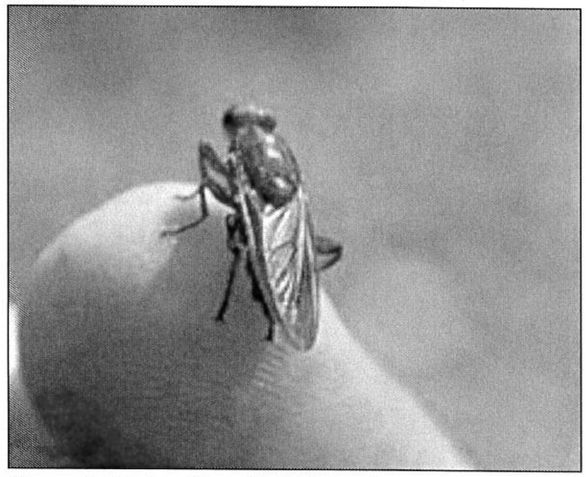

Figure 2. Marked female *H. ferruginea* resting on finger tip upon release

2008. This represented three times the predicted number from one fallen aspen. Males were found emerging first followed by the females thus allowing males to mature their reproductive organs and potentially set up territories.

Of the flies re-sighted, male and female maximum longevity was 32 days and 51 days respectively. Upon emergence individual colour appeared to vary and was found to deepen, redden and finally darken to almost grey/black throughout the adult period. This novel colour change may be important for identification and aging adults in the field.

Adults were observed feeding on sequentially flowering Bird cherry *Prunus padus*, Rowan *Sorbus aucuparia*, and Hawthorn *Crataegus monogyna*.

Dispersal, breeding site and behavioural ecology

The most effective method for locating adult *H. ferruginea* was observing fallen aspen of suitable condition. Throughout the flight season adult males were observed aggressively defending small territories on fallen logs, which females attend during oviposition. These territories reduced in size as male presence increased perhaps reflecting a trade off between the energy costs and the reproductive benefits of defending a territory.

The minimum linear dispersal distance measured 1km from emergence to breeding site. In order to reach the site, adults would have had to move across a large expanse of open field vulnerable to high winds, which indicates that *H. ferruginea* are more capable of dispersing than previously thought.

Management

A key element in the maintenance of *H. ferruginea* populations is managing the amount and quality of fallen wood. Management strategies to boost and maintain populations are being tested, such as creating artificial breeding sites by cutting down suitable trees. However, this has not proved totally successful as wet decay under the bark dried out too soon: it lasted up to 17 months. At this rate cutting trees is unsustainable for most aspen stands. Extending the time that wet decay persists is an option currently being investigated by cutting wind blown, but live, trees halfway along their length so that the upper half decays to form a breeding site and the lower half survives and can be cut later when the upper half becomes unsuitable. When managing in this way it is important to know the number of flies any size of decaying aspen log can hold. Based on the number caught in emergence traps, the average minimum capacity for one insect was found to be 0.55 to 1 larvae per 100cm^2 (Rotheray *et al.*, 2008).

Conclusion

The results of this investigation provide a first estimate of the dispersal abilities and adult ecological requirements which should be taken into account in prescriptions for continuing

Aspen bristle moss in Scotland

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At the Aspen conference in 2001 (Rothero, 2002), I told the story of the discovery of *Orthotrichum gymnostomum*, new to Britain, on an aspen near Loch an Eilean in Rothiemurchus in 1966 and of subsequent unsuccessful attempts to re-find it in Rothiemurchus and in a number of other aspen woods, particularly my (GPR) reasonably intensive survey in 2000 (Rothero, 2003). The conclusion in 2001 was that the occurrence of *O. gymnostomum* in Rothiemurchus was probably a chance event; a spore from Scandinavia producing a small cushion which was collected in 1966 giving the moss the dubious distinction of being added to and removed from the British flora in one fell swoop.

Alan Watson/Forest Light

Figure 2. Orthotrichum gymnostomum on Aspen

However, what the unsuccessful search in 2000 did produce was a realisation that some aspens were really good for epiphytes in general. A new site for the RDB species *Orthotrichum obtusifolium* was found at Tromie, an exciting find as, up to then, this species was thought to have been reduced to a single British site at Leith Hall near Huntly, on elms and sycamore in the gardens. The find at Tromie led directly to the discovery of several other sites for this moss on aspen, initially all fairly close to Tromie but, later, Andy Amphlett (AA, a local bryologist) found stands further afield in the Spey valley (Rothero, 2003a). The survey also showed that the nationally scarce moss *O. speciosum* was quite frequent on the 'better' aspens and that virtually all of the UK population occurs in NE Scotland, much of it on aspen. It is probably worth mentioning here that sites for both *O. obtusifolium* and *O. speciosum* have been found recently in SE England, on apple not aspen trees, part of a welcome return of a more diverse epiphytic flora to areas where air pollution was presumed to have taken its toll in the past.

Andy Amphlett

Figure 1. Orthotrichum obtusifolium

The remarkable lichen flora also discovered on aspens is responsible for the next stage in the aspen bristle moss story. In June 2003, Chris Ellis, Conservation Officer for Lichens at the Royal Botanic Gardens, Edinburgh, while surveying lichens on aspens at Kinrara, found what he took to be *O. obtusifolium* on at least three aspen trees. As a result of this find, the site was selected to be included as part of the Cairngorms *Orthotrichum* Survey. The Cairngorms National Park Authority / Cairngorms LBAP joined together with Plantlife,

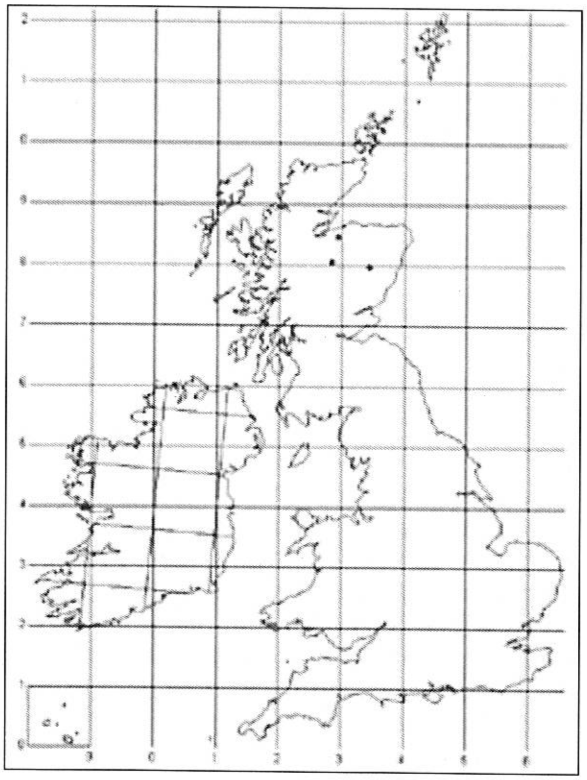

Figure 5. The distribution of *Orthotrichum gymnostomum* in Britain in 2008

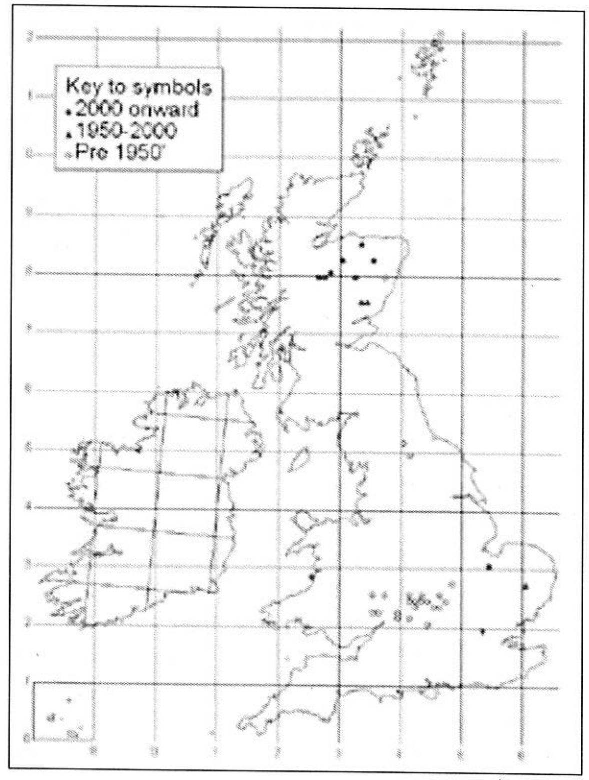

Figure 6. The distribution of *Orthotrichum obtusifolium* in Britain

by are covered in a range of species, giving a community more closely resembling that on ash or elm.

- Is this disparity in 'epiphyte-friendliness' clonal? Does bark pH or nutrient status vary between clones?
- Is the bark pH or nutrient status of the tree affected by fungal infection? It is noticeable that the best trees for epiphytes often have obvious damage, dead limbs and obvious fungal growth.
- Finally, is the 'epiphyte-friendliness' of the provenance considered when growing on aspens for restocking? ■

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Gordon Rothero is a consultant botanist specialising in bryophytes. He authored the bryophyte sections in the Flora of Rum and the Flora of Assynt. He is currently researching bryophyte-dominated snowbed vegetation, linked to climate change.

- To what extent do lichen communities differ within clones?

Study site

RSPB Insh Marshes National Nature Reserve, near Kingussie in the Cairngorms National Park, is one of the most important wetlands in Europe and home to a range of rare and endangered birds. Within the reserve is the 2.8 mile woodland trail of Invertromie, a Site of Special Scientific Interest and home to several stands of Aspen clones (RSPB, 2008). Highland Aspen Group has been working to identify clones at Invertromie from phenological traits, such as leaf flush and autumn leaf senescence, assign a unique number to each clone and to propagate these for reforesting schemes. Clones BD11, BD12 and BD5 (fig. 2) were selected based on a minimum population size of 15 ramets per clone. There has been an attempt to sex the clones based on a rare flowering event in 2006, though many clones remain unsexed due to a lack of flowers during that period.

Genotyping

During January 2008, buds were collected from 77 ramets across the three clones selected: 20 from BD11, 40 from BD12 and 17 from BD5. DNA was extracted from approximately 200mg of bud tissue and genotypes verified through the use of six molecular markers. Information about these markers was obtained from the International Populus Genome Consortium (IPGC, http://www.ornl.gov/sci/ipgc/ssr_resource.htm).

After positively identifying a minimum of five ramets from each of the clones, the lichen communities were assessed.

Assessing lichen communities on Aspen

Trees of a similar size and circumference were selected from each clone, based on the information gained from genotyping. A 10x10cm quadrat method was used, modified from Asta *et al.* (2002). The quadrat was divided in 1cm^2 subunits and used to record presence of each lichen species. Quadrats were replicated five times along the height of the trunk at a distance of 40 cm apart, and at each of the four compass points around the tree (Figure 1). The first point was measured 40cm from the ground; on sloping ground the highest side was used on each tree.

Each quadrat was given a unique identifying label, based on a pre-assigned number given to each tree (601-676), the aspect (N, E, S, W), and height from 1 to 5 (each being 40cm apart) with 1 being the lowest (40cm from the ground) and 5 being the highest (200cm from the ground). For example, the first quadrat on tree 601, at the north aspect, and lowest height would be 601N1.

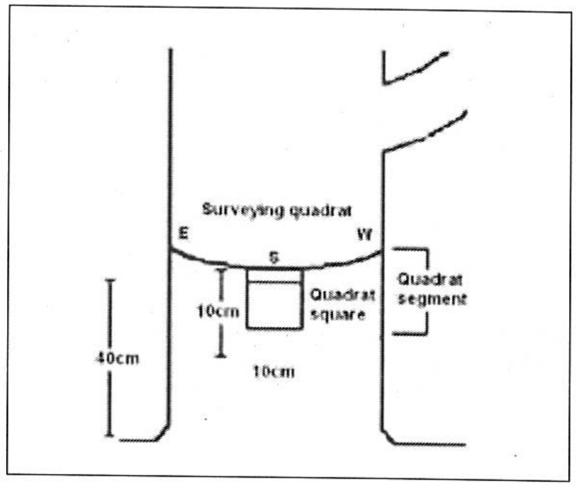

Figure 1. Diagram of lichen sampling transects with square quadrats (modified from Asta *et al.*, 2002)

The proportion of cover for each lichen species found in each quadrat was generated by adding together the counts from the quadrat's subunits, and transformed using the arcsine squareroot transformation, which is commonly used to transform proportional count data. The transformed data for each species were averaged over all quadrats per tree and a hierarchical cluster analysis performed using R v2.7.1 (2008), loaded with the libraries "vegan" (Oksanen *et al.*, 2008) and "labdsv" (Roberts, 2007). A Detrended Correspondence Analysis was carried out using PAST (Hammer *et al.*, 2001).

Summary of results

Based on the preliminary analysis of the lichen communities for each tree, three discrete clusters have been identified and colour-coded for easy recognition. BD11 is red; BD12 is green; and BD5 is blue (Fig 2).

Overall the clusters are true to the clones from which the samples were taken, though BD12 contains one member of BD5 (BD564 – indicated or similarities (a) within and amongst clones at each level of sampling, i.e., aspect and height; (b) most and least abundant lichen species; (c) whether there are any strong relationships between lichens, e.g, does the abundance of species A have an effect on species B? ■

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Developments in the study of the Dark Bordered Beauty moth

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Introduction

The Dark Bordered Beauty moth, *Epione vespertaria* (formerly *Epione paralellaria*) is a species that has always had a restricted distribution in Britain and is currently only known from two locations in Scotland and one in England. Both the Scottish sites are in the Cairngorms, one being in Deeside, the other in Strathspey. Due to its rarity, small population size and extent of occupied habitat, the location of these sites is kept confidential.

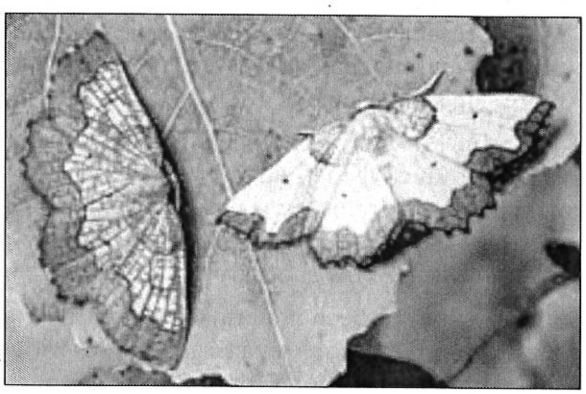
As the Dark Bordered Beauty has a very restricted distribution and small population size it has been listed by the UK government as a UKBAP Priority Species, in need of urgent conservation action and has its own published Biodiversity Action Plan (Anon 1999). It is also listed in the Red Data Book as RDB2 (Vulnerable).

The moth formerly occurred in the Scottish Borders in Roxburghshire where it was last recorded in 1976 and at a site in Northumberland where it has not been seen since 1999. At these sites and the currently occupied site in England in North Yorkshire, the larval foodplant is creeping willow *Salix repens*, though other low growing willows (*Salix* sp.) may also be utilised (Young 2002). However, at the two Cairngorm sites the larval foodplant is aspen *Populus tremula*.

Work on Dark Bordered Beauty initially focussed on fieldwork to gain a better understanding of its population size, distribution, ecology and habitat requirements (Leverton 2001, Palmer 2003a & 2003b). This knowledge has subsequently allowed targeted management to be undertaken at both of the currently occupied sites in the Cairngorms. This paper summarises this information.

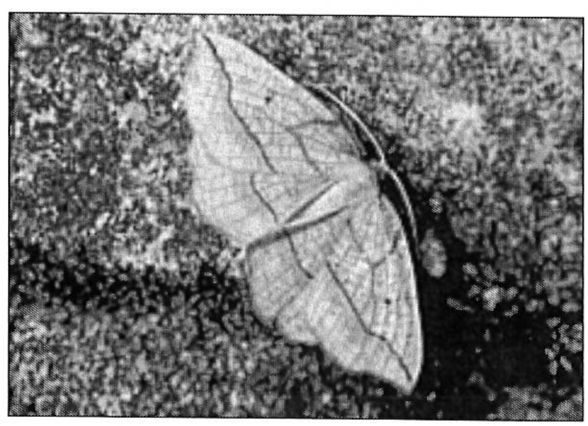
Identification and life-cycle

The Dark Bordered Beauty is a small to medium-sized moth with a wing-span of 26-29mm. The sexes differ in appearance (Fig 1); the males are orangey-yellow flecked with golden-brown and have a darker, golden, brown border that runs parallel to the rear edge of the wing on both the fore and hindwings. The female is a similar size, but is more yellow and its darker golden brown border tapers off to meet the corner of the forewing. The most similar species is the Bordered Beauty *Epione repandaria* (Fig 2)



Roy Leverton

Figure 1. Dark Bordered Beauty, male (left) & female (right)



Tom Prescott

Figure 2. The similar Bordered Beauty

sub-colonies in Deeside (Palmer 2006 & 2007, Picozzi 2008), but none in Strathspey. It would be surprising if there were not further colonies that await discovery. In fact the Strathspey site was only rediscovered in 1996 having been "lost" for almost fifty years.

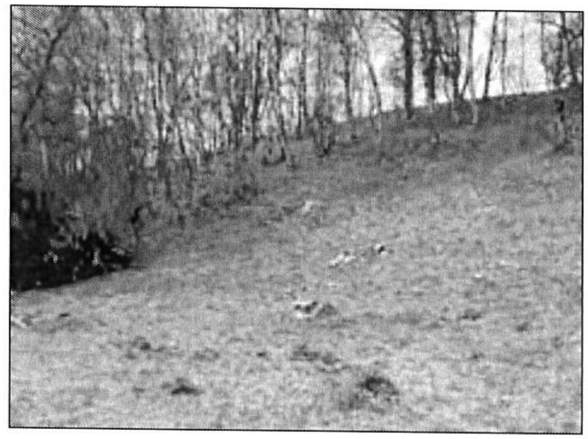
Little is known about the dispersal abilities of the adult moths in Scotland. The small population size and small areas of suitable habitat have meant that an intensive study to monitor and measure adult dispersal by mark-release-recapture is inappropriate. However, dispersal studies were undertaken in England in 2005 where the moth occurs in a number of connected colonies in a far more robust habitat (Robertson 2005, Downton 2006). A total of 230 adult moths were caught, marked and released. Only 5% of these were recaptured before being released again. All of the re-caught moths were males and they had moved an average of just 13.2metres.

Management

Tom Prescott

Figure 5. Suitable habitat with abundant short suckers

Armed with a better knowledge of the species' requirements it has been possible to undertake management work at both of the Scottish sites. The aim of the management is to provide areas of short aspen suckers growing in sheltered, yet open locations (Fig 5). In Strathspey this is achieved through stock grazing as the site is seasonally grazed, primarily by sheep, from September through until the winter. The suckers are effectively coppiced almost to ground level by the sheep grazing, re-growing during the spring and summer. This maintains suitable habitat



Tom Prescott

Figure 6. Newly created clearing

by preventing the suckers getting too tall. This management also maintains a rich-diversity of ground flora with a high density of nectar plants.

In Deeside it is not possible to introduce livestock grazing to the site though there are reasonable numbers of roe deer that browse the suckers restricting their growth. However, this is insufficient to maintain the site in suitable condition for Dark Bordered Beauty and the colonies are managed by scrub clearance. Once the suckers get above c1.5metres tall they are cut down using either hand tools or a power saw. This is done on a rotational basis, usually cutting around a third of each colony every year or every alternate year depending on growth rates.

Trial habitat management has been undertaken over the last three years through the creation/expansion of glades (Fig 6) to favour the establishment of aspen suckers in sunny locations. This has recently been proven to work as adults were seen for the first time in one of the newly created glades in the summer of 2007. This work was therefore expanded the following winter with the creation of 21 small glades in suitable locations where aspen suckers would readily establish over the coming years.

Future plans

When conditions are right butterflies and moths can be quick to respond and already we have observed an increase in the populations of Dark Bordered Beauty at both sites. However this is just the beginning. The area of suitable habitat is still very small and further work is required to increase the amount of young aspen and connect these sites with nearby areas where suitable

Beavers and Aspen: looking to the future

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Introduction

In Spring 2008 the Scottish Government granted a licence for a trial reintroduction of European beavers *(Castor fiber)* in mid-Argyll. The key project partners are the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS). The trial site, Knapdale Forest, is managed by Forestry Commission Scotland (FCS). Scottish Natural Heritage (SNH) will carry out independent monitoring. Along with many others, Trees for Life (TFL) believes this project to be a very positive step in the enhancement of our natural heritage; the beaver is a keystone species in both wetland and woodland ecosystems, and has a beneficial influence on biodiversity (Gaywood *et al* 2008).

It is well known that aspen *(Populus tremula)* supports a wide variety of species, and that it is favoured by a number of herbivores, including red deer (*Cervus elaphus)* and roe deer *(Capreolus capreolus)* (Cosgrove *et al* 2005). It is also clear that beavers favour aspen where it is available. In the past, questions have been raised about the possible impacts beavers might have on aspen in Scotland.

In the 2001 Aspen Conference Dave Batty of SNH addressed this issue in his presentation *Beavers: Aspen Heaven or Hell?* (Batty 2002) and concluded that beavers could prove to be hugely

Laurie Campbell

Figure 1. European beavers eat a wide range of plant material, including the leaves and bark of trees and shrubs. They are particularly partial to Aspen.

Aspen and beaver interactions

The beaver trial will include a robust monitoring programme which will answer many of our questions about the role of beavers in today's landscape (Scottish Beaver Trial 2008). While more detail on known beaver / aspen interactions is provided in Batty (2002), it is worth briefly noting here that while beavers can undoubtedly have a major impact on aspen, this tree can still thrive in the presence of this mammal. For example, at the Danish beaver release site at Klosterheden, there are large old aspen adjacent to the riverbanks that are intact, as well as coppiced shoots that have not been browsed (D. Batty, pers. comm.). On a visit to the beaver reintroduction site near Brasov, Romania, the project worker informed me that beavers had not had a dramatic impact on the riparian aspen in the locality (M. Scurto, pers. comm.). While these are only two of many cases in Europe, they illustrate the potential for the co-existence of beavers and an expanded aspen population in Scotland.

Trees for Life's riparian aspen work

TFL has been carrying out aspen restoration work in a number of areas since 1991. One of the locations we have been focussing on is Loch Beinn a Mheadhoin in Glen Affric NNR, which is managed by FCS. The loch already has many of the features of suitable beaver habitat. While there are no official plans for beaver releases in Glen Affric at any point, from TFL's perspective it is worth further enhancing the habitat in case such a decision is ever taken in the future.

There are currently 62 aspen stands in Glen Affric, and we have carried out further aspen enhancement work in a variety of locations within the glen. These have mainly involved planting in small stock-fenced exclosures, as well as protecting ramets of existing stands with small fences or tree guards. A total of 957 trees have been planted in the immediate vicinity of the loch, and some of these are already producing ramets.

FCS has been controlling deer numbers to the point where there is good regeneration of a number of tree species in parts of the glen, but young aspen can still be vulnerable, even in the presence of lower deer densities. The dimensions of the stock-fenced exclosures we erect are usually around 3m x 6m. Having stock-height fences dramatically reduces the threat to woodland grouse, and while deer are physically capable of jumping into these exclosures, they tend to be reluctant to enter such a confined space. It is rare for deer to get in and when it has happened it has probably been due to the netting being too low. Anecdotal reports suggest that there is a risk of deer becoming entangled in the netting if they do attempt to jump in, and although we have not encountered this problem, it should not be ignored; where practical, regular inspections of the fences should be made. We have erected 38 small fences around the loch over a seven-year period, and only one has shown signs of deer entry and damage to trees.

Growth rates are quite variable, with some of the trees that were planted in 2001 having reached only 50cm, while others are over 3 metres tall and are producing ramets. A variety of factors possibly come into play here, including the clone, individual site conditions and perhaps the presence of mycorrhizal fungi.

Glen Moriston and Dundreggan aspen

Glen Moriston holds more aspen than Glen Affric, with a substantial amount beside the River Moriston. TFL recently took ownership of the 4,000 hectare Dundreggan Estate in Glen Moriston. A small part of the estate is immediately adjacent to the River Moriston, and part of our management plan is to create a large riparian aspen zone, including 9,000 aspen trees mixed with willow *(Salix spp)* and other species, beside the river. We have an agreement in principle for this to be a joint project with FCS, who manage the adjacent land.

Thoughts on strategy

The current trial beaver reintroduction will end in 2014 (provided there is no reason to use the exit strategy), and if a licence for a further reintroduction were granted, it would be a considerable time before there were substantial numbers of beavers in Scotland. Therefore we have a reasonable amount of time in which to significantly expand the aspen population (D. Batty, pers. comm.).

Even if beavers do not return, an increase in

Managing dead wood in Aspen stands

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Background

The aspen stands in northern Scotland are a unique resource not only in UK terms but also European terms. Although they are secondary in nature and do not form part of a "boreal wildwood habitat" they have features which make them ideal for the study of woodland processes and the way in which insects in particular, but perhaps also fungi and lower plants, utilise woodlands on a landscape scale.

Within Strathspey aspen commonly exists as isolated stands of trees. Each of these contains varying numbers and sizes of trees located at varying distances apart. These features effectively allow for the study of "islands" containing differing qualities and quantities of habitat within a landscape setting. This situation offers great opportunities for the study of population dynamics and habitat usage by insect species within woodlands as well as their potential dispersal abilities between sites.

Dead wood is an important component of all woodland systems; it supports a rich range of saproxylic (dead wood associated) insect species many of which are now considered rare or declining. Aspen in particular is an exceptionally good tree species when it comes to supporting this saproxylic fauna. It possesses a relatively thick and nutrient rich sub-cambial layer which, when it decays, provides an excellent habitat for the larvae of many insect species. In Scotland some 15 rare or notable insect species depend entirely or largely on this habitat, the majority of these specialised insects are flies (Diptera) (Rotheray et. al. 2001). In northern Europe much of the research on the insect biodiversity of aspen has focussed on its important saproxylic beetle fauna and assessments have been made on that basis (Jonsell et. al 1988) . However in Scotland this beetle fauna is entirely absent and our main concern is the conservation and management of the important saproxylic Diptera species. The reasons for this difference in faunas are not yet understood.

When an aspen tree is uprooted or part is snapped off by storms the decay process begins. After about 18 months the fresh white sub-cambial layer decays to form a thick brownish decay layer in which the Diptera larvae develop. However, this layer only persists for a period of two - three years before the bark breaks up and the layer dries out and becomes useless as a larval habitat. As a consequence, in order to sustain healthy populations of these insects, a relatively continuous supply of dead wood is required. Only aspen stands which contain a relatively large number of trees are capable of ensuring this continuous natural input of dead wood.

The size of the tree is also important – for example the aspen hoverfly requires dead trees to be over 25cm in diameter in order for the sub-cambial layer to be deep enough to support the hoverfly larvae. Larger trees also tend to decay more slowly perhaps providing acceptable conditions for some larvae for up to four years.

The Invertromie study

The Malloch Society first started recording aspen and the presence of the aspen hoverfly *Hammerschmidtia ferruginea* on the RSPB reserve at Invertromie during the late 1980's. Initially records were not detailed but subsequently we have significantly increased our knowledge of the aspen resource present, the dead wood inputs and population fluctuations of the aspen hoverfly (Rotheray 1999).

During 2008 we attempted to measure all of the aspen trees in the RSPB-owned Invertromie stand which were over 20cm circumference

Management action

Through monitoring the amount of dead wood at Invertromie over the past 20 years it became obvious that there were periods of up to three years when no fresh dead wood over 75cm CBH was entering the system. There is an 18 month time lag until a fresh dead tree is in a suitable state for most Diptera larvae and it soon became obvious that there were periods when there were apparently no *Hammerschmidtia* larvae present on the reserve. Although *Hammerschmidtia* may still have been present on the site in very low numbers or may have been able to disperse from the neighbouring woodland area which contained aspen, it was considered that in order to ensure the survival of a healthy population on the site management action should be taken. The objective was to ensure that the amount of dead wood on the site remained at a level which would continue to support a population of *Hammerschmidtia.*

There were several ways of achieving this objective – the first was to ensure that any dead or dying wood on the site was made available for *Hammerschmidtia* larvae to use. In effect this meant cutting down standing, but still living snags, dropping windblown tops to the ground and severing fallen trees from their root-plates. The second phase of action was to use when available any other source of suitable dead aspen which was available locally within Strathspey or finally, as a last resort, to fell healthy, suitable trees on the reserve. A further management action which we did not foresee initially, was the felling of large aspen on the site for reasons of Health & Safety, where these trees were thought to be unsafe and near to public paths.

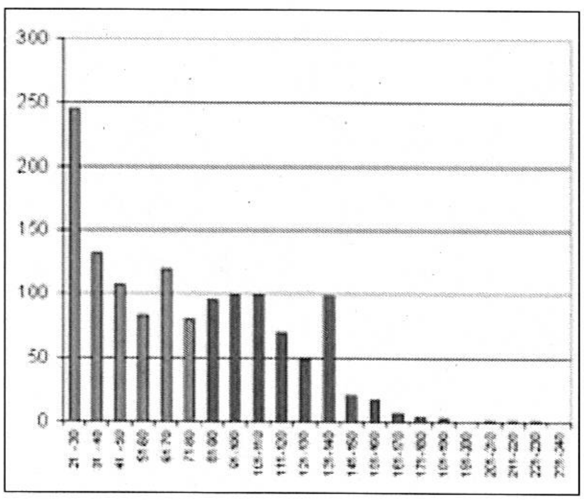

Figure 2. Input of fallen trees over 75cm CBH at Invertromie over a 21 year period to 2008. Blue columns = natural inputs. Red Columns = man-made inputs.

Once the trunk of an aspen has been snapped the tree will not produce any new growth from the standing trunk. Exposed to the wind and the sun the tree will dry out relatively quickly and although of a large size it will not produce a long enough lasting habitat in which *Hammerschmidtia* larvae can develop. The most effective management is to drop the tree to the ground, to moister, cooler conditions where slow and suitable decay can take place. The same principle applies to large tops of trees which are suspended by neighbouring trees in the canopy. If a tree is on the ground with its root- plate still attached the decaying under-bark layer will be invaded by *Armillaria* fungus thus making it unsuitable for larval development. Severing the tree from its root plate greatly reduces the chances of this happening.

In 2007 the opportunity arose to obtain large aspen trunks which had been felled as part of a development some kilometres away from the site. The RSPB were able to obtain these trunks and they have now been placed within the reserve in order to provide further habitat for the aspen hoverfly. These should be suitable for the hoverfly larvae during the summer of 2009.

What now happens is that each spring the Invertromie stand is quickly surveyed for freshly fallen timber or for newly created snags over 75cm CBH. If suitable snags are present they will be felled to the ground and if fallen trees are present they will also be assessed to see

Distribution of Aspen in Strathspey

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Introduction

Aspen *Populus tremula* is widespread in Scotland, but generally rather uncommon. It is most frequent in the uplands and islands, and especially in the Cairngorms.

Various attempts have been made to map aspen. Worrell (1993) gathered data for a sample of approximately 600 stands throughout Scotland, while MacGowan (1997) mapped the larger stands most likely to support a population of the Aspen Hoverfly *Hammerschmidtia ferruginea*. MacGowan found 21 stands over 1.5 hectares in extent in the Highlands. Together these covered 159.5 ha, of which 105.0 ha (66%) were located in Strathspey, where aspen and its dependent species have their UK stronghold.

This paper describes a survey of aspen in Strathspey, and considers some of the factors which may determine its distribution.

How does aspen spread?

Aspen can disperse in two ways: by seed and vegetatively. Although aspen flowers irregularly, it can seed prolifically, a single mature tree producing 54 million seeds in a good year (Reim, 1929, in Wyckoff & Zasada, 2003). The seed is wind-dispersed, and can travel many kilometres (Perala, 1990). This may account for its widespread occurrence on the Scottish mainland and islands.

Aspen has exacting requirements for successful establishment from seed. The seed is short-lived, and will only germinate where there is adequate moisture, drainage and light, and limited competition from other vegetation (Perala, 1990). Once germinated, seedlings are vulnerable to dessication, wash-out from heavy rain and trampling (De Chantal et al., 2005), whilst young plants are particularly palatable to grazing animals.

Having overcome these obstacles, however, established aspen trees are able to consolidate their presence by suckering. The new stems or 'ramets' thus formed are genetically identical to the 'parent' and together form a clone. This can produce mono-clonal stands comprising many hundreds of stems. Although the age of Scottish aspen clones is not known, it is likely that many have occupied the same site for many centuries, and perhaps millennia.

Aspen colonisation

Aspen was one of the first trees to colonise Scotland after the last ice age. As an early successional species, it is likely that aspen

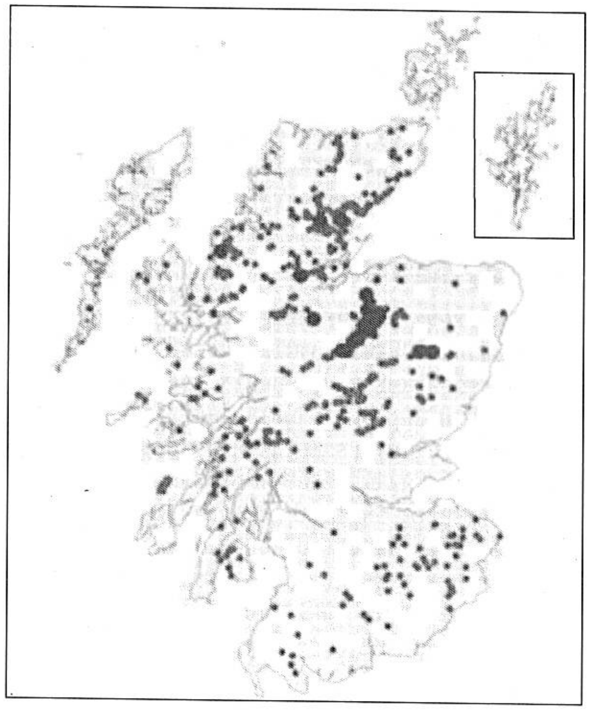

Figure 1. Aspen records from BSBI and NBN Gateway (10 km grid) in grey; Worrell (1993) in blue; MacGowan's (1997) larger stands in red.

in gorges and on crags, where it escapes grazing. In Strathspey, however, it is most frequent in birchwoods, often in association with hazel and juniper. Many of these woods have a long history of seasonal grazing.

There can be little doubt that the occurrence of many aspen stands in Strathspey is closely linked with livestock management practices, but the relationship is complex. Browsing of young trees has a major impact on tree establishment, and aspen is more palatable than most other broadleaves. However, aspen suckers may perhaps recover more quickly from browsing damage than birch seedlings. It is possible that some grazing regimes could provide aspen with a competitive advantage over other broadleaves. Grazing, especially with cattle, may create niches for aspen regeneration and perhaps encourages suckering.

Although the dynamics are not fully understood, aspen certainly thrives on many livestock farms in Strathspey. It is particularly common in sites where there is a small-scale mosaic of arable land and woodland, this mix often appearing to be determined by topography.

It has been widely reported that the regeneration of aspen from seed is very unusual (Worrell *et al.*, 1999). However, circumstantial and anecdotal evidence suggests that, at least in Strathspey, it may not be such a rare event as has been supposed. This view is supported by recent work in Finland (Latva-Karjanmaa *et al.*, 2003).

Caledonian Air Surveys

Figure 4. Aerial photograph showing a mosaic of arable land and birch-aspen woodland (aspen-rich stands delineated in blue) typical of some of the best aspen sites in Strathspey

Figure 5. Arable land and unfenced aspen/birch woodland. Note the undulating topography, a legacy of Strathspey's glacial history

Inducing flowering and fine root growth in Scottish Aspen

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Introduction

Aspen arrived in Scotland in the wake of the receding ice age about 10,000 years ago. About 4,000 years ago, the change from a continental to a more oceanic climate reduced the capacity of aspen to reproduce sexually. Nowadays widespread aspen flowering occurs only very infrequently, prompted by an unusually dry, hot summer the year before. On the rare occasions when aspen does flower in the wild, fragmentation of our aspen populations reduces gene flow. This may promote inbreeding, leading to a possible loss of viability and reduced genetic variation.

The demand for Scottish aspen has increased, but there is insufficient supply to satisfy this because of irregular flowering. Plants can be raised from root cuttings taken from mature trees, but this is both laborious and inefficient producing too few saplings to meet the demand. Therefore, Forest Research designed two different experiments to explore the possibilities of 1) inducing aspen plants to flower in a greenhouse environment and 2) inducing fine root growth for faster and more efficient propagation from root cuttings.

Inducing aspen flowering in the greenhouse

Creating an environment in a greenhouse where aspen could be induced to flower would be advantageous, not only in producing copious amounts of seed, but also enabling the crossing of plants from different populations. This would create new genetic combinations and maintain genetic variation. In addition, there is the advantage of decreased cost per sapling in comparison to propagation from root cuttings. Our hypothesis for the experiment is that aspen needs a warm summer and/or drought stress for it to flower the following year.

Material

Aspen scions were collected on January 16th 2007 from seven locations in Perthshire. These comprised four female clones and three male clones.

Fourteen cuttings were taken per location. These were grafted onto aspen rootstocks in January 2007 and potted into 8litre polythene bag-pots during summer 2007. The plants were maintained in these pots for the duration of the experiment. The flowering experiment was set up in spring 2008. All plants were fertilised once with Sincron (8g/plant). The plants were also drenched once for vine weevil with Intercept (Imidoclopryd), using 0.16 g in 800 ml of water per plant.

A set of four microsatellites were used to confirm the clonality of the grafts in their locations. Only one location was observed to consist of two clones (male tree from Tenandry), where one graft out of 14 was different.

Experimental treatments

The aspen grafts were subjected to three different treatments: Control, Temperature and Drought. Four replicates were established per treatment; thus 12 grafts were used in total per clone.

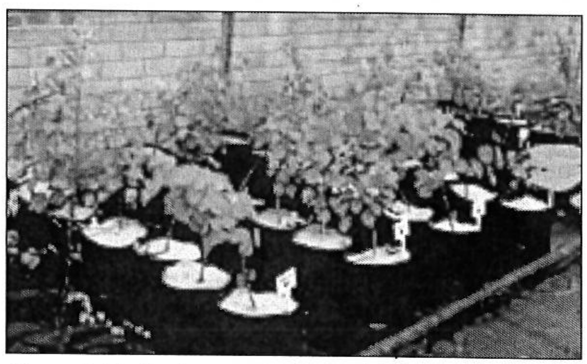

Figure 1. Grafted aspen in the outdoor control

were consistently drier on average than the temperature or the control plants. The soil moisture content recovered after watering started again, but only twice rose to the level of the temperature or the control plants.

Minimum soil moisture across the whole growing season was 4% for a drought plant. At that point the plant started showing some signs of wilting. The highest soil moisture across the whole growing season was 72% for a control plant. On average, across the whole growing season the drought plants were 8-11% drier than the temperature plants and during a drought period they were slightly drier than that (9.5-12%). During drought periods the drought plants' soil moisture was on average 15-20% at the driest point while temperature plants on the same days were 25-50% and control plants 30-45%.

Plant growth seemed to affect the soil moisture content. When plants were growing fast, the soil dried faster and when the plants were not growing (e.g. when the graft accidentally lost its leading shoot), the soil moisture remained high, even without watering.

- **The length of the leading shoot.** On average the final height of the control plants was approximately 60cm smaller than that of the temperature and the drought plants. The temperature and drought plants ended up being approximately the same height, although there was a notable difference in growth rate. The maximum difference between average height of temperature and drought treatments was 20cm; this occurred during the middle of the growing season. Subsequently the growth rate of temperature plants slowed down whereas drought plants kept on growing until they too reached the same height as the temperature plants. The average length of the leading shoot was 172-174cm. The tallest drought and temperature plants were approximately 300cm and 240cm. The tallest control plant was 185cm. Two plants in the control treatment did not grow at all during the summer.

- **Leaf predawn pressure potential.** These measurements were only taken during the first four drought periods, because the plants grew too big and covering them with plastic bin-liners became impossible. The drought plants were notably more stressed during the 1st and 4th drought periods than the plants in the other treatments. However, during the 2nd drought period, the temperature plants were slightly more stressed than the drought plants, and during the 3rd drought period, the temperature plants were almost as stressed as the drought plants. This is possibly due to the high temperatures in the greenhouse (29°C during the 2nd and 3rd drought period bagging day in comparison to 25°C and 21°C during the 1st and 4th drought period bagging day), which caused visible scorching and general heat stress inside the bin-liner. In general, the amount of stress increased as the plants started to grow (e.g. from 0.11 to 1.06 MPa in drought plants, 1st to 4th drought period). Control plants were virtually stress free (0.03-0.3 MPa overall).

Thus, drought caused stress, but so did the high temperatures inside the bin-liner, as did fast growth.

What next?

Potential flower buds will be observed once the grafts are fully dormant. The final results will be available during spring – early summer 2009, when we hope to see flowering depending on the treatment. The number of flowering plants will be counted, any seeds will be collected and their viability assessed.

Inducing fine root growth

Propagating aspen from root cuttings obtained from the wild is not an easy task. Root material collection is time consuming and costly. It is recommended that new stock trees be used to avoid stressing the same sites for too long. Because cuttings from old trees do not root as well as cuttings from young trees (see Stenvall, 2006), the stock trees should be relatively young. Root diameter, the time of year, soil conditions, health and physiological state of the stock tree, and subsequent handling of the root cuttings (drying and light exposure should be avoided) have a big impact on how well the cutting will develop into a plant (see Stenvall, 2006 for review). Because rooting and sprouting ability are genetically controlled, major differences occur in the yield of saplings from different clones. In general, fast and vigorously growing trees tend to yield well-rooted cuttings. Due to the suckering nature of aspen the collection of

Not merely a habitat: utilisation of Aspen

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Introduction

A review of the relatively scant literature on Aspen in Scotland, or even Britain, might lead quickly to the conclusion that interest in this tree is largely limited to its many qualities as a habitat for a unique and rare guild of aspen loving taxa (Cosgrove and Amphlett, 2002). The limited distribution of these wonderful species is inevitably a consequence of the relative infrequent occurrence, although not necessarily a restricted distribution, of Aspen in the wider countryside (Preston *et al,* 2002).

There is evidence that Aspen was more widespread in the Scottish landscape (Birks, 1970) and it may well have occurred in larger stands similar to those found in other parts of the North European boreal forest (Kouki, 2009). However, nowadays there are few stands in Scotland that exceed 1-2ha (Worrell, 1995a) and, outside Badenoch and Strathspey, it is often just a remnant within a woodland or the last vestiges of a former woodland clinging on in an ungrazed area.

It is possibly worth stopping for a moment to consider its current distribution and why it is so relatively uncommon in Scotland. While one conclusion which can be drawn is that Aspen had little value to our predecessors, the paucity and relatively poor management of many woodlands in Scotland suggests that it may have been woodland in general, rather than Aspen *per se,* which was under-valued.

In these days of uncertain economic future it may be sensible for an apparently affluent society which has been promoting the increased use of Aspen in woodlands, largely for biodiversity reasons, to step back and consider the uses of Aspen which might result in recognition being given to its wider values to society and therefore being planted and grown for other reasons. [Note some references draw upon the qualities of the genus *Populus,* rather than Aspen *per se.*]

Historical uses

The historical uses of Aspen are varied. Its bark contains salicin, an aspirin-like substance, which is anti-inflammatory and analgesic. This property was known by a number of societies, including North American Indians. Consequently, bark of the trees and roots along with leaf buds were used in teas, tinctures, salves and poultices to help stem bleeding, alleviate stomach pain, and combat venereal disease, urinary ailments, worms, colds, fevers, rheumatism and arthritis (Foster & Duke, 1990; Miles, 1999).

The 'disappearance' of Aspen from large parts of Scotland and its restriction in many places to inaccessible crags and ledges points to the palatability of the foliage. Historically its foliage was used as fodder for sheep and cattle, both in a green and a dry state (Grigor, 1881); because of this it is perhaps surprising that there is not greater evidence of pollards.

Our predecessors recognised the low density of aspen and poplar wood and used it in situations where heavier wood would have been less suitable, such as straining hinges so it was used for doors and gates, particularly those of large dimension (Grigor, 1881). Its soft and even-grained texture meant that it was easily carved, leading to its use in furniture and clogs and the ability to peel it into veneers allowed its use in basket making and, more recently, for matches (Tabor, 2000). It does not splinter or crack when nails are used on it so, like willow, it was valued for cladding of carts, barrows and wagons (Grigor, 1881).

The twigs and branches were used in the making of the shafts of arrows and were also believed to have divinatory qualities (Miles, 1999). The name

Property	Density (dry) (kg/m³)	Maximum bending strength (N/mm²)	Stiffness (Elasticity) (N/mm²)	Compression (N/mm²)
Aspen	430	71	10,500	37.7
Native hardwoods				
Common alder	513	80	8,800	41.1
Ash	689	116	11,900	53.3
Birch	673	123	13,300	59.9
Gean	625	110	10,200	54.5
Wych elm	609	105	10,600	49.2
Oak	689	97	10,100	51.6
Crack willow	433	66	7,000	28.1
Other species				
Black poplar	450	72	10,400	37.4
Beech	720	118	12,600	56.3
Sycamore	610	99	9,400	48.2
Douglas fir	497	91	10,500	48.3
Scots pine	513	89	10,000	47.4
Sitka spruce	384	67	8,100	36.1

Figure 1. A comparison of wood properties of Aspen with other tree species found in Scotland. (after Worrell, 1995b; Building Research Establishment, 1972)

Chemical composition

Aspen wood is characterised by having a high cellulose and low lignin content; the latter is under moderate genetic control (Yu *et al.*, 2001). The cellulose element is made up of 30% hemicellulose and 50% cellulose (Balatinecz *et al.*, 2001). This composition leads to high yields of sulphate pulp (in the range of 52 – 56%), significantly higher than the yield gained from conifers (44-46%). The low lignin and other extractive content means that other forms of pulping – mechanical, semi-chemical and sulphite processes are all suitable, but it also results in wood which is more susceptible to decay.

A recent review of the chemical properties of trees commissioned by the Forestry Commission revealed 40 different compounds (Watkins *et al.*, undated) found in Aspen, although little commercial development of these products appears to have taken place.

Calorific values

Aspen lies towards the lower middle zone of calorific values found in trees. With an estimated value of 8.6GJ/m³ it exceeds that of willow and Sitka spruce but does not match sycamore, ash or birch. The higher timber yield expected from Aspen on some sites will allow it to provide a respectable yield of dry matter and consequently energy when compared with other native broadleaves (see Harrison, 2009, for more detailed account), but it is out competed by introduced trees such as Sitka spruce, rauli and eucalypt (Lavers, 2002).

Tony Kryzanowski / Gilgalad Publishing

Figure 3. An oriented strand board (OSB) plant specialising in Aspen in High Prairie, Alberta. OSB has supplanted plywood as the board of choice used in new home construction in most of North America

Pulp and paper

The fibre characteristics of Aspen and its low content of wood chemicals means that it is well suited to pulp and paper-making and has become a preferred species for these products with over 20 million m^3 harvested in the upper Great Lakes region and the boreal mixed-wood region of Canada in 1998 (David, 2000). To put this in context, note that the annual production of timber of all species in Great Britain is around 7 million m^3 and consumption around 50 million m^3.

Undoubtedly wood supply is a key issue in Scotland and any processor, except for the smallest micro-business, would, with the existing growing stock, face difficulties over continuity of supply. The answer is, of course, to encourage expansion of the existing resource.

Conclusion

There is no doubt that international evidence demands that Aspen is considered as more than just a habitat. In addition to the ecological services that it can supply, it should be recognised as a tree which is capable of supplying a lightweight timber with low chemical content. It is likely that it is the lack of supplies that has led to only restricted attention being paid to the silvicultural attributes of the species (Worrell, 1995a; 1995b; Worrell *et al.*, 1999) and a domination of the ecological values of the species. Hopefully with rising interest in Aspen there will be increased quantities in Scotland which will provide scope for

- With increasing energy costs, its use as a fuel source
- Its use as raw material for particleboard manufacture

and, if planted in sufficient quantity, there is also the possibility of

- Using it as a general sawn wood
- Developing a small scale specialist sawn wood industry
- Using it as a source of material for pulp and paper manufacture

Further work will be required to confirm whether the chemical qualities of the bark and leaves are of economic viability. However, it is clear that insufficient attention has been paid to the utilisation of Aspen in Scotland and more effort should be made to find and develop its markets as 'a forest that pays is a forest that stays'. ■

Acknowledgements

I am grateful to Highland Aspen Group for asking me to present this review and to Mary Winsch and Alan Harrison for assistance during its preparation.

[Note the views expressed in this paper are those of the author and not of Forestry Commission Scotland.]

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Aspen growth trials: showing the species' potential in Scotland

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Introduction

European aspen (*Populus tremula* L.) is a widely distributed species throughout Europe and Northern Asia, extending south into North Africa and eastwards to Japan. In the UK, the species is commonest in northern Scotland, though its present wide but scattered distribution owes much to human activity and the low esteem in which the tree and its timber were held (Quelch, 2002). The tree occurs mainly in small groups, rarely greater than one hectare in extent. The total area of aspen throughout Scotland is estimated to be in the region of 500 ha (Mason, Easton & Ennos, 2002). It is a dioecious species and many locations appear to be single sex only and may be mono-clonal. Seed is rarely produced and even more rarely does it find a suitable germination site within its short period of viability. Most existing stands maintain or expand themselves via root-suckers (Worrell, 1995).

Aspen distribution

In 1992, Forest Research (FR) and Scottish Natural Heritage (SNH) jointly commissioned a survey of aspen distribution throughout Scotland. Information was gathered from a wide variety of sources including Forestry Commission and SNH personnel, landowners and private individuals, over about six months. At the end of this period around 500 point locations had been logged into a database. Though the survey was far from systematic, it showed how widespread and adaptable aspen is in Scotland, being found from Shetland to the Borders on a wide range of site types, from just above sea level in Ardnamurchan to 570 m elevation on Beinn Eun above Glen Affric. Since the original survey, the database has slowly been added to and now stands at 736 entries. However, the sex of trees was recorded for only five locations.

Clone garden

Having located the trees, the decision was made to establish a collection of clones at FR's Northern Research Station nursery in Roslin. Roots from a geographically representative sample of 120 clones were taken in spring 1993/94 and used to propagate the clones via root cuttings. Cutting production and subsequent rootability varied considerably between clones. The number of cuttings obtained per metre of root varied from zero up to 75. This, allied to rooting failure, resulted in 105 of the original 120 being successfully propagated. The resultant young trees were planted out in rows of five of each clone in an area of the nursery, spaced at 1.0 metre along the row and 2.0 metres between.

This clonal archive remains intact 14 years on and has shown some interesting clonal differences. The phenology between clones is clearly different and tends to be constant, i.e. those clones flushing early or late do so every year. There is also a distinct visible difference, though as yet untested, in clonal susceptibility to foliar browsing by the brassy leaf beetle (*Phratora* sp.) and its larvae. Linked to aspen chemistry and possibly allied to the beetle browsing, the rate of lichen colonisation on the bark varies significantly between clones. This resource offers excellent but untapped potential for comparative clonal analysis.

The clones were coppiced in 1997 and, therefore had ten years' re-growth in spring 2008 when four male trees flowered for the first time. This is an indicator of the minimum age at which aspen flowering can be expected to occur and could usefully inform seed orchard establishment.

Kilmichael		**Moray**	
Clone No.	**Mean Height (m)**	**Clone No.**	**Mean Height (m)**
1	13.3	1	11.6
105	9.5	70	8.6
70	7.8	105	8.4
117	7.0	80	8.2
47	6.4	47	7.6
78	6.2	48	7.4
48	6.0	78	7.1
75	5.9	74	6.8
80	5.9	107	6.6
84	5.7	57	6.4

Figure 3. Ranking of the 10 tallest native aspen clones on each site (Kendall's coefficient of rank correlation).

- The species is highly adaptable.
- Genetic growth characteristics are strongly expressed and tend to override site influences.
- The origin of a clone does not necessarily predispose it to being more suited to its original location than other clones.

The use of aspen for biomass production

The adaptability and relatively rapid growth of aspen revealed in these trials is indicative of how potentially useful a species it is for biomass production. Though not as quick growing as poplar, it is able to grow in conditions that are less favourable and the vigour of the best native clones and the Scandinavian hybrid material is impressive. It also has a higher wood density and therefore higher calorific value by volume than poplar, making it more suitable as a biofuel. Added to this is its position as a native species and the wide biodiversity that is associated with it.

Trials with aspen, and other species, grown for biomass as short rotation forestry, are currently underway in Scotland and other northern European countries. It is possible that the species could become a major component of biomass production on more marginal upland and northern land in the UK. ■

Acknowledgements

My thanks go to members of the Technical Support Unit of Forest Research for their continuing management and assessment of these trials, to Tom Connolly of Biometrics for his assistance in data analysis and to Skogforsk of Sweden for the original supply of the hybrid aspen material.

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Scottish Lepidoptera associated with Aspen

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Butterfly Conservation Scotland
Saving butterflies, moths and their habitats

buglife

The following three lists detail the moths associated with aspen that occur in Scotland. Species are categorised according to their feeding preferences.

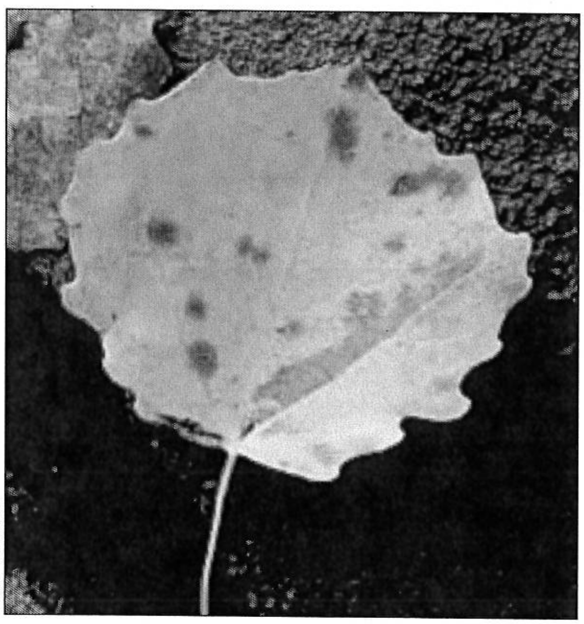
LIST 1: Species predominantly found on aspen.

LIST 2: Species that also utilize other poplars and willows.

LIST 3: Polyphagous species (ones that feed on several different foodplants) that have been recorded on aspen.

Details are given on habits, phenology (both adult and larval)*, Scottish status and distribution. Photos of many of these species and their larvae can be found on www.ukmoths.org.uk and www.ukleps.org. Buglife have also compiled similar lists of aspen-associated invertebrates – see www.buglife.org.uk

**e.g. "Adult 5-6" indicates adult is on the wing May-June.*



Alan Watson

Figure 1. Ectoedemia argyropeza

List 1:
Predominantly on Aspen in Scotland (10 micro-lepidoptera & 7 macro-lepidoptera)

- ***Ectoedemia argyropeza*** (Nepticulidae) (*Figure 1*) Larva mines upper leaf-stalk and makes a green-island mine at base of leaf. Larva 7-10. Adult 5-6. Widespread.
- ***Stigmella assimilella*** (Nepticulidae) Larva makes irregular leaf-mine, sometimes terminating in a small blotch. Larva 8-10. Adult 6-7. Widespread.
- ***Leucoptera sinuella*** (Lyonetidae) Larva forms blotch-mine. Has two broods. Larva 7 & 9. Adult 6 & 8. Last seen by Aviemore railway station in 1950, also Grantown in 1945.
- ***Anacampsis populella*** (Gelechiidae) Larva in a rolled leaf, 5-6. Adult 7-8. Widespread N of central belt.
- ***Ancylis laetana*** (Tortricidae) Larva in a folded leaf or between two leaves spun neatly together. Larva 7-4. Adult 5-6. Widespread.
- ***Epinotia cinereana*** (Tortricidae) (now a distinct form of *Epinotia nisella*) Larva in catkins or between two leaves spun flatly together 4-6. Adult 7-8. Local.
- ***Epinotia maculana*** (Tortricidae) Larva in a rolled leaf 6. Adult 8-10. Widespread.
- ***Gypsonoma aceriana*** (Tortricidae) Larva in shoot or leaf stalk, 5-6. Adult 7-8. V local in SE.
- ***Gypsonoma nitidulana*** (Tortricidae) Larva in spun leaves or folded leaf edge over-wintering on ground still within spun/folded leaf, 7-4. Adult 6. Last seen on old aspens at Aviemore, 1908 or 1911.
- ***Gypsonoma sociana*** (Tortricidae) Larva initially in a twig mine, but in spring enters expanding leaf bud 9-5. Adult 7-8. Widespread but not common.

List 2:

Aspen along with willows and poplars (2 micro-lepidoptera & 12 macro-lepidoptera)

- ***Batrachedra praeangusta*** (Batrachedridae) Also white poplar, white willow, goat sallow. Larva in a female catkin, mining the flowers and seed 4-6. Adult 7-8. Local, commoner in S.
- ***Gypsonoma dealbana*** (Tortricidae) Also poplars, willows, hawthorn, hazel, oak. After hibernation in catkins. Larva 9-5. Adult 7-8. Widespread in S.
- **Chevron** *Eulithis testata* (Geometridae) Also sallows, creeping willow, birch, hazel, heather, rowan. Larva 5-6. Adult 7-9. Common.
- **Scallop Shell** *Rheumaptera undulata* (Geometridae) Also sallow & bilberry. Larva 8-9. Adult 7. Local S.
- **Clouded Border** *Lomaspilis marginata* (Geometridae) (*Figure 6*) Also poplars, sallows, willows. Larva 7-9. Adult 6-7. Common.
- **Common Wave** *Cabera exanthemata* (Geometridae) Also sallows (esp goat & grey), poplars. Larva 6-10. Adult 5-10. Common.
- **Poplar Hawk-moth** *Laothoe populi* (Sphingidae) Also black, white, Lombardy poplar, grey sallow, goat sallow & other willows. Larva 6-9. Adult 5-7. Common.
- **Puss Moth** *Cerura vinula* (Notodontidae) Also goat sallow, poplars & willows. Larva 7-9. Adult 5-7. Common.
- **Sallow Kitten** *Furcula furcula* (Notodontidae) Also grey & goat sallows, white willow & poplars. Larva 7-9. Adult 6-7. Common.
- **Pebble Prominent** *Notodonta ziczac* (Notodontidae) Also sallows, willows & poplars. Larva 7-8. Adult 6-7. Common.
- **Pale Prominent** *Pterostoma palpina* (Notodontidae) Also poplars & willows. Larva 7-8. Adult 5-6 & 8. Widespread.
- **Small Chocolate-tip** *Clostera pigra* (Notodontidae) Also creeping willow, eared sallow & other low willows. Larva 8-9. Adult 6-7. Local.
- **Minor Shoulder-knot** *Brachylomia viminalis* (Noctuidae) Also grey sallow & other willows. Larva 4-6 hiding by day in spun leaves. Adult 7-8. Common.
- **Herald** *Scoliopteryx libatrix* (Noctuidae) Also willows & poplars. Larva 5-9. Adult 7-6. Common.

List 3:

Polyphagous including aspen (1 micro-lepidoptera & 11 macro-lepidoptera)

- ***Diurnea fagella*** (Oecophoridae). Larva 5-10. Adult 3-5. Common.
- **November Moth** *Epirrita dilutata* (Geometridae) Larva 4-6. Adult 9-10. Common.
- **Grey Pug** *Eupithecia subfuscata* (Geometridae) Larva 6-10. Adult 5-6. Common.
- **Oak Beauty** *Biston strataria* (Geometridae) Larva 5-7. Adult 2-4. Widespread mainly S & W.

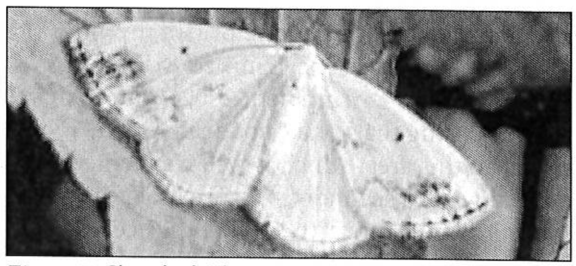

Roy Leverton

Figure 7. Clouded Silver

- **Clouded Silver** *Lomographa temerata* (Geometridae) (*Figure 7*) Larva 6-8. Adult 5-7. Common S, spreading N.
- **Coxcomb Prominent** *Ptilodon capucina* (Notodontidae) Larva 6-8. Adult 5-7. Common.
- **Pale-shouldered Brocade** *Lacanobia thalassina* (Noctuidae) Larva 6-9. Adult 5-7. Common.
- **Twin-spotted Quaker** *Orthosia munda* (Noctuidae) Larva 4-6. Adult 3-4. Local mainly W.
- **Brick** *Agrochola circellaris* (Noctuidae) Larva 4-6. Adult 8-12. Common.
- **Miller** *Acronicta leporina* (Noctuidae) Larva 7-10. Adult 5-8. Widespread but infrequent.
- **Dun-bar** *Cosmia trapezina* (Noctuidae) Larva 4-6. Adult 7-9. Common.
- **Green Silver-lines** *Pseudoips fagana britannica* (Noctuidae) Larva 7-9. Adult 5-7. Local & infrequent. ■

Acknowledgements

The authors would like to thank Roy Leverton, Mark Parsons and Mark Young for their comments on earlier drafts.

Results

At 102 sites in over 50 ten km squares we searched Aspen trees and found no evidence of *P. tremulae*. This suggests that the distribution of the pathogen is not merely a reflection of its host species and might be controlled by other ecological parameters or host tree factors.

The distribution of *P. tremulae* in the Scottish Highlands as we currently understand it is shown in Figure 2. Following its initial discovery it has now been found at over 60 sites in 36 ten km squares in the Scottish Highlands.

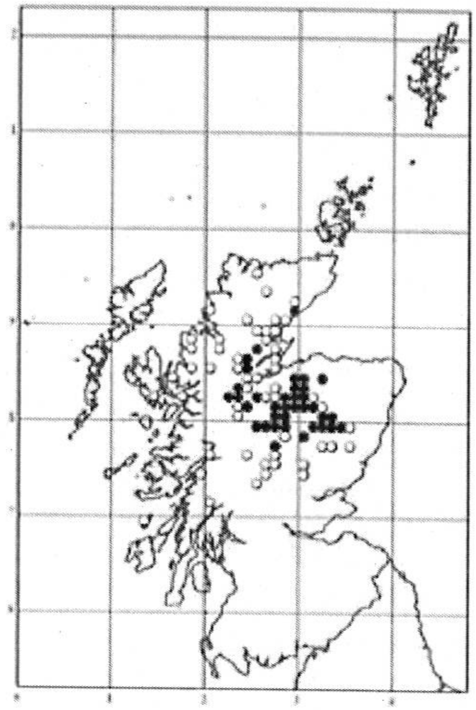


Figure 2. Distribution of *Phellinus tremulae* in the Scottish Highlands. Aspen sites checked where *P. tremulae* present (filled dots), and not present (open dots)

Size of trees

The size distribution of trees in stands which were infected by *P. tremulae* is given in Table 1. The smallest diameter of tree on which basidiocarps were found was 11 cm. The modal diameter class of trees checked was 20-24 cm, while the modal diameter class of trees on which *P. tremulae* occurred was 30-34 cm. In smaller tree sizes the proportion of trees infected by *P. tremulae* increased with increasing tree diameter (Figure 3). The sample sizes of the large diameter classes are small and this may disguise trends in larger diameter trees.

Number of trees in group

The probability of finding *P. tremulae* increased with an increasing number of trees in a stand of Aspens; it was found less frequently in small stands with fewer than 20 stems (Figure 4).

Soils

The soil type was recorded at 52 sites.

Tree diameter range (dbh)	10-14 cm	15-19 cm	20-24 cm	25-29 cm	30-34 cm	35-39 cm	40-49 cm	50-59 cm	60+ cm
Number of trees checked	45	151	161	110	105	63	48	17	5
Percentage of trees with P.t.	6.7%	6.6%	13%	19%	28%	22%	21%	35%	20%

Figure 3. Occurrence of *P. tremulae* on Aspen stems of different size classes (dbh - diameter measured at breast height).

No. of trees in group	No. of groups checked	*P. tremulae* present	%
< 11	30	3	10
11 - 20	23	3	13
21 - 50	21	8	38
51 - 100	11	3	27
> 100	3	1	33

Figure 4. Occurrence of *P. tremulae* on Aspen stands of different sizes

of the ecology of its host species which, with Aspen's Cinderella status, has been neglected by mycologists visiting the Highlands.

It is important to recognise that in this study the presence/absence of *Phellinus tremulae* was judged through the presence of basidiocarps; we were not able to judge whether it may have been present on other sites where basidiocarps were not present and the fungus just not in a reproductive stage. Thus it may be that the ecological conditions in which it is found are those required to induce fruiting.

The conditions in which it has been found can be summarised as larger stands of trees containing large diameter stems. It is more prevalent on rocky soils at higher altitudes where lower accumulated temperatures and lower soil moisture deficits are present. These conditions provide some guidance to those who wish to plant Aspens for timber rather than ecological reasons; if you wish to reduce the risk of this parasite, plant on a richer loamy soil where risk of soil moisture deficit is reduced. ■

Acknowledgements
We thank the Forestry Commission for access to Ecological Site Classification data and Scottish Natural Heritage for access to the Aspen database. Additional records were provided by Peter Beattie, Peter Cosgrove, Alan Featherstone Watson, Liz Holden, Carol Robertson and Alan Ross.

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Using BEETLE to plan Aspen habitat networks

Forest Research

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The urgent need to conserve biological diversity and ensure its future viability and integrity in a fragmented landscape has led to strategies that facilitate a more holistic view of biodiversity conservation across more extensive areas. The Cairngorm National Park Forest and Woodland Framework outlines a major aspiration to develop forest habitat networks (FHNs) through the restoration and improvement of existing woodland, including Aspen woods, and the incorporation of targeted new planting. To achieve this, the Forest Research model BEETLE uses a focal species approach to assess the functional connectivity of habitat for specific and generic focal species. BEETLE is being used in a project to develop FHN plans across the national park. The outputs will assist in targeting grants and incentives for woodland expansion.

Recent advances in remote sensing suggest that the extent of the highland aspen resource has almost certainly been underestimated. The largest stands and area of aspen woodland is in Strathspey in the highlands of Scotland (Fig. 1) where it forms a distinctive boreal broadleaved

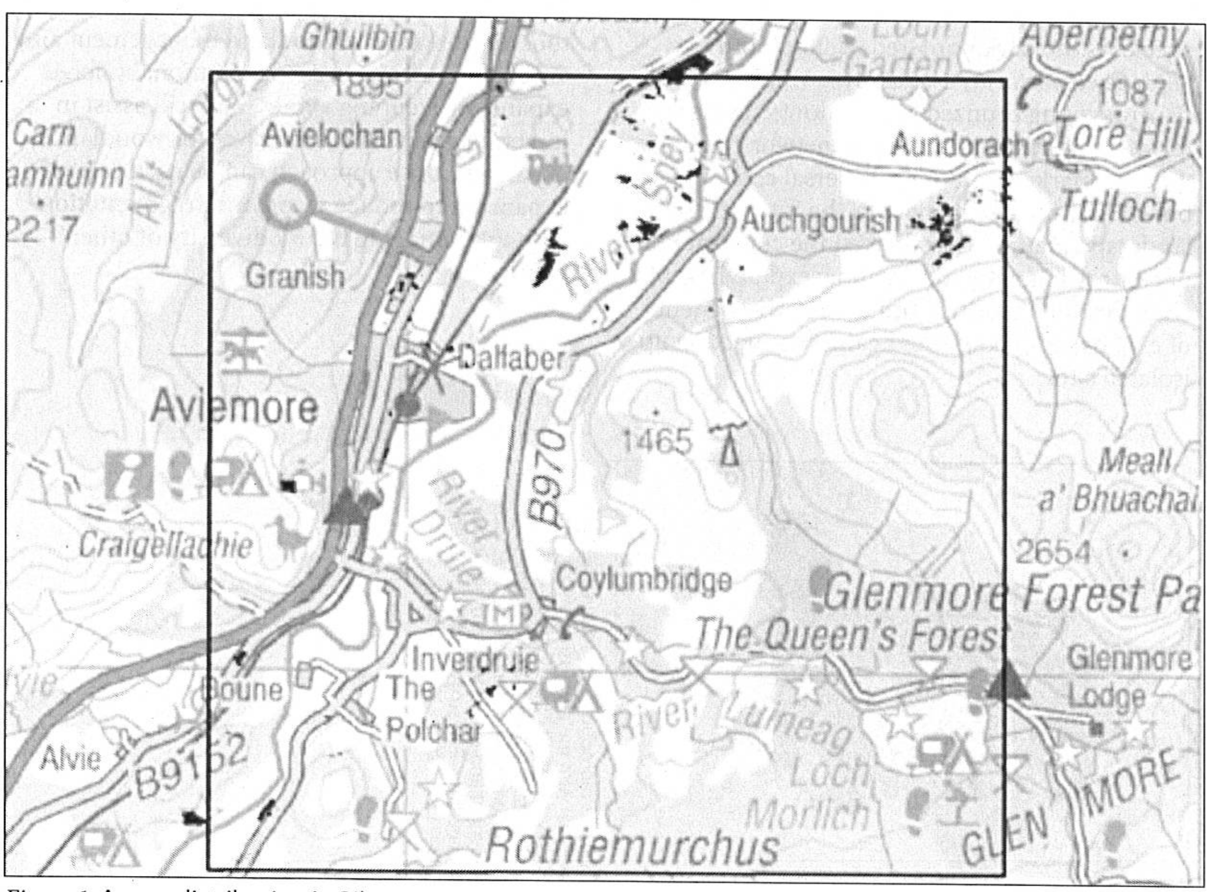

Figure 1. Aspen distribution in Pilot area

Trees for Life Aspen Project

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TREES FOR LIFE
Restoring the Caledonian Forest

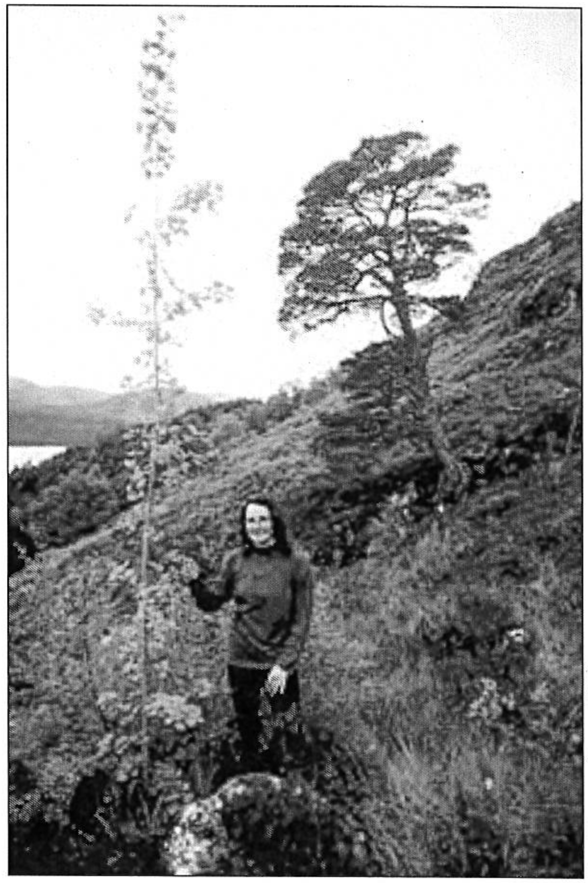
Aims of the Aspen Project

- Undertake a comprehensive and systematic survey of the aspen stands within the 2,300 square kilometre Trees for Life Target Area. This includes identification and mapping of key aspen-dependent species at each stand.
- Facilitate baseline biological surveys of priority areas to inform future management.
- Protect existing stands to allow their continued survival and expansion.
- Substantially increase the size and connectivity of existing aspen stands.
- Create a substantial increase in the number of aspen stands within the Trees for Life Target Area targeted to benefit a wide range of associated species.
- Increase understanding of aspen ecology and conservation, and promote this through our web site, articles, presentations, at events etc.

Achievements

The following is a summary of some of our main achievements since the TFL Aspen Project began in 1992:

- Total number of aspen stands surveyed: over 380
- Total number of aspen trees planted: over 10,000
- Total trees propagated: over 17,000
- Number of planting and/or site protection projects: 71
- Commissioning specialist surveys on galls, lichens, Lepidoptera, Diptera etc...
- Coordinating aspen research projects with various universities



Alan Watson/Forest Light

Figure 1. Aspen planted by Trees for Life in Glen Affric

Future plans

Over the next few years we have plans for a significant expansion in our Aspen Project. We aim to plant 9,000 aspen trees on the Dundreggan Estate by 2010, as well as substantial planting in Glen Affric, in partnership with Forestry Commission Scotland, and planting on private land. We are currently building a second polytunnel at our nursery, and we are also investigating the potential for developing a seed orchard. ■

Figure 2. At work at 650 m in Firth Hope, March 2008

Figure 3. Beginning to make a difference, July 2008

rowan and hazel. This diverse woodland type still occurs in the Southern Uplands, especially along rocky burnsides, and it was doubtless once more widespread.

Peterken's (1981) classification of stand types in ancient, semi-natural woodland provides some additional insight into the role of aspen. His birch woodlands (stand type 12), which are typical of mildly acid soils, are defined primarily by the absence of species (e.g. oak, alder, lime, ash, elm) used to define other woodland types. Birch (normally *B. pubescens*) is the most constant tree, routinely accompanied by hazel on the slightly heavier and more nearly neutral soils, where rowan, hawthorn and bird cherry are often also present and aspen occurs occasionally. However, Peterken points out that on freely draining and slightly more acid soils, where hazel is absent and juniper frequent, clones of *aspen* may be scattered throughout and not just on moist soils which are associated with the species in the lowlands.

It therefore seems likely that in the Southern Uplands, before the area came under intense pressure from domestic stock, birch woodland with juniper, rowan and aspen – or with hazel, hawthorn, bird cherry and aspen in some places – may have formed a band along the upper edge of the woods dominated by oak and ash that once occurred at slightly lower levels. Aspen doubtless occurred in patches (often comprising single clones) and even with natural levels of browsing the species may have tended to occur mainly in the less accessible places. In surviving cleuch woodlands near Carrifran aspen is sometimes associated with the montane form of goat willow, *Salix caprea sphacelata*, suggesting that this – along with more scrubby willows – may also have been a significant element in the ancient high altitude woods.

This band of boreal treeline woodland in the Southern Uplands was clearly envisioned by Peterken *et al.* (1995) as a component of the forest habitat network that they deemed desirable for Scotland, and restoration of this band could help to forge the missing link between native forests of the Tweed, Clyde and Annan drainage systems.

The Wildwood Group of Borders Forest Trust is in full agreement with the comment by Quelch (2002) that "*There is evidence that it* [aspen] *was once a great component of Scottish natural woodlands, and there seems to be no good reason why, with help, it could not be so again. It is time for a 'Comeback Code' for Aspen!*" When planning the restoration of the whole wooded ecosystem at Carrifran, it was decided that aspen should be planted in many different parts of the valley, from lower sites at 170 m a.s.l. up into the treeline planting at over 650 m a.s.l., but avoiding peaty areas.

Production of planting stock starts each spring in February and March, when Wildwood volunteers collect sub-surface roots from aspen stands in the general vicinity of Carrifran. In the early years of the project propagation was in back-garden nurseries and greenhouses, following guidance provided in Forestry Commission Research Information Note 200, published in 1991. Success was variable, with fungal attack (which we nicknamed 'black death') sometimes causing severe mortality. More recently, the root cuttings have been passed for propagation to the

BULB Aspen Project

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Figure 1. Clare Darlaston of AMEY, Peter Livingstone and Andy Harrison (BULB) planting aspen at Roadhead Roundabout

BULB are a small community group based in Lochwinnoch. We formed in 2006 to take forward a variety of biodiversity related projects in the local area. Currently our main project involves the study, research and conservation of the local Aspen (*Populus tremula*) resource.

BULB identified a need to take action to conserve the remaining handful of aspen trees (clones) in Renfrewshire and prepared a Species Action Plan (SAP) which will shortly be published in the Renfrewshire Local Biodiversity Action Plan (LBAP).

The principal aims of the project are to conserve and expand this tree species through the propagation of root cuttings from the remaining stands, identify and collect cuttings from clones in the local provenance area for propagation to increase genetic diversity and to create new aspen stands using this material.

To date a temporary nursery has been established in a residential garden. Cuttings from a total of 30 clones have been collected and propagated in the nursery producing in the region of 700 saplings. The temporary nursery is fast approaching capacity and BULB are currently searching for a suitable nursery site in the village.

Ecology, conservation and management of Aspen: A Literature Review

SCOTTISH NATIVE WOODS

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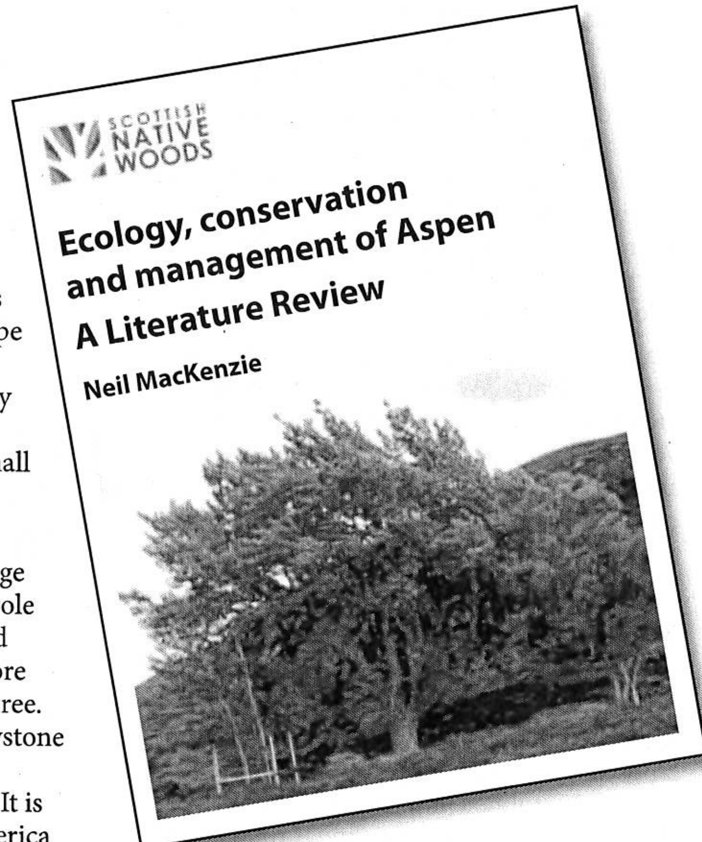

The Eurasian aspen *Populus tremula* is the most common and most widespread broadleaved tree in the northern circum-boreal region. Together, the Eurasian aspen and the closely related Quaking aspen (*P. tremuloides*) of North America have the widest natural range of any tree species in the world. In Scotland aspen was one of the first trees to colonise the landscape after the last ice age but it subsequently 'disappeared" from the pollen record. Today it is found throughout mainland Scotland and the islands but usually exists only as small stands or solitary trees, rarely sets seed and propagates mainly by suckers.

Studies on aspen in different parts of its range have established that it plays an important role in the ecology of a diverse range of flora and fauna. In Europe for example aspen has more host-specific species than any other boreal tree. In North America aspen is considered a keystone species and critical to the maintenance of biodiversity in western and boreal regions. It is also an important timber tree in North America and several of the Baltic states, particularly for the pulp and paper industry. In Scotland aspen is host to over 300 species of lichen, up to 100 fungi, several rare bryophytes, numerous aspen-dependent saproxylic insects, rare moths and other invertebrates. It also plays a valuable role in landscape diversity and amenity. Although the Scottish resource is too scarce at present for any timber use, new planting and expansion may offer the potential for future opportunities.

The purpose of this literature review is to collate current information, review recent publications and provide an up to date examination of the current knowledge of aspen. As there is very little information on the ecology and management of aspen in Britain, the review has drawn heavily on published material from Europe and North America. Although the habitat associations of *P. tremuloides* in North America are different to those in Scotland, the two species are morphologically and genetically very similar. The review has extracted information from over 220 publications covering taxonomy, distribution, biology, biodiversity, threats, cultural context, current values, utilisation, propagation and management. The information gleaned from these publications will thus be a useful source of reference for guiding conservation work. This will help sustain a long-term future for aspen in Scotland. ■

If you would like a copy, contact john.parrott@scottishnativewoods.org.uk or visit www.scottishaspen.org.uk to download a pdf.

support research and raise awareness

- publish and disseminate information on Aspen, its dependent species and provide management guidance
- hold demonstration events to raise awareness of Aspen and appropriate management
- help investigate aspects of aspen management, such as grazing impacts and propagation methods

restore and expand Aspen woodlands

- engage with land-holders to bring existing stands into management, and establish new stands
- develop networks of Aspen habitat in core areas by enhancing functional connectivity between stands

improve the availability of local origin Aspen for planting

- support the development of nurseries growing local origin Aspen
- establish a national clone collection and regional seed-orchards to supply all Scottish seed zones.

Figure 1. Partnership is key to the project's success. Improving the availability of planting material requires the collaboration of many bodies including Highland Aspen Group, Royal Zoological Society of Scotland, Forest Research and Scottish Native Woods.

If you would like to learn more about the project, or help with surveying and mapping aspen stands, visit www.scottishaspen.org.uk ■

Ssshhh ... listen! Look out for Aspen.

Figure 2. Tom Prescott of Butterfly Conservation Scotland discusses the biodiversity associated with Aspen at a demonstration event organised by Scottish Native Woods in Carrbridge. Raising awareness is an important element of the project.

Question and answer sessions

Q *Some landowners in the Highlands want to use fire as a management tool in their pinewoods. Is fire used in Finnish forests and what is the effect of fire on the Aspens that are found in the pine and spruce forests?*

A **Jari Kouki** described an experiment which he set up in 2003 into the effects of burning on subsequent forest regeneration. Twenty-four matched plots were chosen with different tree densities, ranging from uncut forest with trees of different ages and sizes to clearfell. Twelve were burnt and the others were kept unburnt as controls. It is too soon to measure the results; the experiment has to run for many years.

Q *What is the effect of Beavers on Aspens in Finnish forests?*

A **Jari Kouki** observed that most of the Beavers in eastern Finland are not native European Beavers, but Canadian Beavers and their behaviour is much more aggressive and damaging to trees. They do use Aspens, as well as other deciduous tree species, as food and they do damage standing trees in the.

Q *Have differences in longevity been observed in adult Hammerschmidtia depending on the nature of the available food sources?*

A **Ellie Rotheray** commented she has no such evidence at this stage. During the winter she plans to analyse samples of fly droppings for pollen to try to identify which food plants are being used by the flies and if it changes over the lifetime of the mature insect. Further field work is planned for the summer of 2009.

Q *In the seed orchard trial at NRS, did stress result in an increase of Venturia infection of the leaves?*

A **Tytti Vanhala** had noted no evidence of any increased infection. Alan Harrison commented that stress affects plants' survival response; this may affect chemical composition of the leaves and hence their resistance or vulnerability to infection. **John Parrott** said that, as opposed to the effects on animals, increased stress can provoke flowering. **David Jardine** commented that stress causes hormonal changes in plants which stimulate flowering.

Q *At what age do Aspens start flowering?*

A **Tytti Vanhala** explained that normally trees have to be mature before they will flower and set seed. The experiments in the seed orchard are using grafts of mature shoots onto root stock in the hope this will provoke flowering when the resulting small trees are stressed. **Alan Harrison** commented that they have observed that some of the grafted shoots have, however, reverted to a juvenile leaf shape.

Q *Is it possible to identify the female clones in the grafted trees, for example from bud shapes?*

A **Tytti Vanhala** responded that at this stage it is not possible to sex the trees from the bud shapes. It has been reported that female trees need more water than male trees and they had noticed that grafted trees from one clone were transpiring faster than other clones. In due course this might prove to be a female and support the hypothesis.

Q *How will climate change affect Aspen and the organisms it supports?*

A There is speculation that climate change could result in an increase in storms in Britain; this might result in an increase in the number of fallen trees and hence dead wood. This could benefit the organisms that depend on dead wood, but it would work against those organisms that use standing live trees as their habitat.

Q *In order to increase the amount of dead wood, is the plan to fell only snags, or does it include felling healthy living trees as well?*

A **Iain MacGowan** explained the plan is to survey the woodlands in the spring to look for snags caused by winter storms and then to fell them to the ground. Other options include cutting up fallen living trees lying on the ground with their root plates still attached.

Jari Kouki commented that in Finland and other Scandinavian forests, old mature aspens can be found in the middle of old growth forests, but there are usually few young trees. This might be due to grazing by herbivores (elk and hares) rather than the effect of dense shade from taller mature trees on the growth of young ramets.

Q *Aspen spread very well after the last Ice Age. How can we mimic the conditions that existed then to enhance the spread of Aspen today?*

A **Alan Harrison** commented that the rapid spread of Aspen was probably by seed, but Aspen does not flower as frequently today. **Tytti Vanhala** commented that the conditions that pertained after the Ice Age are quite different to conditions now; initially it was drier and then wetter and cloudier than it is now. **John Parrott** commented that elsewhere in its range, Aspen flowers more regularly.

Q **Jari Kouki** *observed that the 21 year monitoring programme in Finland goes to the heart of Aspen biodiversity and they have been studying the availability of specific habitats to different organisms. They have found that, even after a long period without fallen trees, when events occur that result in a supply of dead wood then invertebrates colonise the fallen trees. Are standing living mature trees being used by hoverflies as well as by Coleoptera?*

A **Iain MacGowan** commented that unlike the situation in Scandinavia, no rare species of beetle are associated with dead aspen in Scotland, possibly due to past extinctions or to the fact that colonisation by these species never actually took place after the ice age. We do however have the rare Diptera and so we need to manage the Aspen in a manner which is suitable for them. He did not know of any information about colonisation by Diptera after a gap in the supply of suitable dead wood, but further studies looking at the dispersal abilities of these species is planned.

Q *What are the criteria for good sites?*

A **David Jardine** commented that sites need to be big and varied, thereby offering the potential for varied microclimates. **Iain MacGowan** commented that for the Hoverflies to survive, then more than 100 trees with girths greater than 75cms are needed at each site. **David Jardine** asked how many young trees are needed to provide a sustainable supply of trees for food for the other organisms.

Q *Does biodiversity lose or gain if Aspen stands are thinned? Is it better to fence single trees in a field in the hope they will produce young ramets, or to fell Birch and encourage Aspen regeneration in the birchwoods?*

A **David Jardine** reiterated his comments that management plans should aim for big and varied sites and appropriate steps should be taken to encourage regeneration.

Q *Would it be better to plant commercial hybrids since they grow faster and bigger?*

A It is not known if the rare insects can use hybrids as a food source or if the bark can support the range of rare lichens and bryophytes. **Ern Emmett** commented that it is probably best to concentrate on the propagation and spread of native trees, especially in the National Park and not introduce hybrids that could dilute the stock of native material.

Q *The Minister for the Environment was unable to attend and open the conference as originally planned. What questions should be directed to the Minister?*

A **David Jardine** commented that there was a need to raise awareness about the potential for growing Aspen, not only for its contribution to biodiversity but also for economic reasons; but there was a need for trees to be available for planting. Hence the need for propagation of young trees. Forest Enterprise will continue planting Aspen in the forests it manages if stock is available. It was generally agreed there is a need for support mechanisms to encourage planting by landowners. ■

residents, with waymarked paths and a proposed cycle track.

Achnagonalin
Part of Revack Estate, Achnagonalin is ASNW on flat ground by the River Spey. The Aspen comprises a single age-class of old Aspen (50-60+cm dbh), which are senescing and providing abundant deadwood. The site is noted for bryophytes and saproxylic diptera.

Auchernack
Part of Auchernack Farm, and owned by Malcolm Smith, the site comprises a mosaic of arable, grassland and woodland, much of which is ASNW. The whole area is grazed by 300 hog (yearling) sheep from October to late December. The woodland is dominated by Birch and Aspen, the latter suckering vigorously into grassy areas. The site is managed for its biodiversity interest.

Balliefurth Wood
Formerly part of Seafield Estate, Balliefurth Farm is owned by Alastair Maclennan. The woods (38ha) are managed by Scottish Native Woods. The woods comprise a conifer plantation (P1964-67) dominated by Scots pine, with some larch, other conifers and broadleaves. Some areas are seasonally grazed by cattle.

In 2007, the pine and larch were thinned and Grand Fir removed. Small coupes were partially restocked with Aspen, Bird Cherry and Goat Willow. Other broadleaves (Birch, Rowan) will establish naturally. Standing deadwood (1.5 – 5m, 8 stems/ha) was created for Crested Tit. ■

Figure 4. Achnagonalin has many large Aspen

Figure 5. Delegates gather around an Aspen to discuss the merits of girdling to induce flowering

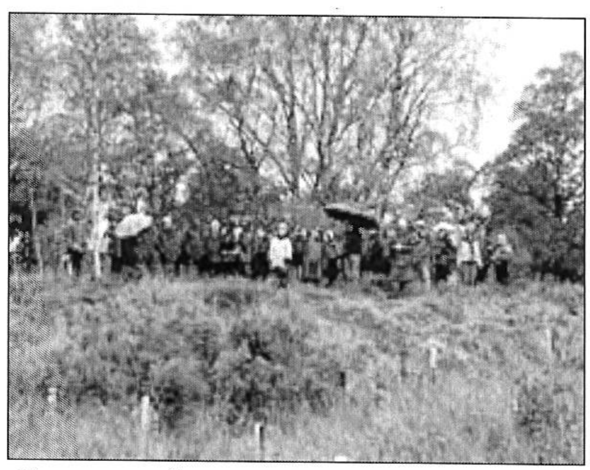

Figure 6. An open area at Balliefurth planted with Aspen and Bird Cherry

Highland Aspen Group

Highland Aspen Group was established in the wake of the Aspen conference held in Kingussie in 2001.

It is a membership organisation of enthusiasts from all walks of life who share an interest in improving the future for Aspen in the Scotland. Our work includes gathering and disseminating information on Aspen and its dependent species, and promoting the establishment of new Aspen stands.

The Group has been operating a propagation unit in Kincraig to supply local origin Aspen since 2004.

We produce an annual newsletter and have meetings twice a year.

The current Management Committee comprises:

Ern Emmett	Chairman	ecubed@btinternet.com
Mary Winsch	Secretary	winscm01@clara.co.uk
John Parrott	Treasurer	john.parrott@scottishnativewoods.org.uk
Helen Armour		harmour@rzss.org.uk
Amanda Calvert		amandacal@hotmail.co.uk
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If you would like to support the Group's activities, subscription details are available at www.scottishaspen.org.uk or contact the Secretary.