Harrison, A.F.; Helliwell, D.R.. 1981 Growth of sycamore and birch in relation to soil chemical properties. In: Last, F.T.; Gardiner, A.S., (eds.) *Forest and woodland ecology: an account of research being done in ITE.* Cambridge, NERC/Institute of Terrestrial Ecology, 75-77. (ITE Symposium, 8).

Trees and their nutrition and effects on soils

16. GROWTH OF SYCAMORE AND BIRCH IN RELATION TO SOIL CHEMICAL PROPERTIES

A.F. HARRISON and D.R. HELLIWELL

Six seed-lots of sycamore (*Acer pseudoplatanus* L.) and 4 seed-lots of birch (*Betula pendula* Roth.) from various European provenances were grown in a range of Cumbrian soils, in a pot experiment to study variation in seedling response to soil chemical properties. Seedlings from all seed-lots of both species responded in a similar manner to the whole range of soils (Helliwell & Harrison, 1978), so only the relationships between species and soil chemical properties of the soils are examined.

The seed-lots of sycamore were stratified in moist sand at 2°C for 6 weeks before being sown directly and those of birch were germinated on peat to the '2 leaf' stage, before being planted out into the experimental soils in May 1974. Twenty-five soils with a wide range of physical and chemical properties (Table 19) were collected within 40 km of Merlewood. Before filling polythene pots of 2 sizes, each soil was sieved at field moisture through a 13 mm mesh and afterwards thoroughly mixed. After planting, the pots were arranged in a randomized block design on raised gravel beds within a bird and mammal proof cage for protection (Helliwell & Harrison, 1978). They were watered after rain-free days in spring and summer and were periodically weeded before being harvested after 16 months in September 1975. Both tops and roots were dried and weighed. Soil samples for chemical analyses were taken from pots in June/July of the first season, when plants were growing at their fastest rate.

Probably because of an initial advantage attributable to the nutrient content of larger seeds, sycamore grew more than birch. There was an overall correlation (r = 0.75) between the growth of the 2 species, but sycamore grew significantly better than birch on some soils and *vice versa* (Figure 37). There was, however, no significant difference between the growth of different seed-lots within either species (Helliwell & Harrison, 1978). Also, growth of plants in small pots was highly correlated (r = 0.97) with growth of plants in big pots for both species (Table 20).

TABLE 19 Some properties* of 25 Cumbrian soils on which different seed-lots of sycamore and birch were grown

Soil property	min	mean	max
Loss-on-ignition %	7.5	25	89
pH	3.2	4.5	7.9
Total P $\mu g g^{-1}$	100	1080	3600
Total N %	0.21	0.82	2.32
Extractable P $\mu g g^{-1}$ (a)	2.6	12.3	97
Isotopically exchangeable P $\mu g g^{-1}$ (b)	9.8	191	1700
Phosphatase activity (c)	71	608	3309
Extractable NH_4 -N$\mu g g^{-1}$ (d)	4.3	72	220
Extractable NO_3 -N$\mu g g^{-1}$ (d)	1	24	61
Extractable K $\mu g g^{-1}$ (a)	38	129	300
Extractable Ca mg100g^{-1} (a)	10	317	5400
Extractable Fe $\mu g g^{-1}$ (e)	7	207	1066

(a) Extractable in 2.5% acetic acid (Allen *et. al.,* 1974)

(b) Method 3, (18 hrs), (Harrison, 1975)

(c) Expressed as phenol liberated from disodium phenylphosphate at soil pH and 13°C in $\mu g Ph g^{-1}$ soil (Harrison, 1979)

(d) Extractable in 15% aqueous KC1

(e) Extractable in ammonium citrate (0.001 M) – HCl (0.02 M) adjusted to soil pH.

*Properties of individual soils have been presented elsewhere (Jeffers, 1977; Helliwell & Harrison, 1978).

TABLE 20 Growth of sycamore and birch seedlings in 25 Cumbrian soils

	Mean dry wt per plant after 16 months' growth (g)		
	Minimum	Mean*	Maximum
Sycamore			
small pots	0.002	3.90	10.44
large pots	0.006	5.76	20.32
Birch			
small pots	0.014	2.38	10.16
large pots	0.014	3.90	19.22

* Means of all replicate seedlings, ie amalgamating all seed-lots

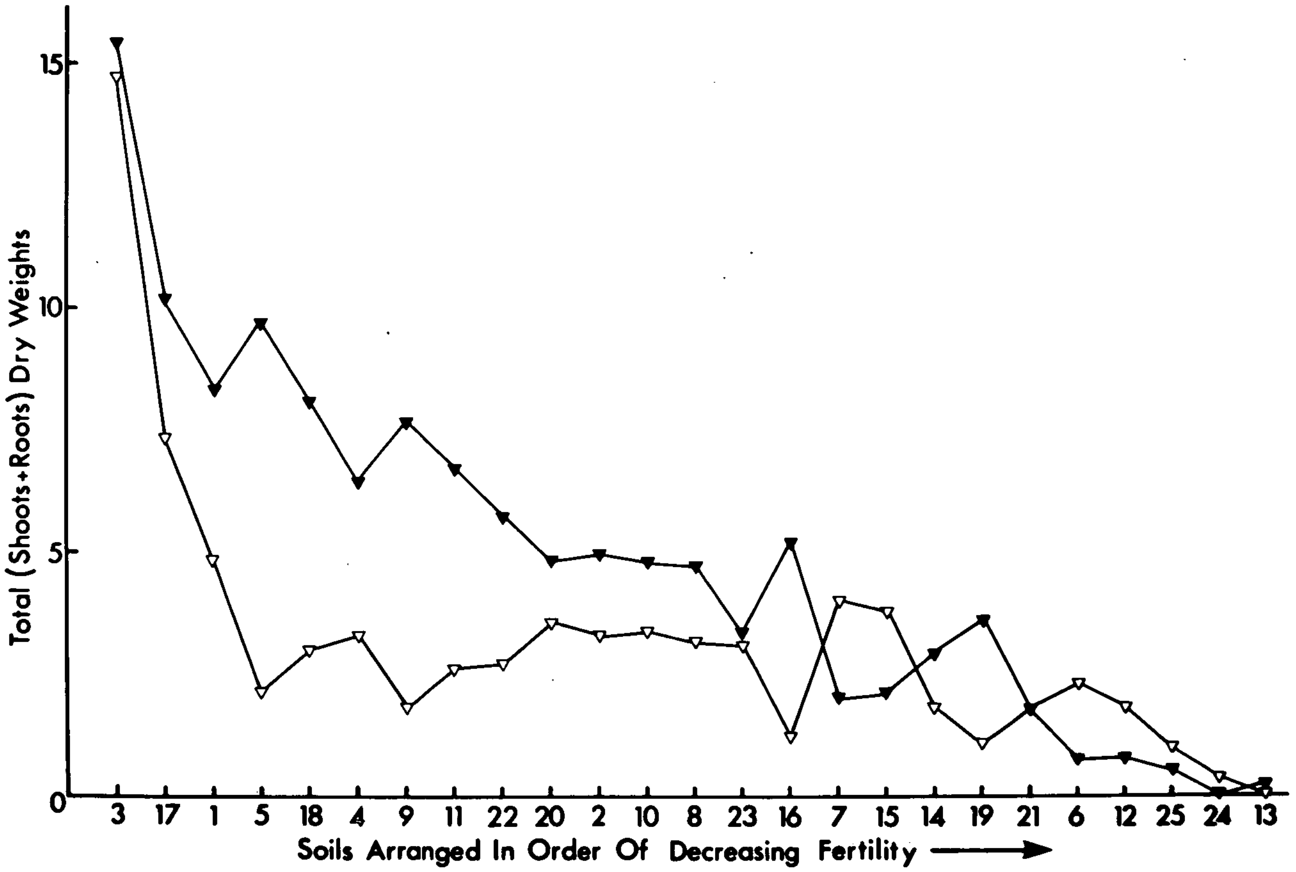

Fig. 37 *Total dry weights of sycamore and silver birch after growing for 16 months in a range of 25 Cumbrian soils. (▼—▼ sycamore, ▽ – ▽ birch).*

Growth in the different soils varied by a factor of at least x740. Dry weights (overall mean of plants in both sizes of pots) of both sycamore and birch were positively and significantly related to (i) total soil P (ii) extractable soil P, (iii) isotopically exchangeable P (iv) soil phosphatase activity and (v) extractable Ca (Table 21). In addition, growth of sycamore, but not that of birch, was related to pH and extractable K. In multiple regression analyses, the combination of soil phosphorus properties accounted for 72 and 80% of the variation in the growth of sycamore and birch respectively. Adding pH and extractable K in the analysis increased the proportion for sycamore to 87%. One soil (no. 3) contributed strongly to these percentages, but even when data for this soil were omitted, the growth of both species was still significantly correlated with soil phosphorus properties and, in the case of sycamore, with pH and calcium. However, as a consequence of omitting the data for soil 3, the growth of sycamore was found to be negatively correlated to (i) total N, (ii) extractable NH_4-N, (iii) loss-on-ignition and (iv) extractable iron. The relations with (i) and (ii) are difficult to comprehend at present but those with (iii) and (iv) might be expected, as they themselves are negatively related to pH.

These results indicate the over-riding importance of soil phosphorus to seedling growth so confirming earlier work done with soils from Cumbria and

TABLE 21 Proportion of variation (r^2), accounted for when considering the production (g dry wt) of sycamore and birch in relation to soil chemical properties

Soil Properties	Sycamore	Birch
Loss-on-ignition	.02	.02
pH	(.52*)	.01
Total P	.44	(.75*)
Total N	.001	.09
Extractable P	.30*	(.70*)
Isotopic exch. P	.32*	.69*
Phosphatase activity	(.45*)	(.70*)
Extractable NH_4 -N	.10	.01
Extractable NO_3 -N	.09	.12
Extractable K	(.24*)	.001
Extractable Ca	(.40*)	(.35*)
Extractable Fe	.09	.01

* r^2 significant at $P < 0.05$

( ) = significant deviation from linear regression at $P < 0.05$

north Wales. Helliwell (1973) found that growth of sycamore and birch could be related neither to soil nitrogen nor extractable potassium; instead correlations with amounts of soil extractable phosphorus were significant and positive. More

Plate 1 Hedges and hedgerow trees—the damage wrought to elms and the landscape by the aggressive strain of the Dutch elm pathogen, *Ceratocystis ulmi.* Photograph: Forestry Commission.

N. procera/nervosa

N. obliqua

Plates 2 & 3 *Nothofagus* spp.—will either of these South American species be grown on a large scale in Britain introducing diversity to the stock of plantation forests? Photographer: F T Last.

Plate 4 Cona Glen, Highland Region, Scotland. National Woodlands Classification: Type 28. Tree species: *Pinus sylvestris, Betula* spp. Ground vegetation: *Calluna vulgaris, Molinia caerulea.* Altitude *c.* 250m. Bedrock: Schist. Photographer: R G H Bunce.

Plate 5 Harrow Weald, Middlesex, England. National Woodlands Classification: Type 17. Tree species: *Betula* spp, *Quercus petraea.* Ground vegetation: *Deschampsia flexuosa, Pteridum aquilinum.* Altitude *c.* 140m. Bedrock: London clay. Photographer: F T Last.

Plates 6 & 7 These photographs illustrate the impact of trees in residential areas. The trees form a considerable resource which needs to be sustained. But is this being done? Are sufficient attempts being made to provide improved planting stock? Photographer: J E Good.

Plate 8 Majestic open-grown trees like this parkland oak can still be found but in decreasing numbers. More determined efforts should be made to characterise and analyse the range of variation within native trees. Photographer: J E Good.

Plate 9 Woodland dynamics: these seedlings grew when soil from neglected coppice at Chalkney, Essex, was incubated in an unheated glasshouse. Seedlings include species of *Carex, Cirsium, Hypericum, Juncus, Poa, Rubus, Rumex* and *Scrophularia.* Photographer: A H F Brown.

Plate 10 Dunham Massey Park, Greater Manchester, in the spring: a pasture-woodland. Photographer: P T Harding.

Plate 11 Effects of small and large concentrations of phosphate and calcium on cuttings of *Betula pendula* growing on nutrient jelly in sterile conditions. Photographer: J Pelham.

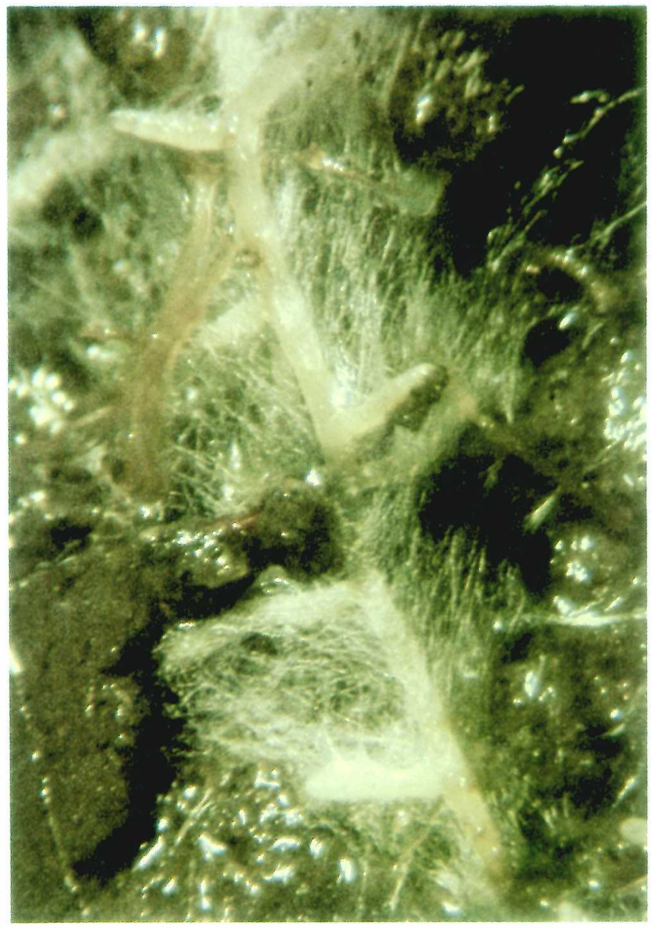

Plate 12 The stubby roots (mycorrhizas) formed when *Hebeloma* sp.—a fungus—colonises the roots of birch, *Betula* spp. Photographer: P A Mason.

Plate 13 Fruitbodies produced by mycorrhizal fungi in the autumn around a birch tree *(Betula pendula)*, about 8 years-old. The fruitbodies of *Leccinum rigidipes* are nearest the stem, those of *Hebeloma crustuliniforme* are the most distant, with those of *Lactarius pubescens* in between. Photographer: J Pelham.

Plate 14 Presumably it might be profitable to exploit these birch saplings, *Betula pendula,* which are successfully colonising an old coal tip. Have they innate tolerance which could be exploited by vegetative propagation? Photographer: J Wilson.

Plate 15 Flower induction in trees—the formation of cones by Sitka spruce, *Picea sitchensis,* 16 years-old; see front cover for flowers of *Triplochiton scleroxylon.* Photographer: E D Ford.

Plate 16 Characteristic crown of the West African timber tree *Triplochiton scleroxylon* growing in Nigeria. Attempts are being made to conserve the full range of variation found within this species. Photographer: F T Last.

Plate 17 One of the hazards sometimes encountered when vegetatively propagating: cuttings from lateral shoots of *Triplochiton scleroxylon* with leaves arranged in two rows (distichous) sometimes grow horizontally (plagiotropically), in contrast to the erect growth of cuttings with leaves arranged in spirals (polystichous). Photographer: R R B Leakey.

Plate 18 Transverse maternal gallery (with female present) and larval galleries burrowed beneath the bark of oak by the bark beetle *Scolytus intricatus.* Photographer: M G Yates.

Plate 19 Crotch feeding on oak, *Quercus robur,* by a female bark beetle, *Scolytus intricatus*—the wound is typically made at the junction between the current and preceding season's growth. Photographer: M G Yates.

Plate 20 A newly emerged white admiral, *Ladoga camilla,* which exploits areas of light shade abounding in neglected coppice. Photographer: J Grant.

Plate 21 Fifth instar larva or caterpillar, of the white admiral, *Ladoga camilla.* It feeds on honeysuckle which abounds in neglected coppice. Photographer: E. Pollard.

Plate 23 Bark stripping of sycamore attributed to grey squirrels. Photographer: R D Kenward.

Plate 22 Grey squirrel, *Sciurus carolinensis.* Photographer: R D Kenward.

Plate 24 Norway spruce, *Picea abies,* browsed by red deer, *Cervus elaphus,* in Rannoch Forest, Perthshire. Photographer: B W Staines.

Plate 25 Bark stripping on lodgepole pine, *Pinus contorta,* by red deer, *Cervus elaphus,* in Glen Hurich, Inverness-shire. Photographer: B W Staines.

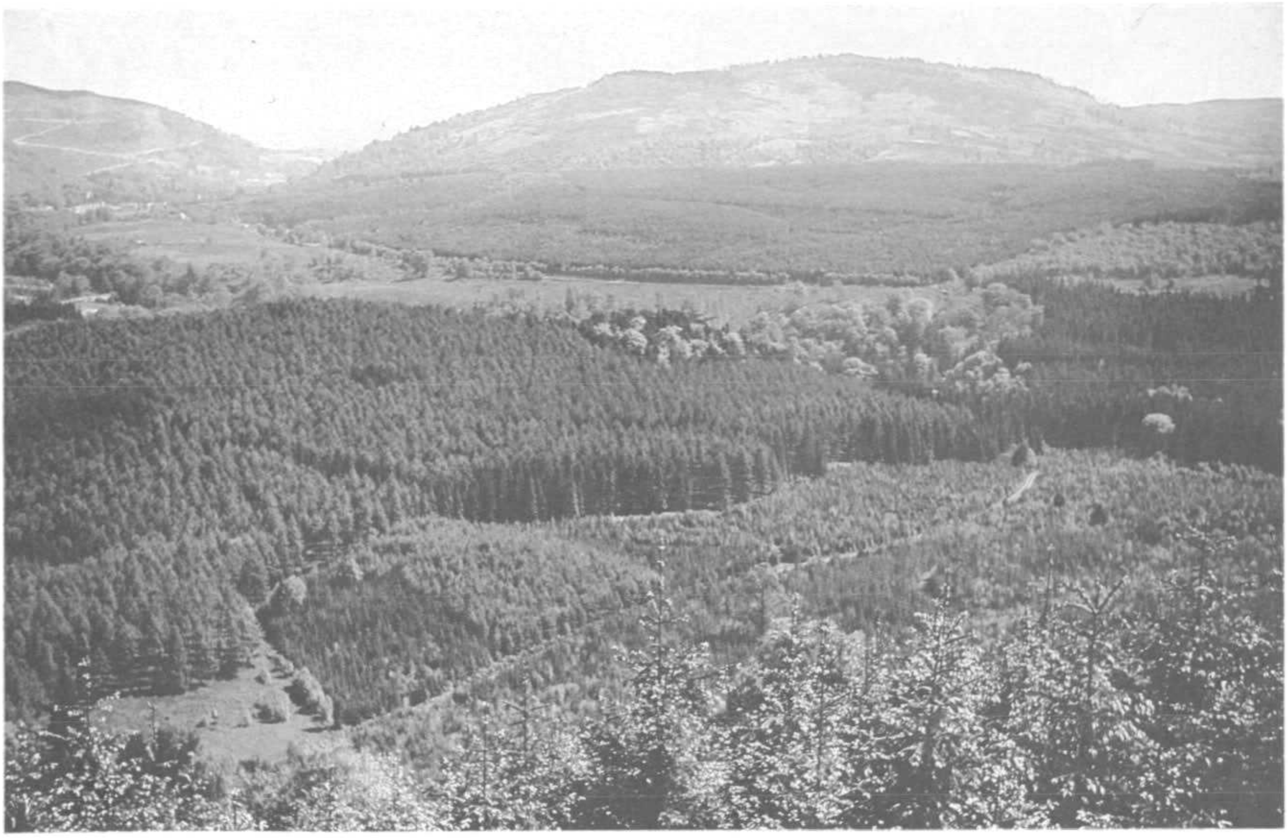

Plate 27 Ladywell plantation, Craigvinean, Scotland. Photograph: Forestry Commission.

Plate 26 Doirean na h-Earba, Compt. 297. Natural Scots pine, *Pinus sylvestris,* viewed from the south, Glengarry. Photograph: Forestry Commission.

recently the responsiveness of sycamore and birch to phosphate fertilizers was estimated using a bioassay technique based on the differential uptake of ^{32}P-labelled phosphorus (Harrison & Helliwell, 1979). These results parallel those obtained in production forestry where positive responses to phosphate fertilizers are commonplace (Zehetmayr, 1960; Everard, 1974; Binns, 1975). Nitrogen fertilizers can stimulate tree growth on heather-dominated sites except when heather has been killed by herbicide applications, but are otherwise usually of little value.

It was not surprising to find that sycamore grew badly on soils more acid than pH 3.9, this species preferring base-rich sites (Klotzli, 1970). On the other hand, one would expect the invasive birch to be more tolerant of low pH, but it too grew poorly on soils of $<$3.9 pH.

Clearly the production of sycamore and birch is dependent on phosphorus availability in soils. But what about other species of trees? How do the demands of tree species compare with those of other types of plants? Answers to these questions are being sought in a continuing programme of research, enlarged to study the responses of *Agrostis tenuis* and *Trifolium repens,* as well as birch, to 104 different soils of 8 pedological classes.

References

Allen, S.E., Grimshaw, H.M., Parkinson, J.A. & Quarmby, C. 1974. *Chemical analysis of ecological materials.* Oxford: Blackwell.

Binns, W.O. 1975. Fertilizers in the forest: a guide to materials. *Leafl. For. Commn,* no. 63.

Everard, J.E. 1974. Fertilisers in the establishment of conifers in Wales and Southern England. *Bookl. For. Commn,* no. 41.

Harrison, A.F. 1975. Estimation of readily-available phosphate in some English Lake District woodland soils. Oikos, **26,** 170-176.

Harrison, A.F. 1979. Variation of four phosphorus properties in woodland soils. *Soil Biol. & Biochem.,* **11,** 393-403.

Harrison, A.F. & Helliwell, D.R. 1979. A bioassay for comparing phosphorus availability in soils. *J. appl. Ecol.,* **16,** 497-505.

Helliwell, D.R. 1973. The growth of sycamore (*Acer pseudoplatanus* L.) seedlings in different woodland soils. *Merlewood Res. Dev. Pap.* no. 48.

Helliwell, D.R. & Harrison, A.F. 1978. Variation in the growth of different seed-lots of *Acer pseudoplatanus* and *Betula verrucosa* grown on different soils. *Forestry,* **51,** 37-46.

Jeffers, J.N.R. 1977. Lake District soils: a case study in cluster analysis. *Bull. appl. Statist.,* **4,** 40-52.

Klotzli, F. 1970. Oak, high quality broad-leaved and swamp woods in the British Isles. *Schweiz. Z. Forstwes.,* **121,** 329-366.

Zehetmayr, J.W.L. 1960. Afforestation of upland heaths. *Bull. For. Commn Lond.,* no. 32.