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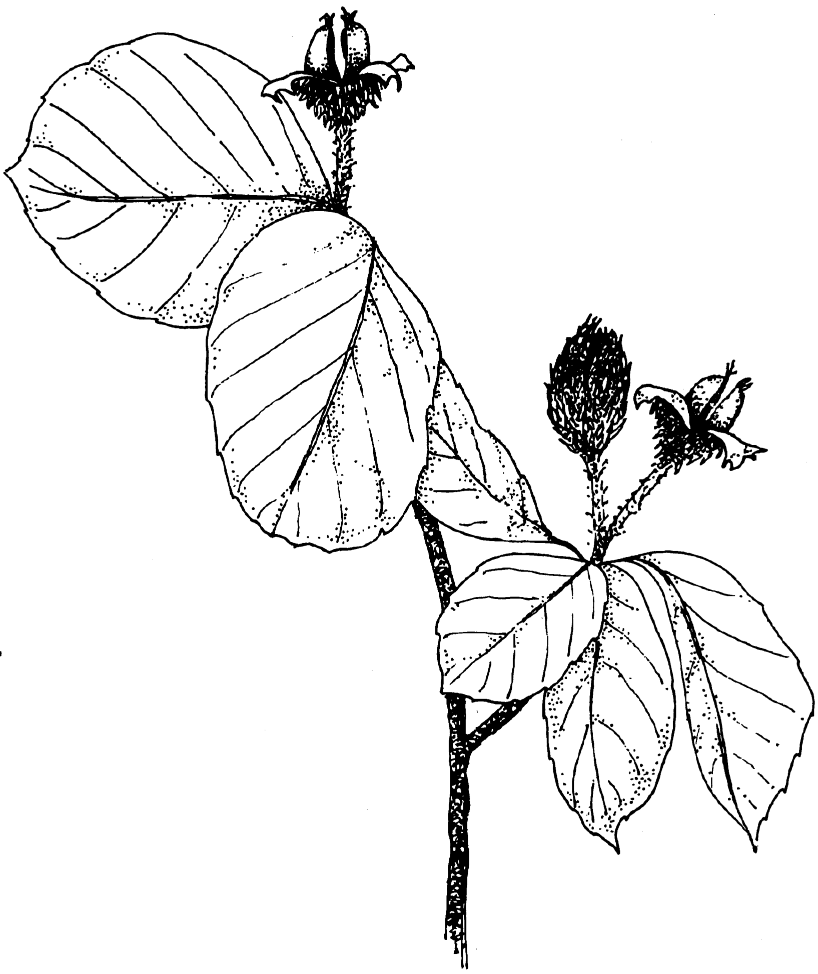

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Preface

English Nature is grateful to the author for the opportunity to include this report in its Research Report series. By doing so we hope that there is more chance that the records and knowledge of them will be maintained. The work was however done independently and any views expressed are not necessarily those of English Nature and its staff.

Acknowledgements

Thanks are due to Ed Mountford, Phil Page and Eirene Williams for their advice and assistance during this project.

Summary

This report is part of a long term monitoring project undertaken by English Nature at Dendles Wood National Nature Reserve. The reserve is a mixed broadleaved wood, the main canopy species being beech (*Fagus sylvatica*) and oak (*Quercus* spp.). The project was initiated in 1988 when a single belt transect (20 x 330m) survey was initiated to monitor the development of the wood. English Nature is interested in the interaction of oak and beech on unmanaged sites and the study of the dynamics of this relationship is the main aim of the project.

The species composition of the study area has remained stable in the ten year period since the original survey. Overall, size class distribution has not changed greatly, with the exception of the smallest category (<5cm girth at breast height) which has shown a marked increase.

The study found that beech are growing more rapidly than oak. There was a significant amount of regeneration beneath canopy gaps, mostly of beech, but this regeneration was being severely, possibly fatally, damaged by squirrels. Canopy gaps were surveyed and found to be a comparatively large proportion of cover. Grazing was found to be an important factor in the wood, hampering regeneration and contributing to an open structure. The deadwood resource was quantified and is relatively high in comparison with other published figures. The action of squirrels in damaging mature crown limbs may contribute to the continued presence of a significant amount of dead wood.

Management of the wood consists of a minimum of intervention. The consequences of this policy are that regeneration, particularly of beech will be hampered, this may lead, in time, to an increase in the proportion of gaps in the canopy and the consequent creation of glades. Since many of the species considered to contribute to the interest of the woodland prefer an open structure, a supply of dead wood or glade edge conditions, the current management policy should ensure the continued nature conservation interest of the wood.

Contents

Introduction

General Introduction

The importance of conserving natural woodland has been widely discussed (Peterken 1993; Rackham 1980; Saunders 1993). The position of ancient semi-natural woodland in the British flora is one of great importance (Peterken 1996). Ancient semi-natural woodland accounts for only 21% of the British forest reserve or 1.5% of the land area. Only 21% of this area is subject to SSSI or nature reserve designation (Kirby *et al*1998).

Peterken (1987) has identified Dendles Wood (Appendix 1) as being of interest due to the presence of the mixture of beech *Fagus sylvatica* and oak *Quercus* spp. making this an ideal site for the study of the interaction of the two species. The presence of beech of such age [>300 years (Page 1997)] is also an interesting feature since this predates the widespread planting of beech which took place in Devon in the late 19th century.

Long term monitoring of the oak/beech species interaction is part of the English Nature management prescription for the site (Page 1997). The monitoring programme is intended to provide information useful to site managers in making decisions over policy. Detailed information is crucial to the effective conservation of habitats and species. Cycles of change in woodland ecosystems are long-term and any successful monitoring programme must, therefore also be long-term. The site has been designated a research natural area to be managed by minimum intervention (Page 1997).

Forestry Commission guidance on monitoring forest vegetation change recommends a strategy of surveillance monitoring for high value sites such as nature reserves (Ferris-Kaan & Patterson 1992). Surveillance monitoring has been defined by Goldsmith (1991) as "an extended programme of surveys undertaken in order to provide a time series to ascertain the variability and/or range of states or values which might be encountered over time". Such a strategy will provide information on process and change over the long term and, information thus gathered will feed back into the decision making process enabling the value of the site to be maintained.

The monitoring project at Dendles Wood has been conceived to fulfil these objectives and provide information on the development of semi-natural ancient woodland.

Study Site

Dendles Wood National Nature Reserve is situated on the southern edge of the Dartmoor National Park (National Grid Reference SX 615 620) South Devon, England (Appendix 1). It lies 2.5 kilometres north of the village of Cornwood in the valley of the river Yealm. The reserve covers an area of 28.56ha and was purchased by the predecessors of English Nature, who now manage the site, in 1965.

The original reason for the acquisition was to protect the wood against the threat of conversion to conifers by commercial forestry interests. The ecological and scientific value of the site for research has since been recognised. The wood forms part of a larger SSSI (re-notified in 1981) which is also called Dendles Wood. Most of the reserve is steeply sloping but there are level areas at the north-eastern and south-western ends of the site.

The altitude ranges from 160-280m above datum and rainfall is high at 1900mm per annum. The substrate comprises Dartmoor granite to the north and Upper Devonian metamorphic rocks, mainly hornfels and slates, elsewhere. The soils are well-drained loams and silts (Page 1997).

The main canopy tree species are beech (*Fagus sylvatica*) and pedunculate oak (*Quercus robur*) with some sweet chestnut (*Castanea sativa*), silver fir (*Abies alba*) and European larch (*Larix europea*). The understorey consists mainly of holly (*Ilex aquifolium*).

The ground flora has been affected by the continued presence of grazing animals, both sheep and wild deer, and the deep shade characteristic of beech woodland (Rodwell 1991), and as a consequence is impoverished. The main ground flora species are mosses: *Polytrichum commune*; *Polytrichum formosum*; *Thuidium tamarascinum*; *Hypnum cuppressiforme* (on rocks and tree trunks) *Leucobryum glaucum*; *Hypnum filiforme*; *Dicranum scoparium*; *Rhytidiadelphus squarrosus*; *Dicranella heteromalla*; *Mnium hornum*; *Plagiothecium undulatum*. The moss *Fissidens polyphyllus* is of national interest (Page 1997). There are also patches of bracken (*Pteridium aquilinum*), great wood rush *(Luzula sylvatica)*, wood sorrel *(Oxalis acetosella)* and tufted hair grass *(Deschampsia cespitosa)*.

Some 150 lichen species are present, most of which are corticolous and depend on the presence of oak of some antiquity (O'Dare & Coppins 1991). *Arthonia leucopellaea*, *Calicium lenticulare* and *Pheaographis inusata* are of national importance (Page 1997).

The avifauna of the woodland is typical of upland woods of western Britain (Fuller 1982); notable species being pied flycatcher *(Ficedula hypoleuca)*, redstart *(Pheonicurus pheonicurus)*, wood warbler *(Phylloscopus sibilatrix)* and grey wagtail *(Motacilla cinerea)*.

The main invertebrate interest is the blue ground beetle *(Carabus intricatus)* which is a red data book species (Shirt 1987). Also present is the nationally important ground beetle *Calosoma inquisitor* (Page 1997).

Heath and Oakes (1990) have classified the woodland as comprising NVC classifications W10a, W15b, W15c, W10e, W4a, and W7b. The study area is W15 (*Fagus sylvatica - Deschampsia flexuosa*) (Appendix 14) with a change towards W10e (*Quercus robur – Acer pseudoplatanus – Oxalis acetosella* sub community) at the northern end of the transect. Canopy height was measured using a hypsometer as part of this survey and found to be 24m.

Dendles Wood was recorded as pasture on the 1840 tithe map (Page 1997). This indicates that the wood was probably wood-pasture at that time since many of the trees predate this map. There are several trees that appear to be old pollards (Appendix 7: section 1 no.18; section 2 no.38; section 3 no. 42, section 6 nos.156 & 161, section 9 no.243). This is consistent with a history of wood pasture management (Kirby *et al* 1995). Peterken (1987) has stated that Dendles Wood is "an example of beech oak wood pasture, in which the beech may well be native on the edge of its European range".

Observations of the present woodland structure suggest that the 'A' generation trees, i.e. the oldest generation, may have been planted, probably to provide a source of fuel wood and possibly forage. The exclusion of stock or the reduction in stocking density seems to have resulted in 2 or 3 waves of regeneration at some time in the past (Peterken & Tubbs 1965).

The wood contains many standing and fallen dead trees (snags) both of beech and oak.

The current management plan (Page 1997) states that a minimum of intervention will take place; removal of invasive species such as sycamore (*Acer psuedoplatanus*) and rhododendron (*Rhododendron ponticum*), and maintenance of boundary fencing being the major undertakings.

Aims and Objectives

The aims of this project were to re-survey the permanent belt transect in the wood and analyse changes that have occurred since the last full survey in 1988. The data were examined with a view to determining the dynamics of the wood and specifically the interaction between beech and oak. The nature and quantity of the dead wood resource was ascertained and compared with those published for other woodlands in the UK. The extent and type of damage caused by bark stripping behaviour of grey squirrels (*Sciurus carolinensis*) was assessed. The implications of the various site and management factors as evidenced by the findings of the survey are discussed, and also the ways in which these factors may influence the future development of the stand.

Appendix 3 shows a diagrammatic section of the transect and the accompanying text describes features and soil types. Appendix 2 shows the position of the transect, grazing exclusion plots and Appendix 4 shows the woodland compartments.

Literature Survey

Several similar long term monitoring projects are being undertaken in the UK, some have been in progress for several decades whilst others, such as this survey, are relatively recent. The following are the longer established projects:

- Lady Park Wood, Gwent and Gloucestershire (Peterken & Jones 1987).
- Wistmans Wood, Devon (Proctor *et al* 1980).
- Black Wood of Rannoch, Perth (Peterken & Stace 1987).
- Denny Wood, Hampshire (Manners & Edwards 1986).
- Clairinsh, Strathclyde (Backmeroff & Peterken 1989).

The methodology varies slightly between studies, some using circular plots (Yarner Wood (Korte 1994)) others permanent square quadrats (Wytham Wood (Horsfall and Kirby 1985)) and others again using permanent transects such as that used in this survey (Lady Park Wood (Peterken and Jones 1987 & 1989)). Peterken and Backmeroff (1988), Hall *et al.* (1999) and Kirby and Morecroft (2000) summarise the experience gained and problems encountered during long term monitoring.

Methodology

Fieldwork

A permanent belt transect was established in 1988 (Appendix 2). The transect is identified by iron markers driven into the ground along the centre line with two markers for the corners at each end of the transect. The transect is divided into eleven 30m sections and is 20m wide, the beginning and end of each section is marked by an iron stake positioned on the centre line. Photographs were taken along the centre line of the transect, one photograph being taken at the start of each new section as marked by the iron stake. It is intended that these photographs be repeated at each re-survey to provide a visual record of vegetation change over time.

The original 1988 survey recorded species, position and girth at breast height (GBH) of all trees reaching 1.3m height. The 1998 re-survey re-recorded all these data and in addition recorded species and position of all seedlings reaching 20cm in height and all saplings having reached 1m. Where errors were apparent in the 1988 survey note was taken so that these data could be adjusted for in the analysis.

Trees were assessed for crown condition, i.e. the extent of dieback, if any, in the crown; size of crown and storey; extent of squirrel damage using the classification system developed by Mountford (1997) based on the amount of bark removed as a percentage of the circumference of the damaged limb, or trunk, from the tree above and below 2m. Crown condition and crown squirrel damage assessments were performed with binoculars.

Girth was measured using a girthing tape. Hamilton (1975) has stated the correct procedure (Appendix 9) and this was the method used here. Where trees were covered in ivy at girthing height this was lifted away from the trunk, if possible, and the tape was passed underneath. If it was not possible to lift the ivy away from the trunk this was noted and the stem was excluded from the analysis. The girth of all stems branching from the main trunk below 1.3m was recorded in 1998, although this data was not available for the previous work.

Fallen dead wood was estimated using the line transect method described by Kirby *et al* (1998). The procedure is described in Appendix 8. The use of this method allows the results to be compared with those obtained by Kirby *et al* (1998). Standing deadwood was calculated from GBH measurements and estimates of snag height obtained by using a ranging rod as a guide.

Vertical projection of canopy gaps was recorded by observing the edge of a gap (i.e. where no canopy cover exists) and ascertaining its location by measuring from known positions. Several positional measurements were taken allowing the outline of the canopy gap to be drawn onto the recording charts.

The grazing plots (Appendix 2) were established in 1976 to attempt to ascertain the impact of grazing animals on the woodland flora. Eight pairs of 10m x 10m plots were established throughout the wood, one of each pair being surrounded by a stockproof fence the other being unfenced and open to grazing animals.

The data presented were collected by EN staff and are included to help with determining the extent of grazing impact on the study site. Only the data for plot pairs A and D are presented since these are most relevant to the transect being representative of the transect vegetation cover. Plot A1 and plot D1 are fenced (ungrazed) plot A2 and plot D2 are unfenced (open to grazing). The data for 1976, 1982 and 1988 represent a total count of seedlings present. Those for 1995 were collected by the use of sampling. Each plot was divided into 25 2m x 2m squares, a $0.25m^2$ sample was then taken in the same area of each square. The sample number was then averaged and multiplied by 16 (the sampled area being 1/16th of the total area).

The 1995 data are presented as recorded by English Nature staff. It is not intended to be an exact record of seedling numbers, only an estimate with qualification.

The field work, apart from the grazing plot survey, was conducted by Andrew Guy and Ed Mountford between the 29th September and the 5th October 1998, a period of 6 days, and therefore represents 12 man days of labour.

Data Analysis

The data thus gathered was recorded onto the original Figures and, for the tree descriptions, tabulated. The data was then put into a spreadsheet (Microsoft Excel 97) for ease of analysis. A simple method of producing a 2 dimensional representation of the tree distribution directly from the spreadsheet was devised by Andrew Guy (Appendix 5).

The data were grouped to obtain changes in girth at breast height (GBH) over the 10 year survey period for oak and beech. The data was then sorted to remove obviously erroneous values such as negative growth rates, trees which had died, or where the species had been wrongly recorded in the original survey. The resulting data sets were then subjected to a one-sided t-test (Table 1) to determine if beech was growing at a significantly greater rate than oak.

Data was sorted to provide figures on the size class distribution of tree stems in the two survey years for comparison (Figure 2).

A figure of species composition by stem number was also prepared from data to illustrate change in species composition over time (Figure 1).

The canopy gaps were quantified by counting the area within the gaps using the squares on the original charts, this allowed the proportion of gap in the canopy to be estimated. Appendix 7 shows a graphical representation of the hand drawn charts with canopy gaps overlaid.

Data collected on squirrel damage to stems is presented to illustrate the extent of debarking by size class (Figures 3 and 4). It is hoped that the data presented will provide a base line for future work on the impact of grey squirrel bark stripping.

Results

Growth Rates

Growth rate of girth at breast height for oak and beech in the sampled area between 1988 and 1998 were subjected to a one sided t test to determine whether beech was growing more rapidly than oak in the sampled area.

Table 1 Results of One Sided t test on the Growth Rates of Oak and Beech

	N	*Mean*	*St Dev*	*SE Mean*	*D.F*	*T*	*p*
Beech	91	6.85	4.61	0.48	48	3.01	.0021
Oak	22	2.98	2.98	0.63			

The girth at breast height of beech is growing at a significantly ($p<0.01$) greater rate than that for oak.

Species Composition

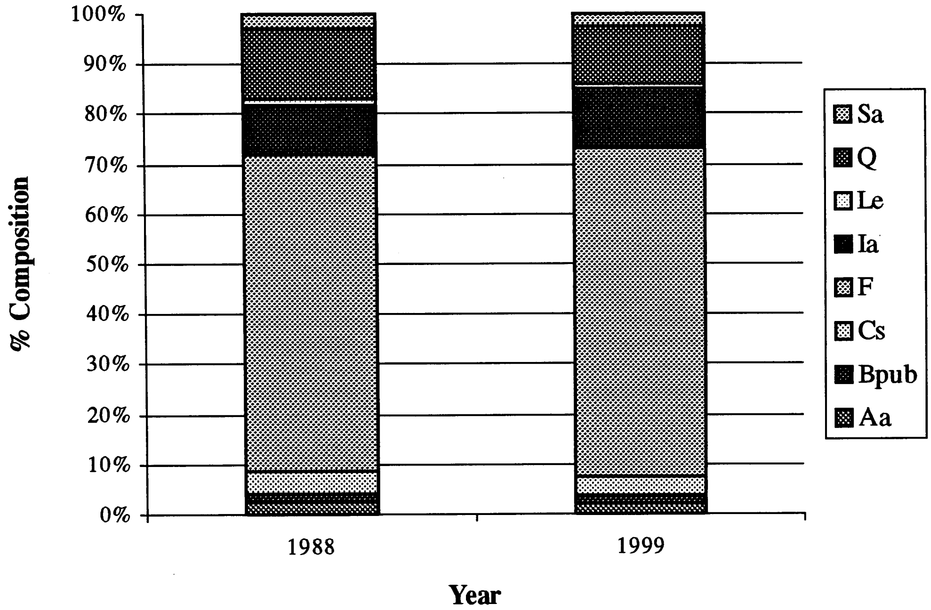


Figure 1 Species Composition 1988 and 1998

Figure 1 shows a graphical representation of change in species composition from 1988 to 1998. Raw data on species composition are summarised in Appendix 11.

Size Class Distribution

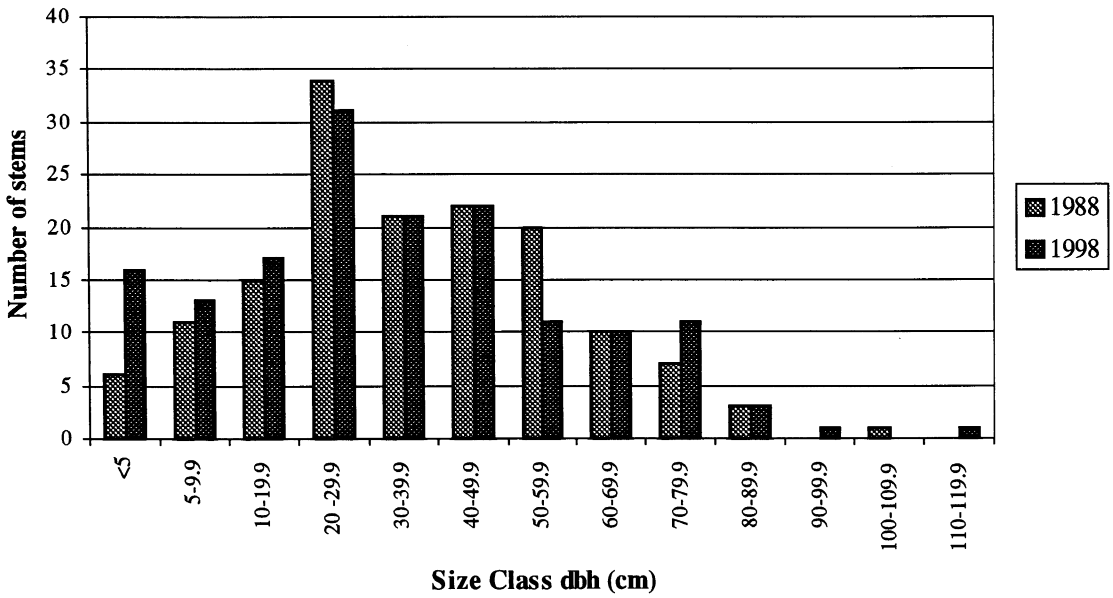


Figure 2 Size Class Distribution 1988 and 1998

Figure 2 shows change in size class distribution between 1988 and 1998. Raw data on size class distribution is summarised in Appendix 12.

Squirrel Damage

Squirrel Damage Below 2m

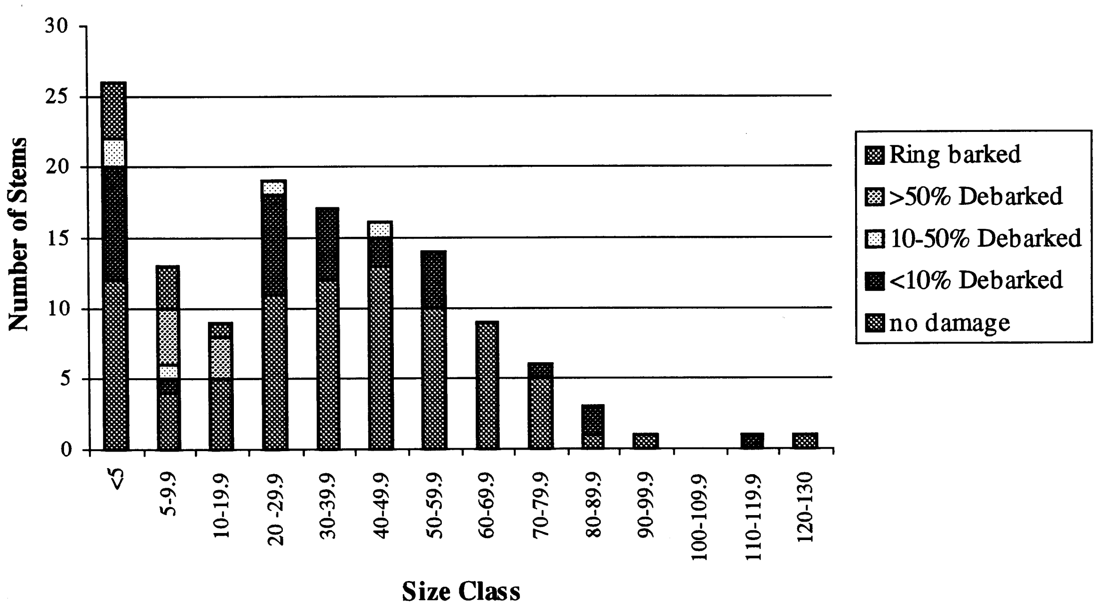


Figure 3 Squirrel Damage Below 2m by Damage Category and Size Class

Figure 3 shows the extent of squirrel damage below 2m in each size class. Raw data for all squirrel damage is summarised in Appendix 10.

Squirrel Damage Above 2m

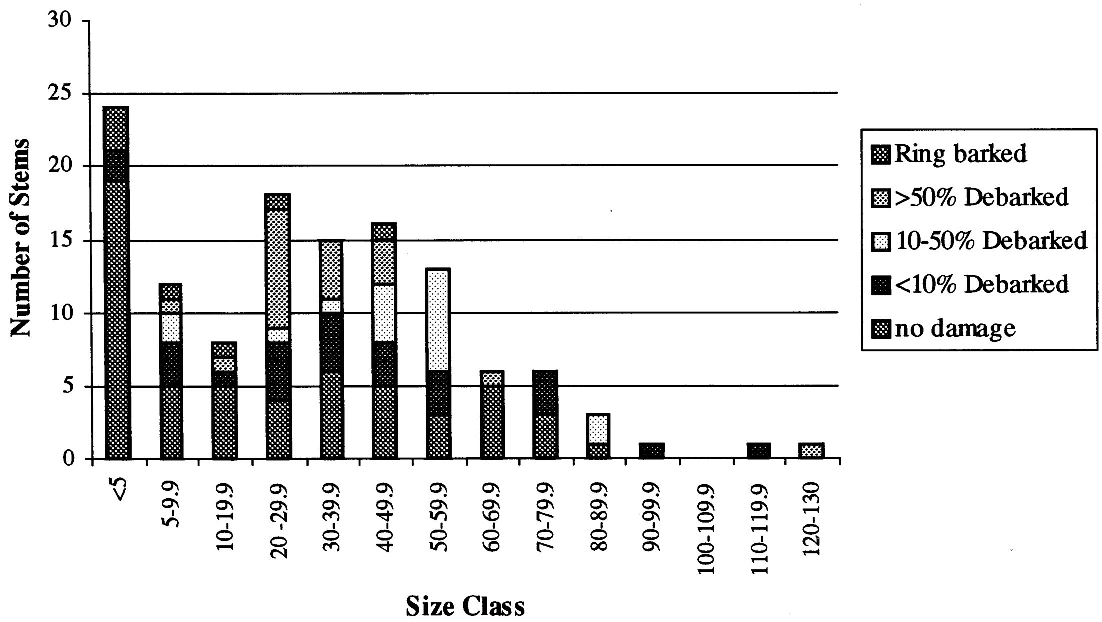


Figure 4 Squirrel Damage Above 2m by Damage Category and Size Class

Figure 4 shows the extent of squirrel damage in each size class above 2m. Raw data for all squirrel damage is summarised in Appendix 10.

Impact of Grazing Animals

The data for plots A1, A2, D1 and D2 are presented below to illustrate grazing impacts. Appendix 2 shows the location of the plots.

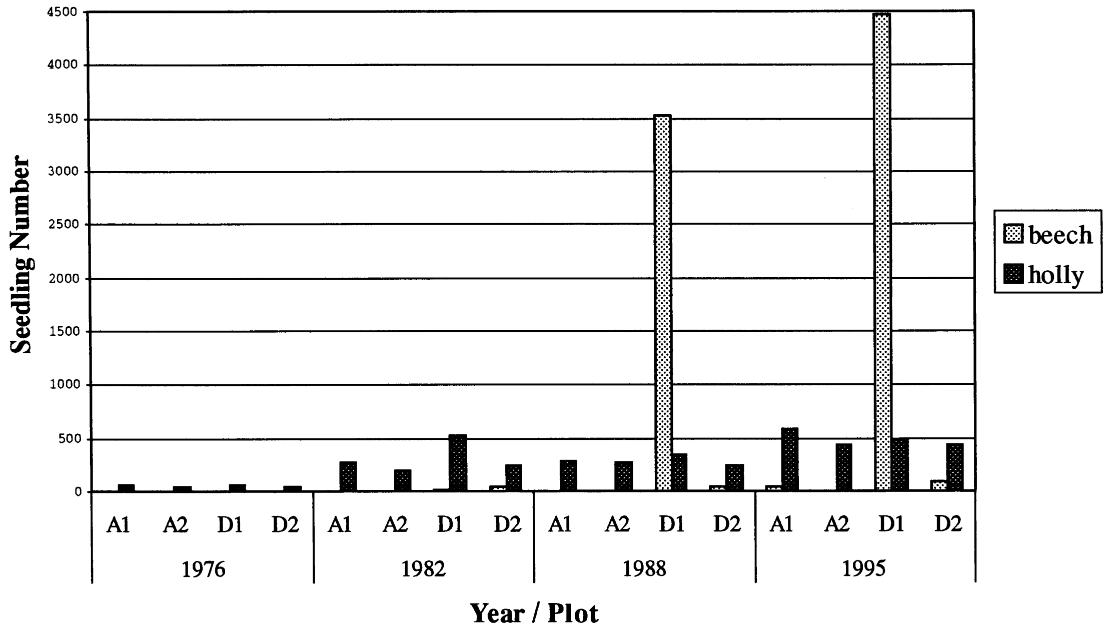


Figure 5 Seedling Numbers in Grazing Plots A1, A2, D1 and D2

Figure 5 shows the change in numbers of seedlings in plots A1, A2, D1 and D2 over the period 1976 – 1995. The only species shown on the chart are holly and beech since other species were present in insignificant numbers by comparison with those shown. Raw data from the surveys are shown in appendix 13. A brief description of the plots is given below:

- Plot A1 - fenced with stockproof fence, below dense beech canopy.
- Plot A2 – unfenced below dense beech canopy.
- Plot D1 - fenced with stockproof fence, below dense beech canopy.
- Plot D2 – unfenced below broken beech/sweet chestnut canopy.

Deadwood

Fallen Deadwood

Data gathered on the quantity and origin of fallen dead wood is presented below (Figure 6). The compartments refer to the English Nature compartments (Appendix 4). The fallen deadwood results are broken down into species to illustrate the relative contributions made to the total. Raw data from the fallen deadwood survey is shown in Appendix 8.

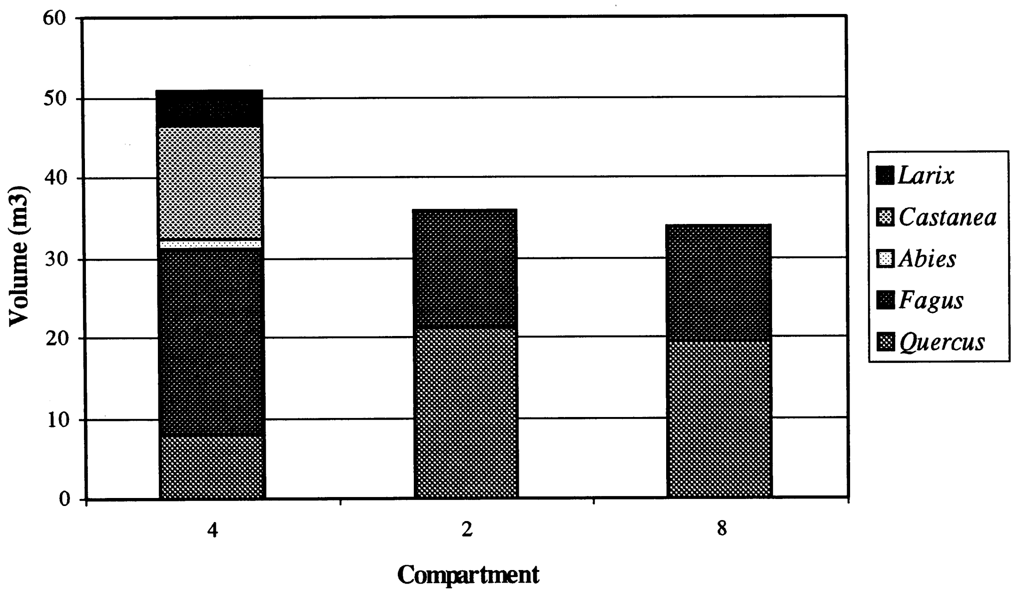


Figure 6 Fallen Deadwood Species/Compartment Breakdown

Standing Deadwood

Data gathered on the quantity of standing deadwood is presented in Appendix 7. The volume of standing deadwood in the transect was estimated at 41.73m^3. By multiplication this gives an estimate of the volume of standing deadwood in the wood of 63.23m^3 ha^{-1}. The survey recorded 46 snags in the transect and this gives an estimate of 69.7 snags ha^{-1} for the wood.

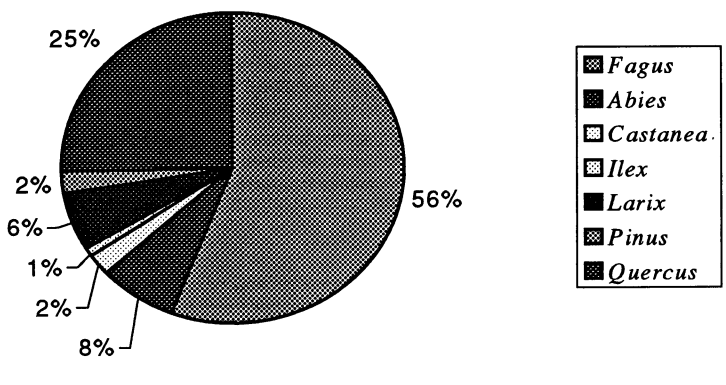


Figure 7 Standing Deadwood Species Breakdown by Volume

Canopy Gaps

Canopy gaps were estimated to account for 20% of cover within the transect. See Appendix 7 for location and extent of gaps.

Discussion

Features of Interest

The open structure of the wood, i.e. the lack of a significant understorey and little in the way of ground cover, can be attributed to a combination of the heavy shade characteristic of beech woodland (Rodwell 1991) and the impact of herbivores (Peterken 1993; Mitchell & Kirby 1990).

The open structure of the wood and the presence of relatively large amounts of deadwood give rise to the wood's distinctive features i.e. corticolous lichen communities, dead wood invertebrates and avifauna (Saunders 1993; Fuller 1982; Collins & Thomas 1991). Maintenance of the current structure and dead wood element is therefore to be seen as an important consideration in future management decisions. Against this must be set the requirement for at least some regeneration long term if tree cover is to be maintained (Kirby et al 1995; Shaw 1974; Peterken 1996).

Grazing

The maintenance of the present structure and interest of the wood depends on light grazing pressure (Mitchell & Kirby 1990). As Mitchell and Kirby (1990) have noted, the presence of low level grazing can create a high diversity of plants and animals. Complete cessation of grazing would be detrimental to the valuable species of the site by allowing the growth of a dense understorey, while overgrazing will hamper regeneration (Gill 1992) tending, *in extremis,* to loss of woodland cover. A balance therefore needs to be struck between these two extremes. This is problematic due to the remote nature of the site making it difficult to monitor and control grazing pressure and maintain effective stock fencing (Page pers. comm.). Fencing is clearly less than fully effective at present since some stock are gaining access to the woodland.

Currently the level of grazing in the wood can be described as high (Mitchell & Kirby 1990) by the presence of a strong browse line and little in the way of ground cover. The impact of deer and sheep is also indicated by the damage to holly stems caused either by fraying by deer antlers or gnawing by sheep.

The data for the grazing plots show the effect of the grazing regime on the wood (Figure 5 and Appendix 13). Holly appears to be able to regenerate in the presence of grazing although observation of holly seedlings in the transect shows that they rarely attain any size remaining suppressed and eventually succumbing to repeated browsing. Further evidence of this can be seen in the disappearance of the holly seedlings noted in 1988 by the 1998 re-survey. Plot D1 contains a large number of beech seedlings (Figure 5). Although this plot is not strictly comparable with D2 since the canopy is sparser in plot D1, the data does illustrate that a mast year occurred between 1982 and 1988. This regeneration has been suppressed by grazing as shown by the difference between plots D1 and D2 and by the absence of beech regeneration immediately outside the fenced area of D1.

Damage by Squirrels

Figures 3 and 4 show the distribution of the type of squirrel damage by size class. Squirrels have been said to favour beech (Rowe & Gill 1985), and no other species was attacked within the transect. Damage appears to be initiated when stems attain a girth of 11cm. This finding agrees with those reported elsewhere (Mountford 1997). It has been suggested that there is tendency for medium sized stems to be attacked (Mountford 1998, pers comm).

The squirrel damage above 2m (Figure 4) shows that the most heavy damage categories (10-50% and greater) occur more often in the smaller size classes (below 60cm diameter at breast height). This may be the result of a preference for faster growing stems and is reflected in the results for damage below 2m (Figure 3). Reasons for this preference are not known. Although it has been suggested that faster growing stems are more nutritionally valuable this may not be a full explanation of debarking behaviour (Kenward 1982).

The data show that 90% of beech recruits within the transect had been ring barked, the remainder having sustained severe, probably fatal damage. It is not known when squirrels began damaging stems in the wood, however, it has been reported to be a recent phenomenon elsewhere (Mountford 1997) with profound implications for the future.

The damage caused by squirrels may be beneficial to valuable species by allowing increased light levels, for instance lichens are more numerous at the edges of glades on well lit trees (Rose 1992). Squirrels preferentially attack beech and sycamore (Rowe & Gill 1985) thus influencing species composition (Gill 1992). Hampering the regeneration of beech may lead to a larger number of glades in the wood, and there may be some changes in the composition of the wood. Over the very long term there remains the question of maintaining tree cover, the combination of grazing pressure and squirrel damage may severely hamper future regeneration.

Regeneration

Previous regeneration appears to have favoured beech rather than oak, shown by the small number of oak and the number of excluded oak stems.

It appears from the survey that beech and holly are capable of regeneration within the wood [beech in canopy gaps (Appendix 7, section 4), holly as an understorey] but are being suppressed by the action of squirrels, in the case of beech, and grazers in the case of both holly and beech. The combined impact of these two factors, and the shading out of oak by beech, has been to produce an open structure favourable to many of the species of interest.

The data show that a mast year occurred between 1982 and 1988 (Figure 5). This seedling pulse has been suppressed almost entirely by the action of grazing animals as shown by the far larger number of beech seedlings in the ungrazed plot D1 (Figure 5).

Long term continuation of the past trend of regeneration waves every 100 years or so, presumably coinciding with a decrease in grazing pressure, may be sufficient to ensure maintenance of current tree cover. Some management may however be required to achieve this since it would be preferable to have small regeneration coups. If the whole wood regenerated at once it could have a negative effect on the flora and fauna by resulting in a too dense understorey.

Many of the lichen species that contribute to the ecological value of the unit favour an oak substrate (O'Dare and Coppins 1991) and may suffer a decline if beech entirely dominated the wood. The current lack of oak regeneration may not be a problem due to the long life the species. However the long term presence of oak of some antiquity is an important consideration for the maintenance of the lichen interest.

It is to be hoped that future surveys will shed more light on the development of the wood under the current management regime.

Species Composition

Species composition has changed little in the study period (Figure 1). Ecological processes in mature woodland tend to be slow in the absence of catastrophic disturbance. There have been no such catastrophic disturbances since the last study. Some beech regeneration has occurred beneath a canopy gap (Appendix 7 section 4) but has effectively been killed off by squirrel debarking. The surviving regeneration, although probably fatally damaged by squirrels, accounts for the slight increase in proportion of beech stems. Beech remains the dominant species in the present survey. Gap formation in the future will provide regeneration sites. If gaps are large enough and squirrels continue to damage young beech, it is possible that other species e.g. birch and oak may invade (Rodwell 1991).

An alternation between oak and beech has been postulated (Peterken 1996; Rodwell 1991) based on the suppression of oak beneath its own canopy and oak's need for light to establish (Peterken 1993). It may be that oak will establish in canopy gaps should they become large enough. Whether this will transpire remains to be seen; the time scale will undoubtedly be long.

Size Class Distribution

Size class distribution is similar in the two survey years. The largest single class of stems falling within the 20-30 cm range. The significant increase in numbers of stems in the < 5cm size class represents a regeneration group of beech found in section 4 (Appendix 7) beneath a gap on the north eastern side of the river Yealm. Changes in size class distribution in the absence of major disturbance are likely to be slow. It is possible that the low number of smaller size stems is caused by the intense shade cast by the beech canopy, but Rodwell (1991) reports that beech seedlings can survive in heavy shade. It is more likely therefore that this distribution is the result of a combination of squirrel damage, grazing and shade.

Deadwood

Dead wood forms an important element of the forest ecosystem, recycling nutrients and providing habitat for invertebrates (Kirby & Drake 1993).

Quantities of fallen deadwood were found to be moderate to high (Kirby *et al* 1998) at a mean between compartments of $40.18m^3\ ha^{-1}$. There was some variation between the compartments as shown in Figure 6. Compartment 4 contained the highest volume at $50.8m^3\ ha^{-1}$, compartment 2 a volume of $35.9m^3\ ha^{-1}$, compartment 8 $33.9m^3\ ha^{-1}$.

Oak and beech were the major contributors (40 and 43% respectively). The quantity of beech is unsurprising since it forms the largest part of the canopy, oak is more prevalent than its cover would suggest. This is due to the loss of oak trees through exclusion in the past and the slow decay of oak timber.

The wood contains a high volume of standing dead wood, estimated at $63.23m^3\ ha^{-1}$ and a large number of snags, estimated at 69.7 ha^{-1} (Kirby *et al* 1998). The high volume could be accounted for by the presence of large beech snags (e.g. Appendix 7, section 4 nos. 109 & 110). These trees were recorded as dead in the 1988 survey. The trunks have been wind snapped, the condition of the crown at the time of breakage is not known. Mortality of large beech could be the result of stress initiated by the drought of 1976 (Peterken & Mountford 1996; Manners & Edwards 1986), but the severe storms between 1987 and 1990 are the most likely cause.

The species of the standing dead wood was recorded during the survey allowing a break down of the contribution made by each species to be presented (Figure 6). Beech makes up the largest component of the dead wood (56%) with oak only other major contributor (25%).

Carabus intricatus appears to be able to breed successfully in the wood and has been stated to require beech or oak dead wood (HMSO 1995); *Calosoma inquisitor* has been said to require dead oak (Lindroth 1974). Both these dead wood types are in good supply in the wood at present. The current management should continue to provide an adequate supply of beech deadwood since squirrels are producing deadwood by damaging crown limbs.

The fallen oak snags are largely found to be without earth mounds around the root plate. This suggests that the trees were dead for some time prior to falling allowing the roots to die and rot. The size and shape of the remaining standing oak snags suggests that the cause of death was exclusion.

Canopy Gaps

The proportion of gaps in the canopy was estimated as being 20% of total transect cover (see Appendix 7 for distribution and extent of gaps). This is a high proportion when compared with the range of 3-24% stated by Peterken (1996) for unmanaged stands in North America.

The high proportion of gaps in the canopy (20%) is a favourable condition for many lichens (Rose 1992). Current management will favour the continued presence of gaps by suppressing regeneration possibly leading to the formation of grass glades within the wood. As further gaps are formed by the death of mature canopy trees more glades may form. As more glades are formed the area of grass will increase, an equilibrium may be reached at some time in the future between the extent of glades and the numbers of grazing animals where the grazing pressure is just sufficient to keep existing glades open. Any increase in canopy gaps above this point may allow some regeneration to occur if the numbers of grazers remains constant.

Management Implications

Table 2 presents a summary of the habitat / species interactions and the implications of current management for species and habitat.

Feature of Interest	Habitat (from Heath and Oakes (1990))				
	W10 e	W11 a	W15b	W15 c	Does current management regime favour ?
Mosses	no	no	yes	no	no
Lichens	yes	yes	no	no	yes
Ferns	no	no	yes	no	no
Birds	yes	yes	yes	no	yes
Invertebrates	yes	yes	?	?	dead wood - yes structure - yes
Does current management regime favour ?	no	yes	yes	no	

Table 2 Correlation of Habitat with Features of Interest and Implications of Management Regime (Heath and Oakes 1990)

Not all habitats benefit from the current management regime. This is not necessarily an immediate problem since some features of interest may benefit from a more open structure or even be characteristic of a transition to wood pasture (Mitchell & Kirby 1990). The action of grazing animals and squirrels may contribute to the formation of glades following the death of canopy trees rather than patches of regeneration. If the glades thus created attained sufficient size it is possible that more light demanding species less susceptible to squirrel and grazing damage (e.g. oak or birch) may colonise. Similarly, a larger proportion of gaps may increase the number of saplings sufficiently for successful recruitment to occur.

Figure 8 presents the possible future implications of management practice for the long term future of the wood. Management decisions examined are as follows:

- No action, continue with the current policy of limited intervention, removing only non-native invasive species (sycamore and rhododendron).

- Exclusion of sheep, making the repair of boundary fences a priority.

- Open grazing, removal of the boundary fence allowing sheep free access.

- Reduced squirrels, through increased control.

Some of these options present difficulties, for instance controlling squirrels is time consuming and costly (Morris and Whipp 1998) and therefore unlikely to be feasible. The analysis is intended merely to illustrate possible future outcomes. Management decisions may then be based on a cost-benefit analysis of the options.

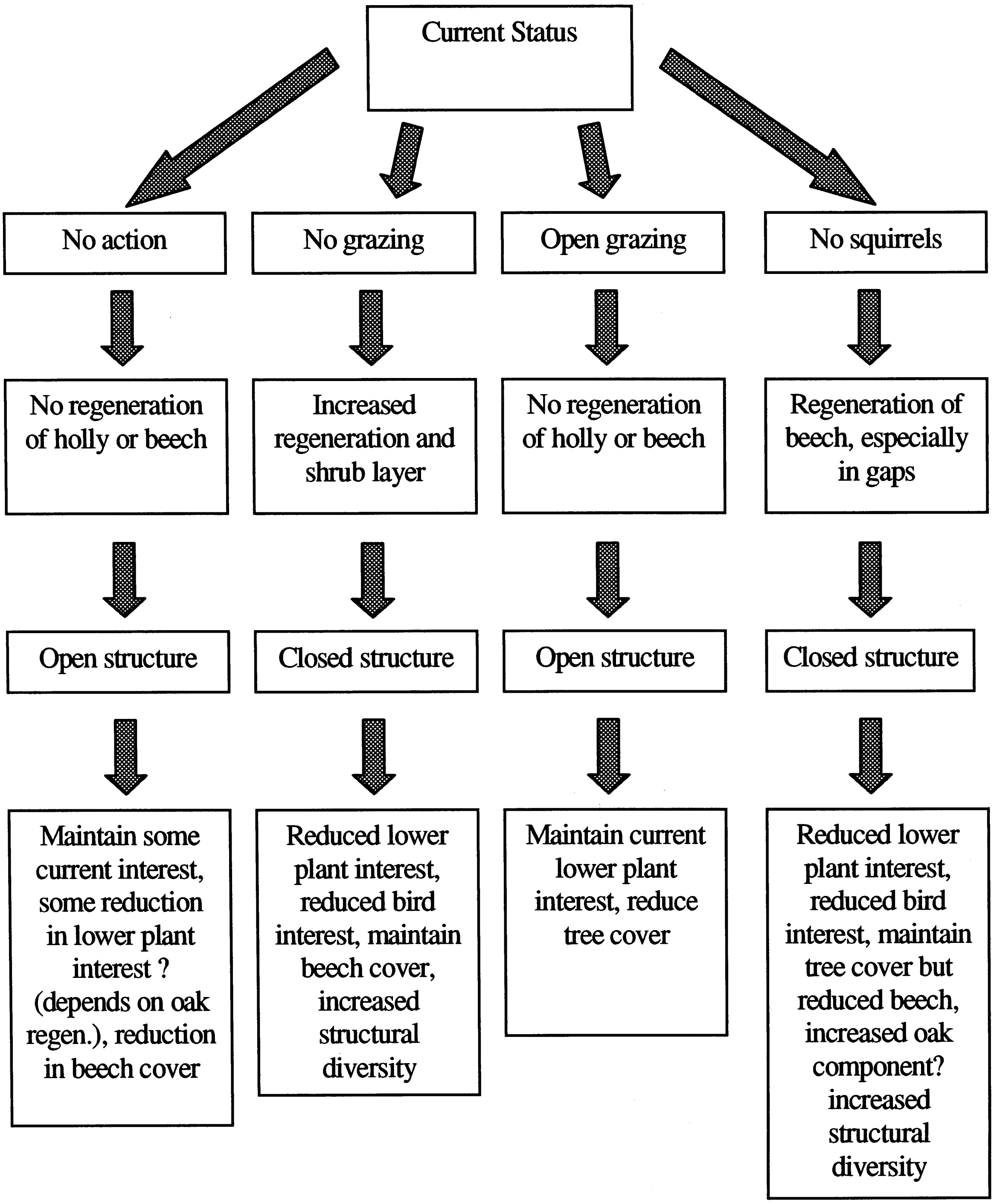


Figure 8 Possible Future Outcomes of Management Decisions

Grazing and squirrel damage may be having a beneficial effect in terms of the features of interest in the woodland. The current management is therefore effective as far as current evidence illustrates. Future monitoring may provide more information on the most appropriate grazing intensity.

Difficulties Encountered During Fieldwork

Some difficulties were encountered during the fieldwork as follows. Little in the way of written material was available from the original survey, only the charts prepared from the fieldwork. These did not include the precise methodology but the survey methods have been well documented by the original surveyor elsewhere (Peterken & Backmeroff 1988).

Some trees had been omitted from the original survey, presumably due to error. Notes written on the figures suggested the presence of large patches of holly regeneration but no attempt had been made to quantify or precisely locate the seedlings precluding any detailed analysis. No trace of this regeneration was found in the re-survey. For the re-survey the location and species of all saplings reaching 1m was recorded, together with the location and species of all seedlings reaching 20cm.

No attempt to quantify the dead wood resource had been made in the original survey although the locations of the larger pieces of dead wood were drawn onto the figures. It was felt that since other researchers had followed a random sampling procedure for recording dead wood and that this was the method recommended by English Nature, this was the most useful course of action. This method also has the advantage of speed. There are several fallen beech of considerable size but the random sampling technique used failed to pick up these specimens. The data (Appendix 8) represents an average for the sampled area and therefore do not reflect its distribution or the nature (size) of the dead wood. The actual volume of deadwood may therefore be greater than this estimate.

The location of the transect was the subject of some concern. The stated intent of the survey has been to study the interaction between beech and oak. The transect was positioned by the reserve manager with a view to ease of use, avoiding the steep slopes of the gorge, ease of relocation, and to incorporate some flat and some sloping ground (Page 1998 pers. comm., 7-1-98). However the transect does not include many oak trees (Table 1). It would improve the quality of data obtained from the survey if the transect included a more oak dominated compartment. Oak is known to suppress regeneration beneath its own canopy (Shaw 1974) but data on beech invasion would be valuable. This could perhaps best be addressed by the instigation of a new transect in a suitably chosen area to be surveyed in parallel with the existing transect.

The nature of the field work required that two operatives be involved as the both speed and accuracy of girth measurements was increased by the presence of an assistant. Data recording was also found to be more efficient with two people.

Conclusions

The data presented show that the trees in the transect were showing steady growth. Beech was found to be growing faster than oak in the study area.

Beech is capable of regenerating in canopy gaps produced by the mortality of mature trees but the debarking behaviour of grey squirrels is killing saplings upon reaching ~ 11cm gbh. Mature trees are also suffering damage to crown limbs by squirrels.

Holly would form an understorey beneath the beech canopy but is being suppressed by the presence of grazing animals. Grazing may also be suppressing beech regeneration especially under canopy cover where some regeneration could be expected.

Oak does not appear to be regenerating in the transect; no oak seedlings were found. The current lack of oak regeneration may not be a problem due to the long life the species. However the long term presence of oak of some antiquity is an important consideration for the maintenance of the lichen interest.

The transect is currently of limited value for the study of the interaction between oak and beech being dominated by beech. At least one further transect is required to improve the value of the monitoring project.

The transect was found to contain a moderate to high amount of fallen dead wood and a high quantity of standing dead wood compared to other quoted figures.

The transect was found to have a high percentage cover of canopy gaps by comparison with other surveyed woodland.

The current management regime appears to be favourable for most species of interest although the high grazing pressure and level of squirrel damage is not beneficial to all the habitats present. The action of grazers and squirrels may have the effect of producing more glades within the wood an outcome that may benefit some of the conservation interest in the wood.

References

BACKMEROFF, C.E. & PETERKEN,G.F., 1989. Long Term Changes in the Woods of Clairinsh. *Transactions of the Botanical Society of Edinburgh,* **45**, pp. 253-297.

COLLINS, N.M. & THOMAS, J.A. eds. 1991. *The Conservation of Insects and their Habitats*. London, Academic Press.

FERRIS-KAAN, R. & PATTERSON, G.S., 1992. *Monitoring Vegetation Changes in Conservation Management of Forests*. Forestry Commission Bulletin No. 108. London, HMSO.

FULLER, R.J., 1982. *Bird Habitats in Britain.* Calton, Poyser.

GILL, R.M.A., 1992. A Review of Damage by Mammals in North Temperate Forests: 3. Impact on Trees and Forests. *Forestry*, **65**, 363-388.

GOLDSMITH, F.B., ed. 1991. *Monitoring for Conservation and Ecology.* London, Chapman and Hall.

HALL, J.E., KIRBY, K.J. & MORECROFT, M., 1999. *Minimum intervention woodlands and their use for ecological research in Great Britain.*

HAMILTON, G.J., 1975. *Forest Mensuration Handbook.* Forestry Commission Booklet **39**. London, HMSO.

HEATH, M.J. & OAKES, H., 1990. *Woodland Surveys in South-west England Using the National Vegetation Classification.* Peterborough, Nature Conservancy Council. CSD Report 1239.

HMSO., 1995. *Biodiversity: The UK Steering Group Report.* London, HMSO.

HORSFALL, A.S. & KIRBY, K.J., 1985. *The Use of Permanent Quadrats to Record Changes in the Structure and Composition of Wytham Woods, Oxfordshire.* (Research and Survey in Nature Conservation No 1.) Peterborough, Nature Conservancy Council.

KENWARD, R.E., 1982. Bark Stripping by Grey Squirrels – Some Recent Research. *Quarterly Journal of Forestry,* **76**, pp. 108-121.

KIRBY, K.J. & DRAKE, M., 1993. *Dead Wood Matters; The Ecology and Conservation of Saproxylic Invertebrates in Britain.* (English Nature Science No.7.) Peterborough, English Nature.

KIRBY, K.J. & MORECROFT, M., 2000. *Long-term Studies in British Woodland* (English Nature Science No. 34). Peterborough, English Nature.

KIRBY, K.J., REID, C.M., ISAAC, D. & THOMAS, R.C., 1998. The Ancient Woodland Inventory in England and its Uses. *In*: KIRBY, K.J. and WATKINS, C. eds. *The Ecological History of European Forests*. Wallingford, Oxon, CAB International, pp

KIRBY, K.J., REID, C.M., THOMAS, R.C., & GOLDSMITH, F.B., 1998. Preliminary Estimates of Fallen Dead Wood and Standing Dead Trees in Managed and Unmanaged Forests in Britain. *Journal of Applied Ecology,* **35**, pp. 148-155.

KIRBY, K.J., THOMAS, R.C., KEY, R.S., MCLEAN, I.F.G., & HODGETTS, N., 1995. Pasture Woodland and its Conservation in Britain. *Biological Journal of the Linnean Society,* **56**, pp. 135-153.

KORTE, S., 1994. *The Development of Ten Woodland Plots in Yarner Wood National Nature Reserve Between 1974 – 1993.* Plymouth, University of Plymouth BSc Hons Project (unpublished).

LINDROTH, C.H., 1974. *Handbook for the Identification of British Insects Vol.4, Pt 2, Coleoptera: Carabidae.* London, Royal Entomological Society.

MANNERS, J.G. & EDWARDS, P.J., 1986. Death of Old Beech Trees in the New Forest. *Proceedings of the Hampshire Field and Archaeology Society,* **42**, pp. 155-156.

MITCHELL, F.J.G. & KIRBY, K.J., 1990. The Impact of Large Herbivores on the Conservation of Semi-Natural Woods in the British Uplands. *Forestry,* **63**, pp. 333-353.

MORRIS, J. & WHIPP, P., 1998. Grey Squirrel Control - Annual Variations in the Uptake of Warfarin Bait from Hoppers in a Small Chiltern Woodland. *Quarterly Journal of Forestry,* **92,** pp. 207-208

MOUNTFORD, E.P., 1997. A Decade of Grey Squirrel Bark Stripping Damage to Beech in Lady Park Wood, UK. *Forestry,* **70,** pp. 17-29.

O'DARE, A.M. & COPPINS, B.J., 1991. *Dendles Wood NNR: Lichen Monitoring.* Peterborough, English Nature (unpublished report).

PAGE, P., 1997. *Dendles Wood National Nature Reserve Brief Management Plan 1997-2002.* Peterborough, English Nature.

PETERKEN, G.F., 1993. *Woodland Conservation and Management 2nd Ed.* London, Chapman and Hall.

PETERKEN, G.F., 1987. *In:* PAGE, P. 1997 *Dendles Wood National Nature Reserve Brief Management Plan 1997-2002.* Peterborough, English Nature

PETERKEN, G.F., 1996. *Natural Woodland: Ecology and Conservation in Northern Temperate Regions.* Cambridge, Cambridge University Press.

PETERKEN, G.F. & BACKMEROFF, C.E., 1988. *Long Term Monitoring in Unmanaged Woodland Nature Reserves.* (Research and Survey in Nature Conservation No.9.) Peterborough, Nature Conservancy Council.

PETERKEN, G.F & JONES, E.W., 1987. Forty Years of Change in Lady Park Wood; The Old Growth Stands. *Journal of Ecology,* **75**, pp. 477-512.

PETERKEN, G.F & JONES, E.W., 1989. Forty Years of Change in Lady Park Wood; The Young Growth Stands. *Journal of Ecology*, **77,** pp. 401-429.

PETERKEN, G.F. & MOUNTFORD, E.P., 1996. Effects of Drought on Beech in Lady Park Wood, an Unmanaged Mixed Deciduous Woodland. *Forestry*, **69,** pp. 125-136.

PETERKEN, G.F. & STACE, H., 1987. Stand Development in the Black Wood of Rannoch. *Scottish Forestry*, **41,** pp. 29-44.

PETERKEN, G.F. & TUBBS,C.R., 1965. Woodland Regeneration in the New Forest, Hampshire Since 1650. *Journal of Applied Ecology*, **2,** pp. 159-170.

PROCTOR, M.C.F., PROCTOR & SPOONER 1980. Changes in Wistmans Wood, Dartmoor: Photographic and Other Evidence. *Report and Transactions of the Devon Association for the Advancement of Science,* **112**, pp. 43-79.

RACKHAM, O., 1980. *Ancient Woodland: It's History, Vegetation and Uses in England.* London, Edward Arnold.

RODWELL, J.S., 1991. *British Plant Communities Volume 1. Woodlands and Scrub.* Cambridge, CUP.

ROSE, F., 1992. Temperate Forest Management: Its Effects on Bryophyte and Lichen Floras and Habitats. *In*: BATES, J.W. and FARMER, A.W. pp *Bryophytes and Lichens in a Changing Environment.* Oxford, Clarendon Press.

ROWE, J.J. & GILL, R.M.A., 1985. The Susceptibility of Tree Species to Bark Stripping Damage by Grey Squirrels *Sciurus carolinensis* in England and Wales. *Quarterly Journal of Forestry,* **79**, pp. 183-190.

SAUNDERS, G., 1993. Woodland Conservation in Britain. *In*: GOLDSMITH, F.B. and WARREN, A., eds. *Conservation in Progress*, pp. 67-95. London, Chapman and Hall.

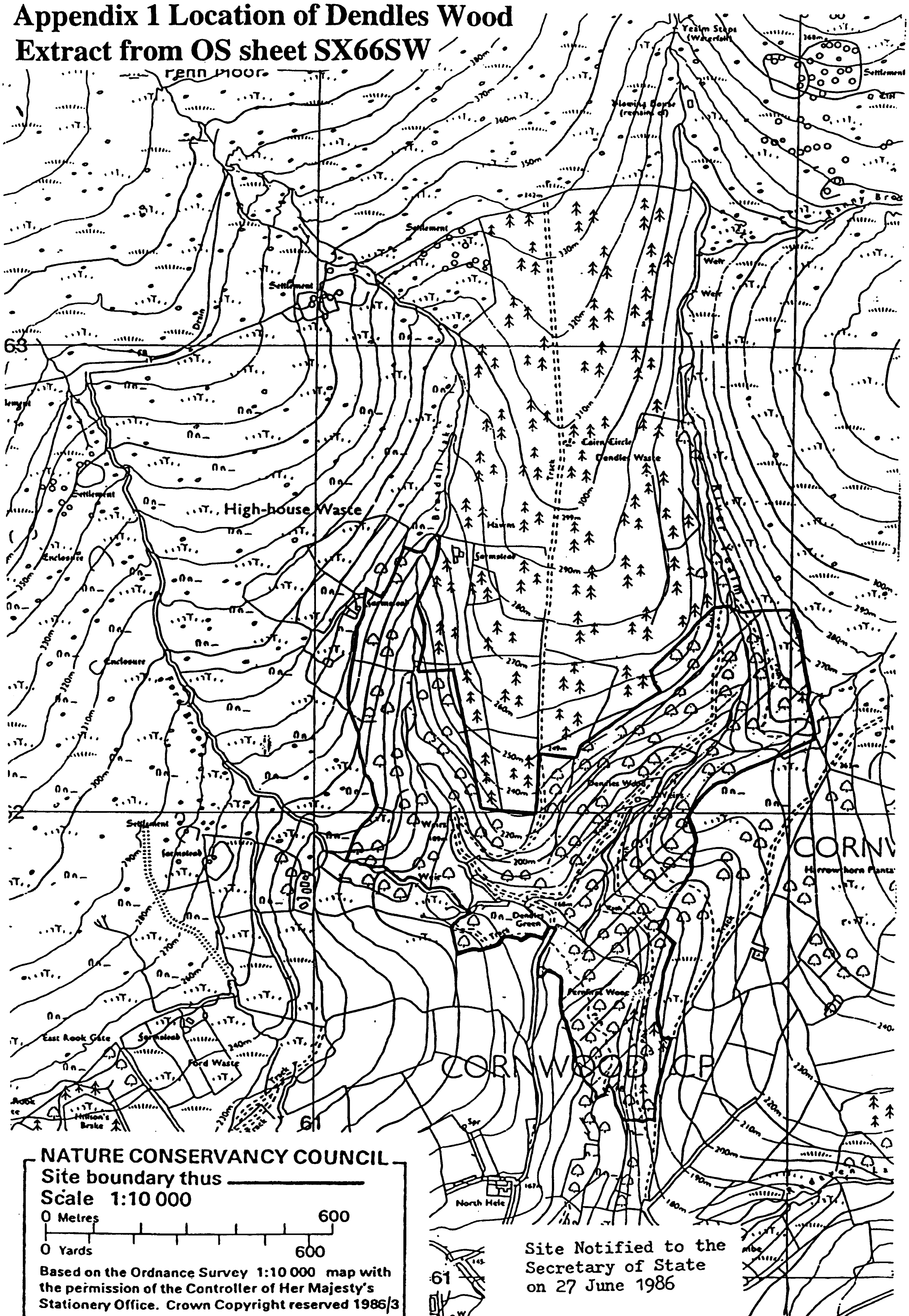
SHAW, M.W., 1974. The Reproductive Characteristics of Oak. *In:* MORRIS, M.G. and PERRING, F.H., eds. *The British Oak.* Farringdon, Classey pp.

SHIRT, D.B., 1987. *British Red Data Books: 2 Insects.* Peterborough, Nature Conservancy Council.

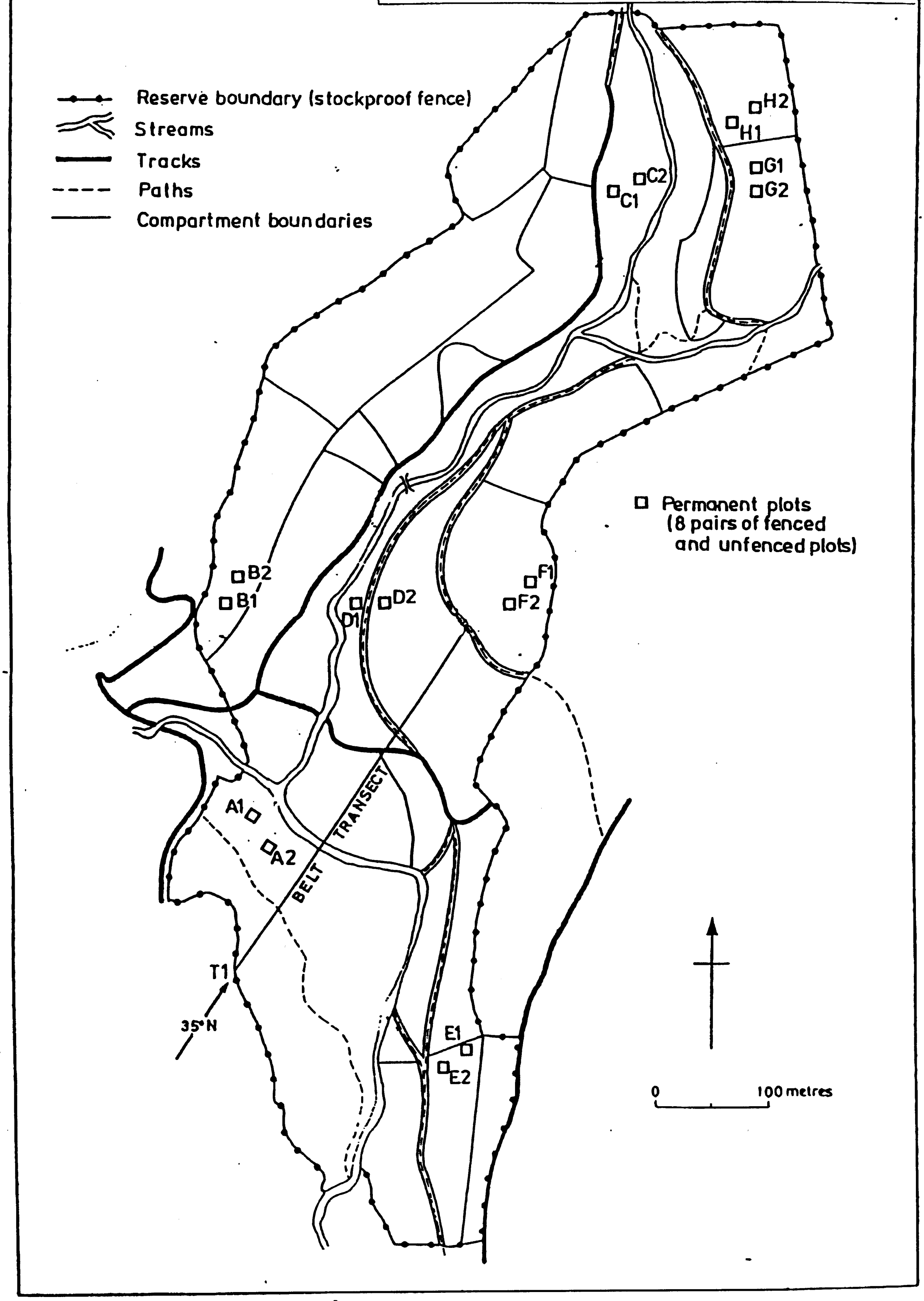
UNIVERSITY OF LANCASTER 1994. *MATCH version 2.0.* University of Lancaster.

Appendices

Appendix 1 Location of Dendles Wood
Extract from OS sheet SX66SW



APPENDIX 2 LOCATION OF THE TRANSECT AND GRAZING PLOTS SOURCE PAGE (1997)



Appendix 3. Section along transect

Key to Dendles Wood Transect Section Drawing.

1) 0-40m; 3° rising slope. Soil free draining acid coarse silty loam with mor humus layer; some granite boulders from old walls.

2) 40-77m; 1.5° falling slope. Soil free draining acid coarse silty loam with mor humus layer; some granite boulders from old walls.

3) At 77m; steep drop ~ 2m.

4) 77-92m; river terrace, level. Soils free draining acid coarse gritty loam with mor humus layer, few surface boulders.

5) 92-98m; 12° falling slope. Steep slope between river terraces.

6) 98-106m; river terrace, level. Soils free draining acid coarse gritty loam with mor humus layer, few surface boulders.

106-122m; River Yealm.

7) 122-124m; river terrace, level. Soils free draining acid coarse gritty loam with mor humus layer, few surface boulders.

8) 124-127m; steep slope between river terraces ~ 2m.

9) 127-191m; 2.5° rising slope. Soils free draining acid coarse silty loam with mor humus layer. Some large piles and some scattered surface granite boulders.

10) 191-222m; 30° rising slope. Soils free draining acid thin silty and coarse loams with rock fragments and mor humus layer, some exposures of siltstone bedrock.

11) 222-330m; 15° rising slope. Soils free draining acid silty loam with mor humus layer, in areas thin and with rock fragments, no surface boulders.

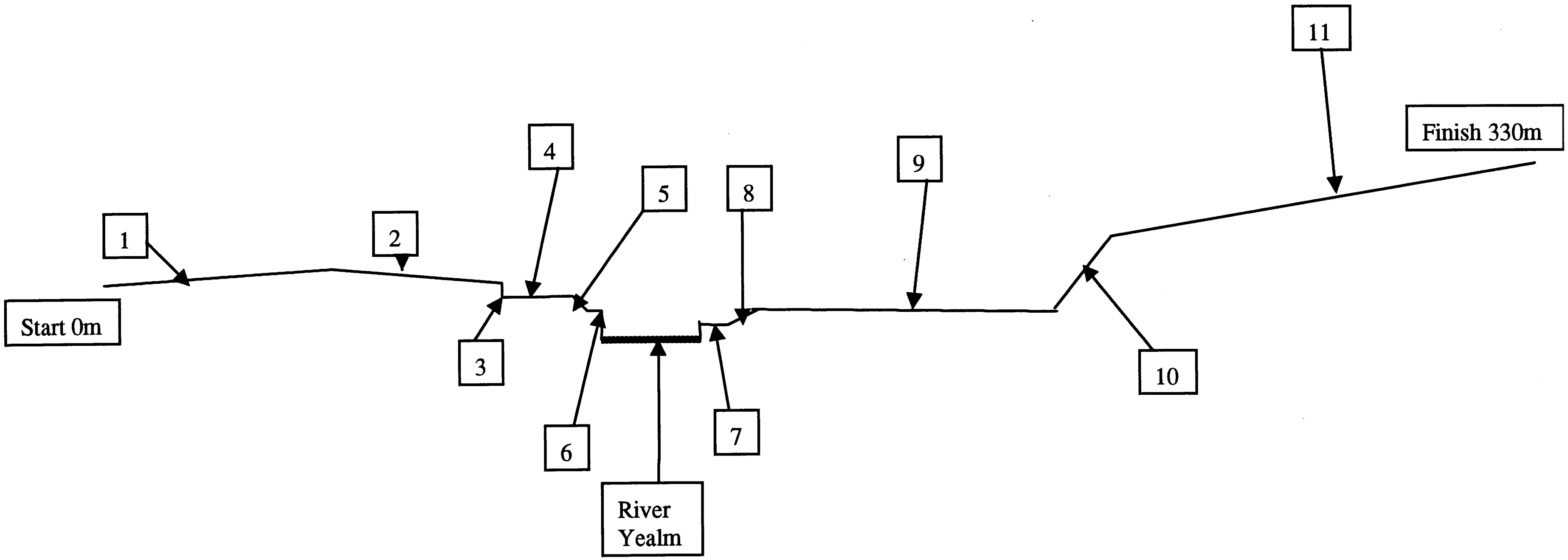
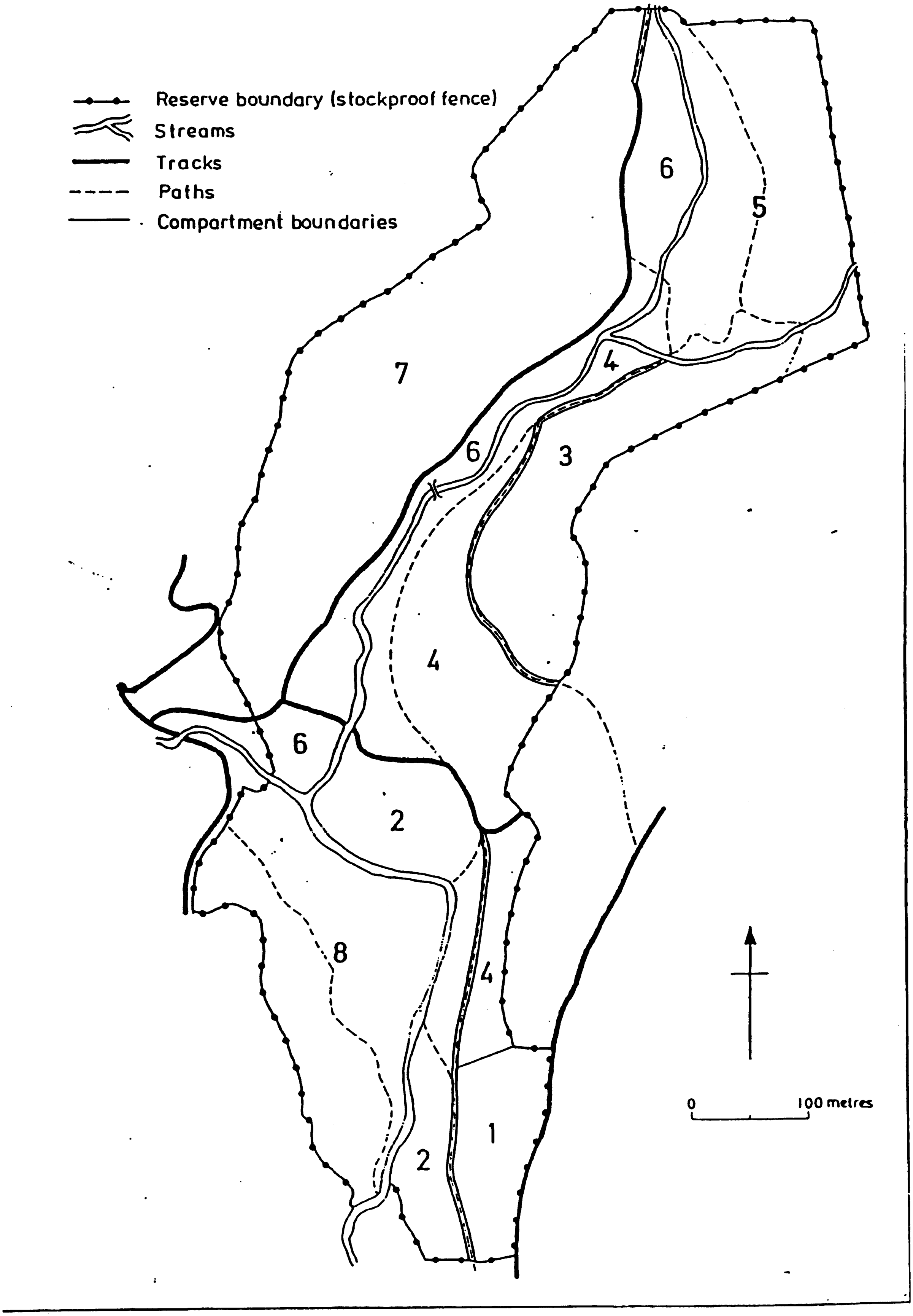


Figure 9. Section along transect

APPENDIX 4 WOODLAND COMPARTMENTS SOURCE PAGE (1997)



Appendix 5. Data input format for production of x-y scatter graph

The format shown below is needed if a scatter graph of tree distribution and species/status is to be produced from the spreadsheet data. The x co-ordinates of the trees in the section to be mapped are entered in a single column (x-value), the corresponding y co-ordinates are then input in separate columns for each species. Dead trees are input twice, once in the x-y columns as described above and again in a separate column for dead trees. This allows the species marker on the graph to be tagged with a symbol to show it is dead. The remainder of the process is the standard Excel chart procedure.

x value	y values				
	Cs	F	Ia	Q	Dead
4.2	4.2				
7.5		5.3			
3.4		16.9			
2.6		27.4			
8.8		26.4			
12.7		8.8			
18.3		15.2			
19.8		18.2			
12		25			
4.2			14.4		
4.2			14.4		
4.2			14.4		
16.2			7.7		
16.2			7.7		
17			7.2		
4.2				6.2	
8.2				18.5	
5.4				22.2	
16.9				8.1	
11.5				14.6	
4.2					14.4
4.2					14.4
11.5					14.6

Appendix 6. Survey Spreadsheet Data Input

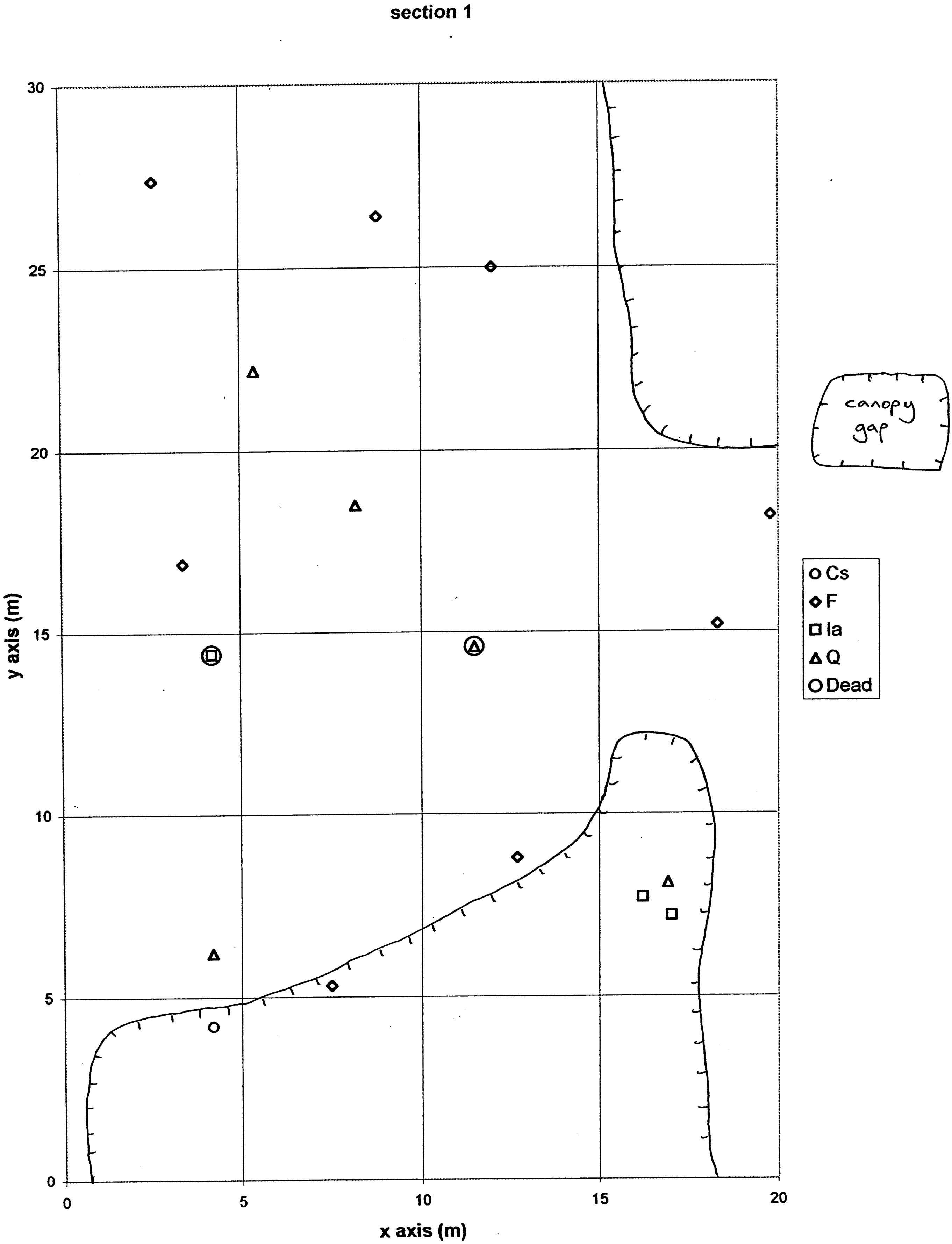
Information

Column title	Description
Number	Individual stem number
Compartment	Compartment number
Section	Section of transect
Side	Side of section, L-left, R-right
Y-axis	Positional distance of stem in m across transect
X-axis	Positional distance of stem in m along transect
In/out	Stem inside or outside transect
Species	F-Fagus sylvatica, Q-Quercus robur, Ia-Ilex aquifolium, Bpub-Betula pubescens, Cs-Castanea sativa. L-Larix decidua, Aa-Abies alba, Sa-Sorbus acuparia; Ps-Pinus sylvestris
Code	Reference code used to identify species & stem number on each individual. 1 = Castanea sativa; 2 = Fagus sylvatica; 3 =Quercus robur ; 4 =Ilex aquifolium; 5 = Sorbus acuparia; 6 = Betula pubescens; 7 = Abies alba; 8 = Pinus sylvestris; 9 = Larix europea. Suffix .00 = first stem on individual, .01 = second stem on individual, etc. (e.g. 3.01 = Second stem on an Ilex individual)
Girth 1988	Stem girth in cm at 1.3m height 1988
Status	Reference code for stem status; 1 = alive: 2 = dead: 3 = alive <1.3m high: 4 = fallen alive
Stool status	Reference code for multi-stemmed individuals showing stool status. 1 = alive; 2 = dead; 3 = alive <1.3m high. 4 = fallen alive
Snag height	Estimated height in m for dead stem in 1998
Dieback	Extent of dieback in crown: S=Severe; M=Moderate; P=Part; N=None
Debarking	Debarking damage: below 2m/above2m: score 1-4; 1=no damage to 4=ring barked
Notes	Miscellaneous notes made in 1998

Appendix 7. Section Data and X-Y Charts Showing Tree Positions, Species and Canopy Gaps in 1998

Section 1 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. in gbh (cm)
2	8	1	L	4.2	4.2	Cs	1.00	126	1			130	1			C	VS	M			4	0.4
3	8	1	L	7.5	5.3	F	2.00	42	1			45.5	1			U	S	M	0/0		4	0.35
4	8	1	L	4.2	6.2	Q	3.00	125	1			133	1			C	S	P			8	0.8
5	8	1	L	4.2	14.4	Ia	4.00	62	1	1	lost top at 7m	62	1		1	U	M	P		measured high	0	0
6	8	1	L	4.2	14.4	Ia	4.01	58	2			58	2	5.5							0	0
7	8	1	L	4.2	14.4	Ia	4.02	40	2			37.5	2	3							-3	-0.25
8	8	1	L	3.4	16.9	F	2.00	161	1			170	1			C	L	P	0/2		9	0.9
9	8	1	L	8.2	18.5	Q	3.00	165	1			166	1			C	VS	M			1	0.1
11	8	1	L	5.4	22.2	Q	3.00	195	1			205	1			C	L	P			10	1
12	8	1	L	2.6	27.4	F	2.00	154	1			159.5	1			C	M				6	0.55
13	8	1	L	8.8	26.4	F	2.00	41	1			51	1			U	M	M	3/1		10	1
14	8	1	R	12.7	8.8	F	2.00	136	1			142.5	1			C	VS	M	0/3		7	0.65
15	8	1	R	16.2	7.7	Ia	4.00	63	1	1		64	1		1	U	S	P	1/0	partly debarked sheep/ deer	1	0.1
16	8	1	R	16.2	7.7	Ia	4.01	19a	1			20	1							trunk shoot	na	na
17	8	1	R	17.0	7.2	Ia	4.00	56	1			60	1			U	M	P	0/0		4	0.4
18	8	1	R	16.9	8.1	Q	3.00	345	1			355e	1			C	M	S	0/0	old pollard recheck size details	na	na
19	8	1	R	11.5	14.6	Q	3.00		2		old windblow ?		2								0	0
20	8	1	R	18.3	15.2	F	2.00	100	1			103.5	1			C	VS	P	O/X	cant see crown debarking	4	0.35
21	8	1	R	19.8	18.2	F	2.00	180	1			190	1			C	L	P	0/X	size good estimate	10	1
22	8	1	R	12.0	25.0	F	2.00	0	na			4	1			G				branch tip layer	4	0.4

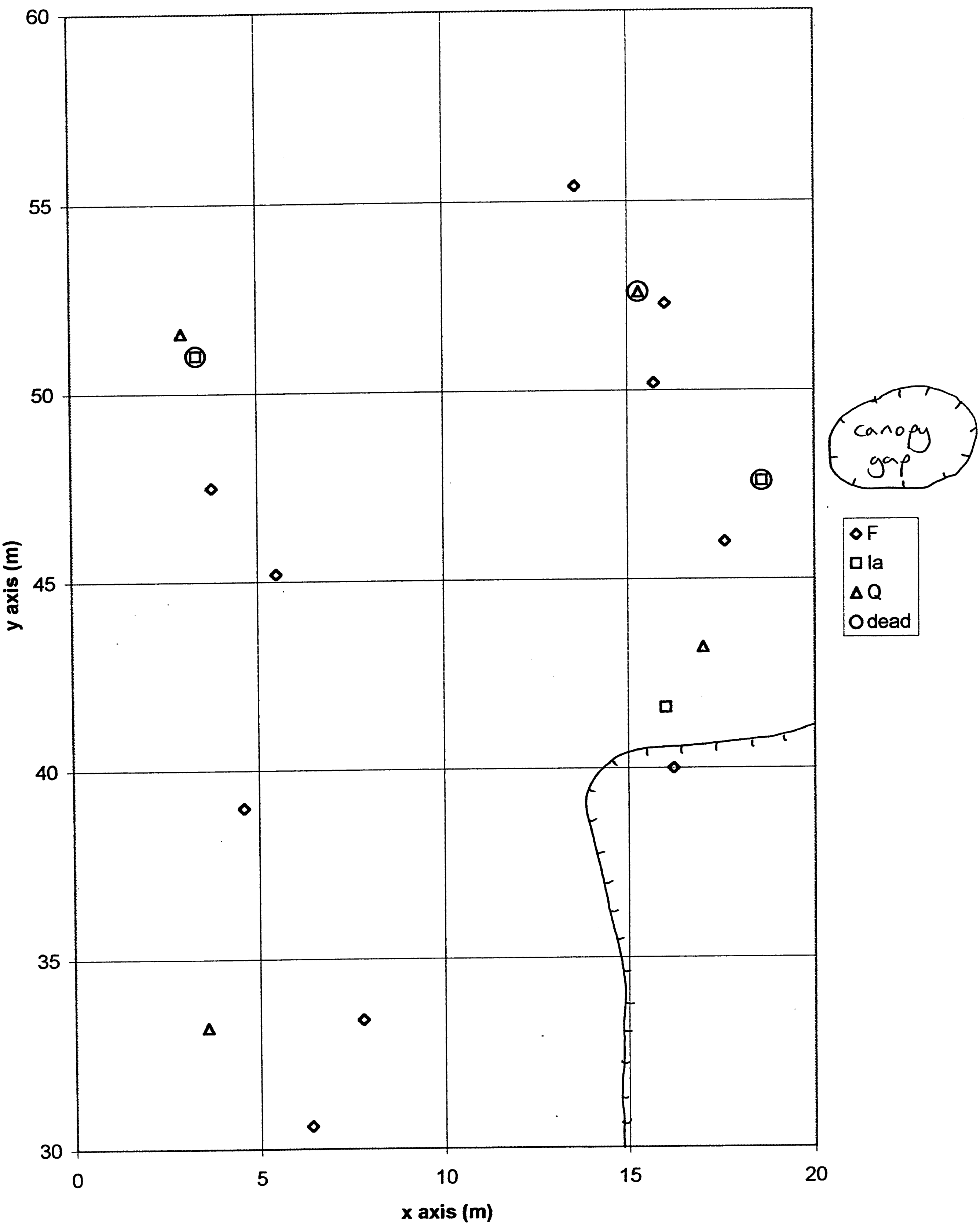


section 1
y axis (m)
x axis (m)
30
25
20
15
10
5
0
0
5
10
15
20
canopy gap
Cs
F
Ia
Q
Dead

Section 2 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
23	8	2	L	6.4	30.6	F	2.00	66	1			70	1			U	L	S	1/3		4	0.4
24	8	2	L	3.6	33.2	Q	3.00	165	1			168	1			C	M	P	0/0		3	0.3
25	8	2	L	7.8	33.4	F	2.00		2		dead stump										0	0
27	8	2	L	4.6	39.0	F	2.00	84	1			89	1			S	M	S	0/3		5	0.5
28	8	2	L	5.5	45.2	F	2.00	187	1			195.5				C	M	P	1/2		8.5	0.9
29	8	2	L	3.8	47.5	F	2.00	26	1			27	1			U	S	P	0/0	very sick	1	0.1
30	8	2	L	3.4	51.0	Ia	4.00	44	2			41	2	3							-3	0
31	8	2	L	3.0	51.6	Q	3.00	220	1			225	1			C	L	P	0/0		5	0.5
32	8	2	R	16.2	40.0	F	2.00	64	1	4		64	1		4					toppled by oak	0	0
33	8	2	R	16.0	41.6	Ia	4.00					3	1			G	VS	P	0/0	recruit on root mound	3	0.3
34	8	2	R	17.0	43.2	Q	3.00	133	1			139.5	1			C	S	M	0/0		6.5	0.7
35	8	2	R	17.6	46.0	F	2.00	140	1			146	1			C	M	P	0/1		6	0.6
36	8	2	R	18.6	47.6	Ia	4.00	50	2			49	2	5						debarked sheep/deer	-1	0
37	8	2	R	15.7	50.2	F	2.00	82	1			82.5	1			S	S	S	0/3		0.5	0
38	8	2	R	15.3	52.6	Q	3.00	171	2			167	2							old pollard excluded	-4	-0.4
39	8	2	R	16.0	52.3	F	2.00	102	1			110.5	1			C	S		1/1	ivy	8.5	0.85
40	8	2	R	13.6	55.4	F	2.00	na			ommitted 1988	174.5	1			C	M	P	0/2	omitted 1988	na	na

section 2

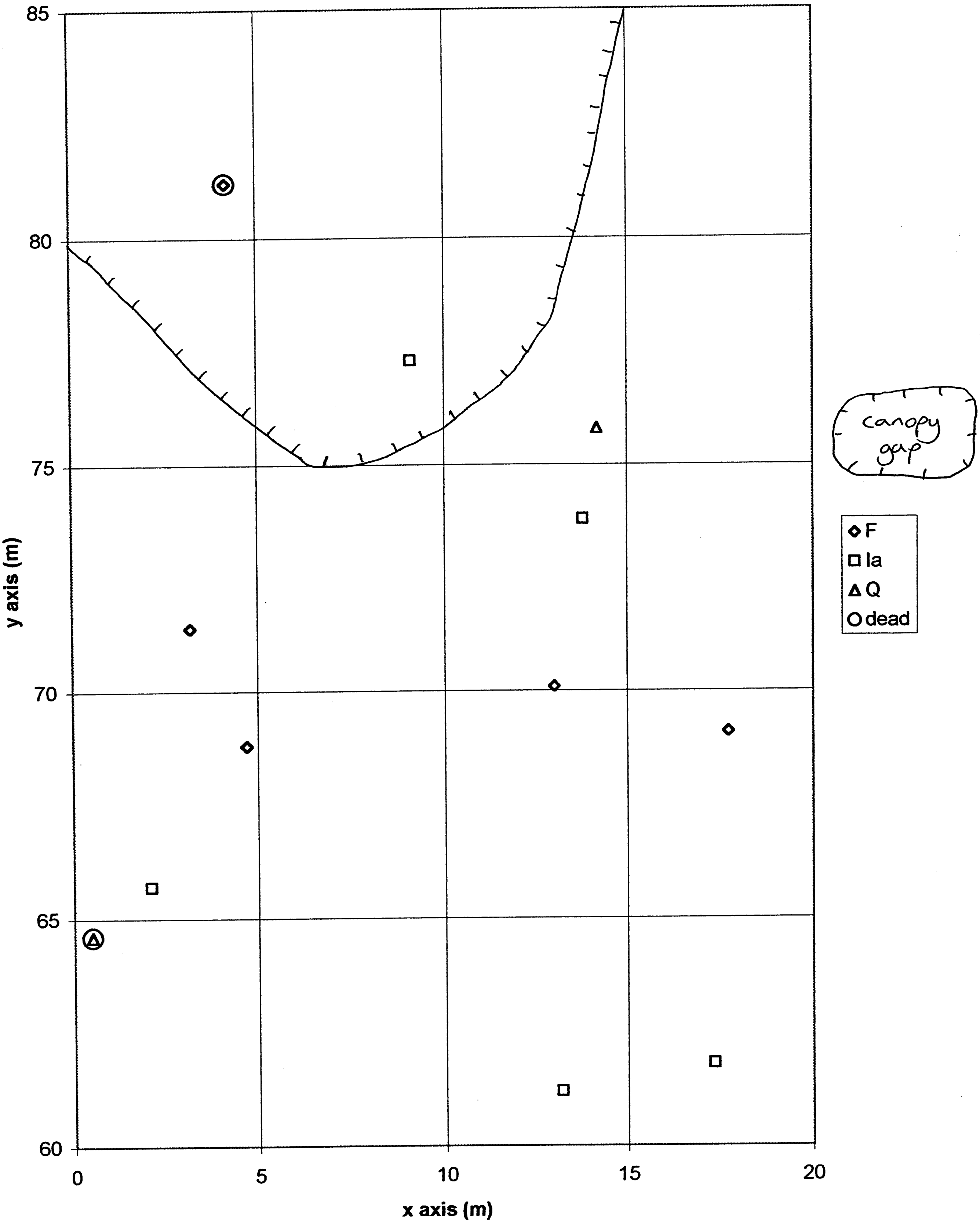


60
55
50
45
40
35
30
0
5
10
15
20
y axis (m)
x axis (m)
canopy gap
F
Ia
Q
dead

Section 3 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
42	8	3	L	0.5	64.6	Q	3.00	240	2			236	2	18						old pollard	-4	-0.4
43	8	3	L	2.1	65.7	Ia	4.00	78	1			78	1			U	M	M		part debarked sheep/deer	0	0
44	8	3	L	4.7	68.8	F	2.00	143	1			149	1			C	M	P	0/0		6	0.6
45	8	3	L	3.2	71.4	F	2.00	175	1			188	1			C	L	P	1/1		13	1.3
46	8	3	L	9.1	77.3	Ia	4.00	75	1			76	1			U	M	P		part debarked sheep/deer	1	0.1
47	8	3	L	4.2	81.2	F	2.00	266	2			267	2	5.5							1	0.1
48	8	3	R	13.2	61.2	Ia	4.00	69	1			71	1			U	M	P		part debarked sheep/deer	2	0.2
49	8	3	R	17.3	61.8	Ia	4.00	na	1		girth not recorded	58.5				U	M	P			na	na
50	8	3	R	17.7	69.1	F	2.00	158	1			162.5	1			C	M	M	1/0		4.5	0.45
51	8	3	R	13.0	70.1	F	2.00	180	1			185	1			C	L	P	0/2		5	0.5
52	8	3	R	13.8	73.8	Ia	4.00	64	1			66	1			U	M	M			2	0.2
53	8	3	R	14.2	75.8	Q	3.00	153	1			153	1			C	VS	S			0	0

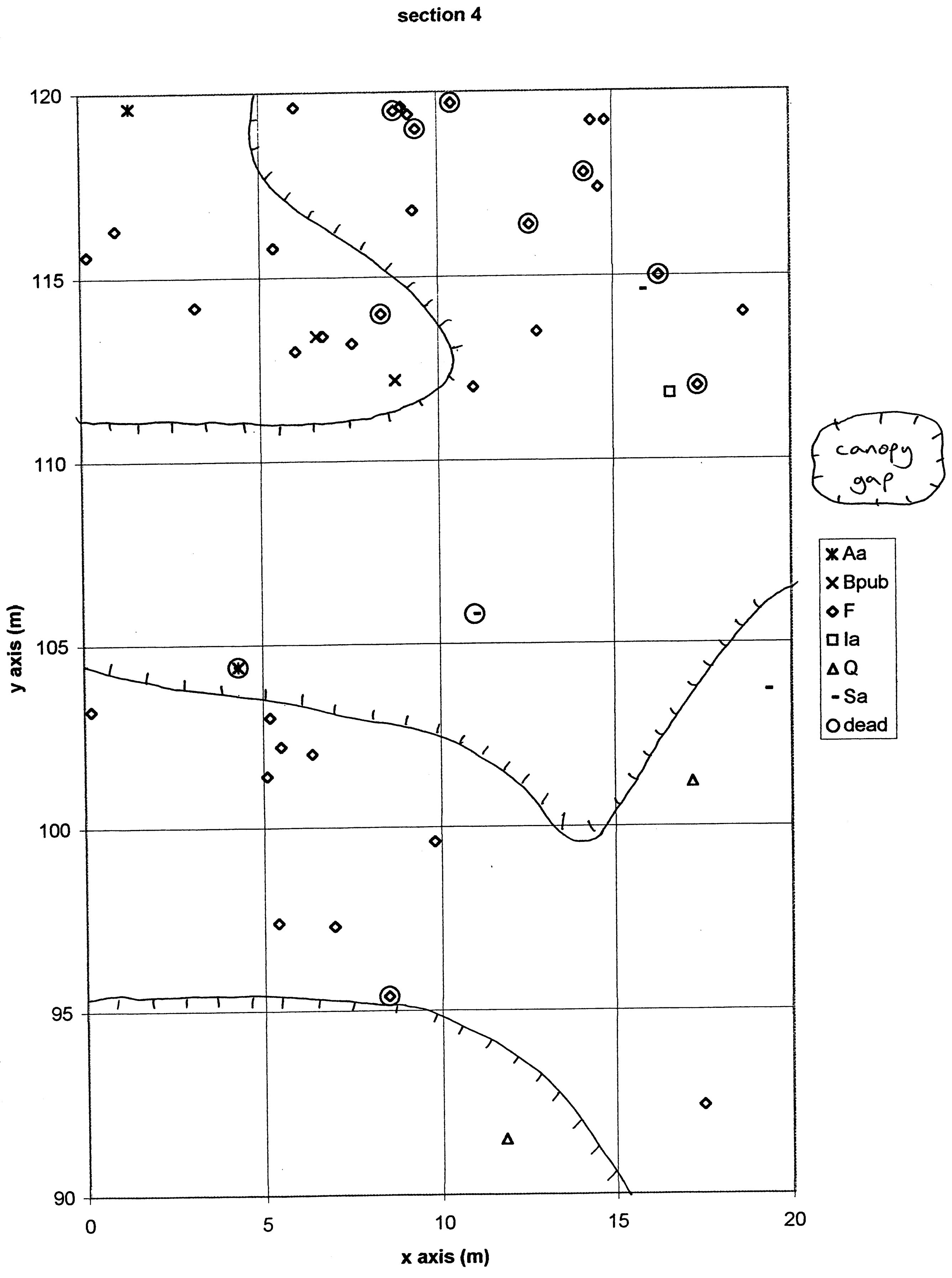
section 3



Section 4 raw data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
54	8	4	L	7	97.3	F	2	136	1			144	1			C	M	P	0/2		8	0.8
55	8	4	L	5.4	97.4	F	2.00	150	1			168	1			C	M	P	0/2		18	1.8
56	8	4	L	8.5	95.4	F	2.00	122	2			114	2	3.5							-8	-0.8
57	8	4	L	9.8	99.6	F	2.00	0				3	1			G	S	P	0/0		3	0.3
58	8	4	L	5.1	101.4	F	2.00	0				1	1			G	VS	P	0/0		1	0.1
59	8	4	L	6.4	102.0	F	2	0				1	1			G	VS	P	0/0		1	0.1
60	8	4	L	5.5	102.2	F	2.00	0				2	1			G	S	P	0/0		2	0.2
61	8	4	L	5.2	103.0	F	2.00	0				3	1			G	S	P	0/0		3	0.3
62	8	4	L	0.2	103.2	F	2.00	0				2	1			G	VS	P			2	0.2
63	8	4	L	4.3	104.4	Aa	7.00	5	1			na	2								na	na
64	8	4	L	4.2	104.4	Sa	5.00	0				2	1			G	VS	P			2	0.2
66	2	4	L	8.8	112.2	Bpub	6.00	22	1			39	1			U	M	M	0/0		17	1.7
67	2	4	L	8.8	112.2	Bpub	6.01	19	1			31	1			U	S	M	0/0		12	1.2
68	2	4	L	8.4	114.0	F	2.00	19	1			31	2	6		U	VS	S	4/4	almost totally debarked by squirrels	12	1.2
69	2	4	L	7.6	113.2	F	2.00	10	1			15	1			U	S	S	2/4		5	0.5
70	2	4	L	7.6	113.2	F	2.01	17	1			24	1			U	S	S	1/3		7	0.7
71	2	4	L	7.6	113.2	F	2.02	na			not recorded	13	1							trunk shoot	na	na
72	2	4	L	6.6	113.4	Bpub	6.00	30	1			67	1			SC	M		0/0		37	3.7
73	2	4	L	6.8	113.4	F	2.00	0				4	1			G	S	S	0/0		4	0.4
74	2	4	L	6.0	113.0	F	2.00	0				3	1			G	S	P	0/0		3	0.3
75	2	4	L	3.2	114.2	F	2.00	11	1			29	1			U	M	P	3/2		18	1.8
76	2	4	L	3.2	114.2	F	2.01	na	1			10	1							trunk shoot	na	na
77	2	4	L	3.2	114.2	F	2.02	na	1			10	1							trunk shoot	na	na
78	2	4	L	3.2	114.2	F	2.03	na	1			13	1							trunk shoot	na	na
79	2	4	L	5.4	115.8	F	2.00	5	1			15	1			U	S	P	2/1		10	1
80	2	4	L	1.0	116.3	F	2.00	0				10	1			U	S	P	1/0		10	1
81	2	4	L	1.0	116.3	F	2.01	0				6	1			U	VS	P	1/0	forked below 1.3m	6	0.6
82	2	4	L	0.2	115.6	F	2.00	0				9	1			U	S	P	1/0		9	0.9
83	2	4	L	9.3	116.8	F	2.00	19	1			32	1			U	M	S	3/4		13	1.3
84	2	4	L	9.4	119.0	F	2.00	na	1			16	2	4					4/0	killed by squirrels	na	na
85	2	4	L	8.8	119.5	F	2.00	na	1			16	2	4					4/3	killed by squirrels	na	na
86	2	4	L	9.0	119.6	F	2.00	0				10	1			U	S	P	1/1	recruit	10	1
87	2	4	L	6.0	119.6	F	2.00	na	1			10	1			U	S	P	0/0		na	na
88	2	4	L	9.2	119.4	F	2.00	0				1	1			G	VS	S			1	0.1
89	2	4	L	1.4	119.6	Aa	7.00	34	1			57	1			U	L	P		recorded as Picea abies in 1988	23	2.3

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
90	8	4	R	11.8	91.5	Q	3.00	132	1			134	1			C	S	P			2	0.2
91	8	4	R	17.5	92.4	F	2.00	139	2			135	1			C	VS	VS	0/0	recorded as dead in 1988	-4	-0.4
96	8	4	R	17.2	101.2	Q	3.00	146	1			145.5	1			U	S	S		part dead and bark flaking	-0.5	-0.05
97	8	4	R	19.3	103.7	Sa	5.00	5	1	1		12	1		1	U	S	P		forked	7	0.7
98	8	4	R	19.3	103.7	Sa	5.01	na	1	1		10	1		1	U	VS	P		trunk fork	na	na
99	8	4	R	19.3	103.7	Sa	5.02	0	1	1		10	1		1	U	VS	P			10	1
100	8	4	R	19.3	103.7	Sa	5.03	0	1	1		6	1		1	U	VS	P			6	0.6
101	8	4	R	11.0	105.8	Sa	5.00	na	1			na	2							washed away	na	na
102	2	4	R	11.0	112.0	F	2.00	na	1			20	1			U	VS	S	4/2		na	na
103	2	4	R	11.0	112.0	F	2.00	na	1			12	1							trunk shoot	na	na
104	2	4	R	12.8	113.5	F	2.00	20	1			39	1			U	S	S	4/2		19	1.9
105	2	4	R	16.6	111.8	Ia	4.00	0				3	1			G	VS	P			3	0.3
106	2	4	R	15.8	114.6	Sa	5.00	18	1			39	1			U	M	P	1/0	recorded as Fagus 1988	21	2.1
107	2	4	R	17.4	112.0	F	2.00	0				11	2	3.5					4/0	killed by squirrels	11	1.1
108	2	4	R	18.7	114.0	F	2.00	0				3	1			G	S	M			3	0.3
109	2	4	R	16.3	115.0	F	2.00	243	2		top lost at 7m	240	2	6							-3	-0.3
110	2	4	R	12.6	116.4	F	2.00	432	2		top lost at 10m	418	2	9							-14	-1.4
111	2	4	R	14.6	117.4	F	2.00	7	1			24	1			U	M	P	3/1	many forked	17	1.7
112	2	4	R	14.6	117.4	F	2.00	na	1			13	1							fork	na	na
113	2	4	R	14.6	117.4	F	2.00	na	1			17	1							fork	na	na
114	2	4	R	14.6	117.4	F	2.00	na	1			8	1							trunk shoot	na	na
115	2	4	R	14.2	117.8	F	2.00	0				13	2	4					4/2	killed by squirrels	13	1.3
116	2	4	R	14.4	119.2	F	2.00	0				17	1			U	S	P	3/1		17	1.7
117	2	4	R	14.8	119.2	F	2.00	0				8	1			G	S	P	0/0		8	0.8
118	2	4	R	10	119.7	F	2	8	1			14	2	2.5						killed by squirrels	6	0.6



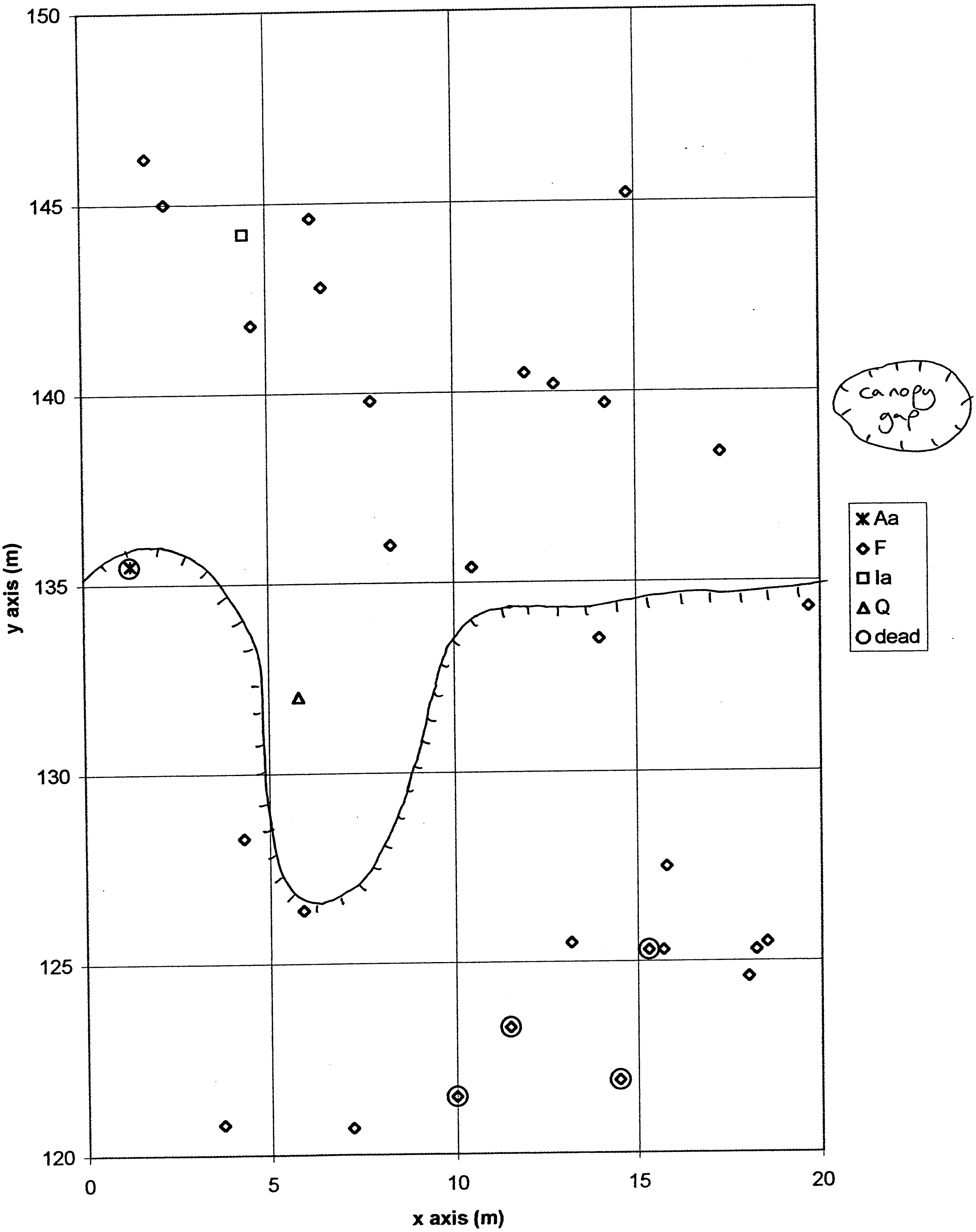
section 4
120
115
110
105
100
95
90
0
5
10
15
20
y axis (m)
x axis (m)
canopy gap
Aa
Bpub
F
Ia
Q
Sa
dead

Section 5 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
119	2	5	L	3.7	120.8	F	2.00	65	1			72	1			SC	M	M	1/3		7	0.7
120	2	5	L	7.2	120.7	F	2.00	5	1			18	1			U	S	P	3/1		13	1.3
121	2	5	L	5.9	126.4	F	2.00	94	1			100	1			U	L	S	1/3		6	0.6
122	2	5	L	4.3	128.3	F	2.00	34	1			38	1			U	S	M	3/3		4	0.4
123	2	5	L	10.0	121.5	F	2.00	0				12	2	3					4/4	killed by squirrels	12	1.2
124	2	5	L	5.8	132.0	Q	3.00	189	1			196	1			C	M	P			7	0.7
125	2	5	L	1.3	135.5	Aa	7.00	264	2		top lost 8m	256	2	4							-8	-0.8
126	2	5	L	8.3	136.0	F	2.00	49	1		laying flat	56	1			U	M	S		knocked over by Abies	7	0.7
127	2	5	L	7.8	139.8	F	2.00	101	1			114	1			C	S	P	0/1		13	1.3
128	2	5	L	4.6	141.8	F	2.00	109	1			119	1			C	S	P	1/1		10	1
129	2	5	L	6.5	142.8	F	2.00	72	1			77	1			SC	S	P	0/2		5	0.5
130	2	5	L	4.4	144.2	Ia	4.00	68	1			70	1			U	M	P		part debarked sheep/deer	2	0.2
131	2	5	L	6.2	144.6	F	2.00	238	1			247	1			C	L	P	0/1	A generation unpollarded	9	0.9
132	2	5	L	2.3	145.0	F	2.00	91	1			98	1			C	VS	P	0/0		7	0.7
133	2	5	L	1.8	146.2	F	2.00	120	1			128	1			C	S	P	0/2		8	0.8
134	2	5	R	14.5	121.9	F	2.00	6	1			16	2	3.5					4/0	killed by squirrels	10	1
135	2	5	R	11.5	123.3	F	2.00	na	1			13	2	4					4/4	killed by squirrels	na	na
136	2	5	R	18.0	124.6	F	2.00	0				7	1			G	S	P	1/0		7	0.7
137	2	5	R	18.0	124.6	F	2.00	0				5	1			G	S	P	1/0	fork	5	0.5
138	2	5	R	18.0	124.6	F	2.00	0				5	1			G	S	P	1/0	fork	5	0.5
139	2	5	R	18.5	125.5	F	2.00	0				7	1			G	S	P	0/0		7	0.7
140	2	5	R	18.2	125.3	F	2.00	0				3	1			G	S	P	0/0		3	0.3
141	2	5	R	15.3	125.3	F	2.00	na	1			12	2	4					4/0	killed by squirrels	na	na
142	2	5	R	13.2	125.5	F	2.00	0				9	1			G	VS	M	0/0	branch tip layer of fallen beech	9	0.9
143	2	5	R	15.7	125.3	F	2.00	0				10	1							description not recorded	10	1
144	2	5	R	15.8	127.5	F	2.00	0				11	1			U	VS	P	1/0		11	1.1
146	2	5	R	14.0	133.5	F	2.00	62	1			66	1			U	M	S	0/3	strongly leaning	4	0.4

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
147	2	5	R	19.7	134.3	F	2.00	107	1			127e	1			U	M	S	0/3	recorded as Fagus 1988 and Quercus 98	na	na
148	2	5	R	17.3	138.4	F	2.00	94	1			94	1			SC	S	S	0/1	top snapped out	0	0
149	2	5	R	10.5	135.4	F	2.00	na			not recorded	8	1			C	VS	P		trunk debarked deer fraying	na	na
150	2	5	R	14.2	139.7	F	2.00	98	1			102	1			C	S	P	0/3		4	0.4
151	2	5	R	12.8	140.2	F	2.00	86	1			97	1			C	VS	P	0/0		11	1.1
152	2	5	R	12.8	140.2	F	2.00	na			not recorded	12	1							trunk shoot	na	na
153	2	5	R	12.0	140.5	F	2.00	63	1			67	1			SC	S	P	0/0		4	0.4
154	2	5	R	14.8	145.2	F	2.00	104	1			108	1			SC	M	P	0/1		4	0.4

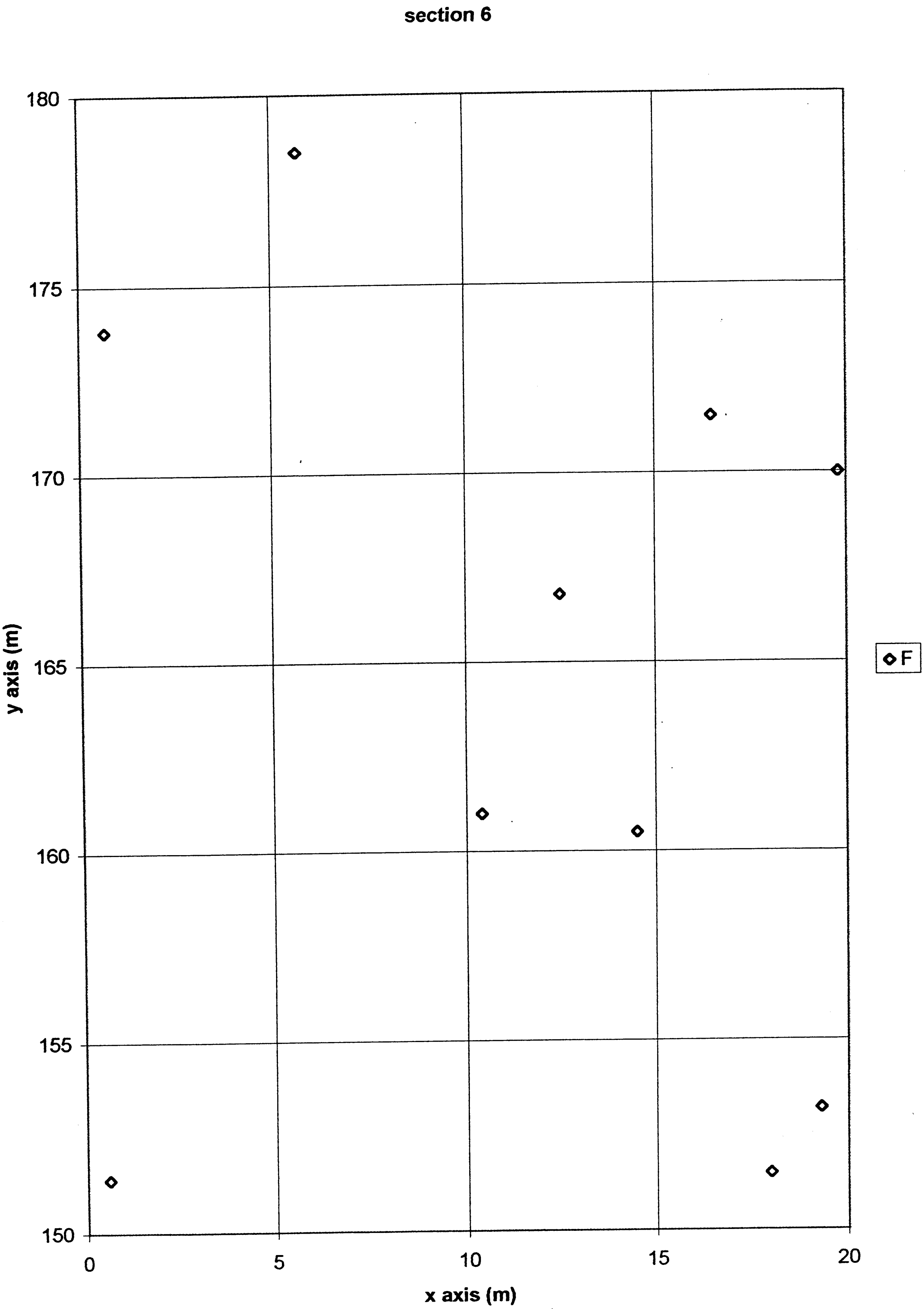
section 5



150
145
140
135
130
125
120
0
5
10
15
20
y axis (m)
x axis (m)
canopy gap
Aa
F
Ia
Q
dead

Section 6 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
155	2	6	L	0.6	151.4	F	2.00	84	1			90	1			SC	M	P	0/1		6	0.6
156	2	6	L	0.7	173.8	F	2.00	272	1			285.5	1			C	L	P	0/1	old pollard	13.5	1.35
157	2	6	L	5.7	178.5	F	2.00	148	1			154	1			C	M	P	0/2		6	0.6
158	2	6	R	18.0	151.5	F	2.00	113	1			115	1			C	VS	M	0/1		2	0.2
159	2	6	R	19.3	153.2	F	2.00	147	1			155	1			C	M	P	0/1		8	0.8
160	2	6	R	14.5	160.5	F	2.00	160	1			161	1			C	S	M	0/2		1	0.1
161	2	6	R	10.4	161.0	F	2.00	250	1			251	1			C	M	M	0/1	old pollard forked at 2.5m	1	0.1
162	2	6	R	12.5	166.8	F	2.00	194	1			194	1			C	M	P	0/0		0	0
163	2	6	R	19.8	170.0	F	2.00	192	1			197	1			C	S	M	0/3		5	0.5
164	2	6	R	16.5	171.5	F	2.00	213	1			217	1			C	M	P	0/0		4	0.4

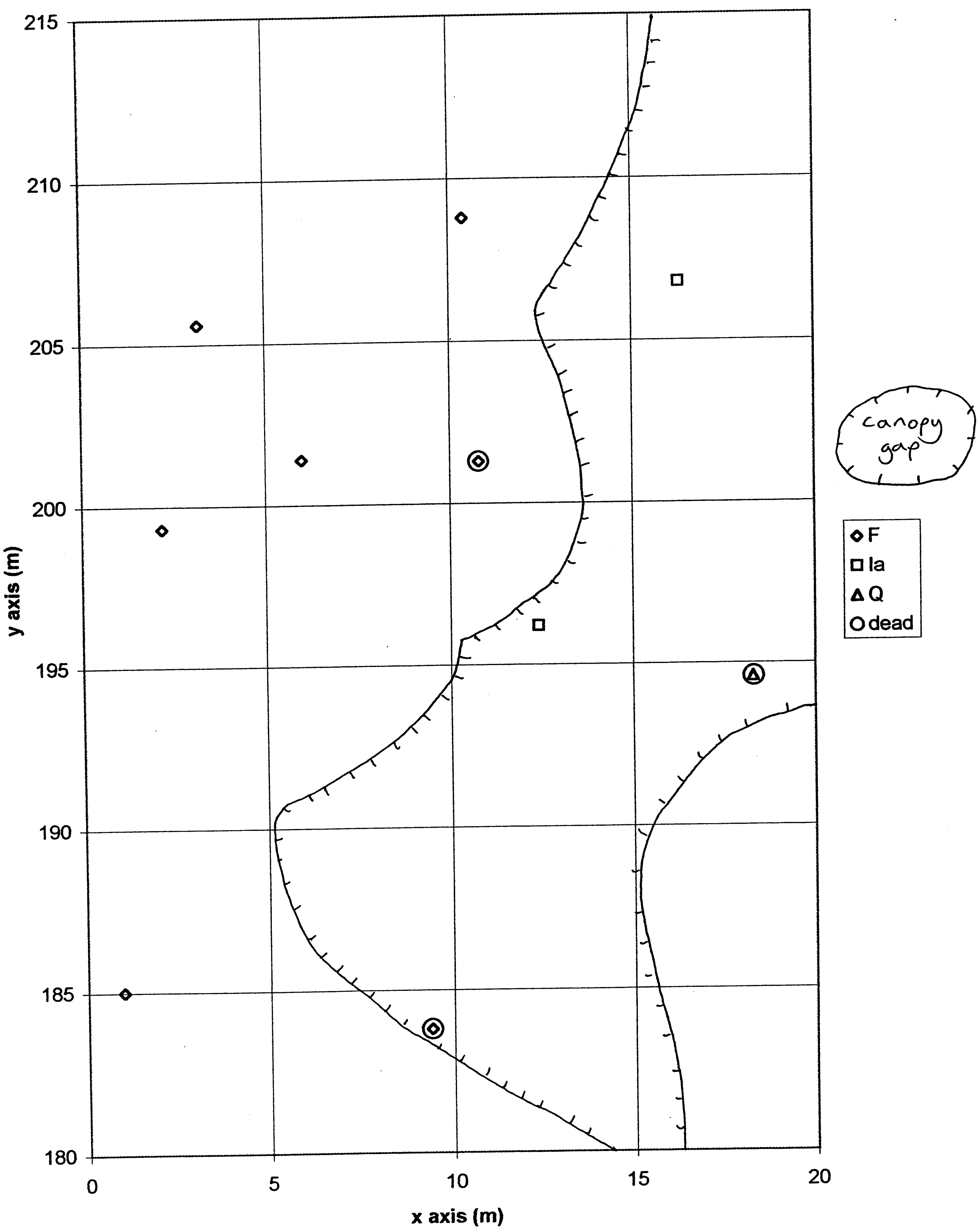


section 6
180
175
170
165
160
155
150
y axis (m)
0
5
10
15
20
x axis (m)
F

Section 7 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
165	2	7	L	9.4	183.8	F	2	207	1			206	2	3						windsnapped	-1	0
166	2	7	L	1.0	185.0	F	2.00	84	1			91	1			C	VS	P	0/X	can't see top for ivy	7	0.7
167	4	7	L	18.3	194.6	Q	3.00	213	2		wind snapped 1988	206	2	3							-7	-1
168	4	7	L	2.2	199.3	F	2.00	150	1			158	1			C	M	P	0/1		8	0.8
169	4	7	L	2.2	199.3	F	2.00	na	1		not recorded	79	1							low branch	na	na
170	4	7	L	6.0	201.4	F	2.00	128	1			132	1			C	S	P	0/0		4	0.4
171	4	7	L	3.2	205.6	F	2.00	158	1			163	1			C	M	S	0/0	forks at 1.1m	5	0.5
172	4	7	L	3.2	205.6	F	2.01	na	1		not recorded	87	1							fork	na	na
173	4	7	R	12.4	196.2	Ia	4.00	80	1			81	1			U	M	S		trunk badly debarked	1	0.1
174	4	7	R	10.8	201.3	F	2.01	118	1			126	2	15						fork	8	0.8
175	4	7	R	10.8	201.3	F	2.00	145	1			146	1			C	S	M	0/3	3 forks at 1m	1	0.1
176	4	7	R	10.8	201.3	F	2.02	121	1			122	1			C	S	M	0/3	fork	1	0.1
177	4	7	R	16.3	206.8	Ia	4.00	0				3	1			G	S	P		recruit on root plate	3	0.3
178	4	7	R	10.4	208.8	F	2.00	211	1			228.5	1			C	M	P	0/0	size probably in error in 1988	17.5	1.8

section 7

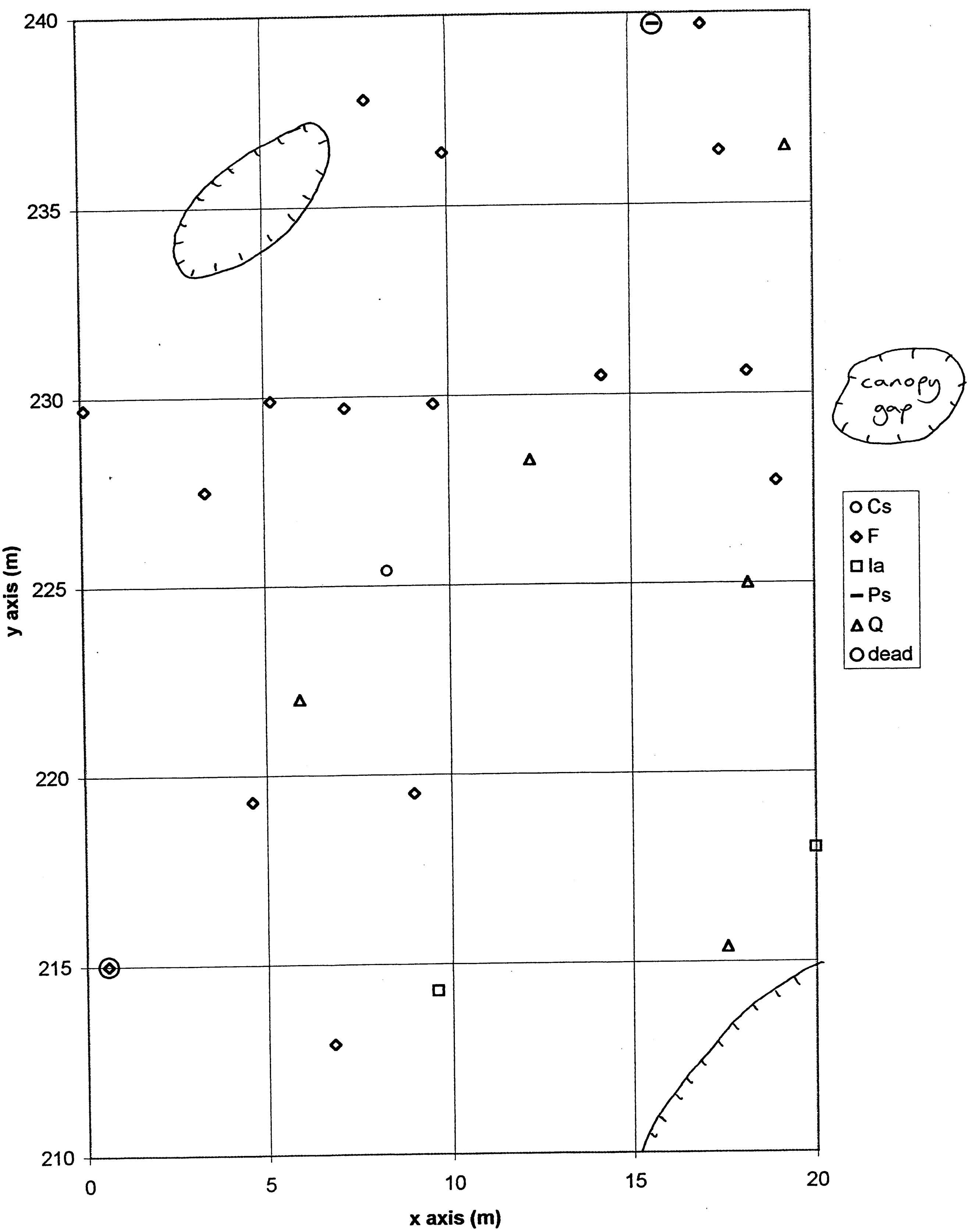


215
210
205
200
195
190
185
180
y axis (m)
0
5
10
15
20
x axis (m)
canopy gap
F
Ia
Q
dead

Section 8 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
179	4	8	L	6.8	212.9	F	2.00	162	1			166	1			C	S	M	0/2		4	0.4
180	4	8	L	9.6	214.3	Ia	4.00	34	1			39	1			G	L	P			5	0.5
181	4	8	L	9.6	214.3	Ia	4.00	na			not recorded	19	1			G	L	P		trunk shoot badly debarked	na	na
182	4	8	L	9.6	214.3	Ia	4.00	na			not recorded	4	1							trunk shoot	na	na
183	4	8	L	4.6	219.3	F	2.00	50	1			52	1			U	M	P	0/0		2	0.2
184	4	8	L	9.0	219.5	F	2.00	28	1			36	1			U	L	P	0/0		8	0.8
185	4	8	L	5.9	222.0	Q	3.00	166	1			173	1			C	S	M			7	0.7
186	4	8	L	8.3	225.4	Cs	1.00	173	1			194	1			C	M	P	0/0		21	2.1
187	4	8	L	3.4	227.5	F	2.00	33	1			36	1			U	L	P	0/0		3	0.3
188	4	8	L	0.1	229.7	F	2.00	91	1			98	1			C	S	P	0/0		7	0.7
189	4	8	L	5.2	229.9	F	2.00	91	1			94	1			C	S	P	0/0		3	0.3
190	4	8	L	7.2	229.7	F	2.00	104	1			110	1			C	S	P	0/0		6	0.6
191	4	8	L	9.9	236.4	F	2.00	109	1			125	1			C	M	P	1/2		16	1.6
192	4	8	L	7.8	237.8	F	2.00	24	1			26	1			U	M	P	2/0		2	0.2
193	4	8	R	0.6	215.0	F	2.00	161	2			155	2	6							-6	-0.6
194	4	8	R	17.6	215.4	Q	3.00	186	1			187	1			C	S	P			1	0.1
195	4	8	R	20.0	218.0	Ia	4.00	38	1			43	1			U	M	P		base rotting some branches debarked	5	0.5
196	4	8	R	20.0	218.0	Ia	4.00	na			not recorded	23	1							trunk shoot	na	na
197	4	8	R	20.0	218.0	Ia	4.00	na			not recorded	25	1							trunk shoot	na	na
199	4	8	R	18.2	225.0	Q	3.00	235	1			241	1			C	M	P			6	0.6
200	4	8	R	19.0	227.7	F	2.00	63	1			68	1			U	L	S	1/3		5	0.5
201	4	8	R	9.6	229.8	F	2.00	70	1		half dead	70.5	1			S	S	S	1/3	top lost at 10m due to squirrels	0.5	0.05
202	4	8	R	12.2	228.3	Q	3.00	177	1			179	1			C	M	P			2	0.2
203	4	8	R	18.2	230.6	F	2.00	58	1			67	1			S C	S	S	1/4	top lost at 10m due to squirrels	9	0.9
204	4	8	R	14.2	230.5	F	2.00	64E			error in measurment	91	1			C	VS	P	1/1		na	na
205	4	8	R	17.5	236.4	F	2.00	46	1	1		47	1		1	U	M	P	0/0	possible coppice	1	0.1
206	4	8	R	17.5	236.4	F	2.01	37E	1	1	error in measurment	26	1		1	U	S	M	0/0		na	na
207	4	8	R	19.3	236.5	Q	3.00	157	1			164	1			C	M	M		major fork lost long ago	7	0.7
208	4	8	R	15.7	239.7	Ps	8.00	122	2			115	2	9							-7	-0.7
209	4	8	R	17.0	239.7	F	2.00	69	1			74	1			C	VS	P	1/1	top lost 6m long ago	5	0.5

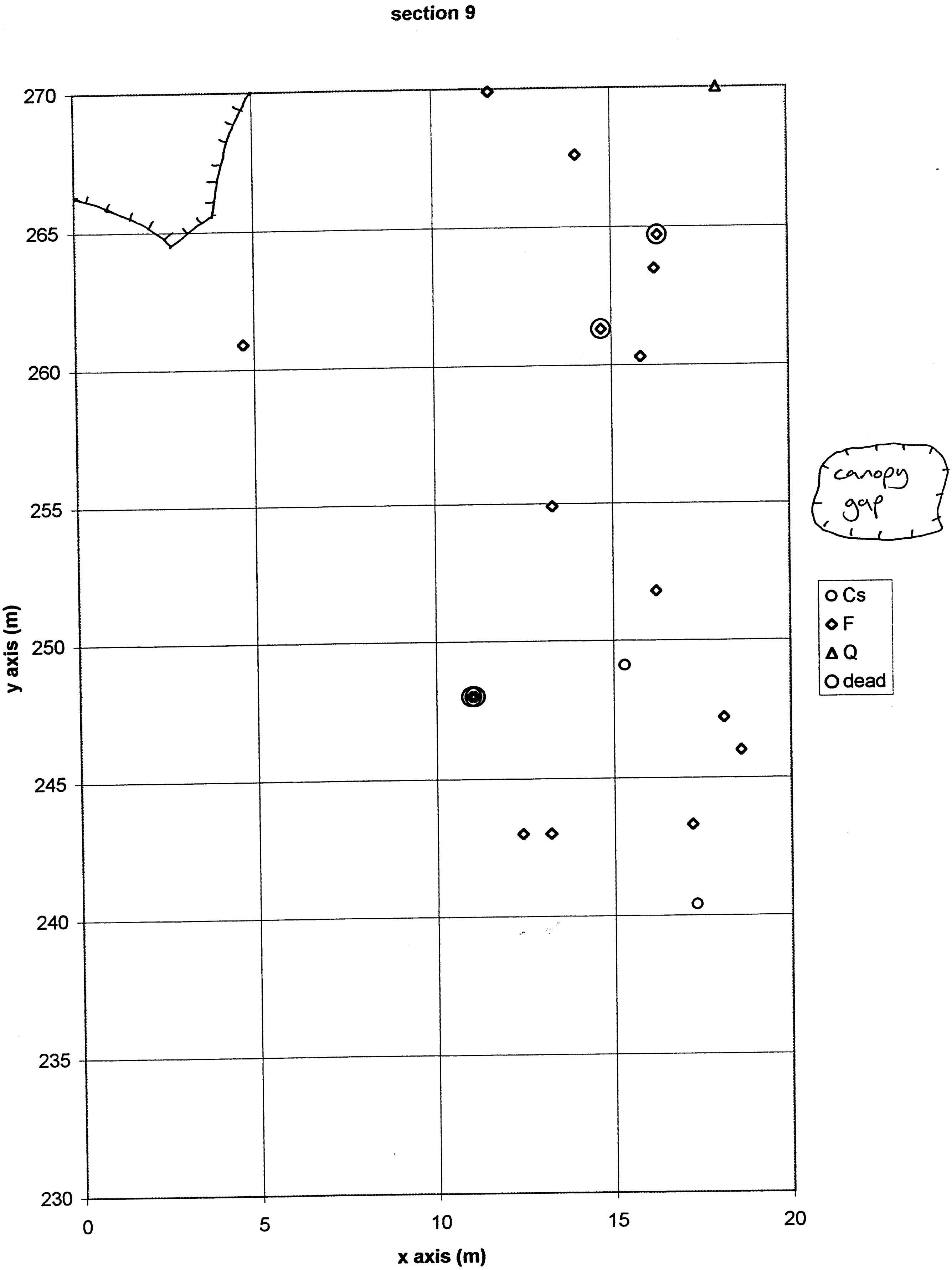
section 8



240
235
230
225
220
215
210
0
5
10
15
20
y axis (m)
x axis (m)
Cs
F
Ia
Ps
Q
dead
canopy gap

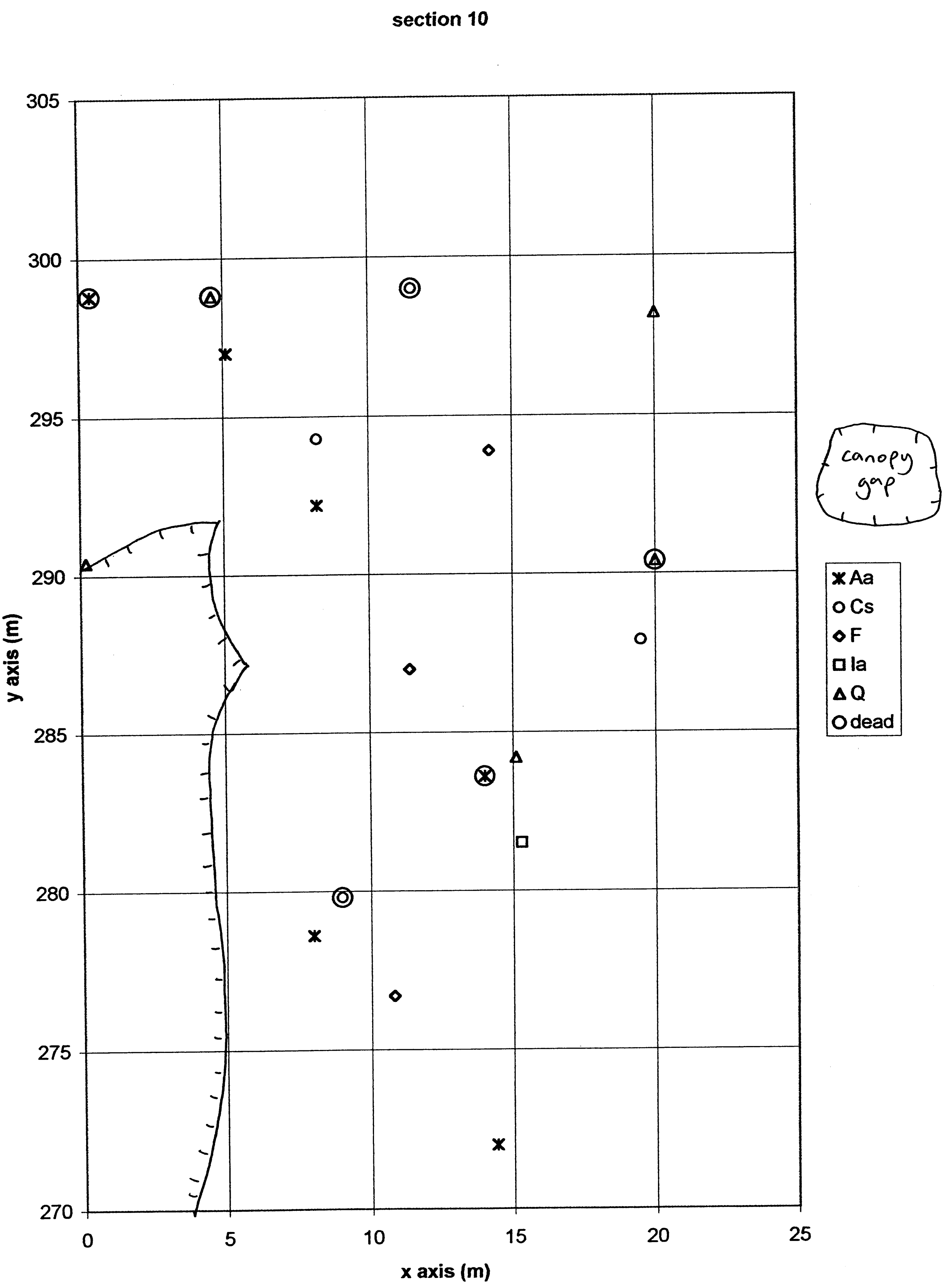
Section 9 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
210	4	9	L	17.3	240.4	Cs	1.00	255	1			270	1			C	L	M		recent branch loss windsnap	15	1.5
211	4	9	L	15.3	249.1	Cs	1.00	213	1			217	1			C	M	S			4	0.4
212	4	9	L	15.8	260.3	F	2.00	26	1			25	1			G	VS	S	0/0	bark flaking	-1	-0.1
213	4	9	L	4.7	260.9	F	2.00	129	1			131	1			C	S	P	0/0		2	0.2
214	4	9	R	12.4	243.0	F	2.00	119	1			133	1			C	S	P			14	1.4
215	4	9	R	12.4	243.0	F	2.01	62	1			65	1			SC	S	P	0/0		3	0.3
216	4	9	R	13.2	243.0	F	2.00	65	1			66	1			SC	S	M	0/0		1	0.1
217	4	9	R	17.2	243.3	F	2.00	129	1			136	1			C	S	S	1/4		7	0.7
218	4	9	R	18.6	246.0	F	2.00	80	1			87	1			SC	S	S	2/3		7	0.7
219	4	9	R	18.1	247.2	F	2.00	206	1			222	1			C	M	P	1/0		16	1.6
220	4	9	R	11.1	248.0	F	2.00	29	2	2		27	2	2	2						-2	-0.2
221	4	9	R	11.0	248.0	F	2.01	40	2	2		39	2	8	2						-1	-0.1
222	4	9	R	16.2	251.8	F	2.00	60	1			60.5				U	S	S	0/0		0.5	0.05
223	4	9	R	13.3	254.9	F	2.00	266	1			275.5	1			C	L	P	1/0		9.5	0.95
224	4	9	R	13.3	254.9	F	2.00	na			not recorded	30	1			U	S	S	0/0	trunk shoot	na	na
225	4	9	R	14.7	261.3	F	2.00	70	2			55	2	9							-15	-1.5
227	4	9	R	16.2	263.5	F	2.00	115	1			118	1			SC	S	M	0/0		3	0.3
228	4	9	R	16.3	264.7	F	2.00	43	2			41	2	2							-2	-0.2
229	4	9	R	14.0	267.6	F	2.00	100	1			105	1			C	V	S	0/0		5	0.5
230	4	9	R	11.6	269.9	F	2.00	215	1			225	1			C	L	P	0/0		10	1
231	4	9	R	18.0	270.0	Q	3.00	234	1			232	1			C	S	S		bark flaking	-2	-0.2


section 9
y axis (m)
270
265
260
255
250
245
240
235
230
0
5
10
15
20
x axis (m)
canopy gap
Cs
F
Q
dead

Section 10 Raw Data

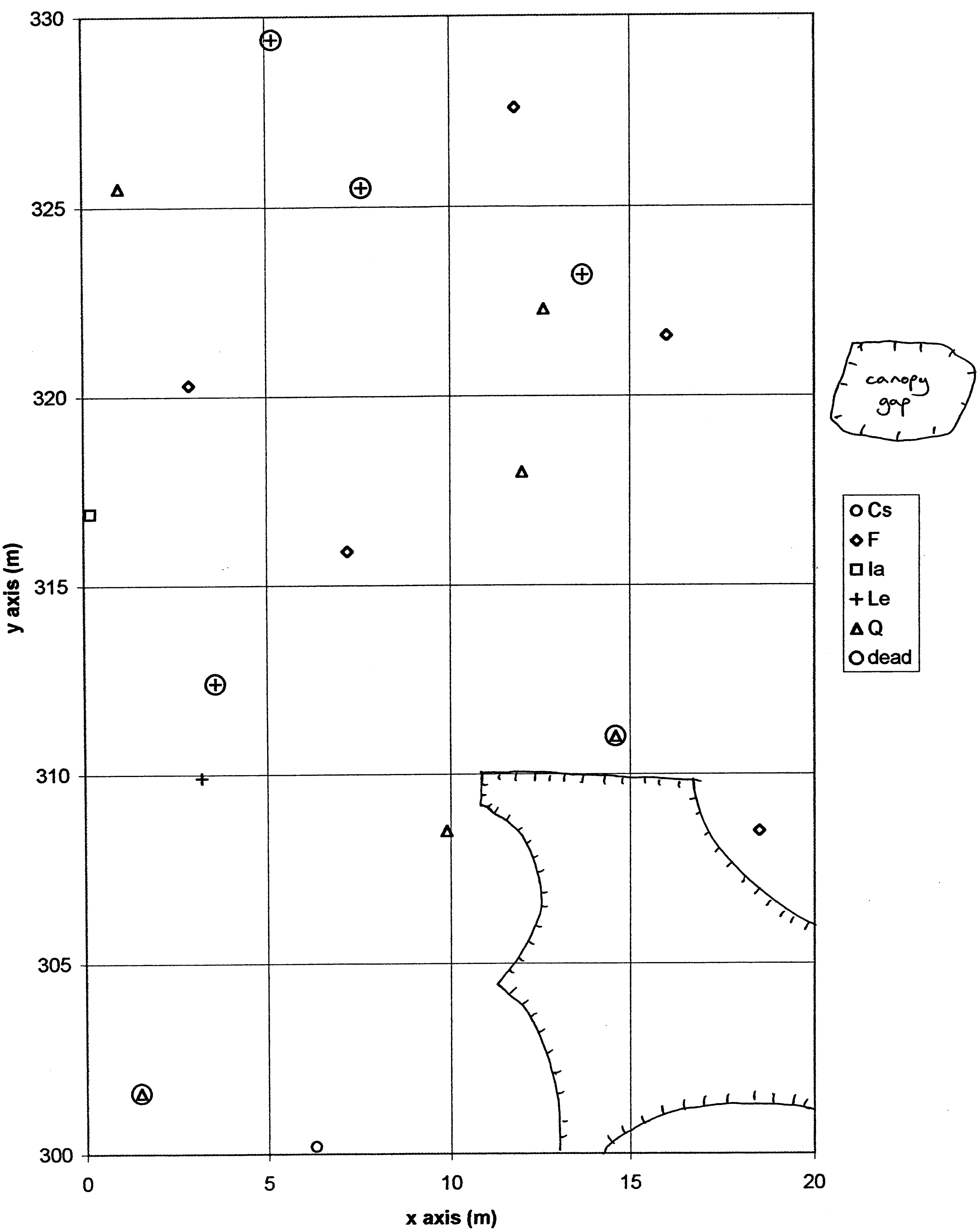
	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
232	4	10	L	14.4	272.0	Aa	7.00	248	2		error alive!	260	1			C	L	P		recorded dead in 1988	12	1.2
233	4	10	L	9.0	279.8	Cs	1.00	135	1			141	1			C	S	P			6	0.6
234	4	10	L	9.0	279.8	Cs	1.01	na				179	2	2						trunk branch	na	na
235	4	10	L	14.0	283.6	Aa	7.00	30	1			na	2							stump only	na	na
236	4	10	L	0.2	290.4	Q	3.00	130	1			129	1			SC	S	S			-1	-0.1
237	4	10	L	8.2	292.2	Aa	7.00	205	1			229	1			C	L	P			24	2.4
238	4	10	L	8.2	294.3	Cs	1.00	104	1			107	1			SC	S	M			3	0.3
239	4	10	L	5.1	297.0	Aa	7.00	64	1			65	1			U	M	M			1	0.1
240	4	10	L	8.0	278.6	Aa	7.00	na			ommitted	39	1			U	S	P	0/0		na	na
241	4	10	L	4.6	298.8	Q	3.00	64	2			62	2	9							-2	-0.2
242	4	10	L	4.6	298.8	Q	3.00	56	2			53	2	8							-3	-0.3
243	4	10	R	10.8	276.7	F	2.00	237e	1		measured at 0.6m	260	1			C	L	P	1/2	old pollard	na	na
244	4	10	R	15.3	281.5	Ia	4.00	122	1			121	1			U	M	M		trunk badly damaged	-1	-0.1
245	4	10	R	15.3	281.5	Ia	4.01	28	1			31	1			G	M	P		fork	3	0.3
246	4	10	R	15.3	281.5	Ia	4.02	na				11	1							trunk shoot	na	na
247	4	10	R	15.1	284.2	Q	3.00	122	1			123.5	1			C	S	P			1.5	0.15
248	4	10	R	19.5	287.9	Cs	1.00	167	1			176	1			C	M	P			9	0.9
249	4	10	R	11.4	287.0	F	2.00	182	1			188.5	1							description ommitted	6.5	0.65
250	4	10	R	20.0	290.4	Q	3.00	63	2			59	2	10							-4	-0.4
251	4	10	R	14.2	293.9	F	2.00	227	1			235	1			C	L	P	0/1		8	0.8
252	4	10	R	20.0	298.2	Q	3.00	241	1			250	1			C	M	S			9	0.9
253	4	10	R	0.4	298.8	Aa	7.00	133	2			130	2	8							-3	-0.3
254	4	10	R	11.5	299.0	Cs	1.00	79	2			77	2	10							-2	-0.2


section 10
y axis (m)
x axis (m)
305
300
295
290
285
280
275
270
0
5
10
15
20
25
canopy gap
Aa
Cs
F
Ia
Q
dead

Section 11 Raw Data

	1988											1998										
No	compartment	section	side	across x-axis	along y-axis	species	code	gbh	status	stool status	notes	gbh	status	snag height	stool status	canopy position	crown size	dieback	debarking	notes	change in gbh 1988-1998	ave. growth p.a. (cm) in gbh
255	4	11	L	6.3	300.2	Cs	1.00	126	1			129	1			C	VS	M			3	0.3
257	4	11	L	1.5	301.6	Q	3.00	29	2			29	2	na							0	0
258	4	11	L	9.9	308.5	Q	3.00	176	1			180	1			C	M	P			4	0.4
259	4	11	L	3.2	309.9	Le	9.00	178	1			181	1			C	M	M			3	0.3
260	4	11	L	3.6	312.4	Le	9.00	48	2			47	2	14							-1	-0.1
261	4	11	L	7.2	315.9	F	2.00	137	1			145	1			C	VS	P	0/3	3	8	0.8
262	4	11	L	0.2	316.9	Ia	4.00	91	1			93.5	1			U	M	P			2.5	0.25
263	4	11	L	2.9	320.3	F	2.00	158	1			170.5	1			C	M	P	0/1		12.5	1.25
264	4	11	L	1.0	325.5	Q	3.00	170	1			172	1			C	M	P			2	0.2
265	4	11	L	7.6	325.5	Le	9.00	98	2			97	2	25							-1	-0.1
266	4	11	L	5.2	329.4	Le	9.00	59	2			54	2	15							-5	-0.5
268	4	11	L	9.5	330.4	F	2.00	233	2		error alive!	255	1			C	L	P	0/2		22	2.2
269	4	11	R	18.5	308.5	F	2.00	100	1			111	1			SC	M	P	1/3		11	1.1
270	4	11	R	18.5	308.5	F	2.01	na	1			13	1							trunk shoot	na	na
271	4	11	R	18.5	308.5	F	2.02	na	1			11	1							trunk shoot	na	na
272	4	11	R	18.5	308.5	F	2.03	na	1			10	1							trunk shoot	na	na
273	4	11	R	14.6	311.0	Q	3.00	154	1			146	2	5							-8	-0.8
274	4	11	R	12.0	318.0	Q	3.00	203	1			203	1			SC	S	VS			0	0
275	4	11	R	16.0	321.6	F	2.00	360 E	1		error	352.5	1			C	L	P	1/1	3 forked	na	na
276	4	11	R	12.6	322.3	Q	3.00	109	1			115	1			C	VS	P	0/1		6	0.6
277	4	11	R	13.7	323.2	Le	9.00	22	2			22	2	4							0	0
278	4	11	R	11.8	327.6	F	2.00	134	1			137	1			C	S	P	0/0		3	0.3

section 11



330
325
320
315
310
305
300
y axis (m)
0
5
10
15
20
x axis (m)
canopy gap
Cs
F
Ia
Le
Q
dead

Appendix 8. Fallen deadwood survey data

Line transect method for assessing fallen dead wood volume.

- The method used was stratified random sampling based on Kirby (pers. comm.).
- The survey was based on English Nature compartments, conducted within compartment 2, 4 and 8 being the compartments that the belt transects passes through.
- A minimum of 5 samples must be taken in each strata (compartment).
- Starting point were allocated within the compartment by the use of random numbers to avoid bias.
- At each starting point the bearing to be followed was taken from the following list:

240	130	300
310	180	170
260	270	
280	70	
90	40	
350	170	
190		

The first bearing was taken from the list at random, subsequent bearings were then taken from the list in sequence.

- The transect was then marked out along this bearing for a length of 25m using a measuring tape and a compass, two operatives made this process far easier.
- If the transect is dangerous or impossible (and only in htese cases) to follow, e.g. it goes over a cliff, the procedure should be repeated to find a new sample.
- Note any piece of dead wood, however short, that is crossed by the line, provided that the line crosses the central axis of the piece of wood and itt diameter is greater than 5cm at the point iof intersection.
- Measure and record the diameter of the piece of wood where it crosses the line. The recording need not be exact since the diameters will later be sorted into broad classes. If the line crosses the same piece of wood morew than once each crossing should be recorded as a separate piece of wood.
- If the wood is very decayed and disintegrated as estimate of the diameter of the wood will be acceptable.
- If possible identify the species of wood, observations of the surrounding trees may help to identify where the fallen wood originated from.
- Record each line sample separately.
- The data can now be sorted into 5cm size classes.
  5-9.9; 10-14.9; 15-19.9; 20-24.9; 25-29.9; 30-34.9; 35-39.9.
- The total length of dead wood per hectare in m^3 (L) can be estimated using the following equation:
  $L=\pi 10^4 N(2t)^{-1}$
  Where N is the number of intersection, and t is the total length of the transect, i.e. the number of sample lines multiplied by the length of the line.

- The volume of dead wood per hectare in m3 (V) can be estimated by the following equation, this calculation must be performed for each diameter class separately and then totalled:
  $V=nd^2\pi^2 10^4(8t)^{-1}$
  where d is the mid point diameter for the diameter class in question, n is the number of intersection for logs of diameter class d, and t is the total length of transect as before.

Compartment 4 Fallen dead wood data

Oak

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	6	4	0	0	0	0	0
Volume m^3ha^{-1}	2.77	5.14	0	0	0	0	0
						total	$7.91m^3ha^{-1}$

Beech

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	6	2	0	0	1	0	1
Volume m^3ha^{-1}	2.77	2.57	0	0	6.22	0	11.56
						total	$23.12m^3ha^{-1}$

Silver fir

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	3	0	0	0	0	0	0
Volume m^3ha^{-1}	1.39	0	0	0	0	0	0
						total	$1.39m^3ha^{-1}$

Sweet chestnut

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	0	0	1	0	0	0	1
Volume m^3ha^{-1}	0	0	2.52	0	0	0	11.56
						total	$14.08m^3ha^{-1}$

Larch

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	1	1	1	0	0	0	0
Volume m^3ha^{-1}	0.46	1.28	2.52	0	0	0	0
						total	$4.26m^3ha^{-1}$

Comp 4 TOTAL $50.76m^3ha^{-1}$

Compartment 2 Fallen dead wood data

Oak

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	7	3	4	1	0	0	0
Volume m^3ha^{-1}	3.24	3.85	10.07	4.16	0	0	0
						total	21.32m^3ha^{-1}

Beech

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	15	2	2	0	0	0	0
Volume m^3ha^{-1}	6.94	2.57	5.03	0	0	0	0
						total	14.54m^3ha^{-1}

Comp 2 TOTAL 35.86m^3ha^{-1}

Compartment 8 Fallen dead wood data

Oak

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	5	3	2	2	0	0	0
Volume m^3ha^{-1}	2.31	3.85	5.03	8.32	0	0	0
						total	19.52m^3ha^{-1}

Beech

Diameter Class (cm)	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9
No. Of logs	9	6	1	0	0	0	0
Volume m^3ha^{-1}	4.16	7.71	2.52	0	0	0	0
						total	14.39m^3ha^{-1}

Comp 8 TOTAL 33.91m^3ha^{-1}

Appendix 9. Method for Girthing Trees (adapted from Hamilton 1975)

- Ensure that girth is measured at 1.3m above ground level i.e. breast height.
- Measure perpendicular to the longitudinal axis of the stem
- If the ground is sloping measure at 1.3m above ground level on the upslope side of the tree.
- On leaning trees where ground is level measure at 1.3m (on the underside of the tree) from ground level.
- If a swelling occurs at breat height measure the girth below the swelling where the girth is smallest.
- All forks below 1.3m should be treated as separate stems.
- Where the stem forks at 1.3m the girth should be measured below the fork where the girth is smallest.
- Coppice stems should be measured at 1.3m above ground level not above stool height.
- Measurements should be rounded down to the nearest whole cm.
- The girthing tape should not be pressed into concave portions of the trunk but held without slack around the trunk.

Appendix 10. Squirrel damage raw data summary

Squirrel damage below 2m by category and size class

	Number of stems in category				
Size Class dbh (cm)	No damage	<10%	10-50%	>50%	ring barked
<5	12	8	2	0	4
5-9.9	4	1	1	4	3
10-19.9	5	0	0	3	1
20-29.9	11	7	1	0	0
30-39.9	12	5	0	0	0
40-49.9	13	2	1	0	0
50-59.9	10	4	0	0	0
60-69.9	9	0	0	0	0
70-79.9	5	1	0	0	0
80-89.9	1	2	0	0	0
90-99.9	1	0	0	0	0
100-109.9	0	0	0	0	0
110-119.9	0	1	0	0	0
120-130	1	0	0	0	0

Squirrel damage above 2m by category and size class

	Number of stems in category				
Size Class dbh (cm)	No damage	<10%	10-50%	>50%	ring barked
<5	19	2	0	0	3
5-9.9	5	3	2	1	1
10-19.9	5	1	0	1	1
20-29.9	4	4	1	8	1
30-39.9	6	4	1	4	0
40-49.9	5	3	4	3	1
50-59.9	3	3	7	0	0
60-69.9	5	0	0	1	0
70-79.9	3	3	0	0	0
80-89.9	1	0	2	0	0
90-99.9	0	1	0	0	0
100-109.9	0	0	0	0	0
110-119.9	0	1	0	0	0
120-130	0	0	0	1	0

Appendix 11. Species composition raw data summary

		Species							
		A.alba	*B.pub*	*C.sativa*	*F.sylvatica*	*I.aquifolium*	*L.europea*	*Q.robur*	*S.aucuparia*
Stem numbers in transect	1988	5	3	9	123	18	3	25	6
	1998	5	3	9	139	21	2	25	6

Appendix 12. Size class distribution raw data summary

	Stem numbers	
Size Class dbh (cm)	1988	1998
<5	6	16
5-9.9	11	13
10-19.9	15	17
20-29.9	34	31
30-39.9	21	21
40-49.9	22	22
50-59.9	20	11
60-69.9	10	10
70-79.9	7	11
80-89.9	3	3
90-99.9	0	1
100-109.9	1	0
110-119.9	0	1

Appendix 13. Grazing plots raw data

Seedling numbers in plot A1 (ungrazed)

		Seedling numbers			
		1976	1982	1988	1995
Species	Holly	66	269	278	592
	Sycamore	1	0	11	16
	Beech	0	4	7	48
	Ash	0	1	0	0

Seedling numbers in plot A2 (grazed)

		Seedling numbers			
		1976	1982	1988	1995
Species	Holly	45	199	266	432
	Sycamore	1	0	11	0
	Beech	0	4	7	0
	Ash	0	1	0	0

Seedling numbers in plot D1 (ungrazed)

		Seedling numbers			
		1976	1982	1988	1995
Species	Holly	55	521	338	480
	Beech	0	11	3532	4464
	Rowan	0	0	0	0
	S. Chestnut	0	0	0	0

Seedling numbers in plot D2 (grazed)

		Seedling numbers			
		1976	1982	1988	1995
Species	Holly	47	246	243	432
	Beech	3	50	41	96
	Rowan	1	0	0	0
	S.Chestnut	4	0	0	0

Appendix 14. NVC classification

The MATCH program (University of Lancaster 1994) was utilised to produce an NVC classification for the transect data collected as part of the field survey. The results of hte computer analysis i.e. the best 10 matches, are given below.

Match	Community	Coefficient
1	W15	49.9%
2	W15c	49.8%
3	W15b	47.7%
4	W15d	43.6%
5	W15a	36.8%
6	W16	35.3%
7	W10d	35.1%
8	W17c	33.7%
9	W14	33.5%
10	W17	33.4%

It can be seen from the data that the most likely community is W15.