Progress Report on the Transect Study of Topography, Exposure, Disturbance and Forest Composition in the Harvard Tract, Pisgah State Park, New Hamshire

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Abstract

A 10 m wide x 300 m long transect was run over a ridge in the Harvard Tract to document wind damage due to a severe hurricane in 1938 and to determine if there were any significant relationships between wind disturbance, topography and exposure and community composition, structure and development. I found approximately 1800 m^3/ha of downed wood on the transect. Windthrows accounted for 48% of downed stems, and 62% of the stems were oriented between 260° and 350° roughly aligned with the wind direction of the 1938 hurricane. *Acer* and *Betula* dominated the upper exposed slopes where there was more downed wood and a higher total density of trees. *Tsuga* and *Fagus* were more abundant on low to mid slopes where there was less downed wood and greater total basal area. Understory floristics also coincided with topographic and downed wood patterns. Further research is planned to determine effects of disturbance and topography on age structure and to document past vegetation and reproduction through vegetation reconstruction and seed bank analysis.

Introduction

The effects of disturbance on community composition and structure have been documented throughout most of North America (Sousa 1984, White 1979). Most work on vegetation has been concerned with regional fire and wind disturbance (eg: Heinsleman 1973, Bormann and Likens 1979, Canham and Loucks 1984) although several authors have addressed wind-caused disturbance on a landscape level, (Gratkowski 1956, Reiners and Reiners 1965, White 1976). Researchers generally agree that topography and exposure can affect wind damage and thus community composition and structure, but it is difficult to document this in a concrete way. Study plots placed at different positions in different areas can confound variables such as moisture and temperature regimes, topography, soils, local variation in wind patterns and random variation of vegetation. This study addresses these problems by limiting the study area in the Harvard Tract of Pisgah State Park, New Hamshire, to a 10 x 300 m transect running from a low protected east slope, up an exposed ridge and down its western flank to another relatively protected area. The purpose of this research is to document wind damage due to a severe hurricane in 1938 and to determine if there are any significant relationships between wind disturbance, topography and exposure and community composition, structure and development. The study complements previous work carried out at the Harvard Tract (Spurr and Cline 1942, Henry and Swann 1974) and will draw upon detailed forest records for comparisons of vegetation before and after the hurricane of 1938. This work is part of an extensive survey of present vegetation and past forest records (Foster unpub.) that documents past disturbance and forest development in Pisgah State Park over the last 300 years.

Methods

A 10 m wide x 300 m long transect was established running east - west across the Harvard Tract, and was divided into thirty 10 x 10 m plots (fig. 1). Within each plot, all downed wood over 10 cm dia. at the base was measured. All trees over 2 cm dbh were measured, and cover estimates based on the Braun- Blanquet scale were assigned to herbs and shrubs. I also made a sketch of the topography of each plot and estimated plot landscape and canopy heterogeneity on a relative 0 - 10 scale. These data were analyzed to estimate basal area, density, species richness, understory cover and downed wood volume, decay class and orientation.

Further field work will involve determination of age structure by coring trees on five 5 x 20 m plots, seed propagule and soil sampling in thirty .5 m^2 plots (fig. 1) and the relocation and resampling of a similar transect run in 1948 by Smith and Scudder.

Preliminary Results and Discussion

Downed wood

An average of 1800 m^3/ha of downed wood is about equally divided into decay classes 2 (46%) and 3 (51%) with very little in decay class 1 (2%). Sixty two percent of the stems are oriented between 260° and 350°. Of 162 stems counted 77 (48%) are windthrows, 41 (25%) are snapped and 44 (27%) are of unknown origin. I classified the transect into four different areas of disturbance based on downed wood volume and orientation (figs. 2-3):

1) Lower east slope, very little downed wood, stems randomly oriented.
2) Upper east slope, moderate to large amounts of downed wood with a large proportion of stems oriented NW.
3) Upper west slope, largest volume of downed wood, stems mostly windthrown (74%) pointing to the W, WNW and NNW.
4) Lower east slope, moderate to large amounts of downed wood, orientation to WNW and NNW.

west?

There are at least two points to bear in mind when infering disturbance from these amounts of downed wood. First, volume of downed wood depends on the volume and the decay resistance of the species present during the disturbance. Second, the transect appears to miss much of the downed wood on the upper east slope, so those figures may be low.

Also, biomass may not be distributed uniformly along the transect. Does residual stand on l. east slope indicate that indicate that it was comparable to former stands up slope? (compare figs. 2-7 to fig. 5)

Vegetation Patterns

Total basal area (BA) is 29.2 m^2/ha and total density is 2650 stems/ha (table 1). *Tsuga canadensis* accounts for almost 1/2 of total BA and roughly 1/3 of total density. *Acer rubrum* is the next most dominant species followed by *Fagus grandifolia*, *Betula lenta* and *Betula papyrifera* (table 1, fig. 4).

Total BA and BA relative to density are higher on the low slopes and decrease toward the upper slopes on both sides of the ridge (fig. 4), but total BA does not appear to be correlated with downed wood (fig. 5). Hardwoods account for more than 50% of BA on the lower east slope where large *Fraxinus* individuals occur and on the upper west slope where *Acer rubrum*, *Betula lenta*, and *B. papyrifera* combine for a large BA due to their high density (figs. 4,6,7). Relative percent BA of *Tsuga* appears to decline with increasing downed wood on upper slopes possibly because the severity of the 1938 hurricane killed rather than released *Tsuga*, allowing hardwoods especially *Betula* to colonize tip-up mounds and mineral soil (fig. 8). Rel % BA of *Tsuga* peaks at mid-slope on the eastern side of the transect and at the west end of the transect, both areas of moderate woody debris. There does not appear to be any correlation between relative percent BA of *Tsuga* and downed wood on the lower slopes (fig. 8).

Density is positively correlated with downed wood (fig. 5). Total density rises dramatically at upper slope plots on the east and especially west sides of the transect, roughly in the area of maximum downed wood. *Acer* and *Betula* account for most of the stems on the upper slopes while *Tsuga* and *Fagus* have proportionately more stems in lower areas.

Species richness and combined herb, shrub and seedling cover are both highest on the low moist eastern plots but also peak at the 100 m and 230 m plots (figs. 9,10). Both measures appear to increase with increasing landscape and overstory heterogeneity (fig. 11). This may be due to an increase in the number of niches available in a more diverse landscape. Overstory heterogeneity also increases with landscape diversity, but it is not certain whether this is a reliable observation, or due to subjective estimation of overstory heterogeneity.

Floristic Patterns

I divided the transect into three loosely defined floristic zones based on tree and understory species occurances (fig. 12). These zones coincide roughly with the areas of disturbance based on woody debris.

1) Lower east slope with character species *Carex pensylvanicum*, *Dryopteris marginalis* and *Polystichum acrostichoides*, and differential species *Dryopteris spinulosa* and *Fagus grandifolia*. Five species occur only on the lowest three plots: *Fraxinus americana*, *Acer saccharum*, *Acer pensylvanicum*, *Arisama triphillum* and *Viola blanda*.
2) Upper east and west slopes with character species *Vaccinum angustifolium*, *Trillium undulatum* and *Aralia nudacaulis*. *Fagus grandifolia* is all but absent and *Tsuga canadensis* is not so abundant as on low slopes.

Maianthamum canadense, Polypodium vulgare and Dryopteris spinulosa do not occur on the upper west slope of the hill where as Betula papyrifera occurs only on the west slopes suggesting that upper east and west slopes could be separated into distinct zones.

3) Lower west slope with character species Betula lutea, Aster acuminatus, Mitchella repens, Viburnum alnifolium and Athyrium Felix-femina. Dryopteris spinulosa appears again, having dropped out on the upper west slope. Fagus is present here and on the lower east slope. Betula papyrifera occurs here and on the upper west slope.

Although I have found broad relationships between downed wood, topography, exposure and vegetation structure and distribution, I have not found significant relationships among other variables. Some of these are:

- slope angle vs. species composition, BA and density;
- downed wood vs. species richness, BA and %Tsuga density;
- landscape heterogeneity vs. BA and density;

There are many relationships yet to be examined.

Further Research

This research should be extended by investigating changes at the population as well as the community level and should include a thorough computer analysis of all variables. At the population level, the effects of disturbance on age structure as mediated by topography and exposure could be examined by coring trees in areas that differ in amounts of downed wood and forest structure and composition. I suggest a sampling scheme of 5 x 20 m sub-plots placed in the following contiguous plots: 30 - 40 m, 130 - 140 m, 180 - 190 m, 80 - 90 m, 270 - 280 m. This scheme covers a maximum number of plots and variation with a reasonable sample size. In addition to determining age structure, seeds and propagules should be collected in 30 1/2 meter sub-plots, one per each transect plot, to determine reproduction, dispersal and possibly document past community composition. Soil characteristics and differences could also be examined in these samples.

At the community level several approaches should be pursued. Tree ring samples collected for age structure determination can also be used to estimate growth rates of trees and levels of disturbance on different sites and so may provide a means of estimating pre-hurricane basal area and density if combined with downed wood estimates. As mentioned earlier seed and propagule composition could be compared to past and present vegetation. The analysis of all the above data would benefit from a comparison with data collected from a similar (though smaller) transect by Smith and Scudder in 1948. This should include an attempt to relocate and resample Smith and Scudder's transect. Resampling this transect would not only document vegetation change more directly, but would also add more comparative data to the present vegetation work being done on the Harvard Tract.

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TABLE 1

1984 Pisgah Transect

Density 2650 stems/ha   Basal Area: 29.2 m^2/ha

	Relative Density:	Relative BA:
Tsuga canadensis	.31	.46
Fagus granifolia	.12	.14
Betula lenta	.17	.10
B. papyrifera	.08	.07
B. lutea	.01	.01
Acer rubrum	.26	.16
Acer saccharum	.01	<.01
Fraxinus americana	.01	.06
Quercus borealis	<.01	<<.01
Betula niger	<.01	<<.01
Picea rubens	<.01	<<.01
Pinus strobus	<.01	<<.01

Sampling Scheme · Harvard Tract Transect

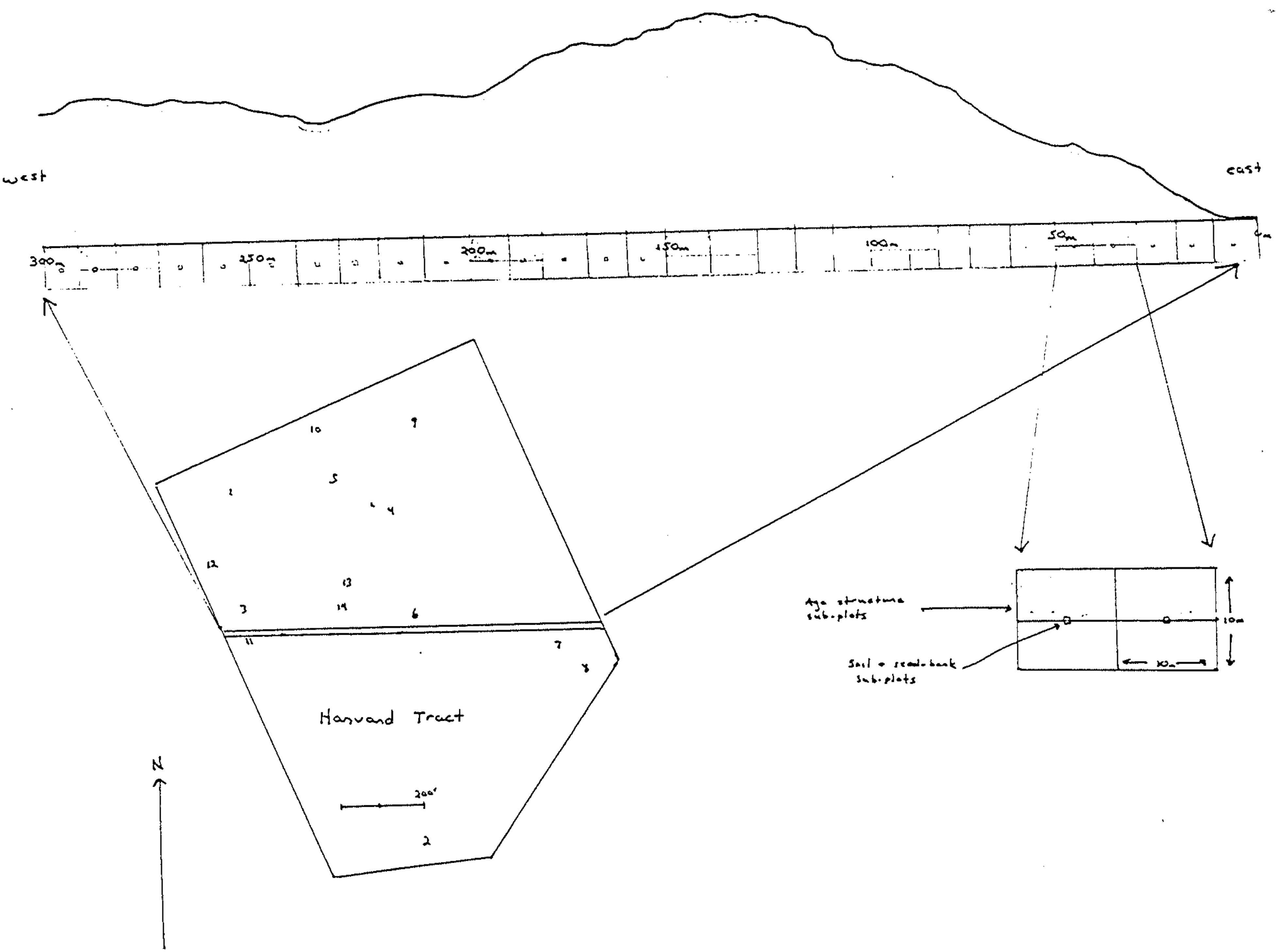
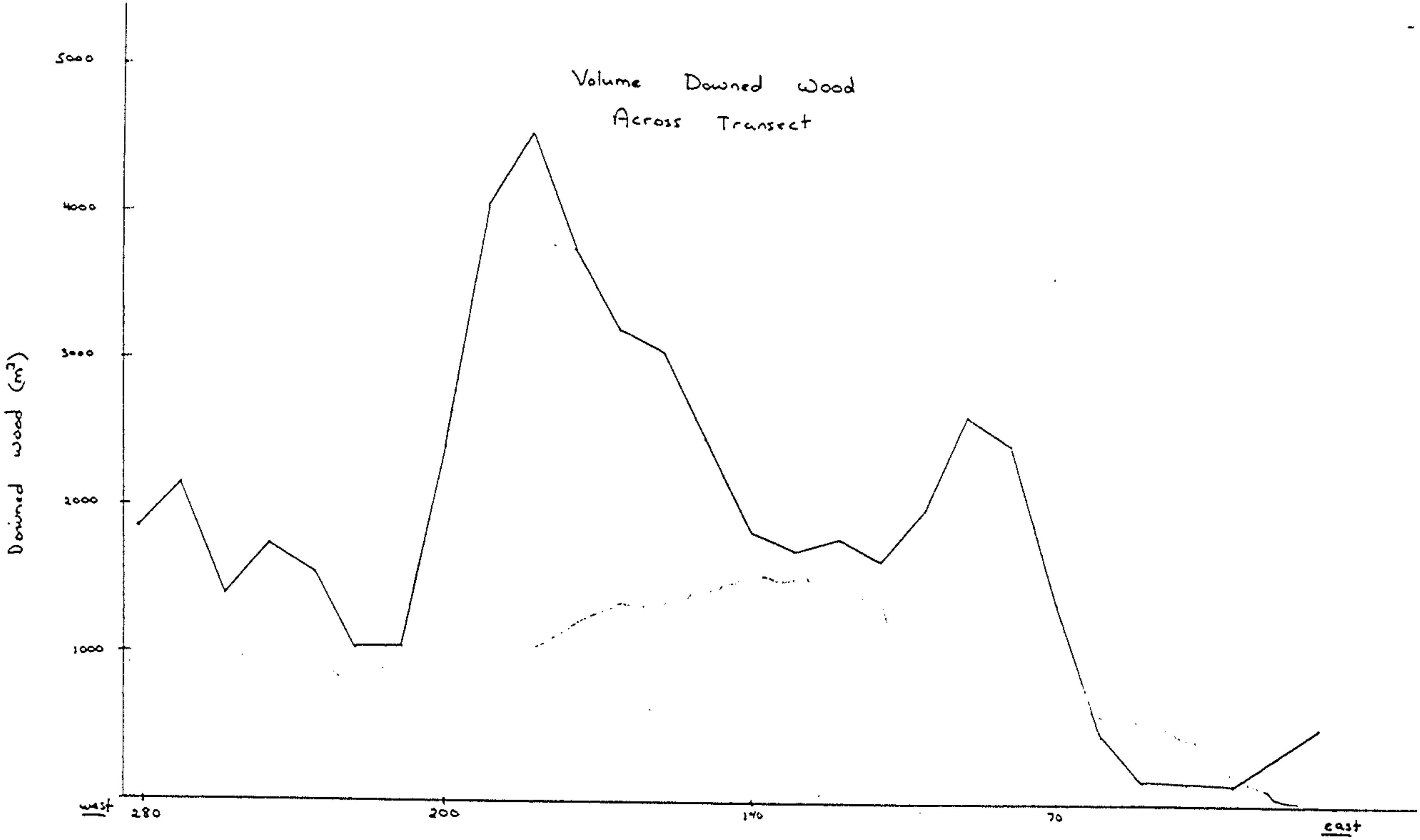


fig 1

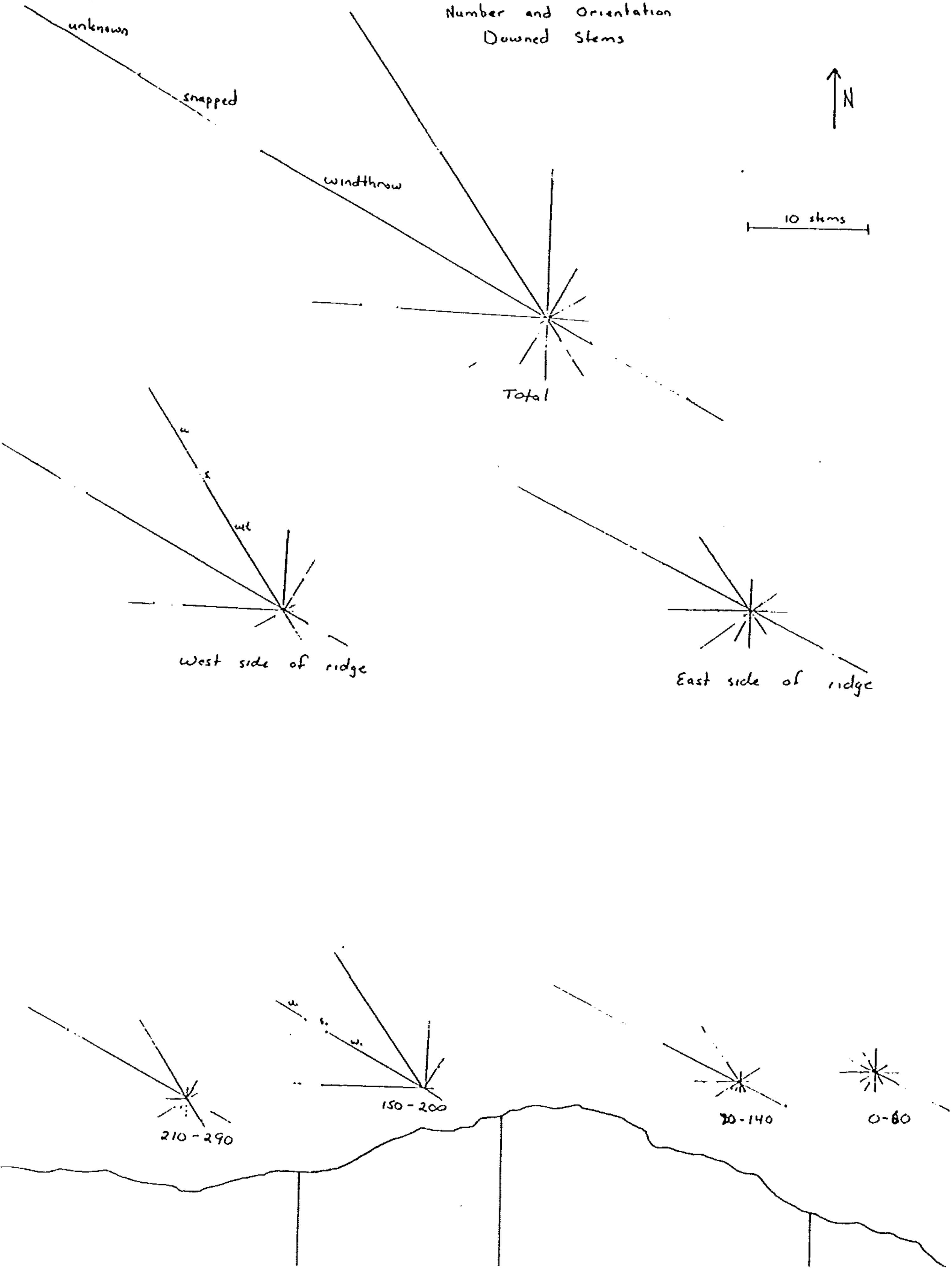
Fig 2



Volume Downed Wood
Across Transect
Downed wood (m³)
5000
4000
3000
2000
1000
west
280
200
140
70
east

fig 3

Number and Orientation
Downed Stems



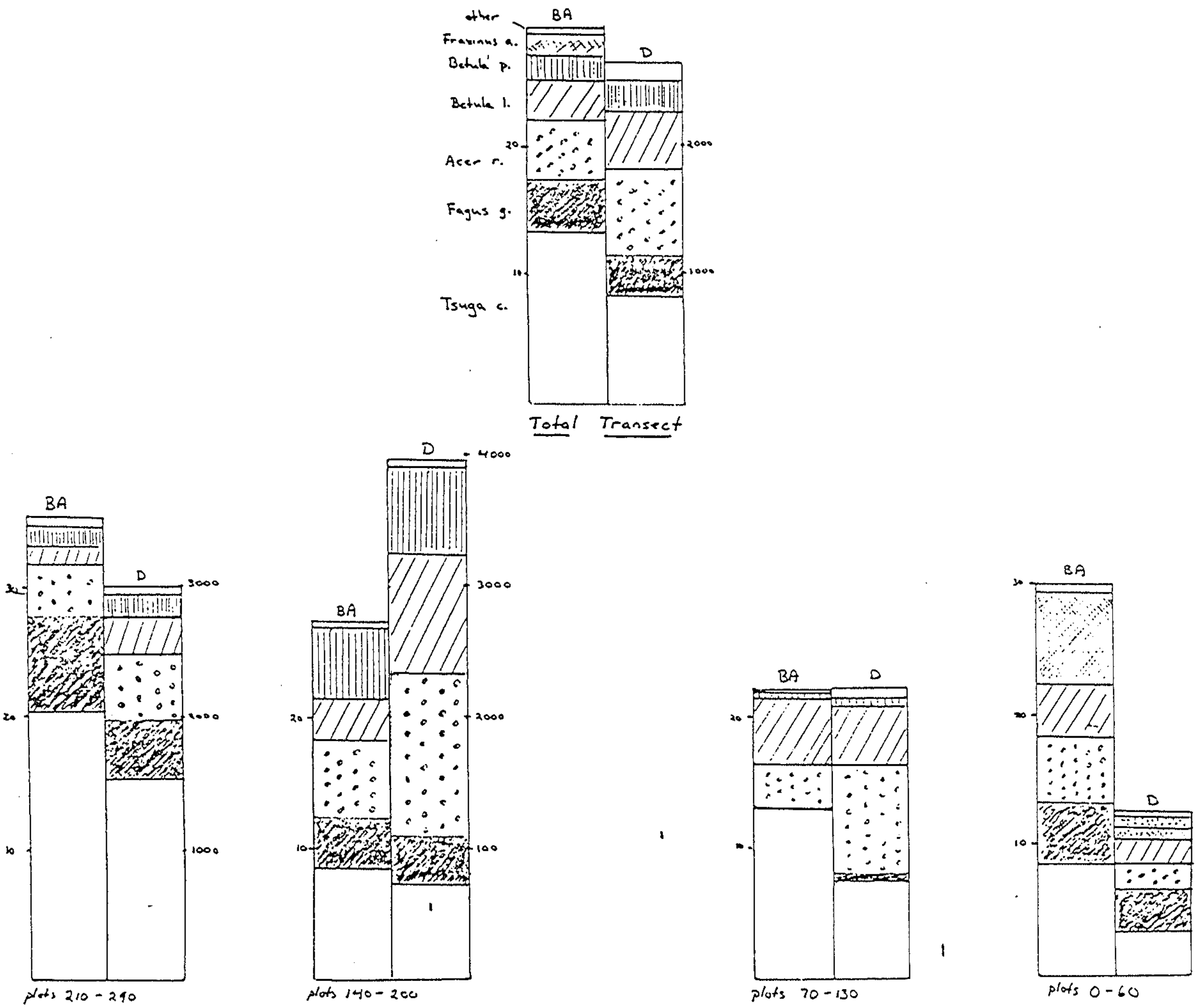

other
Fraxinus a.
Betula p.
Betula l.
Acer r.
Fagus g.
Tsuga c.
BA
D
Total Transect
plots 210 - 240
plots 140 - 200
plots 70 - 130
plots 0 - 60
1000
2000
3000
4000

fig 4

Density (top) and Basal Area (bottom)
vs
Downed Wood

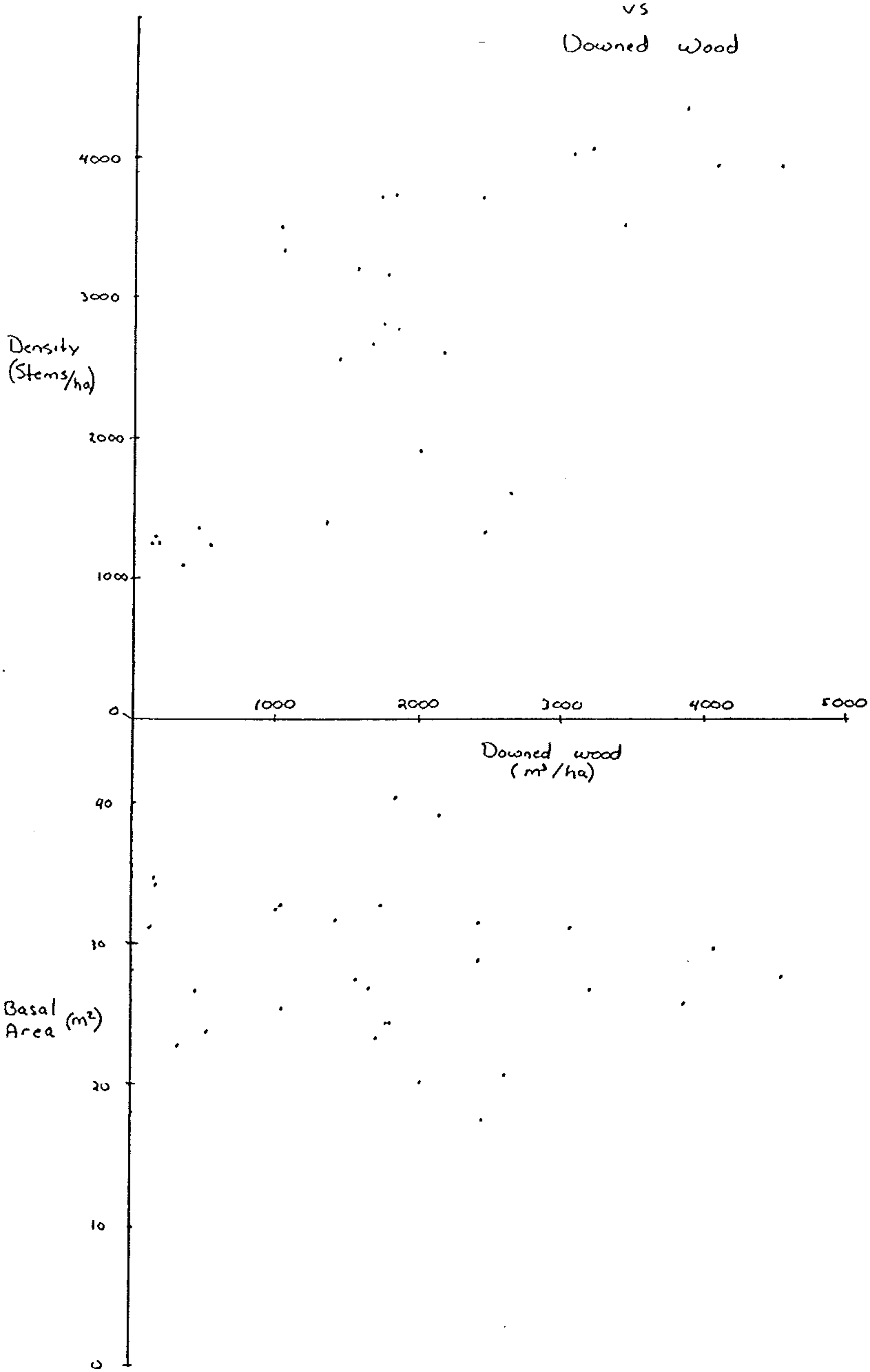
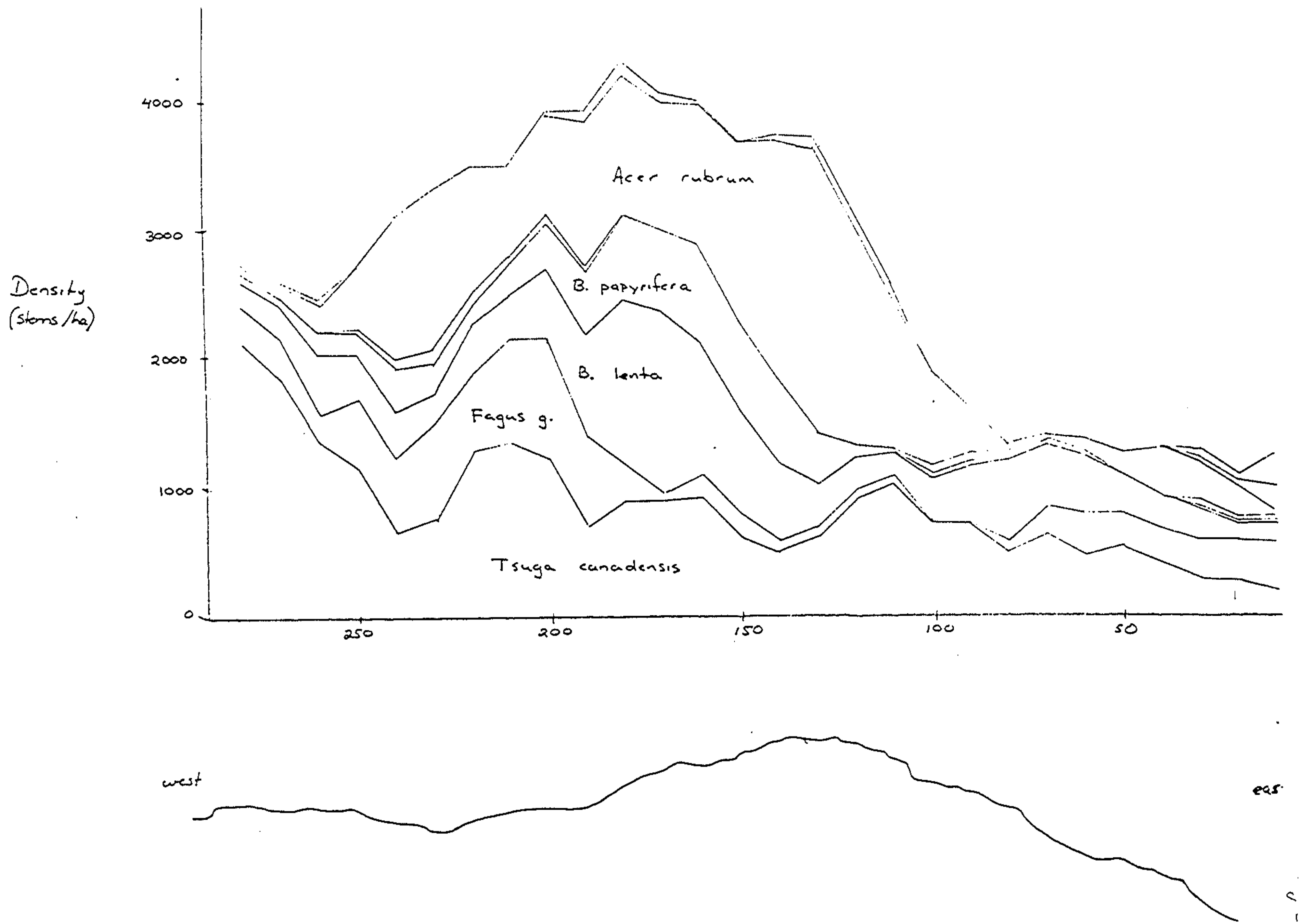


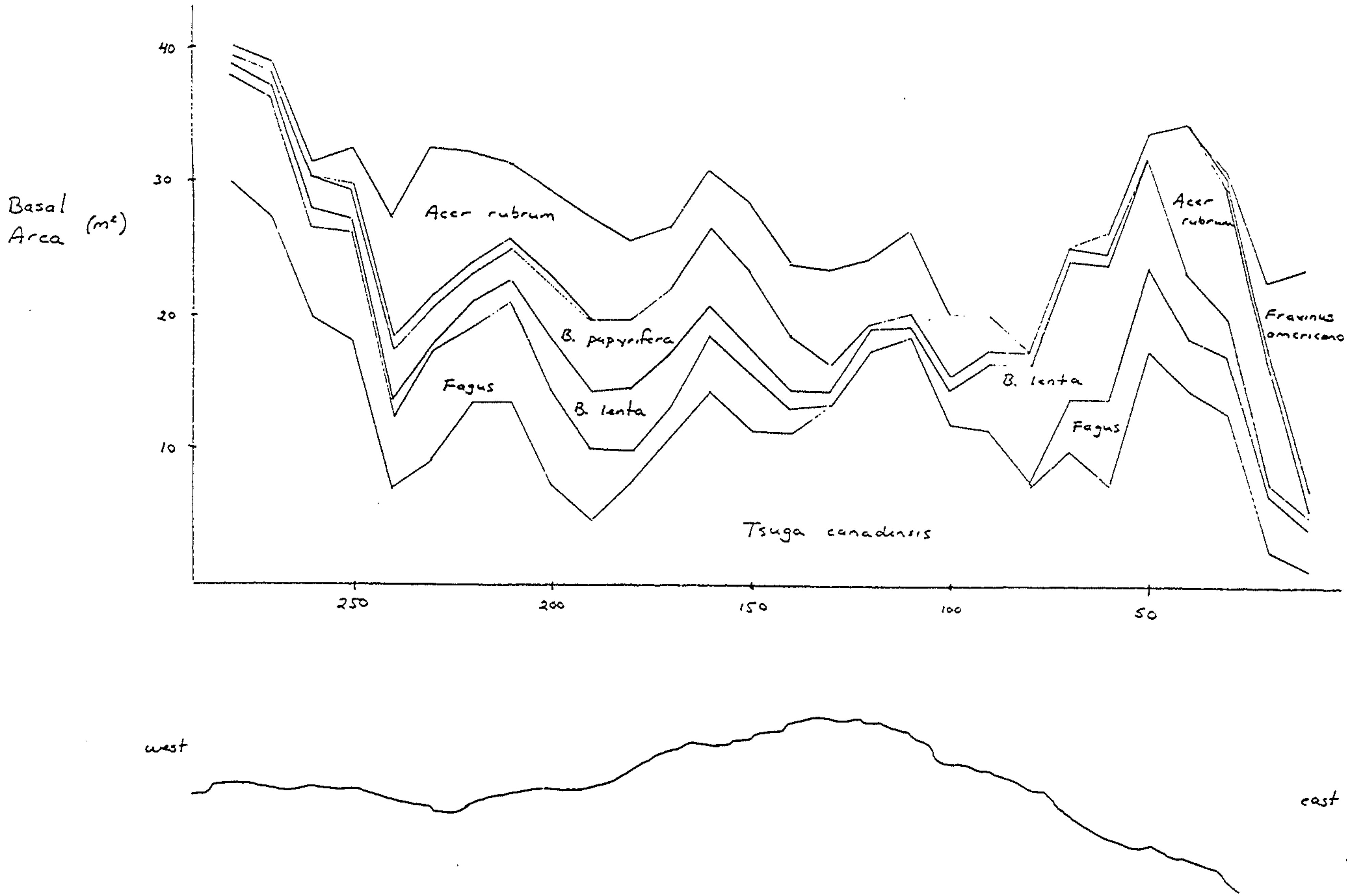
Fig 1

Density (running mean) Across Transect

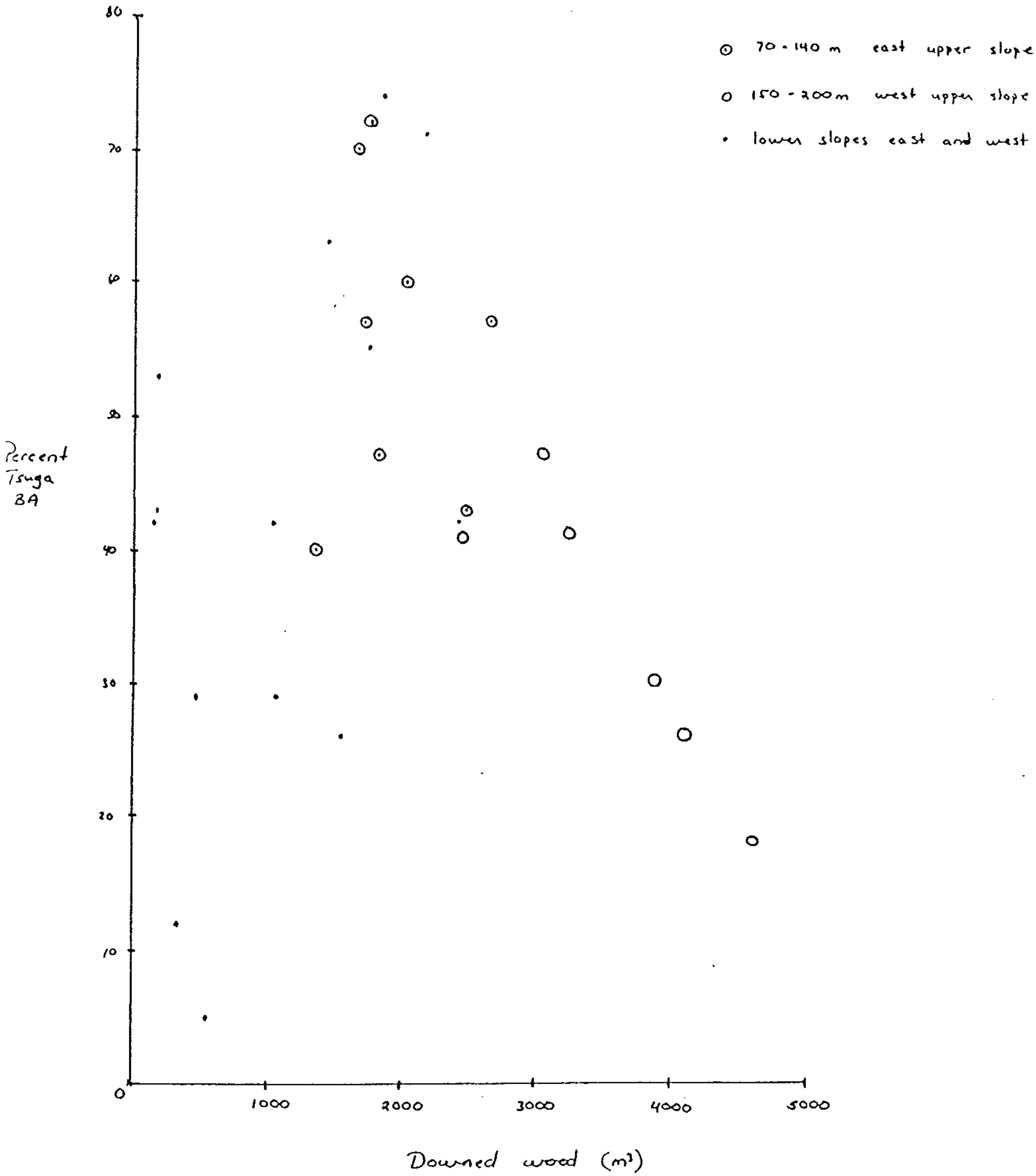


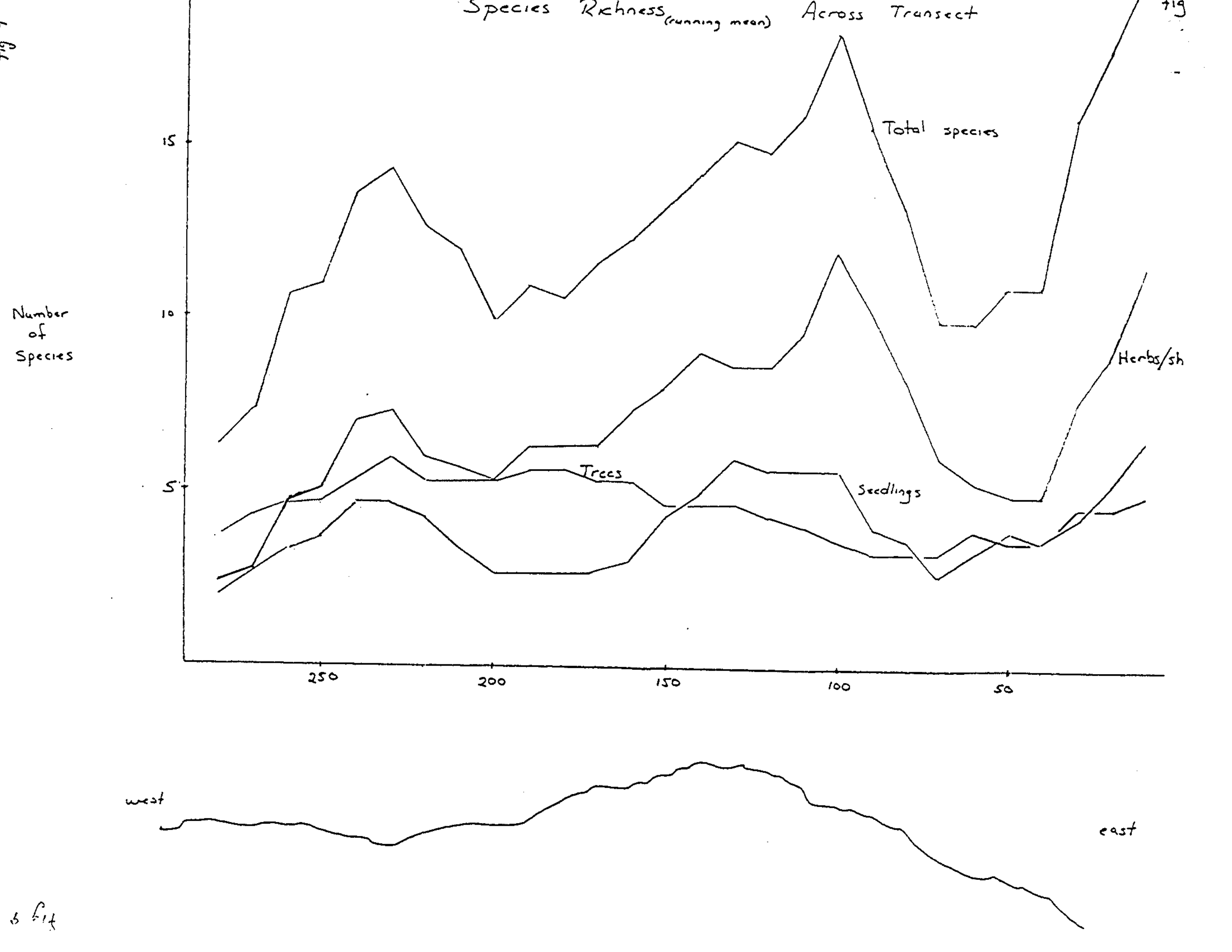
[rolling Average?]

Basal Area (running mean) Across Transect



Percent Tsuga BA (r.m.) vs. Downed wood





Species Richness (running mean) Across Transect
Number of Species
15
10
5
250
200
150
100
50
Total species
Herbs/sh
Trees
Seedlings
west
east

cumulative?

Herb/shrub and seedling cover
(Σ Braun-Blanquet cover values)

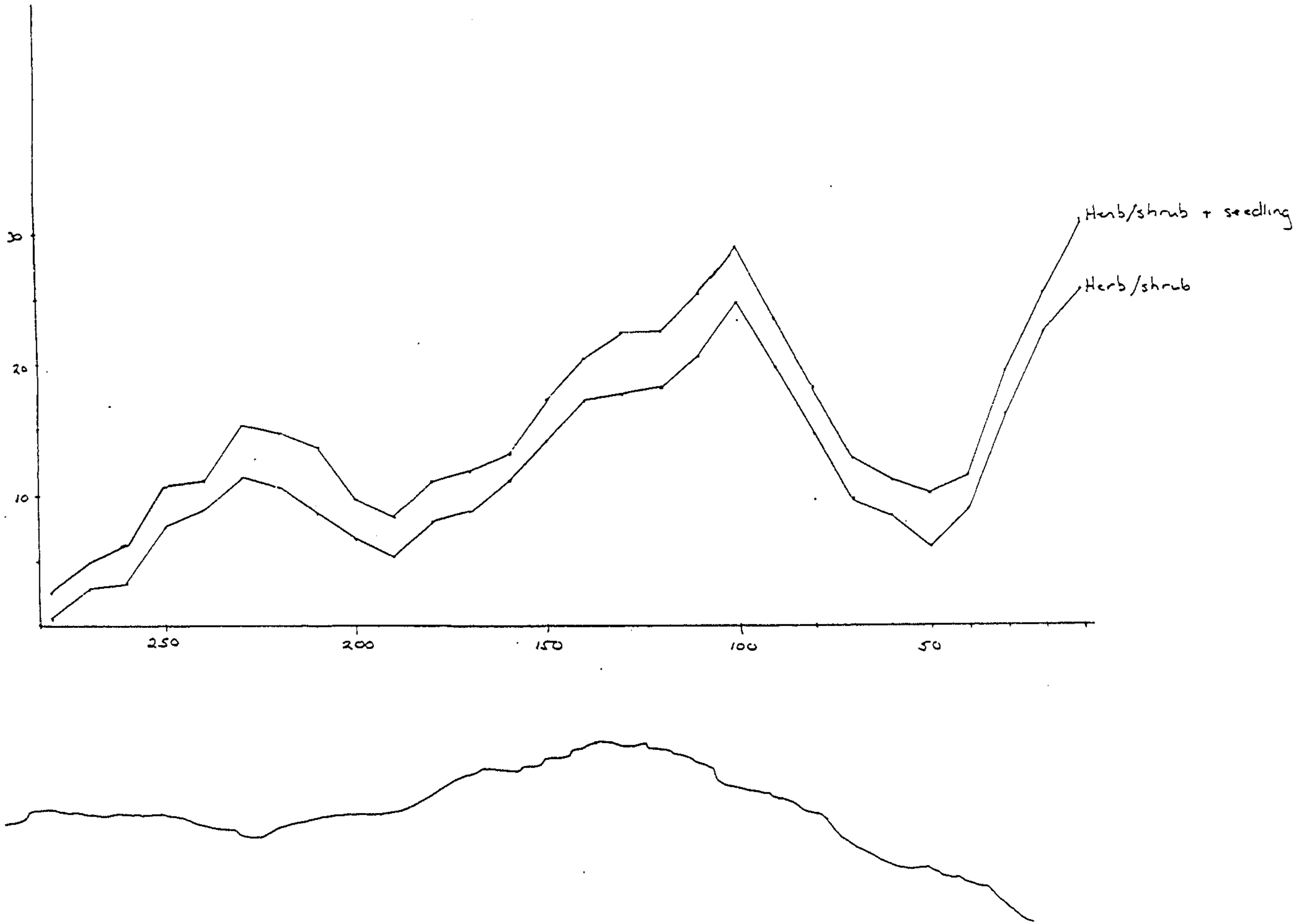
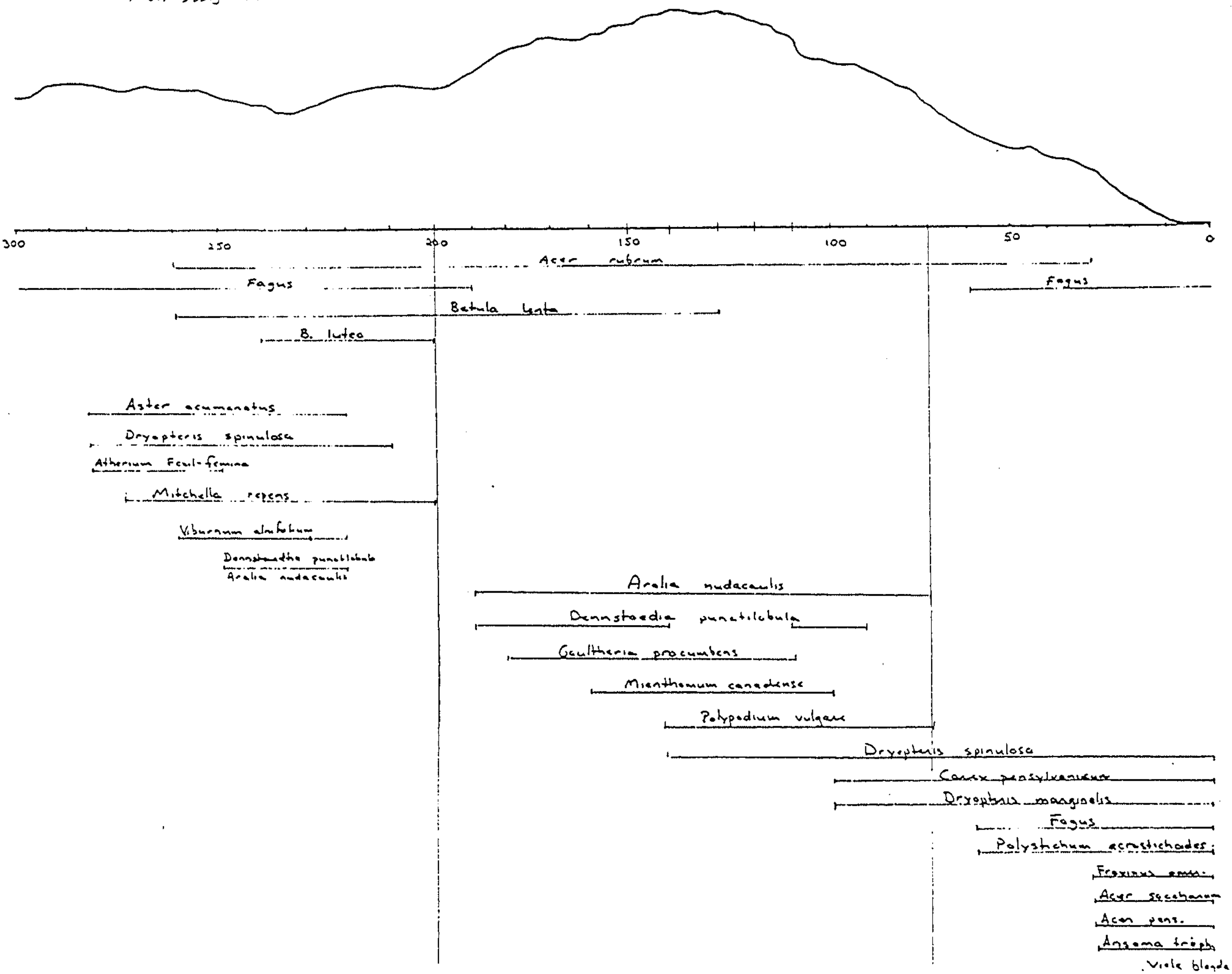
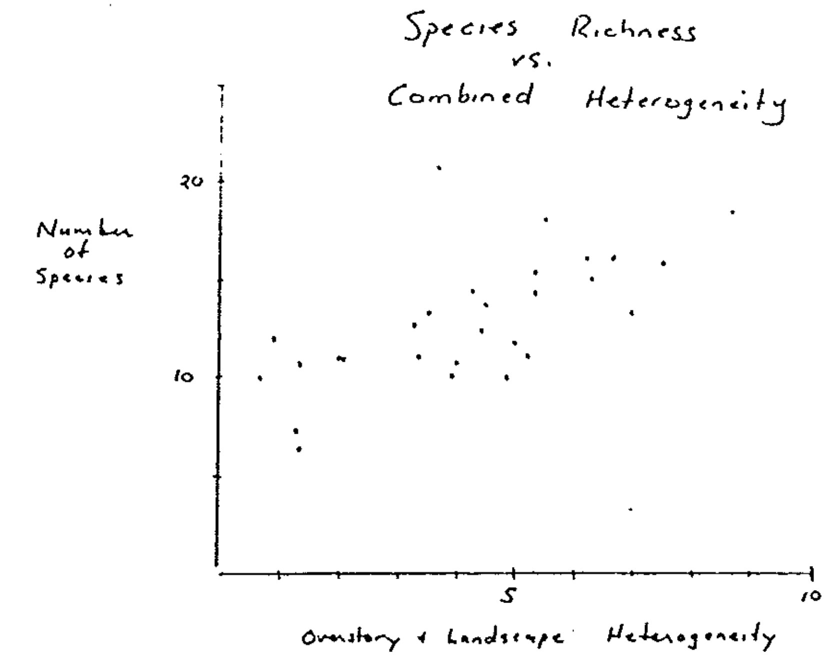
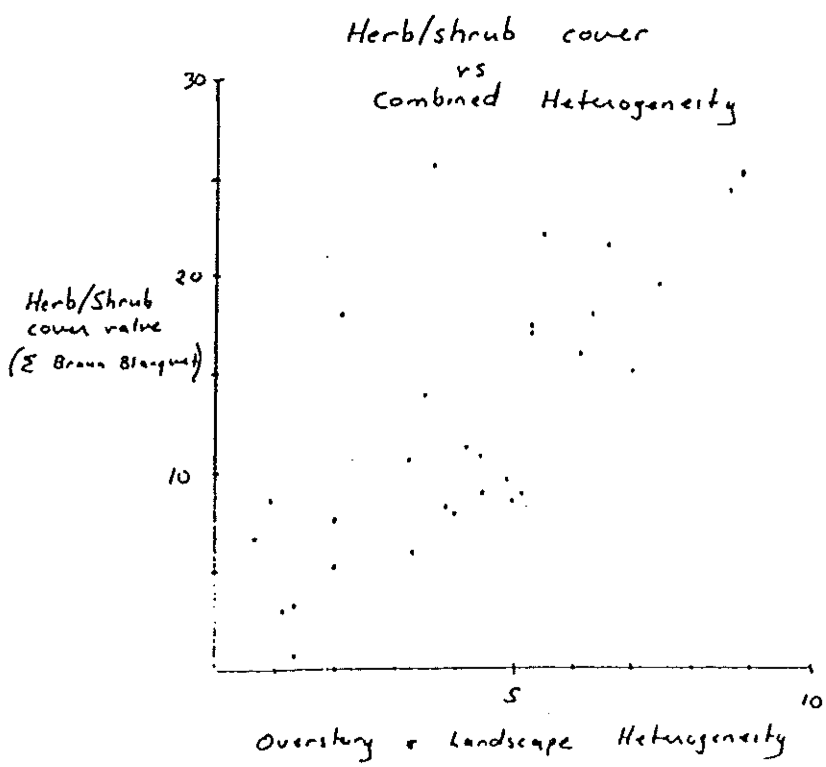


Fig. 1

Approximate Distribution of Selected Species




Species Richness
vs.
Combined Heterogeneity
Number of Species
20
10
5
10
Overstory + Landscape Heterogeneity


Herb/shrub cover
vs
Combined Heterogeneity
Herb/Shrub cover value
(Σ Braun Blanquet)
30
20
10
5
10
Overstory + Landscape Heterogeneity