Changes and limits to change in the forest on BCI: 10 years on the 50 hectare plot

I. Introduction

A. Here are the bole diameters of the 10 largest trees in the 50 ha plot; the top 4 trees together weigh 1 million pounds; the single biggest tree in the plot weighs more than all animals in all 50 ha combined; I suggest that EO Wilson change his slide showing a picture of a giant ant, based on his estimate that ants and termites together weigh almost 5 times all vertebrate species, because all trees weigh 1769 times more than ants and termites

B. The trees make the forest, they determine what can and what cannot live in the forest; all ranges of all animals depend on the trees

C. This seminar will serve to summarize the current status of census of trees in the 50 ha plot

D. Use as a organizing theme the ideas of stability and constancy in ecosystems: a central paradigm of community ecology; we can ask specifically, how constant is the community on BCI, and what forces are there that limit change

II. The whole forest

A. Species number has been constant (slide)

B. Forest-wide mortality (new precise figure with fine size classes, all 4 growth forms, 2 forms per slide)

C. Forest-wide growth (IBID)

D. Total number of stems (new slide that includes 1, 10, 20, 30 cm)

E. Total number of stems in canopy has been regulated (slide)

F. Analysis of regulation within quadrats -- mortality vs. recruitment (one slide with two quadrat sizes) -- does not suggest regulation

G. The canopy data (slide) -- does not clearly jive with expectations

III. Individual species

A. Here the story is different -- the forest is changing, or maybe it's not changing?

B. Bioscience slide showing all species' abundances in 1982 and 1990

C. Numbers of species with different changes (new slide, distribution of changes)

D. Picramnion example (a slid)

E. The species that have changed the most, 5% or more

1. Slide of list, adapted from existing table
2. Maps of distribution of PPAE, making point that the declining species are slope specialists, increasing are pioneer
3. Explain why I think it is not just the drought eliminating species (slide of mortality of all 24 species)
4. List other slope specialists declining, but also some increasing
5. Show similarities of distributions (overhead)

F. Mortality of individual species

1. Two-thirds of species hurt by drought, especially trees (slide of number of species, by growth form, and significant effects)
2. Not a clear relationship between population change and impact of drought on mortality, supporting the hypothesis that it's not just the drought (slide)

G. The community is clearly changing, as a reasonable fraction of the species has been affected; if dryness continues, I anticipate 20-30 extinctions, permanently more open canopy, invasion of pioneers; will dry forest species invade? I'm also interested in knowing other cases of population decline or extinction associated with the drying, as Stan Rand has told me about a couple frog species

IV. Population regulation via density-dependence

A. Summary of density-dependence (slide from ESA talk)

B. I developed a population model incorporating observed degrees of density dependence

1. Slide of population trajectory (from ESA talk)
2. Slide of lambda vs. N (IBID)
3. Carrying capacities (IBID)

C. How this misses density-dependence prior to 1 cm, and how I used Howe's data in Virola (slide of lambda vs. N, different dispersal)

D. General conclusion about neighborhood size and carrying capacity

1. Most abundant species regulated
2. Some others maybe, but <25% of community
3. Density-dependent phenomena play some role in regulating the community by limiting abundance, but many rare species do not have populations regulated in the classis sense

V. Conclusions

A. Regulation at the level of forest structure

1. This may seem trivial, but I would argue that it's not

2. We should understand how forests will change in face of climate change and other intervention -- how much will canopy open if it's drier?

B. Regulation of species composition of community

1. There are limits, BCI is protected from being a monodominant stand

2. Generally, though, limits only apply to most abundant species; if perturbed, rare species being lost, there are no stabilizing forces that I can find that will demand their return

3. Diversity will not maintain itself

RECORD TREES
(50 ha plot, BCI)

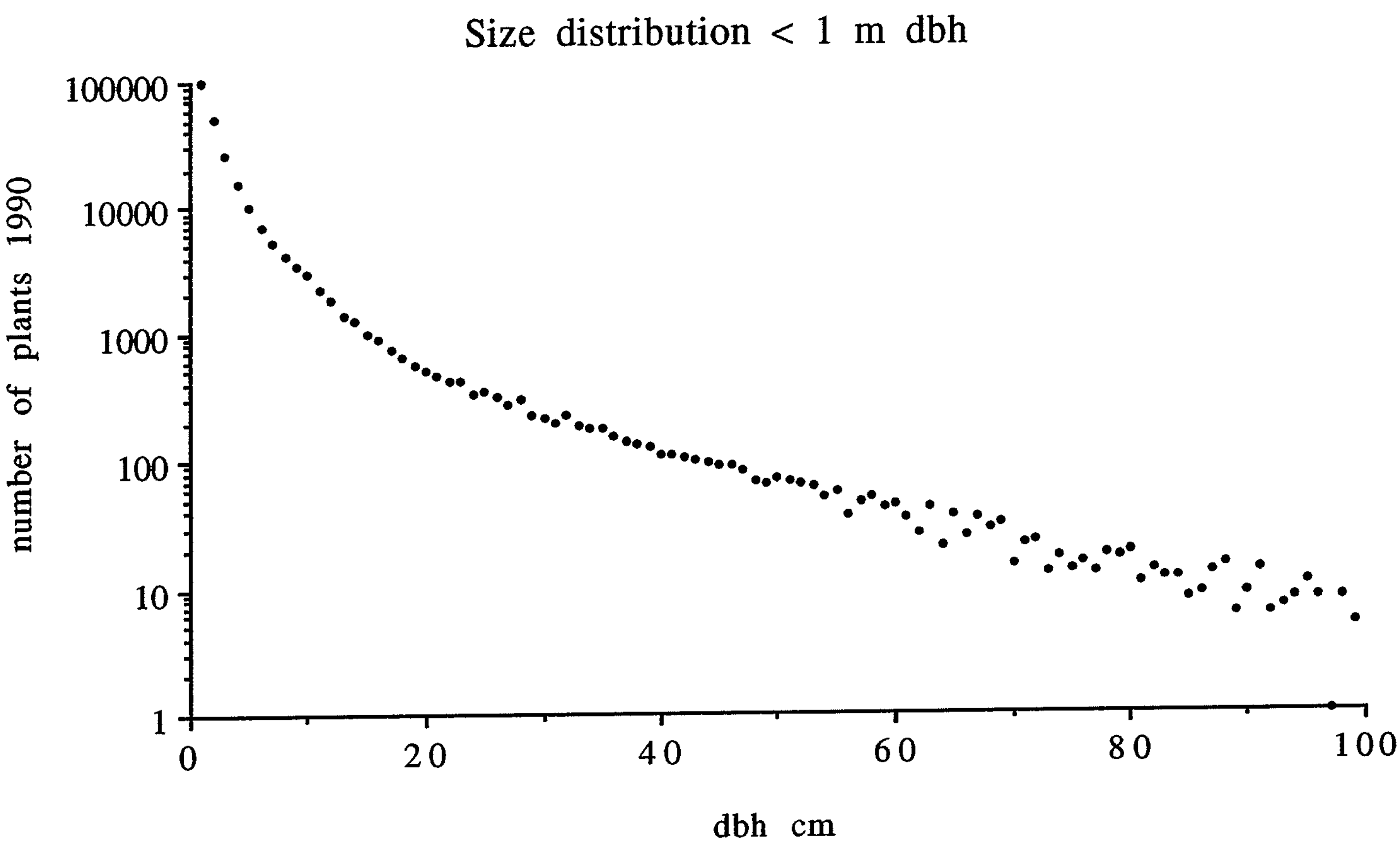
spp	dbh	q20x20
Anacardium:	2.79 m	4516
Cavanillesia:	2.43 m	3202
Hura	2.43 m	4307
Hura	2.42 m	3618
Ceiba	2.39 m	4302
Ceiba	2.39 m	3812
Ceiba	2.33 m	2508
Hura	2.29 m	3902
Ceiba	2.26 m	4603

Total number of stems in the 50 ha plot

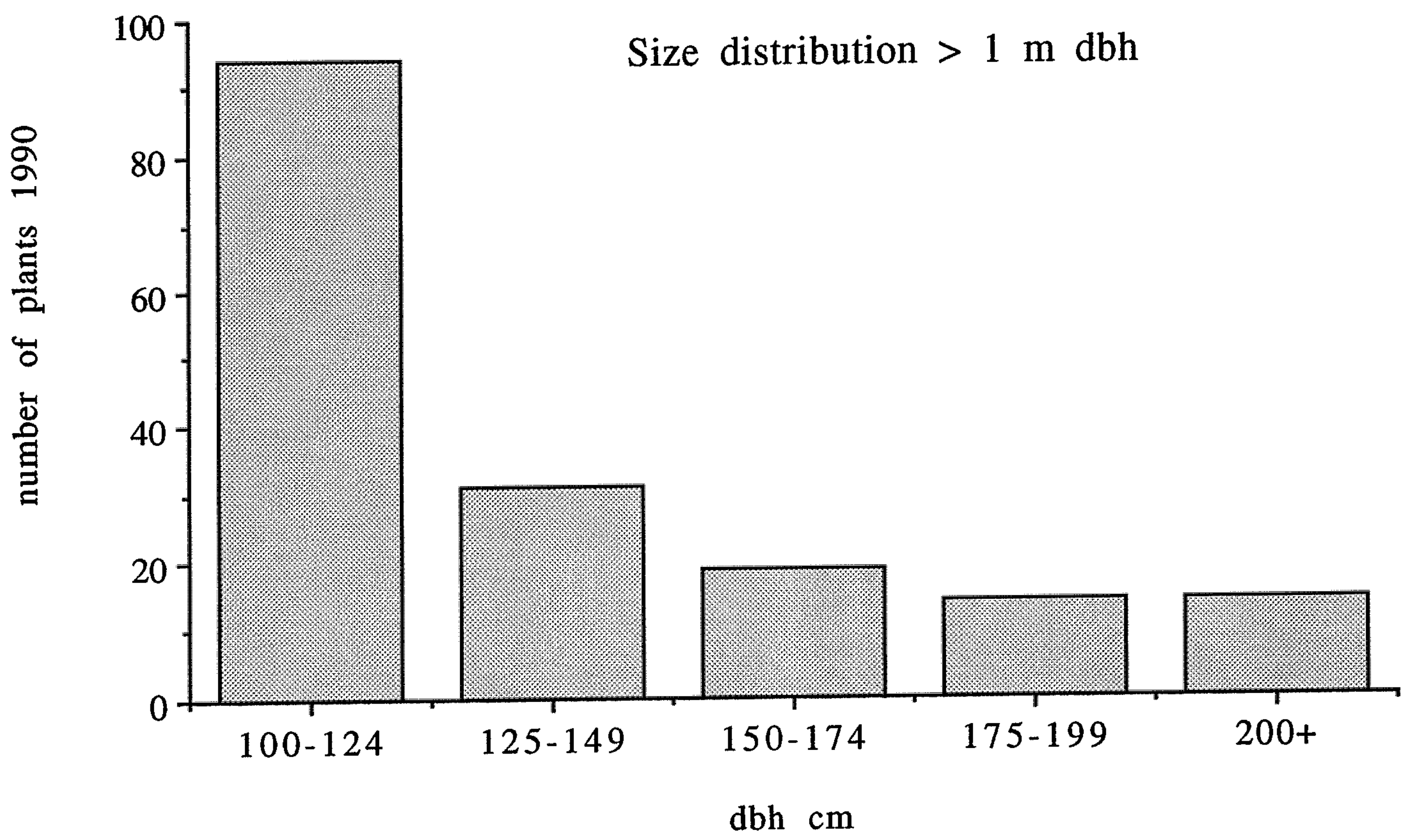
size class:	1982	1985	1990
≥ 1 cm	**234820**	**241415**	**243949**
≥ 10 cm	**20389**	**20387**	**21202**
≥ 20 cm	**7768**	**7584**	**7736**
≥ 30 cm	**4032**	**4021**	**4107**

per ha

size class:	1982	1985	1990
≥ 1 cm	**4696**	**4823**	**4879**
≥ 10 cm	**408**	**408**	**424**
≥ 20 cm	**155**	**152**	**155**
≥ 30 cm	**81**	**80**	**82**



Size distribution < 1 m dbh
number of plants 1990
100000
10000
1000
100
10
1
0
20
40
60
80
100
dbh cm



Size distribution > 1 m dbh
number of plants 1990
100
80
60
40
20
0
100-124
125-149
150-174
175-199
200+
dbh cm

Turnover of individuals in the forest canopy.

Census year	Tree density	Mortality	Recruitment
1982	**80.6**		
1982-1985	....	**3.6**	**3.3**
1985	**80.4**		
1985-1990	....	**2.1**	**2.5**
1990	**82.1**		

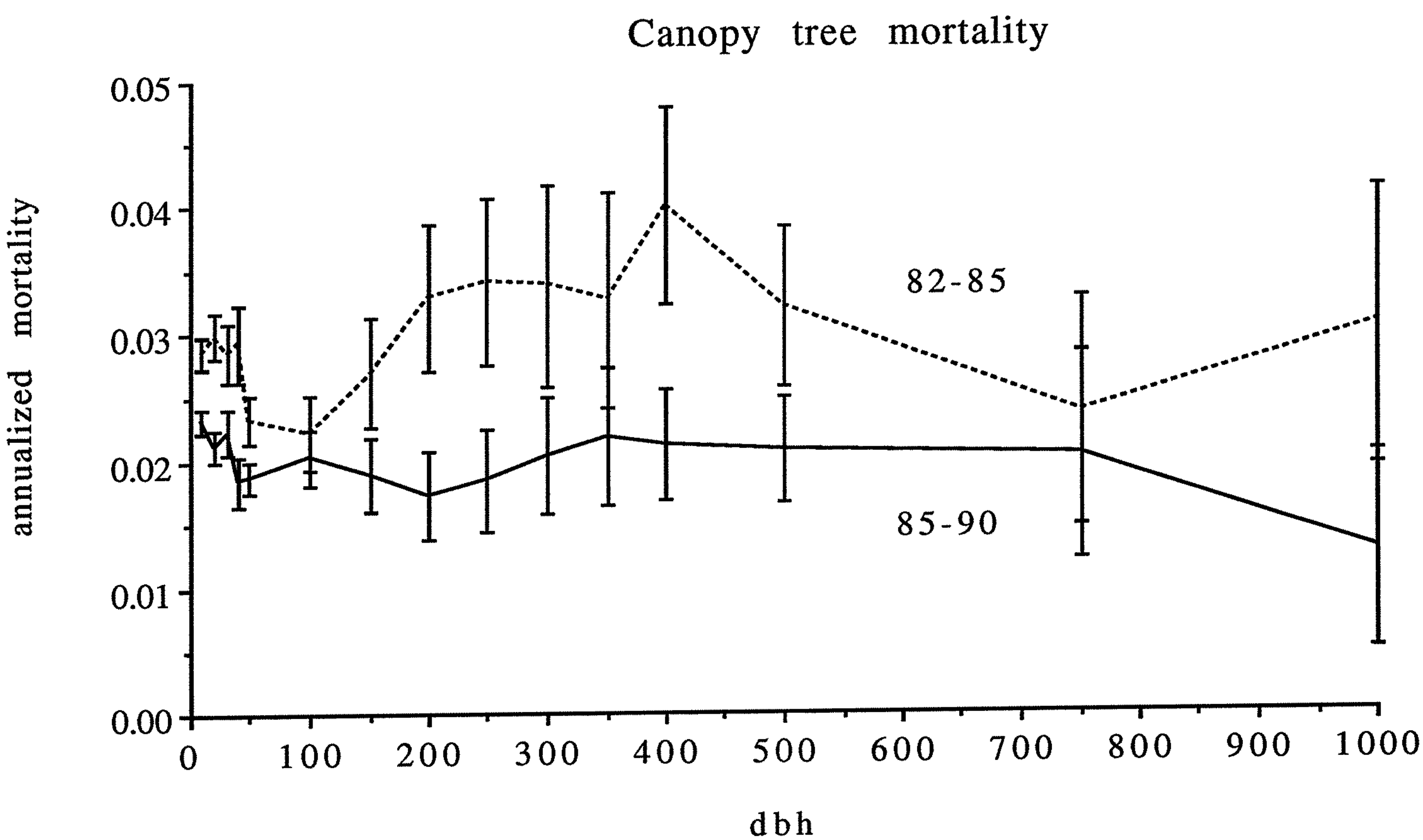
Tree density is the total number of trees above 30 cm dbh per ha. Mortality is the mean annualized percent mortality rate of trees of this size during the two census intervals. Recruitment is the number of trees entering the 30 cm class, annualized, divided by the number present at the start, and multiplied by 100 to make a percent.

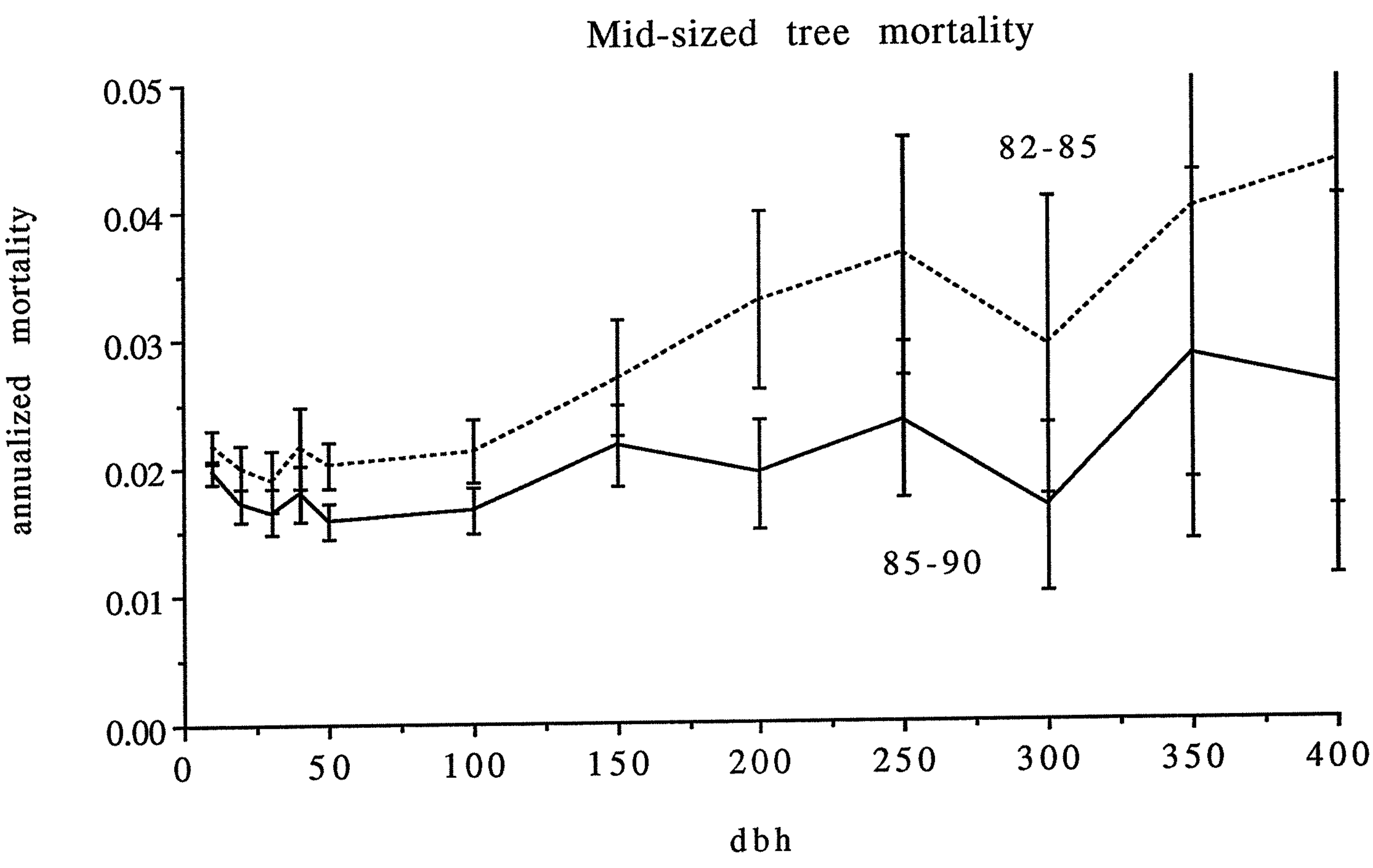
16 species which declined faster than 5% per year
(33% total decline 1982-1990)

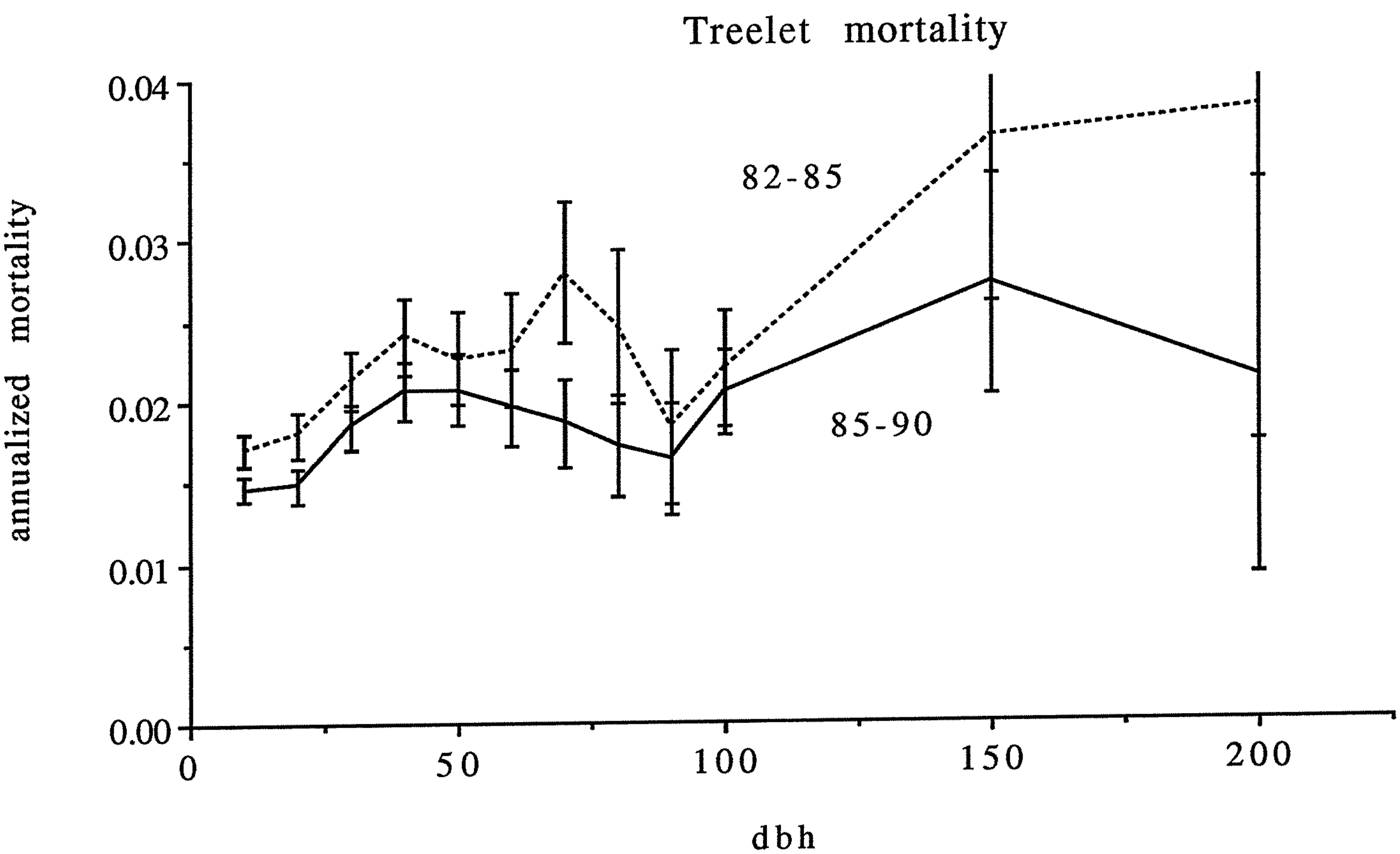
species	growth form	population 1982	population 1990	habitat preference
Acalypha macrostachya	U	81	45	none
Acalypha diversifolia	S	1582	838	slope specialist
Cassia fruticosa	S	205	116	none
Cestrum megalophyllum	S	307	154	slope specialist
Conostegia cinnamonea	S	396	212	slope specialist
Erythrina costaricensis	U	288	183	slope specialist
Hampea appendiculata	M	75	40	none
Olmedia aspera	U	448	282	slope specialist
Poulsenia armata	T	3437	2132	slope specialist
Piper arboreum	S	107	59	slope specialist
Piper aequale	S	221	84	slope specialist
Piper cordulatum	S	3160	1774	anti-slope specialist
Piper culebranum	S	120	53	none
Piper perlasense	S	110	68	slope specialist
Solanum hayesii	M	125	77	gaps, slope specialist
Turpinia occidentalis	T	150	82	none

8 species which increased faster than 5% per year
(47% total increase 1982-1990)

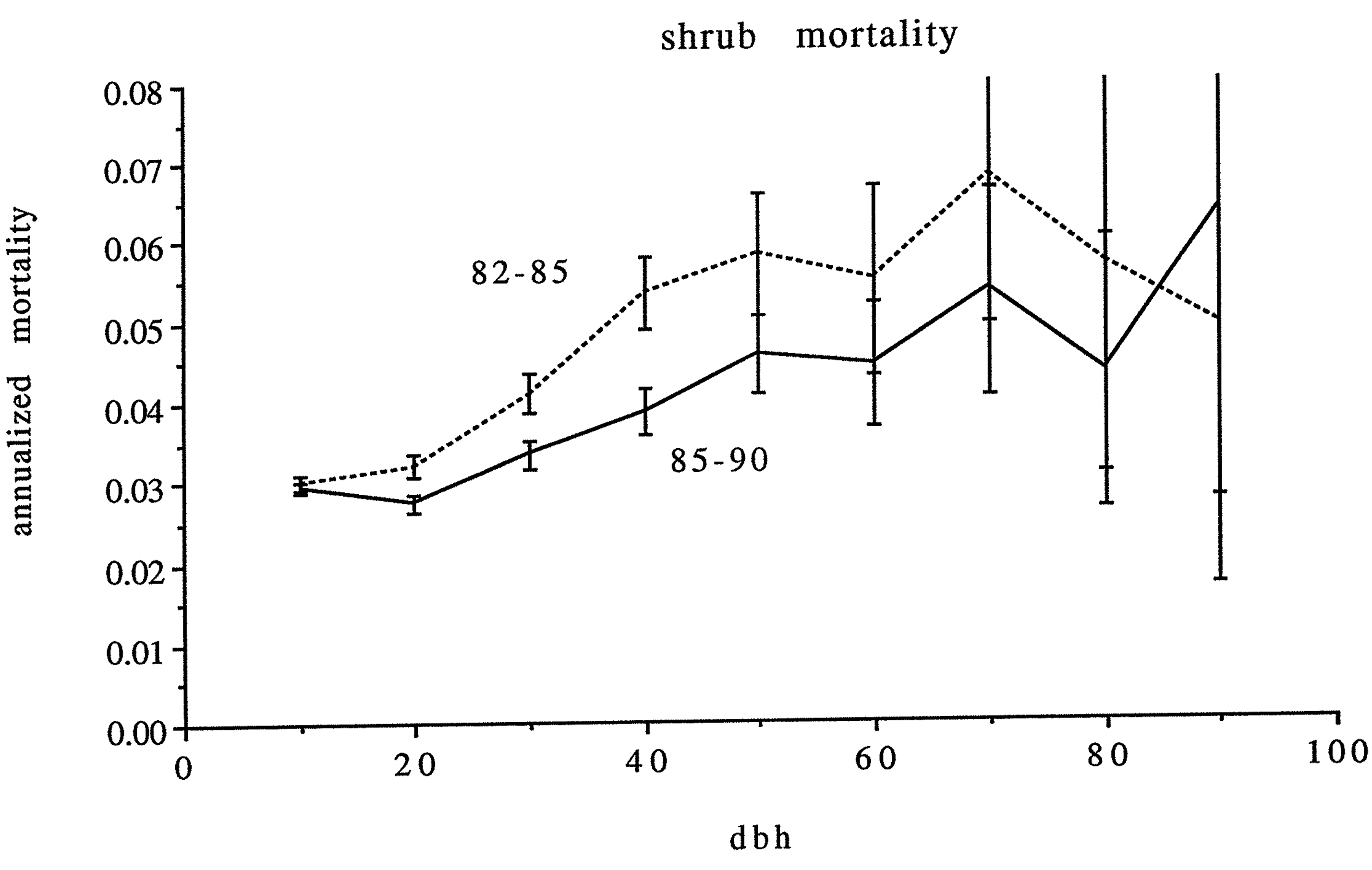
Annona spraguei	M	57	142	gaps
Chrysophyllum cainito	T	71	109	gaps
Chrysophyllum panamense	T	421	679	gaps
Croton billbergianus	U	620	1011	gaps
Cupania rufescens	T	57	97	gaps
Miconia argentea	M	533	902	gaps
Palicourea guianensis	U	381	1473	gaps
Spondias mombin	T	63	100	gaps


Canopy tree mortality
annualized mortality
0.05
0.04
0.03
0.02
0.01
0.00
0
100
200
300
400
500
600
700
800
900
1000
82-85
85-90
dbh

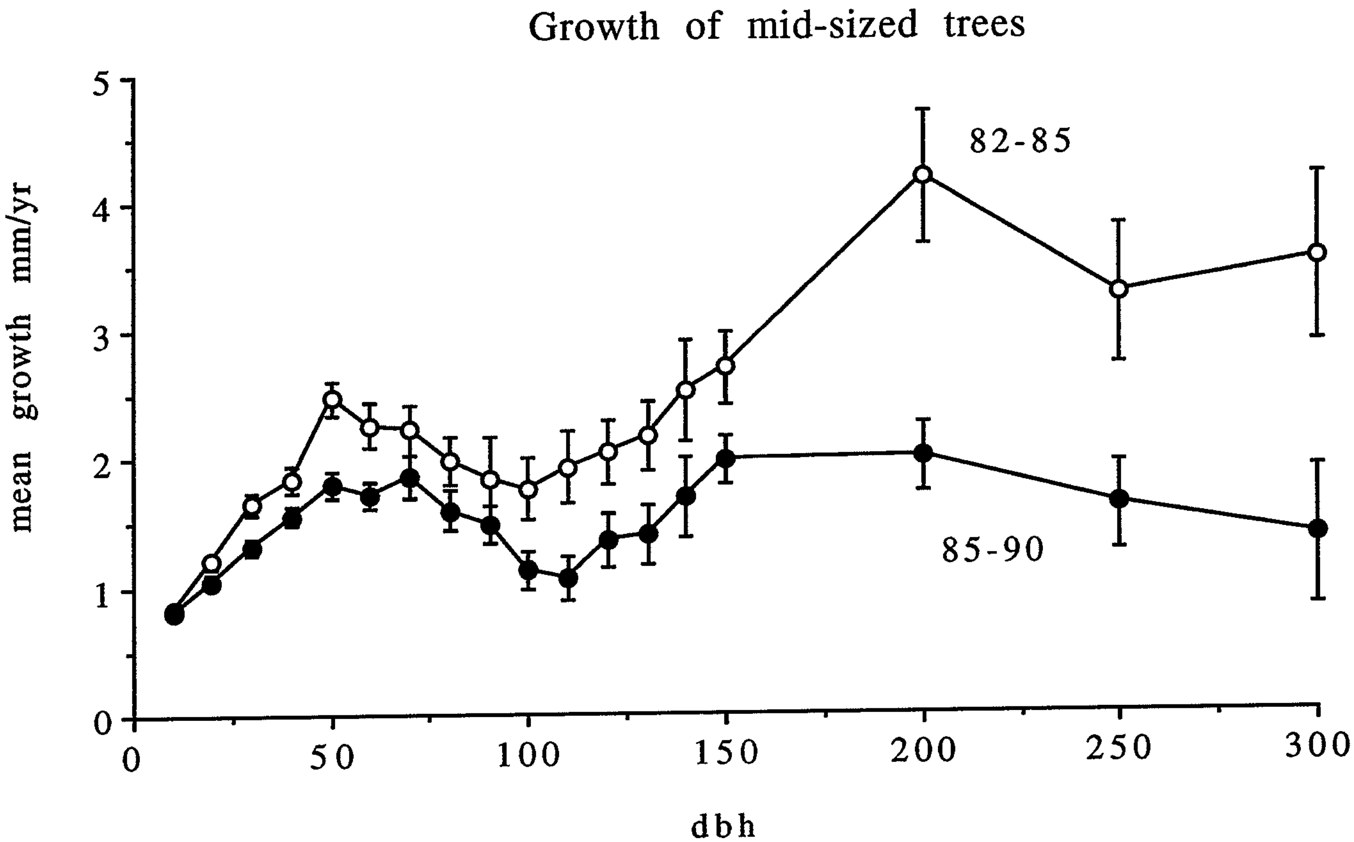

Mid-sized tree mortality
annualized mortality
0.05
0.04
0.03
0.02
0.01
0.00
0
50
100
150
200
250
300
350
400
82-85
85-90
dbh

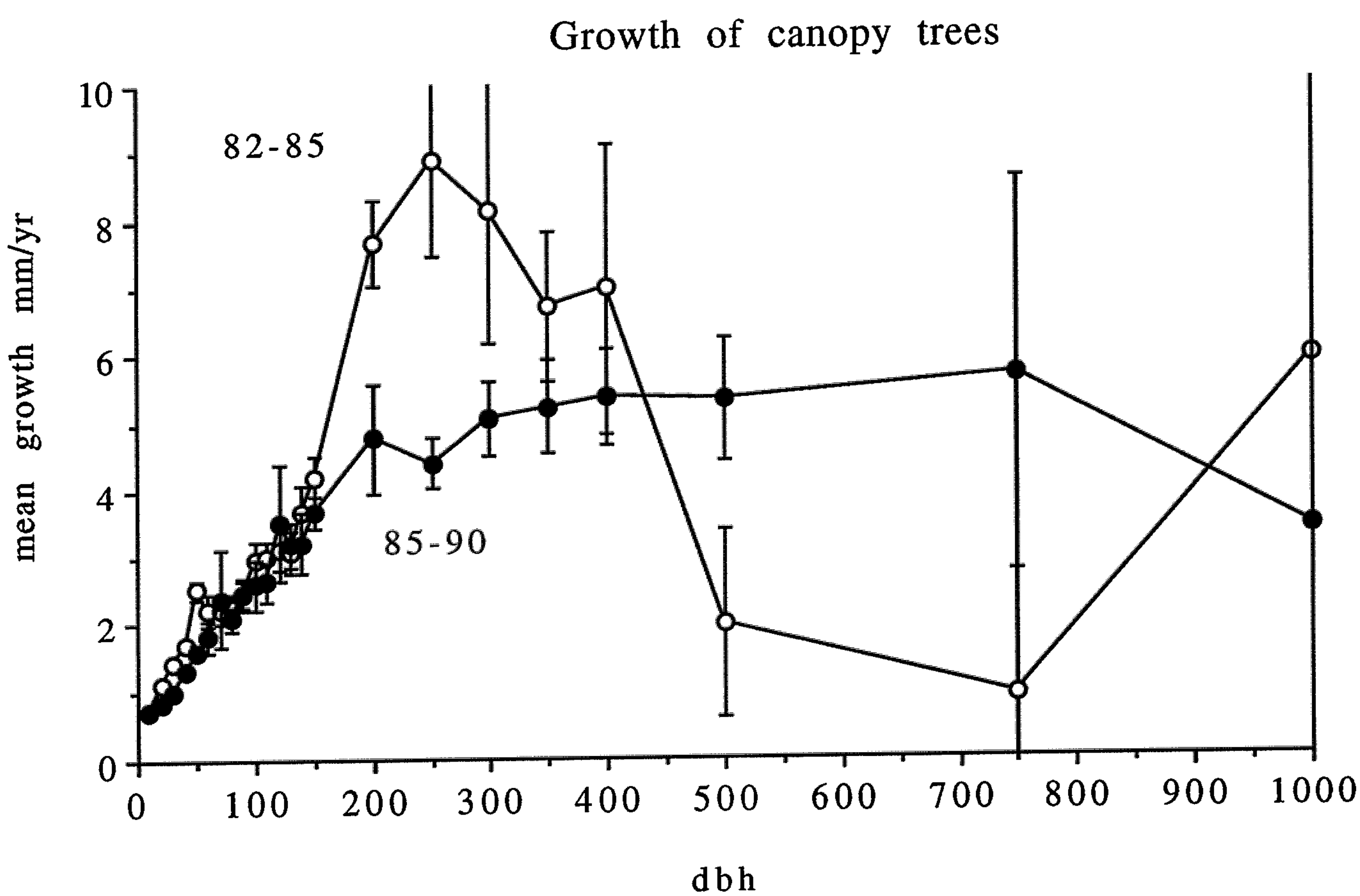


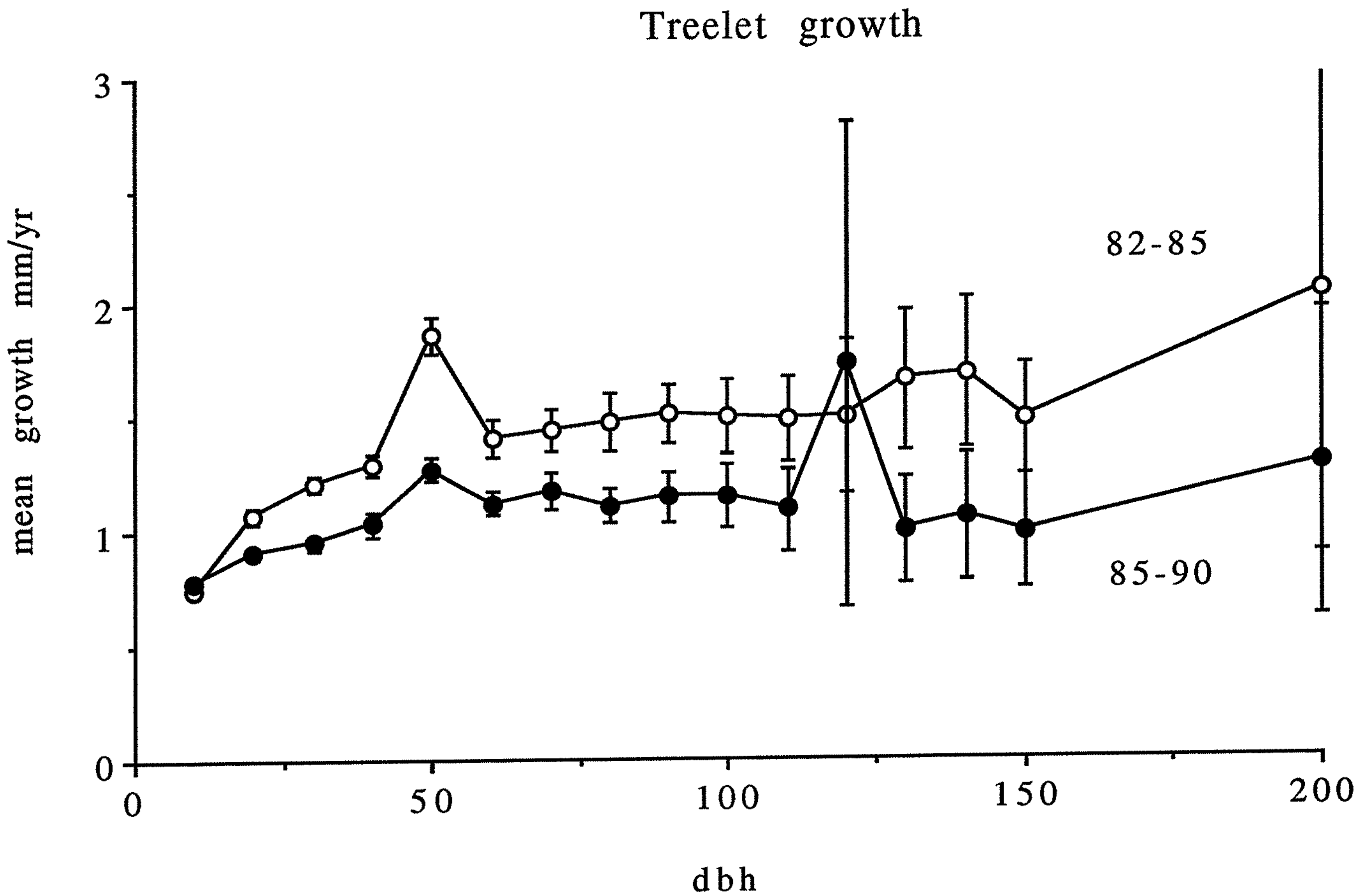
Treelet mortality
annualized mortality
0.04
0.03
0.02
0.01
0.00
0
50
100
150
200
dbh
82-85
85-90

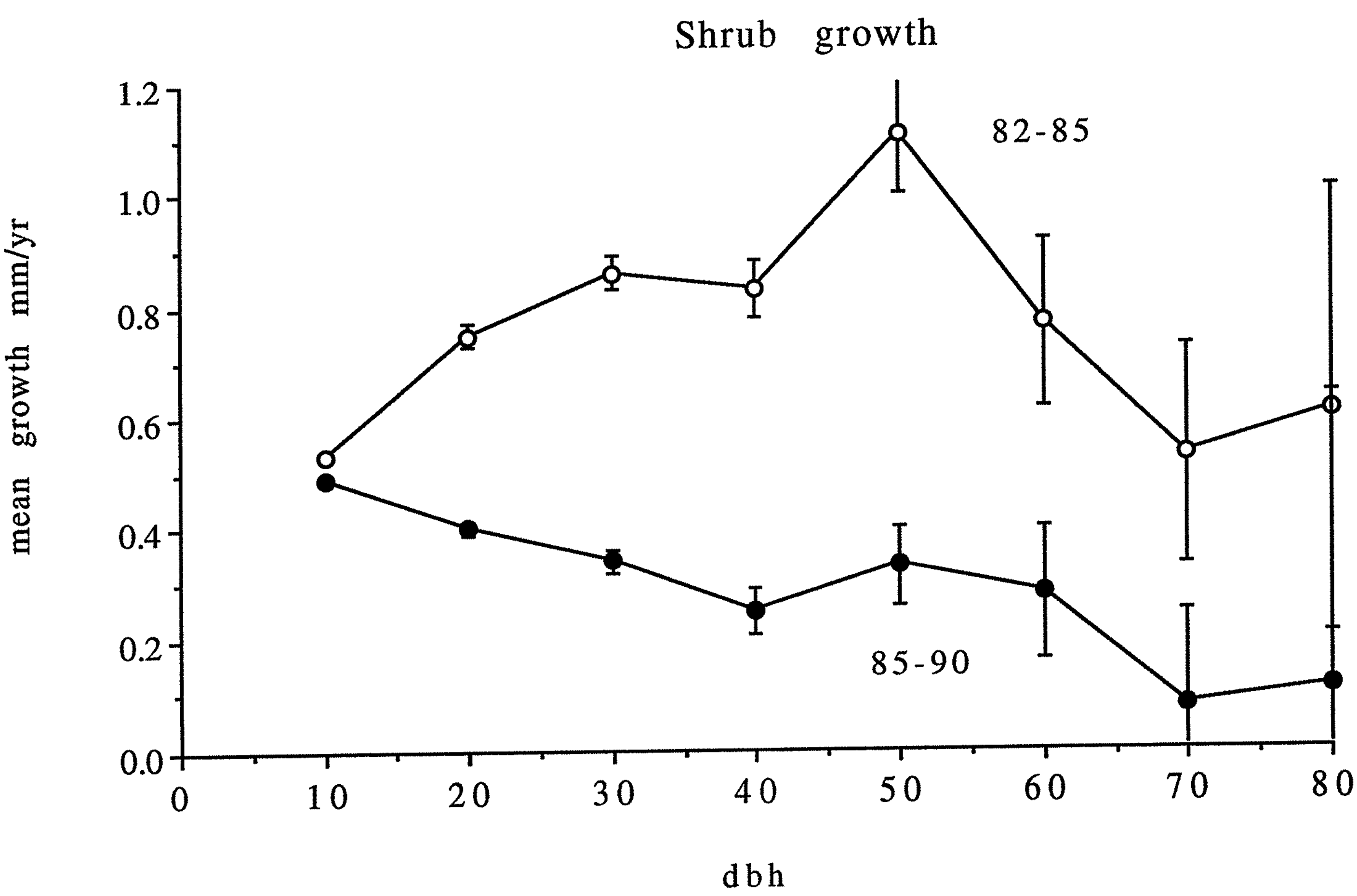


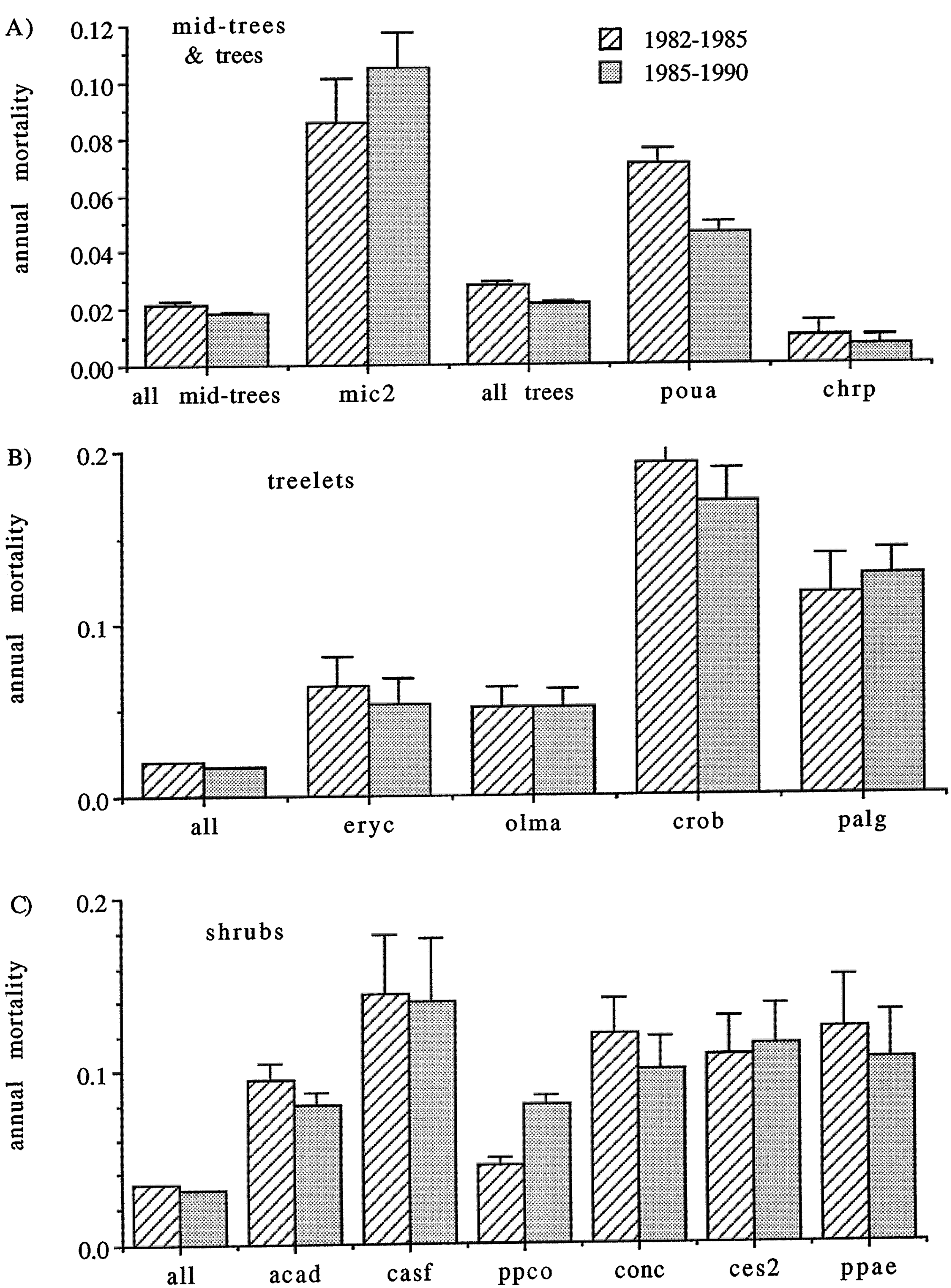
shrub mortality
annualized mortality
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
dbh
82-85
85-90

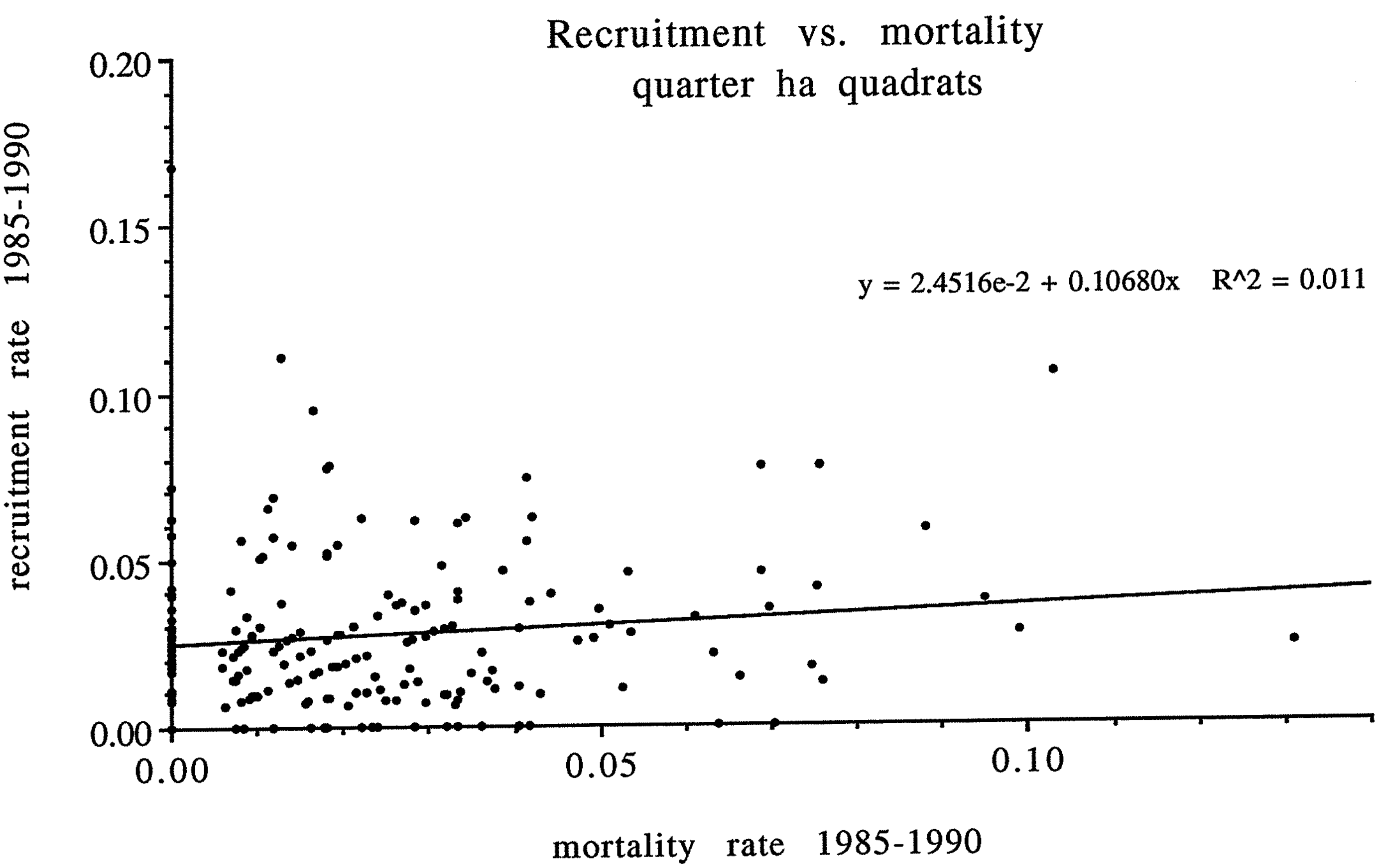

Growth of mid-sized trees
mean growth mm/yr
dbh
82-85
85-90
0
1
2
3
4
5
0
50
100
150
200
250
300

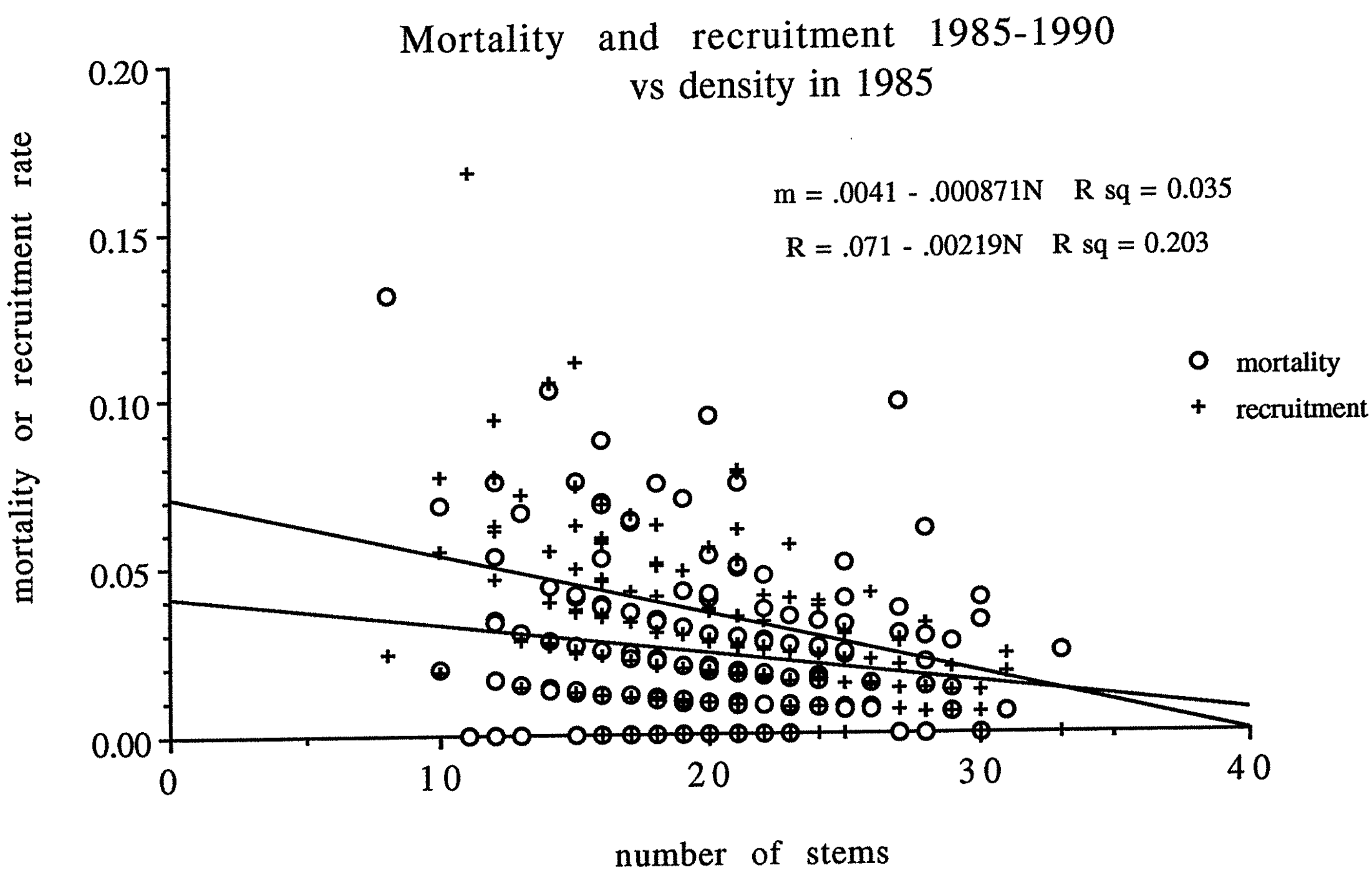

Growth of canopy trees
mean growth mm/yr
dbh
82-85
85-90
0
2
4
6
8
10
0
100
200
300
400
500
600
700
800
900
1000

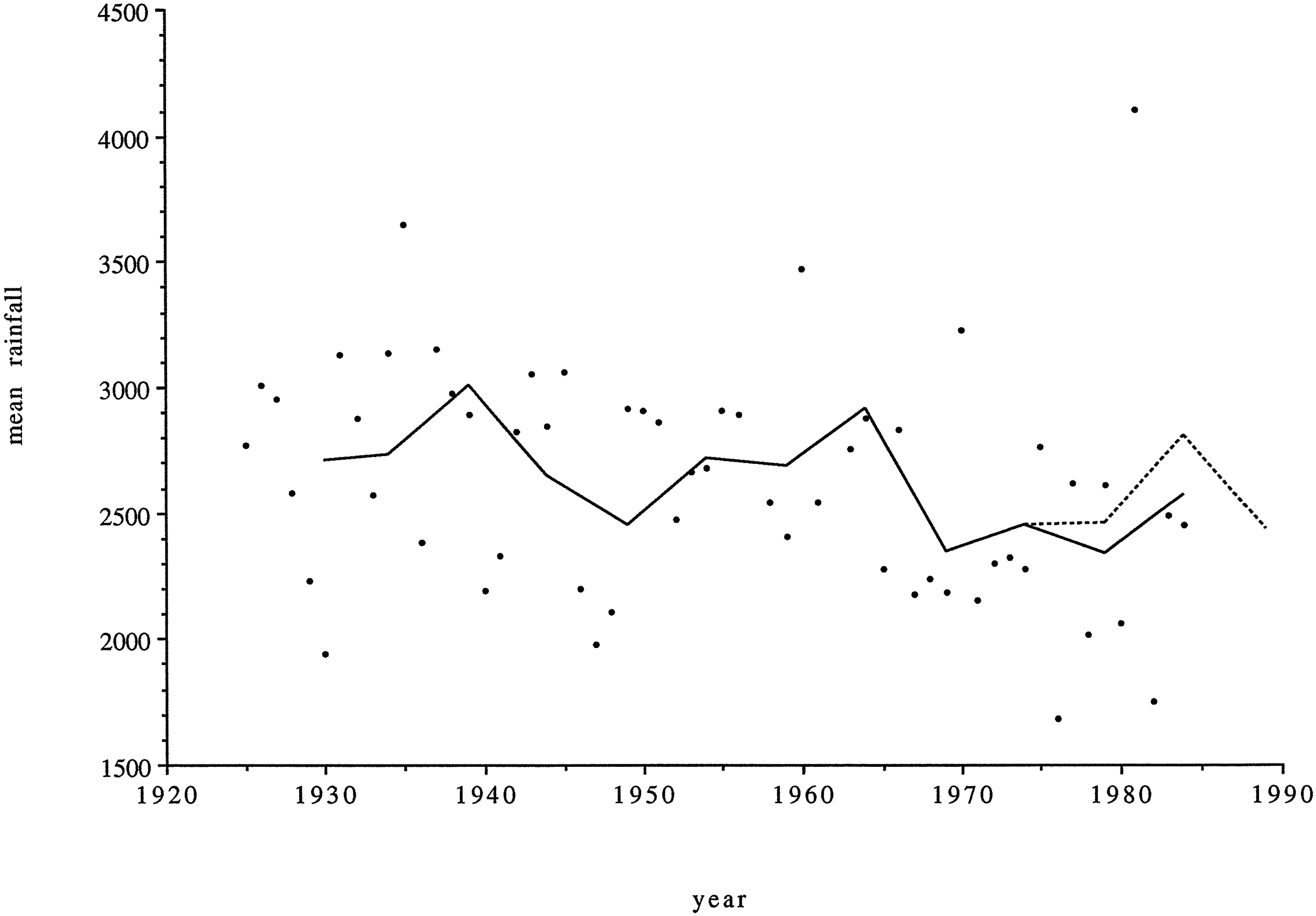

Treelet growth
mean growth mm/yr
3
2
1
0
0
50
100
150
200
dbh
82-85
85-90


Shrub growth
mean growth mm/yr
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
80
dbh
82-85
85-90

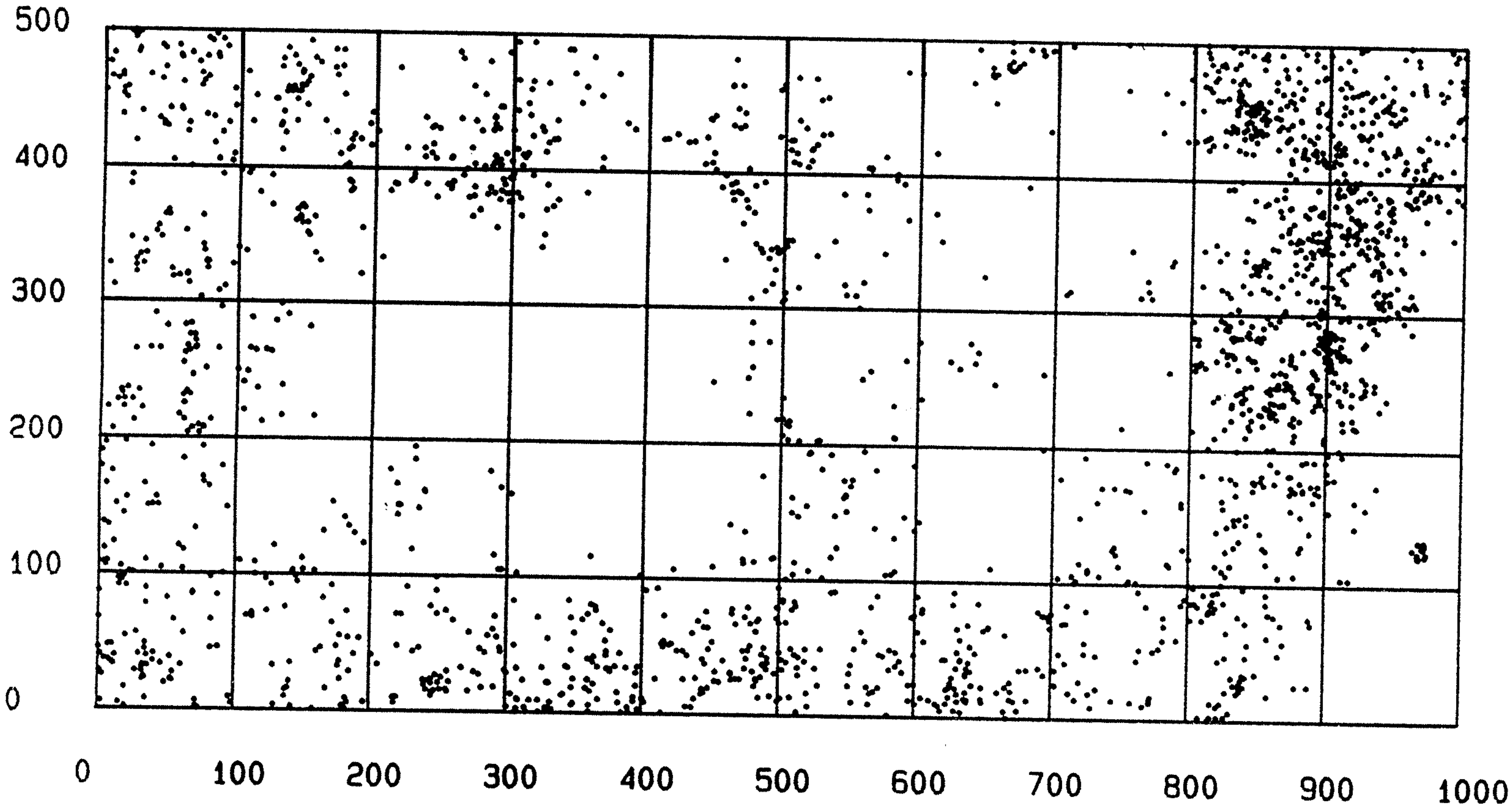

A)
mid-trees
& trees
1982-1985
1985-1990
annual mortality
0.12
0.10
0.08
0.06
0.04
0.02
0.00
all mid-trees
mic2
all trees
poua
chrp
B)
treelets
annual mortality
0.2
0.1
0.0
all
eryc
olma
crob
palg
C)
shrubs
annual mortality
0.2
0.1
0.0
all
acad
casf
ppco
conc
ces2
ppae

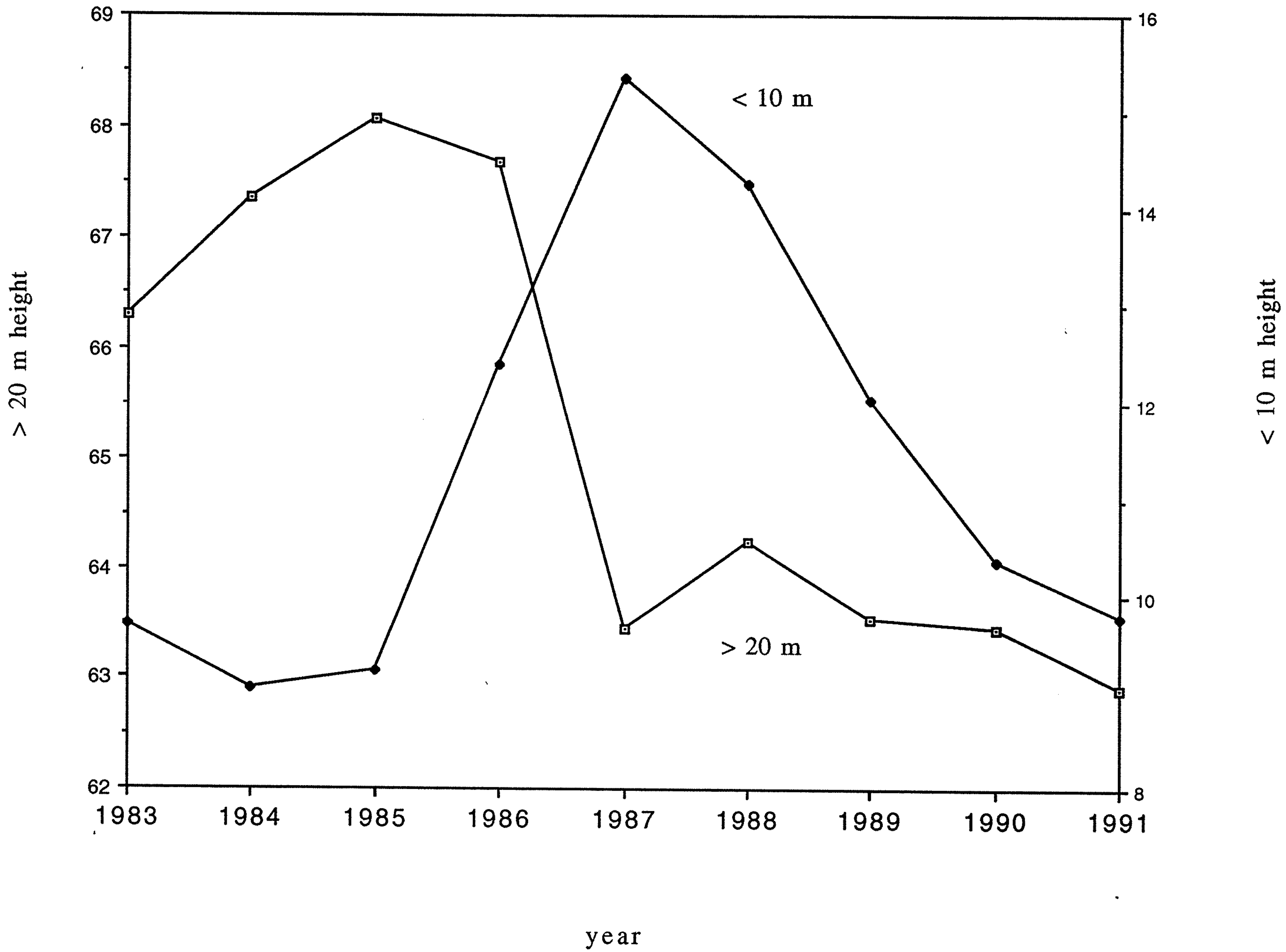

Recruitment vs. mortality
quarter ha quadrats
y = 2.4516e-2 + 0.10680x R^2 = 0.011
recruitment rate 1985-1990
mortality rate 1985-1990
0.00
0.05
0.10
0.15
0.20


Mortality and recruitment 1985-1990
vs density in 1985
m = .0041 - .000871N R sq = 0.035
R = .071 - .00219N R sq = 0.203
mortality
recruitment
mortality or recruitment rate
number of stems
0
10
20
30
40
0.00
0.05
0.10
0.15
0.20

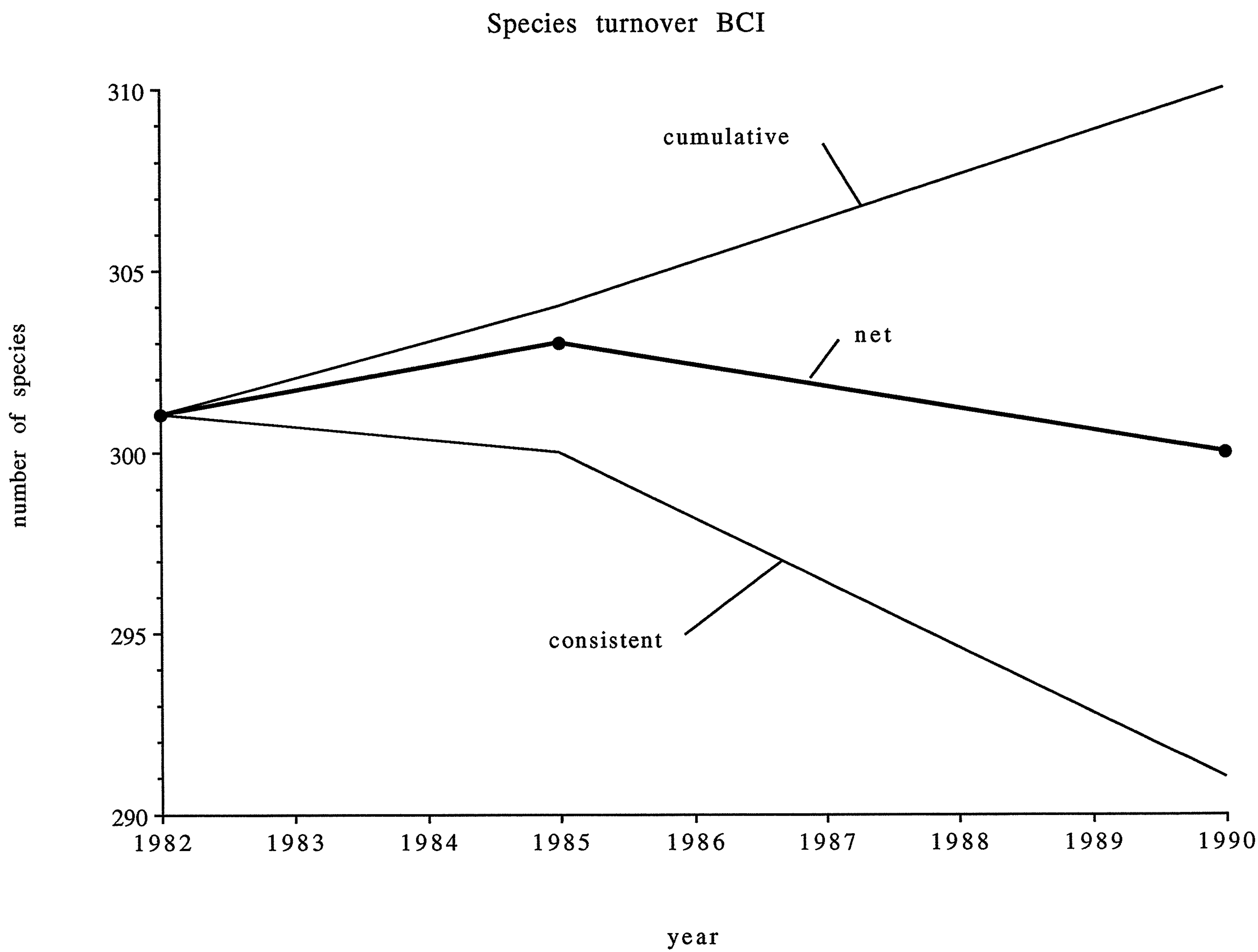


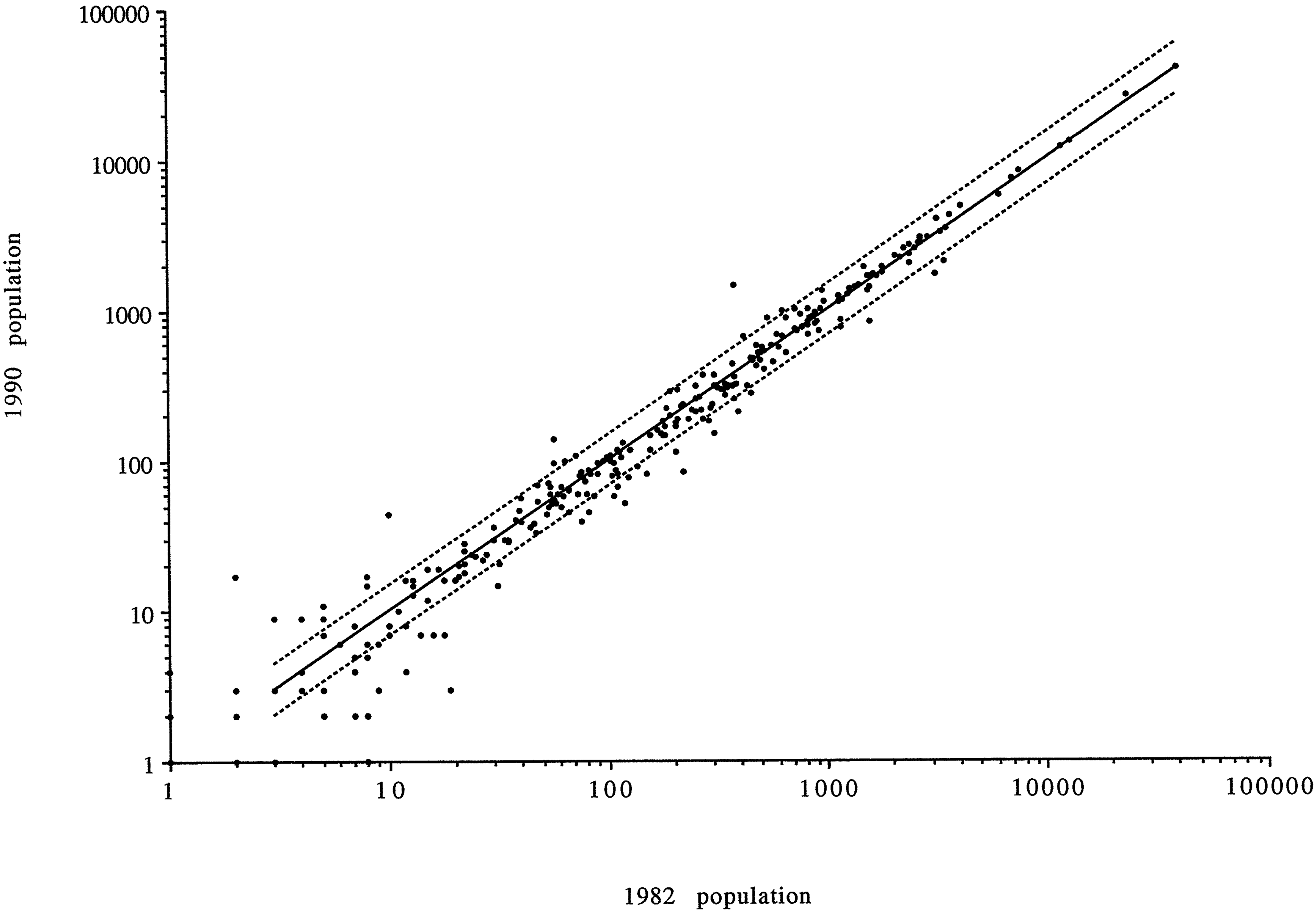
4500
4000
3500
3000
2500
2000
1500
mean rainfall
1920
1930
1940
1950
1960
1970
1980
1990
year

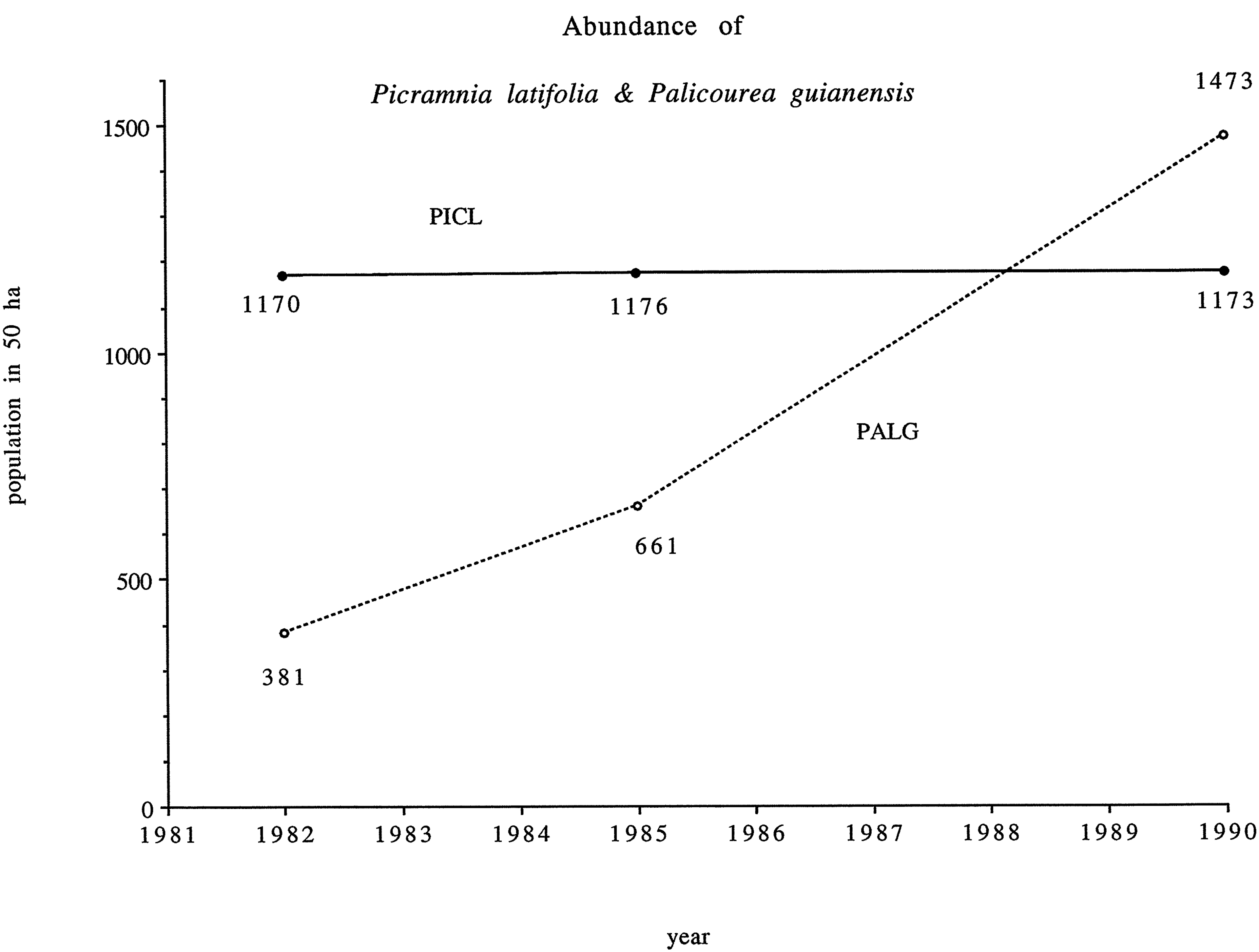

500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
1000



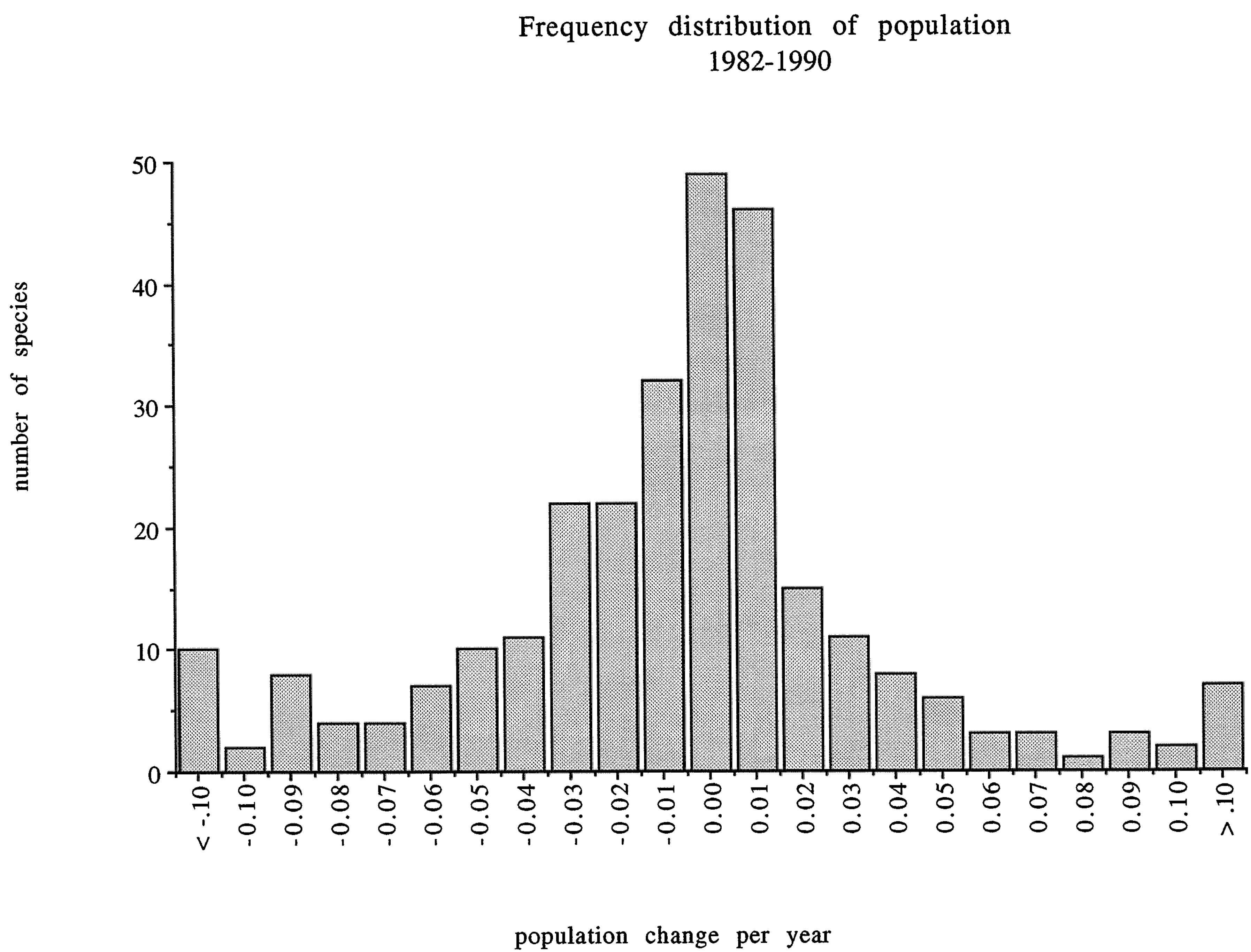
69
68
67
66
65
64
63
62
16
14
12
10
8
< 10 m
> 20 m
> 20 m height
< 10 m height
1983
1984
1985
1986
1987
1988
1989
1990
1991
year


Species turnover BCI
310
305
300
295
290
cumulative
net
consistent
number of species
1982
1983
1984
1985
1986
1987
1988
1989
1990
year


100000
10000
1000
100
10
1
1990 population
1
10
100
1000
10000
100000
1982 population



Abundance of
Picramnia latifolia & Palicourea guianensis
1500
1000
500
0
population in 50 ha
PICL
1170
1176
1173
PALG
381
661
1473
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
year



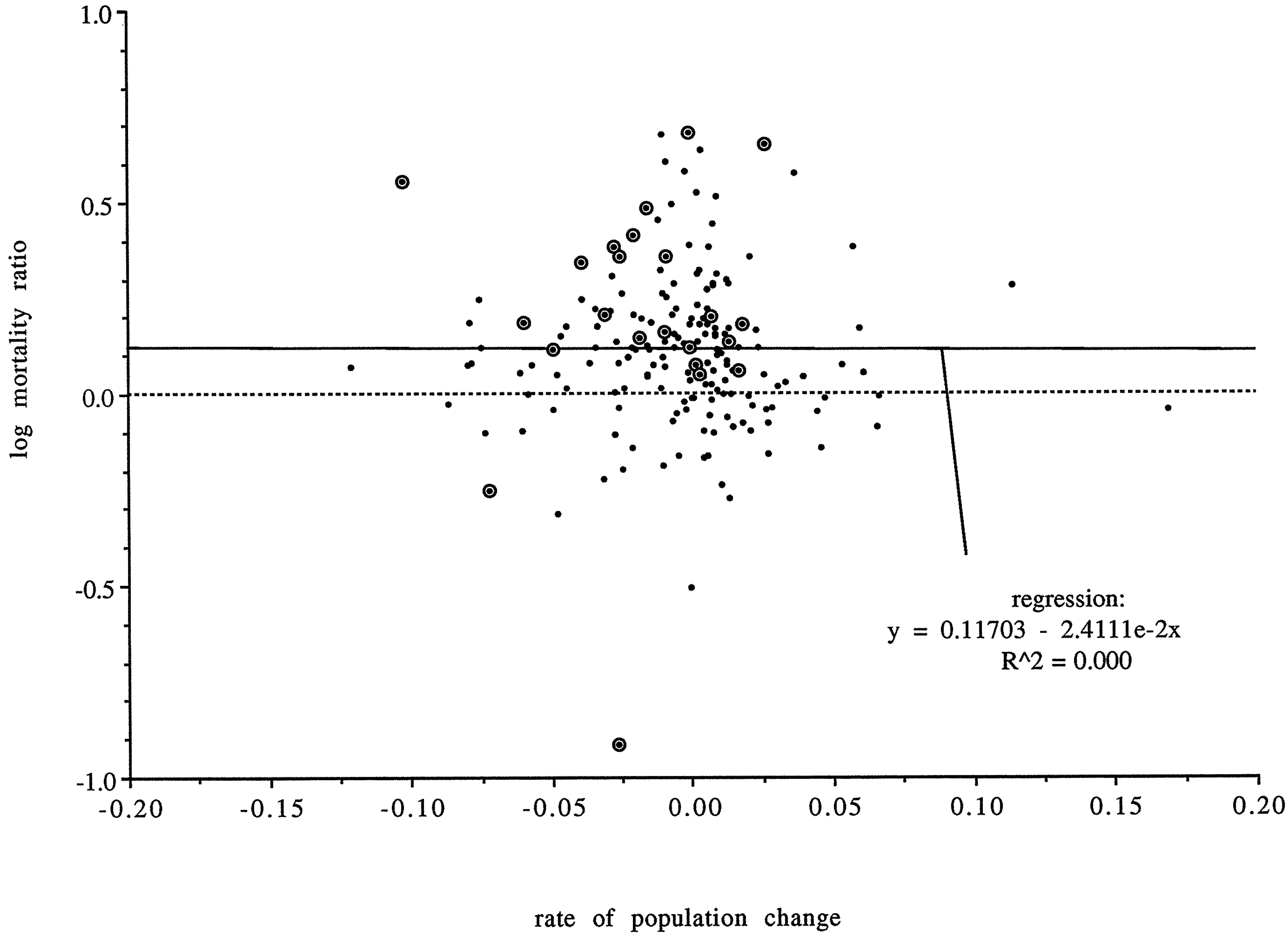
Frequency distribution of population
1982-1990
number of species
0
10
20
30
40
50
< -.10
-0.10
-0.09
-0.08
-0.07
-0.06
-0.05
-0.04
-0.03
-0.02
-0.01
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
> .10
population change per year

Effect of the drought on mortality

fraction of species with higher mortality during the drought interval

(total species given first, then in parentheses the number with a significantly affected mortality)

	no. species with higher mortality during 1982-1985	no. species with higher mortality during 1985-1990	total species	fraction
Growth form:				
Tree	**59 (9)**	**12 (0)**	**71**	**0.83**
Mid-tree	**43 (6)**	**13 (1)**	**56**	**0.77**
Treelet	**24 (4)**	**14 (0)**	**38**	**0.63**
Shrub	**18 (5)**	**9 (2)**	**27**	**0.67**
Total	**144 (24)**	**48 (3)**	**192**	**0.75**



1.0
0.5
0.0
-0.5
-1.0
log mortality ratio
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
rate of population change
regression:
y = 0.11703 - 2.4111e-2x
R^2 = 0.000