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Appendix 1

GLOSSARY OF SCIENTIFIC AND COMMON NAMES

Agrostis capillaris	browntop
Agrostis stolonifera	creeping bent
Alopecurus pratensis	meadow foxtail
Anthoxanthum odoratum	sweet vernal
Asplenium bulbiferum	hen and chickens fern
Blechnum novae-zelandiae	kiokio
Carpodetus serratus	marble leaf, putaputaweta
Coprosma rotundifolia	round-leaved coprosma
Cyathea smithii	ponga
Dacrycarpus dacrydioides	kahikatea
Dacrydium cupressinum	rimu
Dactylis glomerata	cocksfoot
Dicksonia squarrosa	wheki
Griselinia littoralis	broadleaf
Hedycarya arborea	pigeonwood
Histiopteris incisa	water-fern
Holcus lanatus	Yorkshire fog
Lolium perenne	perennial ryegrass
Lotus pedunculatus	lotus
Melicytus ramiflorus	mahoe
Microlaena avenacea	bush rice grass
Myrsine divaricata	weeping mapou
Nothofagus menziesii	silver beech
Pennantia corymbosa	kaikomako
Phormium tenax	flax
Plagianthus regius	lowland ribbonwood
Podocarpus totara var. *waihoensis*	Westland totara
Polystichum vestitum	prickly shield fern
Pneumatopteris pennigera	feather fern
Prumnopitys ferruginea	miro
Prumnopitys taxifolia	matai
Prunella vulgaris	self-heal
Pseudopanax crassifolius	lancewood
Pteridium esculentum	bracken
Ranunculus repens	creeping buttercup
Schefflera digitata	pate
Trifolium repens	white clover
Weinmannia racemosa	kamahi

Appendix 2

DATA ANALYSIS METHODS

Comparison of change over time between control and exclosure transects.

Summed values for each stratum of each transect were compared at successive recording dates; i.e. total numbers of herb species, small seedlings, large seedlings, shrubs and small saplings, and tall saplings and trees, and total basal area. Values for each exclosure transect were expressed as differences from the corresponding control transect on the same date. For each pair of plots (exclosure and control), these differences and the corresponding control values were then plotted as co-ordinates on a single graph.

The rationale for expressing values for the exclosure transects as differences from the controls, rather than absolute values, was that factors causing changes on control transects are also likely to similarly influence the corresponding exclosure transects; if there are effects due to exclosure *per se*, these should result in changes of greater or lesser magnitude than those measured on the control transects.

The change in values between dates can be indicated graphically by vectors, which are arrows showing the direction and magnitude of change. The vectors are formed by joining the co-ordinates for initial and subsequent measurement dates. Figures A2.1 and A2.2 indicate how these vectors are to be interpreted. In Figure A2.1, changes measured along the horizontal axis represent changes within a control transect. The vertical axis represents a change in the value of the difference between an exclosure transect and its control. A positive value on the vertical axis shows that there is a higher number (of species, seedlings, etc., or for basal area) in the exclosure transect than in the control; a negative value indicates a higher number in the control. For example, vector *a* shows that as control numbers decreased from 125 to 25, the difference between exclosure and control increased from 25 to 100. A relative increase in the exclosure is therefore indicated, even though the actual numbers (calculated as exclosure = control + difference) decreased from 150 to 125. Vector *b* shows control numbers increasing from 75 to 175, while exclosure minus control increased from –50 to 13; the actual number in the exclosure transect increased from 25 to 188.

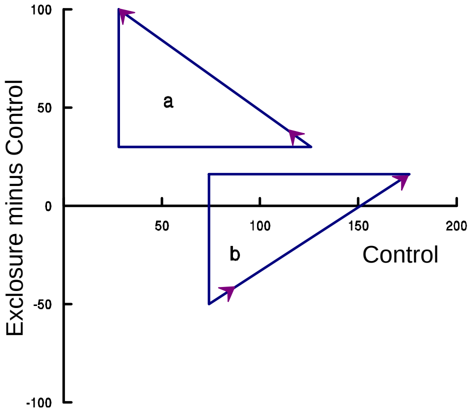


Figure A2.1. Examples of vectors comparing values in control and exclosure transects. The horizontal axis represents control plot values, whereas the vertical axis represents the differences between exclosure and control values. For each triangle, *a* and *b*, the horizontal line indicates values measured in a control plot at the beginning and end of the measurement interval (i.e. in the direction of the arrow). The vertical line indicates the corresponding values for exclosure minus control. The arrow, or vector, links the initial and final values. The examples are discussed further in the text.

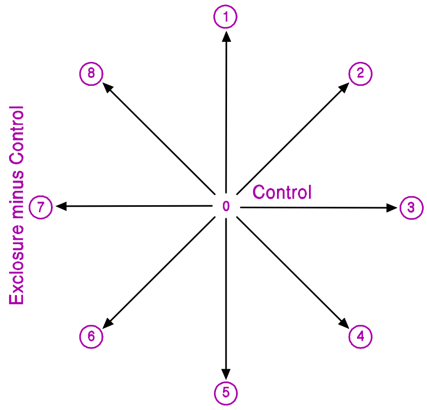


Figure A2.2. Significance of direction of vectors. Vectors directed upwards or downwards represent increases or decreases respectively in the value of exclosure minus control; vectors directed to the right or left represent increases or decreases in the value of control. Vectors in the direction 7-0-3 therefore indicate no change in exclosure minus control, and in the direction 1-0-5 indicate no change in control. The direction 8-0-4 indicates no change in the value for exclosure, whereas the direction 2-0-6 indicates that the exclosure has changed twice as much as the control (also see text).

As a means of further explanation, Figure A2.2 portrays vectors radiating from a common origin, '0'. Along the direction 1-0-5, there is zero change in the control transect; changes in the exclosure, whether positive or negative, are infinitely large in proportion. Vectors directed to the right and left indicate increase or decrease respectively in the control values, with the magnitude of the change being represented by distance along the horizontal axis. Along the direction 3-0-7 values for exclosure minus control do not change because both the control and exclosure transects show equal increases or decreases. Vectors directed upwards and downwards indicate increases or decreases respectively in the value exclosure-control, and again, the distance along the vertical axis shows the magnitude of the change. Along the direction 2-0-6, changes in the exclosure are twice as large as changes in the control, and along the direction 4-0-8 there are no changes in exclosure values. This assumes that both horizontal and vertical axes are to the same scale.

Vector plots for each site (Appendix 4) present numbers of seedlings < 10 cm tall, seedlings 10-30 cm tall, saplings and shrubs 0.3-2 m tall and tree ferns, and trees and saplings > 2 m tall for each transect on each measurement date. Arrows link the co-ordinates of exclosure minus control compared with control values on subsequent measurement dates. Each co-ordinate is accompanied by the transect number (i.e. according to the position of the transect in metres along the plot). To enable clarity of data the horizontal and vertical axes in these plots are not always to the same scale, so interpretation of vector angles must allow for this.

For example, at Cook Swamp (Fig. A4.4) numbers of seedlings < 0.1 m in the 45 m transect increased between 1989 and 1993 from 14 to 32 in the control, and from 44 to 102 in the exclosure minus control (an actual increase from 58 to 136 in the exclosure). Although the angle of the vector is approximately 45°, the scale of the horizontal axis is greater than that of the vertical axis, indicating a change in the exclosure much greater than twice that of the control. Between 1993 and 1997 the vector dropped steeply to the right, indicating an increase in the control with a large decrease in the exclosure. The control increased to 60, while the exclosure minus control value did indeed drop to -44, corresponding to an actual exclosure value of 16. The vector for the 20 m transect to 1993 indicates a decrease in the control (116 to 88) and little change in the exclosure (a decrease in exclosure minus control from -66 to -14, corresponding to an increase in the exclosure from 50 to 74). Between 1993 and 1997 the vector indicates a large decrease in the control with almost no change in exclosure minus control. This equates to a decrease in both control and exclosure of roughly equal proportions (to 13 and 17 respectively). In the grassland transects (0–10 m) seedling numbers were very low and changed little, and for the sake of clarity arrows were not added.

Appendix 3

DETAILED RESULTS

Ground cover

Portions of some exclosure and control plots had considerable changes in ground cover composition in the 8 years or so between plot establishment and second remeasurement, but, except for height and diversity of herbaceous species, no changes in exclosures were consistently significant relative to controls.

Vascular cover (Fig. A3.1) in the grassland portion of the Jackson exclosure increased substantially, and was matched by a decrease in bryophyte cover (Fig. A3.2). However, in the grassland portion of the Cook Young Forest exclosure the decrease in vascular cover was offset by an increase in litter cover (Fig. A3.3). In the ecotone of the Arawata exclosure vascular cover increased at the expense of litter and bare ground (Fig. A3.4), while in the Cook Young Forest and Jackson exclosure ecotones vascular cover and bare ground both decreased in favour of litter and bryophyte cover. Bare ground and litter also decreased somewhat in all control ecotone transects. Litter decreased in most forest transects, offset in the Jackson control by an increase in bryophyte cover.

Herbaceous species

Numbers of herbaceous species gained and lost at each site are presented in Table A3.1. This indicates that continued grazing in the control plots has caused neglible change in the forest portions of most plots, but increased species diversity in the grassland and ecotone. The net gain in the Cook Swamp forest may be an effect of the open canopy in this plot.

Figure A3. 1 Change in vascular cover from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.

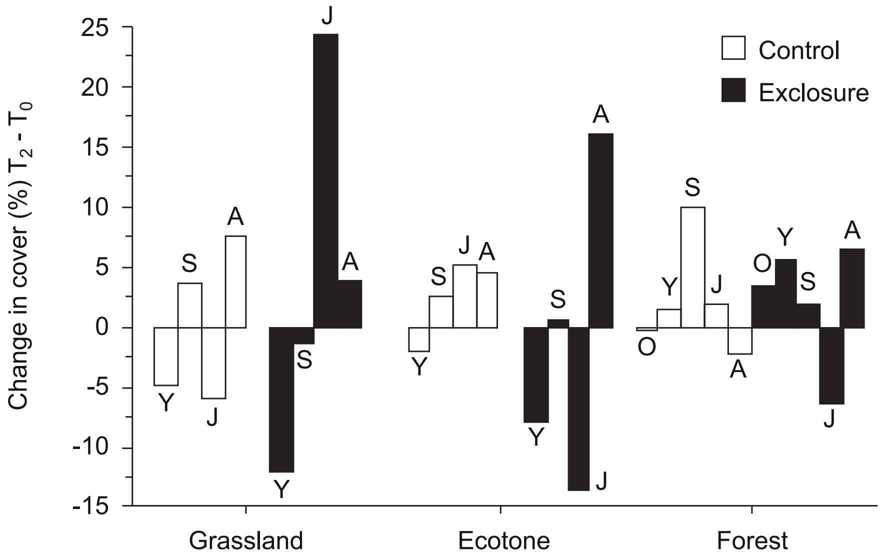


Figure A3.2. Change in bryophyte cover from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.

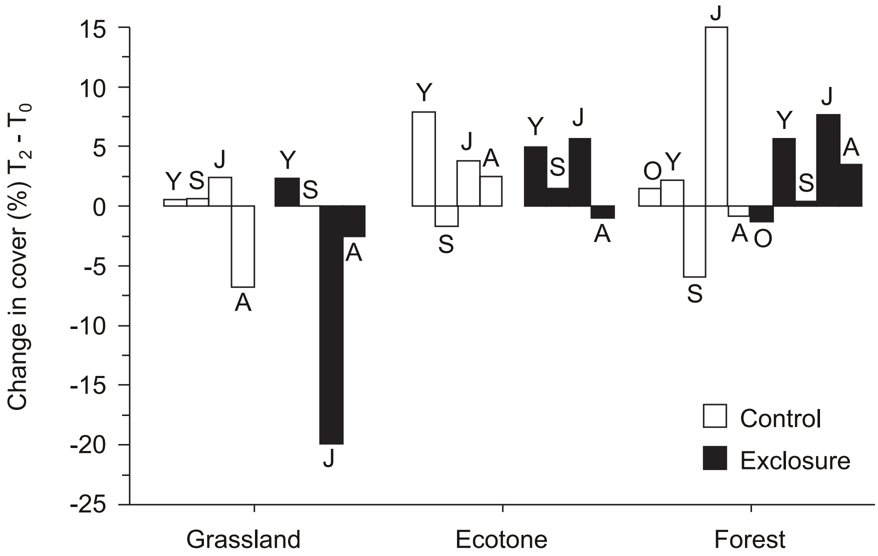


Figure A3.3. Change in litter cover from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.

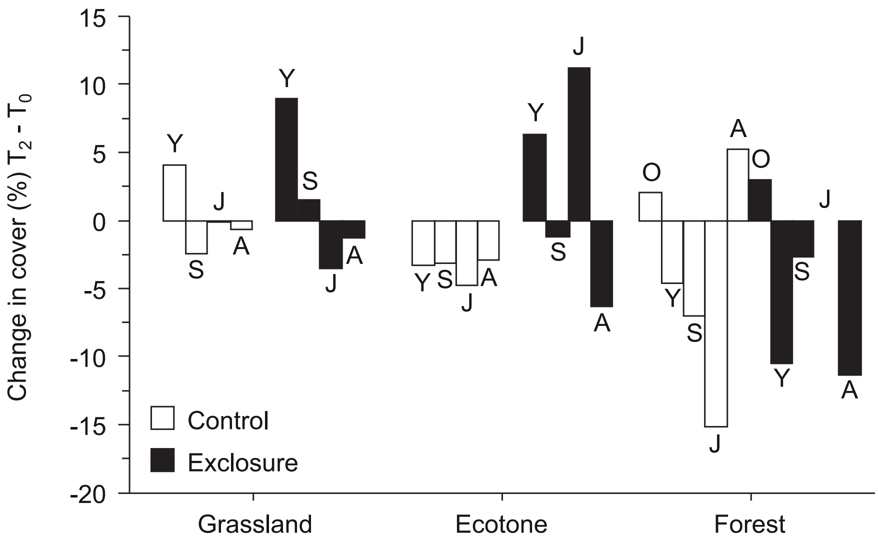


Figure A3.4. Change in cover of bare ground from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.

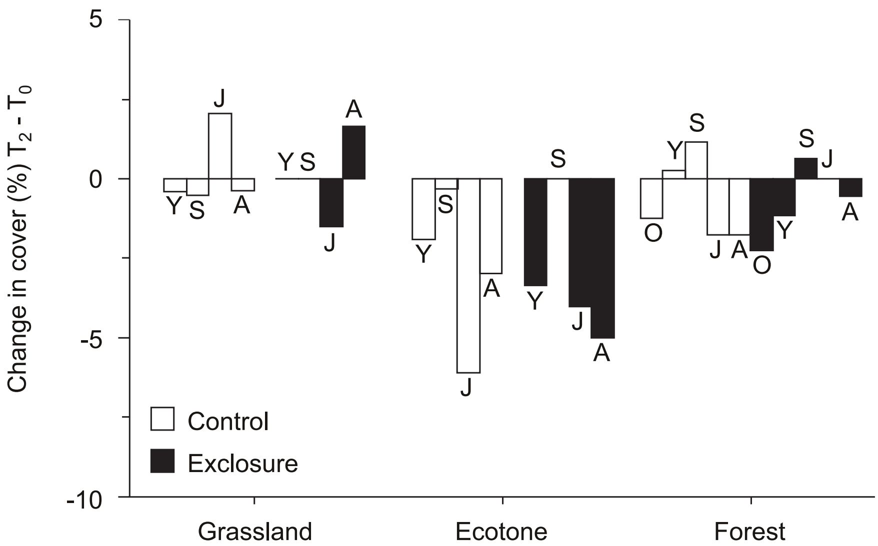


TABLE A3.1. MEAN NUMBER OF HERBACEOUS SPECIES GAINED AND LOST PER TRANSECT BY THE SECOND REMEASUREMENT IN EACH COMMUNITY TYPE AT EACH SITE.

SITE	COMMUNITY	CONTROL		EXCLOSURE	
		GAINED	LOST	GAINED	LOST
Cook Swamp	grassland	6.7	5.3	3.7	11.0
	ecotone	6.0	7.7	3.0	9.3
	forest	8.5	3.8	3.3	8.8
Cook Old	forest	1.5	1.8	2.5	2.3
Cook Young	grassland	7.0	5.3	3.7	5.0
	ecotone	13.0	7.5	6.0	6.5
	forest	1.7	1.7	4.3	0.3
Jackson	grassland	6.0	7.5	6.5	15.0
	ecotone	9.5	4.0	5.0	8.5
	forest	1.3	1.3	1.5	2.8
Arawata	grassland	7.0	5.5	3.0	7.5
	ecotone	7.0	2.5	6.0	5.5
	forest	4.5	3.0	3.8	3.0

Removal of cattle grazing has decreased diversity of herbaceous species in all grassland portions of the exclosures. There was little change in most forest portions of exclosures, however in the Cook Swamp exclosure diversity of herbaceous species decreased in all portions of the plot. This may be related to the substantial increase in herb height recorded in this plot (Fig. 6).

Woody seedlings

In the grassland and ecotone the increase in density of woody seedlings < 0.1 m tall was greater in the Cook Young Forest control plot than in any other site (Fig. A3.5). Herb height (Fig. 6), which was negatively correlated with seedling density (P = 0.03), decreased markedly in these transects, and vascular cover also decreased (Fig. A3.1). Seedling density (< 0.1 m) increased in most forested

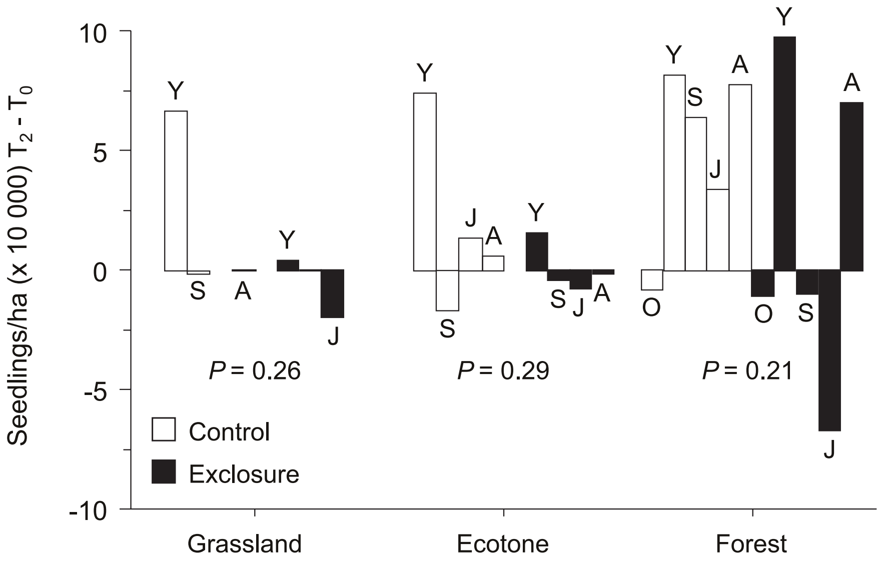
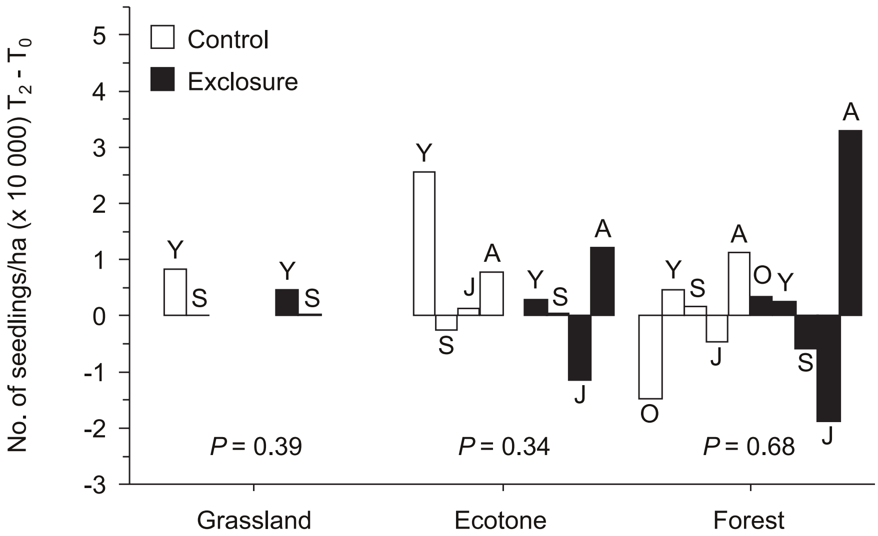


Figure A3.5. Change in number of seedlings < 0.1 m tall from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.

transects, but decreased in the Jackson exclosure. Factors influencing seedling density varied with site, and except for herb height there was no direct relationship with grazing.

The density of seedlings 0.1–0.3 m tall in exclosures was not significantly different from that of controls (Figure A3.6). Seedling densities increased in all Cook Young Forest plots, particularly in the ecotone portion of the control, and in the ecotone and forest portions of the Arawata plots, especially the forest exclosure. However, densities in the ecotone and forest portions of the Jackson exclosure decreased.

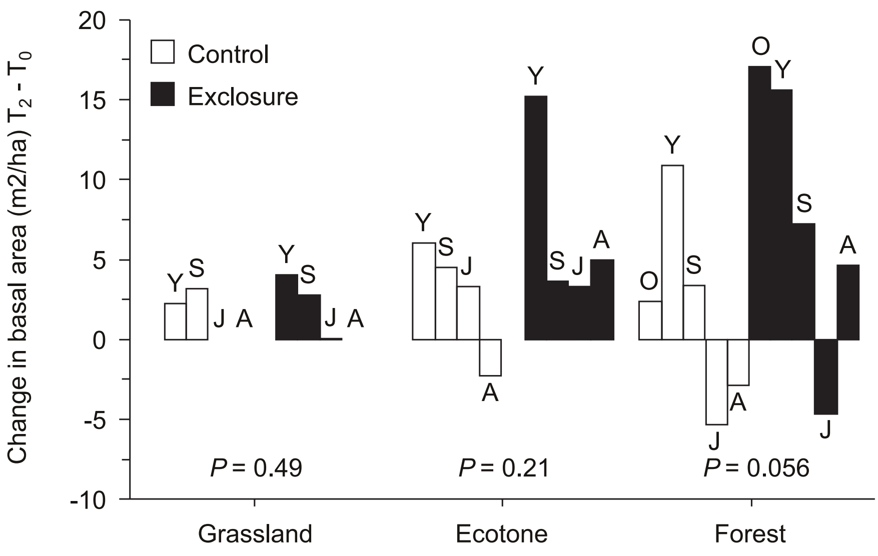
Figure A3.6. Change in number of seedlings 0.1–0.3 m tall from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.



Trees

Basal area increased in most transects, but the greater increase in forest exclosures relative to controls approached statistical significance (Fig. A3.7), and in the next few years this effect of grazing removal is expected to become more apparent.

Figure A3.7. Change in basal area from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; J = Jackson; and A = Arawata, and are in the same order for each community type.



Silver beech

The density of silver beech (*Nothofagus menziesii*) in the exclosures increased significantly relative to the controls in the 0.3–2 m tier (Figure A3.8C), and in the 0.1–0.3 m tier of the Arawata plots (Fig. A3.8B). Smaller seedlings have likely been overwhelmed by herbaceous species, particularly in the grassland portion of the Jackson exclosure (Fig. A3.8A). The removal of grazing has led to an increase in the density of beech trees > 2 m in the Jackson ecotone, but there has been no significant change in the other transects (Fig. A3.8D).

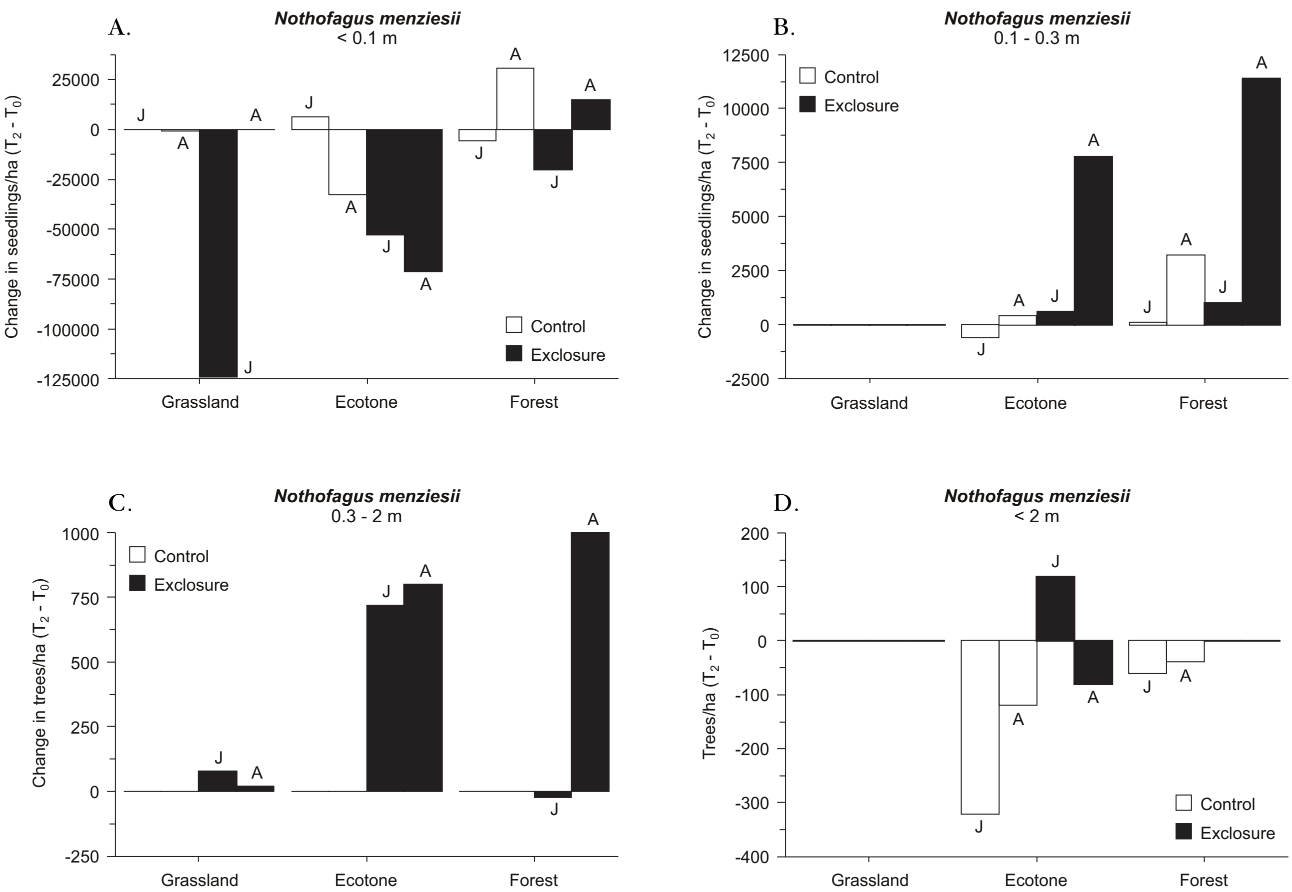


Figure A3.8. Change in silver beech (*Nothofagus menziesii*) density in each tier from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at Jackson and Arawata sites. The bars represent sites: J = Jackson; and A = Arawata, and are in the same order for each community type.

Kahikatea

The density of kahikatea (*Dacrycarpus dacrydioides)* seedlings (< 0.1 m) has increased in the ecotone and forest portions of the Cook Young Forest exclosure, and in the ecotone of the control (Figure A3.9A), but changed little in other sites. Seedling density has also increased in the ecotone of the Cook Young Forest exclosure in the 0.1–0.3 m tier (Figure A3.9B), but these increases are not reflected in higher tiers (Figure A3.9C & D). Natural mortality in kahikatea seedlings is generally high, and this may obscure any effects of grazing removal in the lower tiers. Kahikatea density increased in forested exclosures of the Arawata (0.3–2 m tier) and Cook Old Forest (> 2 m tier) relative to controls, but was not consistent across sites. The effect of removing grazing on kahikatea recruitment may depend on the relative competitive ability of associated species. However, increased density in the forested portion of the Cook Old Forest control in the 0.3–2 m tier, and the ecotones of the Cook Swamp and Cook Young Forest controls in the > 2 m tier, suggests that cattle grazing may facilitate recruitment of kahikatea in these non-beech sites (see Section 5.4.5).

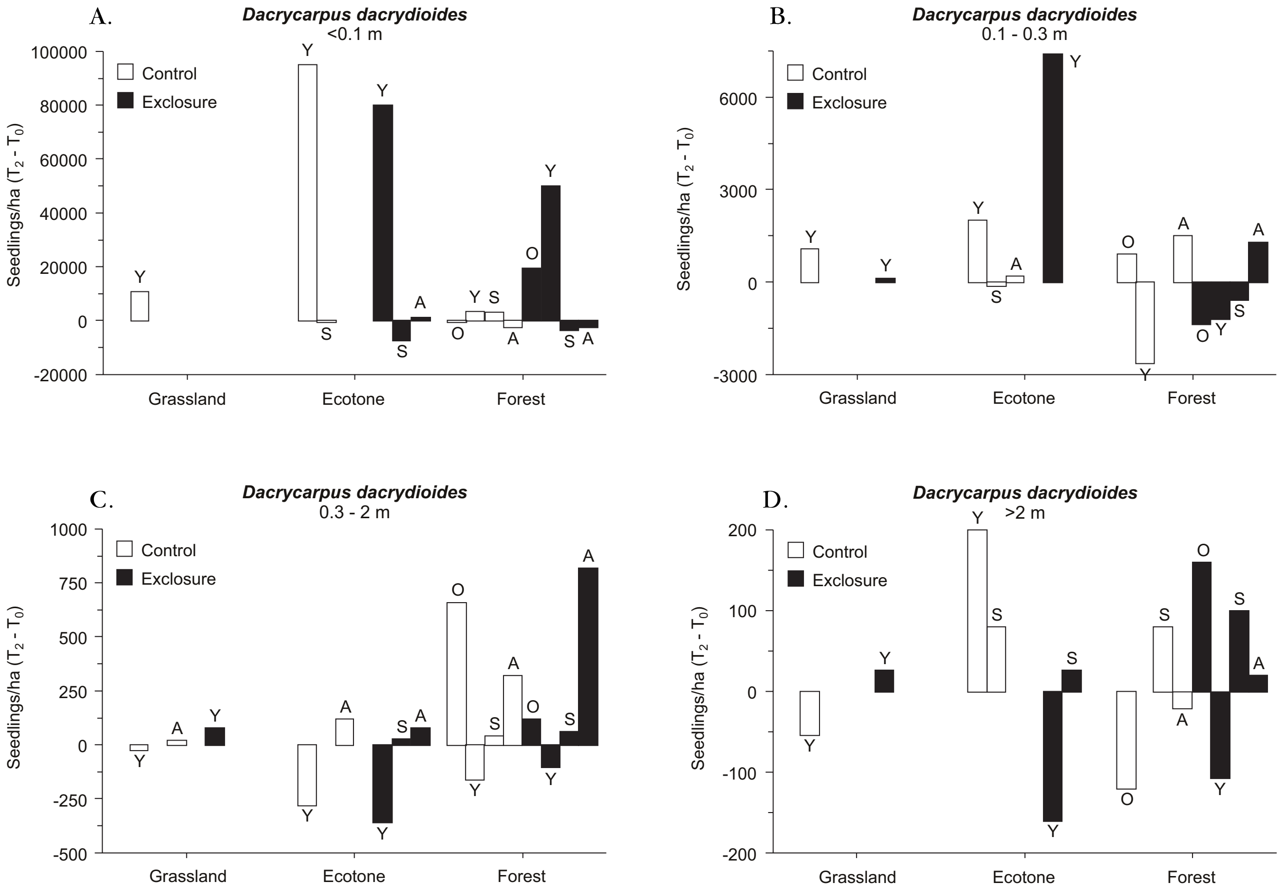


Figure A3.9. Change in kahikatea (*Dacrycarpus dacrydioides*) density in each tier from the time of exclosure (t_0) to the time of the second remeasurement (t_2) at each site. The bars represent sites: O = Cook Old Forest (only forest); Y = Cook Young Forest; S = Cook Swamp; and A = Arawata, and are in the same order for each community type.

Appendix 4

SUMMARISED TRANSECT DATA

The number of native and exotic herb species per transect is shown in Tables A4.1 and A4.2. Individual transect data for each site is summarised in Figures A4.1 to A4.12. Interpretation of the vector plots is described in Appendix 2 and Figures A2.1 and A2.2.

TABLE A4.1. NUMBER OF NATIVE HERB SPECIES PER TRANSECT (0.25 m^2) IN EACH YEAR. COOK OLD FOREST (CO), COOK SWAMP (CS), COOK YOUNG FOREST (CY), ARAWATA (A), JACKSON (J), AND WHATAROA (WH).

	CONTROL											EXCLOSURE						
TRANSECT	89	90	91	92	93	94	95	96	97	98	99	89	90	91	92	93	94	9
CO 0		5			5	5		2		5			4			2	4	
CO 5		4		5		3				4			3		4		5	
CO 10		6	6			7				7			7	3			5	
CO 15		8				5				3			6				7	
CS 0	12	14			15				16			12	11			12		
CS 5	17		14		14		15		14			11		12		16		
CS 10	17			15	13				14			13			10	10		
CS 15	12				14				14			13				13		
CS 20	14				15				11			13				10		
CS 25	9				8				7			6				5		
CS 30	13		12		12		10		11			16		12		9		
CS 35	13	11			15				13			15	11			7		
CS 40	13			12	13				11			13			12	11		
CS 45	10				14				15			12				13		
CY 0		7	10			9		8		9			10	10			11	
CY 5		10		10		10				13			12		9		9	
CY 10		13			14	13				15			13			13	10	
CY 15		16				17				19			14				15	
CY 20		9				15				16			11				14	
CY 25		5			6	6		7		5			3			7	13	
CY 30		2		4		4				4			5		5		6	
CY 35		3	2			3				1			2	2			3	
A 0				9	9		8				13				5	7		
A 5				9		10	8				8				9		6	
A 10				13			11				12				10			
A 15				10			13				13				12			
A 20				10			12				15				9			
A 25				4			6				8				8			
A 30				10	11		15				14				6	6		
A 35				8		11	13				9				9		11	
A 40				8			8				9				7			
A 45				7			6				4				7			
J 0			20	16		17			20	21				14	19		9	
J 5			21		20	21				20				14		17	15	
J 10			10			16				21				19			16	
J 15			10			9				9				10			12	
J 20			6			7				8				8			8	

Table A4.1 *continued.*

TRANSECT	CONTROL										EXCLOSURE							
	89	90	91	92	93	94	95	96	97	98	99	89	90	91	92	93	94	9
J 25			5			3				4				9	9		8	
J 30		3			6	5			4	4				6		6	6	
J 35		5				7				3				6			8	
WH 0								18			21							
WH 5								26			26							
WH 10								24			22							
WH 15								18			21							
WH 20								11			11							
WH 25								11			10							
WH 30								2			1							
WH 35								3			6							

TABLE A4.2. NUMBER OF EXOTIC HERB SPECIES PER TRANSECT (0.25 m^2) IN EACH YEAR. COOK OLD FOREST LIES WHOLLY WITHIN FOREST AND CONTAINED NO EXOTIC HERBS, OTHER SITES ARE COOK SWAMP (CS), COOK YOUNG FOREST (CY), ARAWATA (A), JACKSON (J), AND WHATAROA (WH).

	CONTROL											EXCLOSURE					
TRANSECT	89	90	91	92	93	94	95	96	97	98	99	89	90	91	92	93	94
CS 0	13	14			12				17			12	13			15	
CS 5	16		14		18		14		15			16		14		11	
CS 10	13			15	18				16			13			7	13	
CS 15	14				13				15			12				10	
CS 20	12				14				10			10				9	
CS 25	8				9				7			8				6	
CS 30	5		10		13		9		7			10		9		7	
CS 35	6	8			8				13			5	7			8	
CS 40	8			12	9				14			3			6	6	
CS 45	9				15				12			4				4	
CY 0		11	9			12		11		11			8	8			9
CY 5		9		9		8				9			8		10		4
CY 10		10			8	10				8			8			6	7
CY 15		9				5				8			9				5
CY 20		2				4				3			1				1
CY 25																	
CY 30																	
CY 35																	
A 0				8	7		8				12				6	7	
A 5				12		15	13				10				8		8
A 10				13			11				14				10		
A 15				14			11				12				13		
A 20				6			6				6				11		
A 25																	
A 30					2		2				1				1	2	
A 35						3	2				2						2
A 40																	
A 45																	
J 0			10	9		8			10	8				13	13		9
J 5			13		9	9				12				13		14	9
J 10			7			8				7				8			10
J 15										1							
J 20																	
J 25																	
J 30																	
J 35																	
WH 0								8			8						

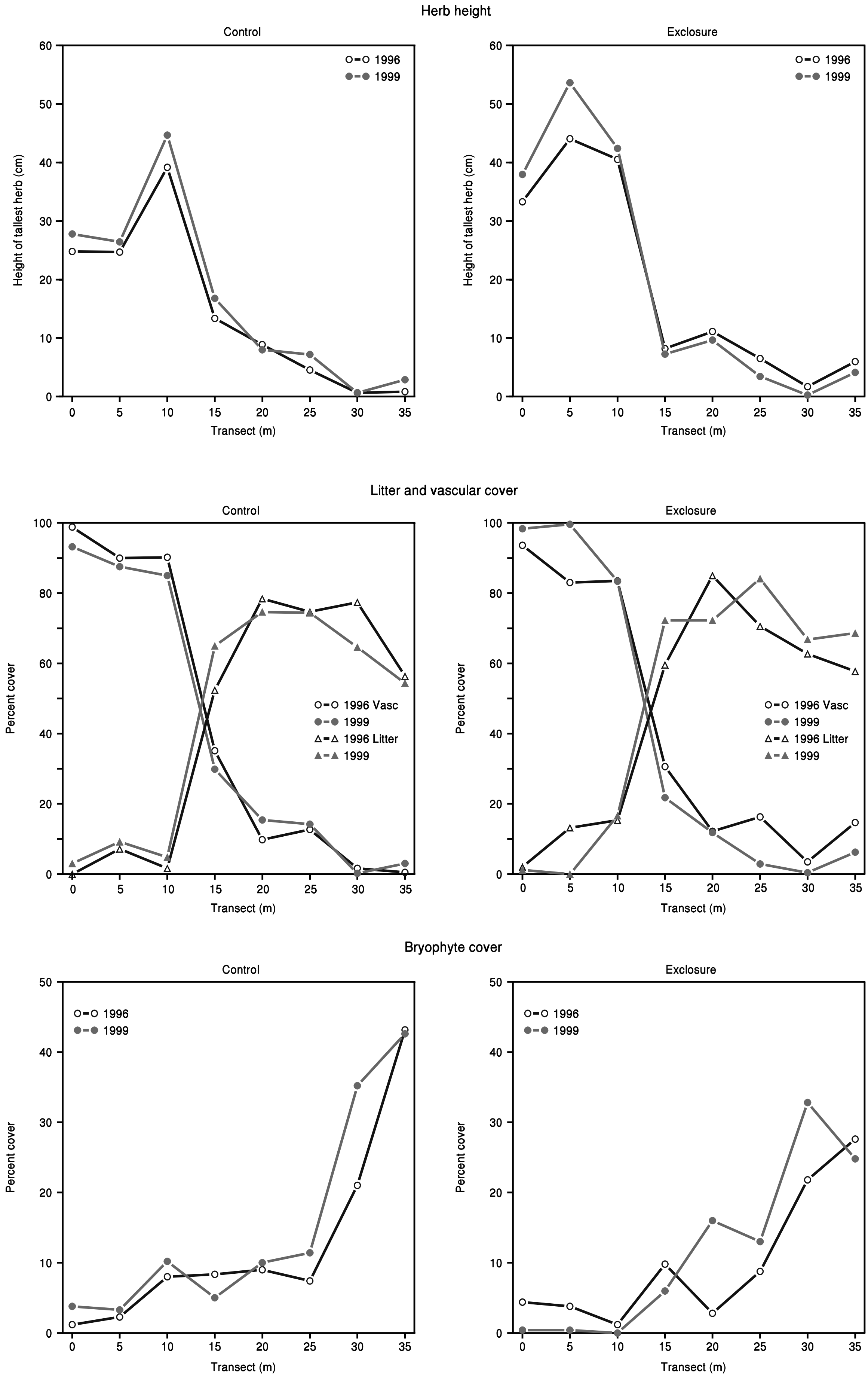


Figure A4.1. Vascular plant height and cover of vascular plants, litter, and bryophytes in each Whataroa transect on each measurement date.

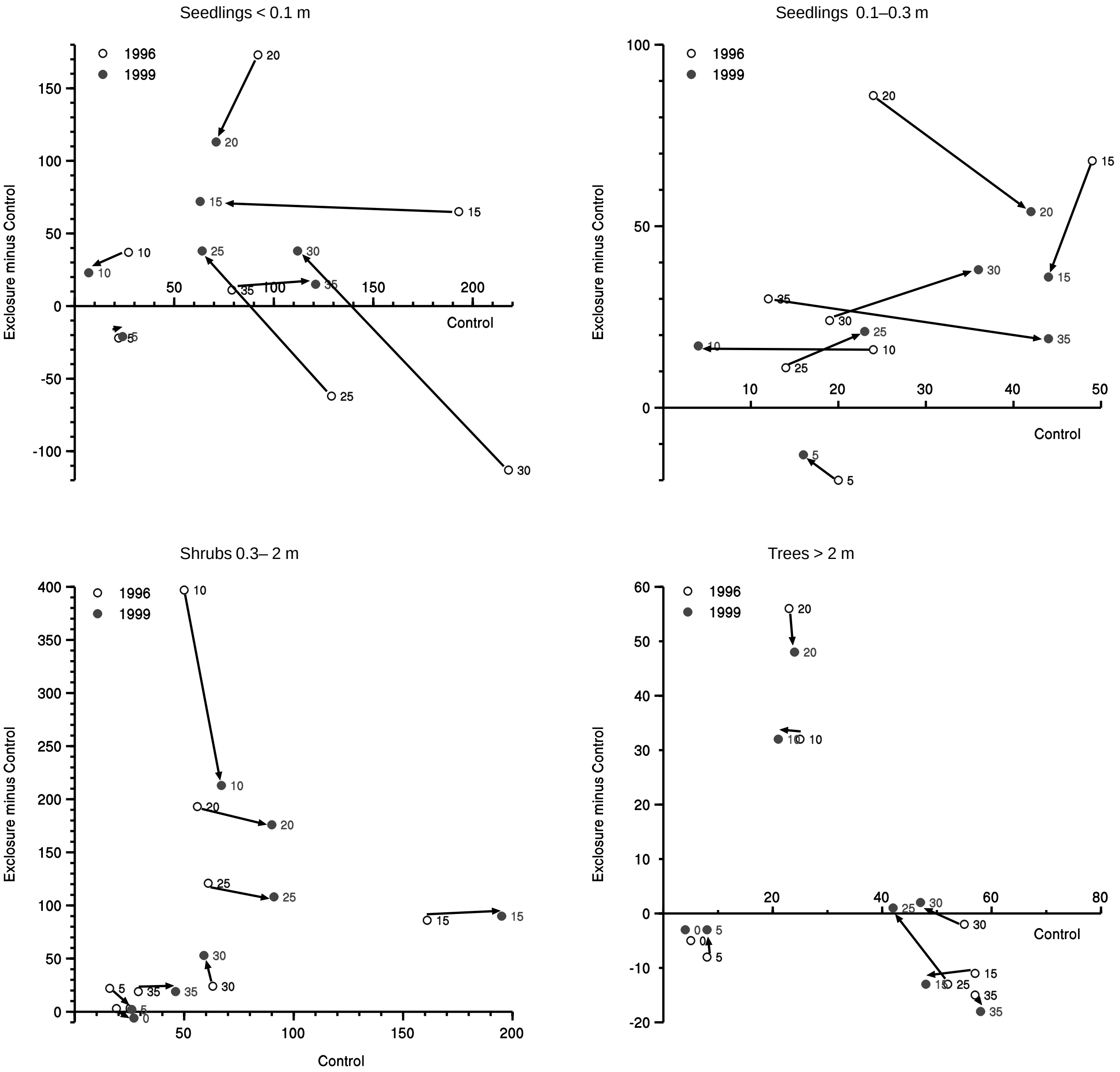


Figure A4.2. Vectors for numbers of seedlings < 0.1 m tall, seedlings 0.1–0.3 m tall, saplings and shrubs 0.3–2 m tall and tree ferns, and trees and saplings > 2 m tall in each Whataroa transect on each measurement date. Arrows link the co-ordinates of exclosure minus control compared with control values on subsequent measurement dates. Each co-ordinate is accompanied by the transect number (i.e. according to the position of the transect in metres along its plot).

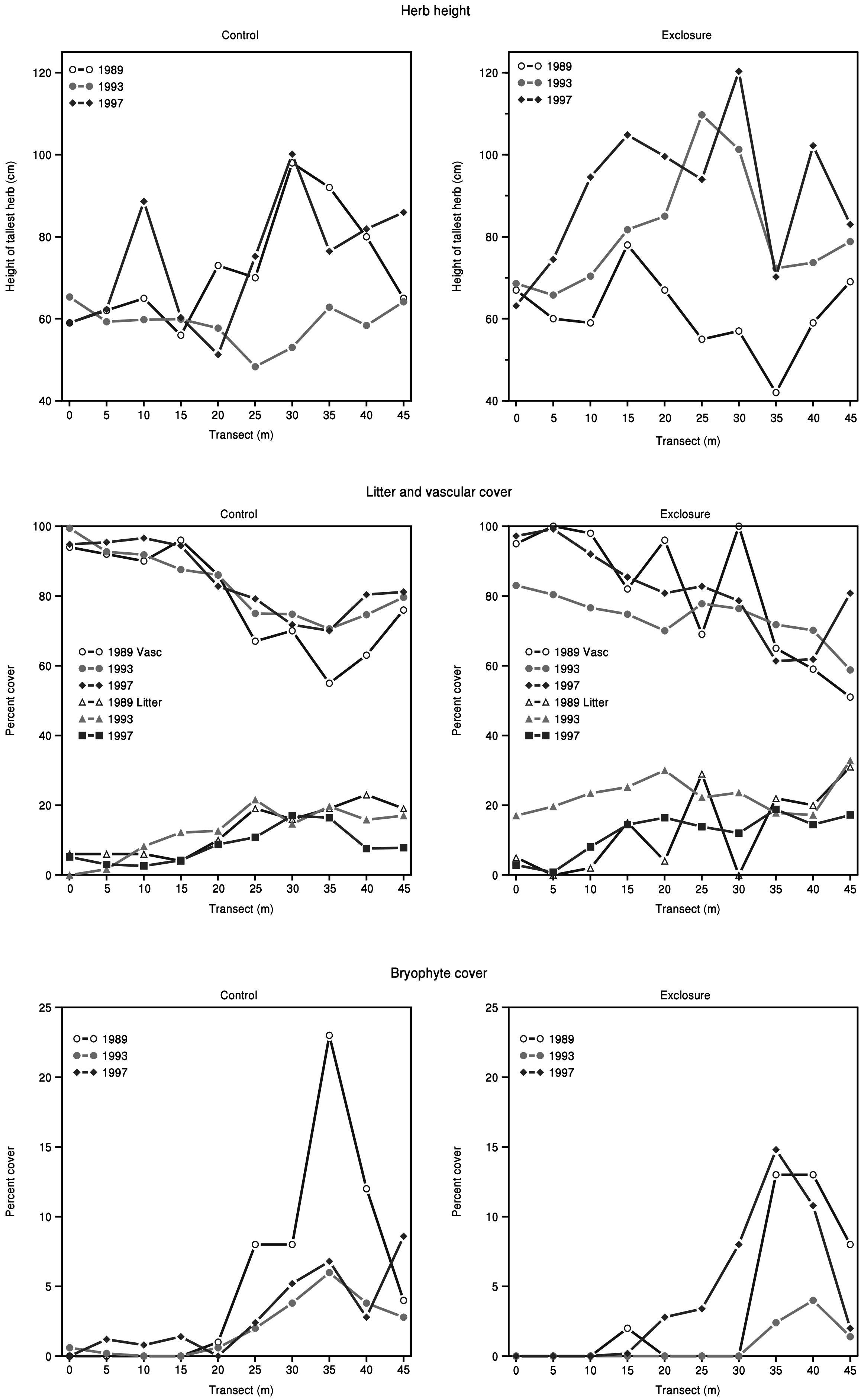


Figure A4.3. Vascular plant height and cover of vascular plants, litter, and bryophytes in each Cook Swamp transect on each measurement date.

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