FURTHER STUDIES ON THE IMPACT OF DEER ON SECRETARY ISLAND, FIORDLAND, NEW ZEALAND

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SUMMARY: The continuing effects of red deer on the rain forest of Fiordland's Secretary Island (80 km^2) over the last six years are described in relation to their initial impact and control operations. On easily accessible sites the range of affected species is increasing as the most palatable become depleted while some previously unmodified sites are now threatened. Photographic records, quantitative samples and permanent plots are used to describe still virgin stands and various levels of modification to the forest composition and structure, as well as to provide a basis for further monitoring.

INTRODUCTION

The initial patterns of browsing by red deer *(Cervus elaphus)* in virgin rain forest on Secretary Island, Fiordland National Park (Fig. 1), were described qualitatively some eight years after the first animal was recorded on the 80 km^2 island (Mark and Baylis, 1975). Among the woody species, araliads were the most keenly sought, in particular two varieties of *Pseudopanax colensoi,* the 3-foliate variety *ternatus* below *c*. 500 m and the 5-foliate var. *fiordensis* mostly above this elevation, together with *P. linearis*. The stripping by deer of all accessible bark from most trunks of *P. colensoi* was selectively eliminating this species while the spindly stems of *P. linearis* were being broken to reach the immature terminal shoots which were being removed (Mark and Baylis, 1975: Figs. 2, 3). By 1975 few trunks of *P. colensoi* had collapsed but many were leafless and dead (Mark and Baylis, 1975: Figs. 4, 8). Occasional mature trees up to 40 cm diameter remained untouched, particularly those with a heavy cover of corticolous bryophytes, and few young plants of this species had been cropped.

There was some non-lethal bark chewing on *Schefflera digitata,* and other woody species are being browsed in 1975; in decreasing order of use these were *Coprosma lucida, Griselinia littoralis, Coprosma foetidissima, C. astonii, C. colensoi, Fuchsia excorticata, Pseudopanax simplex, Hoheria glabrata, Dracophyllum fiordense, Brachyglottis buchananii* (= *Senecio bennettii), Pittosporum colensoi* and *Myrsine divaricata*. Several of the larger stems of *Phyllocladus alpinus* had been damaged or killed with antler rubbing of bark while occasional stems of *Pseudowintera colorata, Dacrydium intermedium* and *Podocarpus ferrugineus* had suffered similarly.

Among the herbs, hen and chicken fern *(Asplenium bulbiferum),* which dominated rocky sites on old debris slopes, was being widely sought and essentially defoliated. What originally had been large crowns up to 1 m tall were reduced to a scant regrowth of small fronds up to 10-20 cm long; only sites rendered inaccessible by large boulders or surrounding bluffs remained intact (Mark and Baylis, 1975: Figs. 5, 6). Accessible fronds of *Dicksonia squarrosa* were also being consumed together with, in decreasing order of use, *Blechnum chambersii* (= *B. lanceolatum), Chionochloa conspicua, Pneumatopteris* (= *Thelypteris) pennigera, Uncinia uncinata, Blechnum capense, B. minus, Astelia nervosa, Todea superba* and *Phormium cookianum*.

Forest species listed as unpalatable were *Blechnum discolor, Alsophila* (= *Cyathea) smithii, Microlaena avenacea and Astelia nivicola* var. *moriceae* among the herbs, together with the woody *Neomyrtus pedunculata* and *Pseudowintera*.

Deer Control Operations

The Island had been declared a "Special Area" within Fiordland National Park in recognition of its virgin state, and special efforts were made to eliminate deer once their presence was observed. Up to the end of 1974, 63 deer had been shot on the Island by N.Z. Forest Service staff.

Poisoning, using 1080 gel on *Griselinia* foliage was introduced in mid 1975 when a faecal pellet survey of the Island indicated a total deer population of about 200 animals (Bathgate, 1977). Poisoning was intensified in 1976 with the assistance of cut tracks and three permanent huts and, late in that year, a significant population reduction was evident both from sighted deer carcases and the decline in fresh sign (Bathgate, 1977). These operations are continuing

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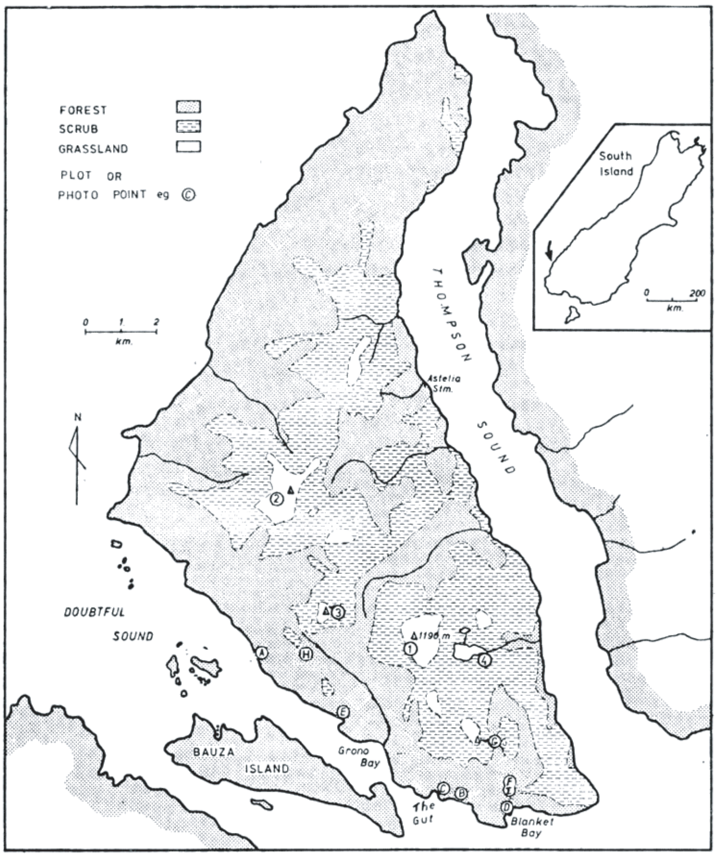

FIGURE 1. *Map of Secretary Island, modified from Mark and Baylis (1975), showing the broad vegetation pattern, four of the island's main topographic features (l = Mt Grono; 2 = All Round Peak; 3 = The Hub; 4 = Secretary Lake), as well as the approximate locations of permanent plots and photographs described in this paper.*

and a further pellet survey is pending. We saw no animals in December 1981 and only two groups of pellets.*

Assessment Of Deer Impact In 1981

We spent one week on Secretary Island in December 1981 to reassess animal modification in areas described during our previous visit in 1975 and to establish some permanent plots to follow future trends more precisely, now that the more sensitive plant species and areas were known (Fig. 1).

Lowland talus slopes beneath steep cliffs that are particularly prominent along the south-west side of the Island (site A in Fig. 1), were briefly described in 1967 (Wardle, Mark and Baylis, 1970: Fig. 6). Deer had not gained access to this area by 1975 (Mark and Baylis, 1975: Fig. 5), but in 1981 there was slight modification, particularly to the dense herb layer of *Asplenium bulbiferum* (Figs. 2, 3), probably caused by one or a few deer venturing along the boulders from the south-east. However, it was still possible to obtain a quantitative measure of the composition

* A party visiting the island in late May 1982 reported at least three sets of deer tracks in snow in the area of open manuka woodland on the poorly drained glacial bench within 1 km of Secretary Lake but no signs above the tree line where snow depth averaged 30 cm (Mr S. A. Brasch, pers. comm.).

and density of both the woody and herbaceous components of this essentially two-layered community (see Mark and Baylis, 1975): Fig. 5) before species are selectively eliminated or reduced. Modification to the woody species, while less immediate, is likely to involve elimination of the smaller stems of *Melicytus ramiflorus* and *Schefflera,* the foliage of which is being browsed. The present level of bark chewing on *Schefflera* appears to be tolerated without obvious impairment.

The quarter method of plotless sampling was used in traverses across the stand c. 20 m and 40 m above the high tide line. With points located 10 paces apart, distances were measured in each quadrant to: a) the base of the nearest woody plant in the canopy; b) any nearer sub-canopy woody plant > 30 cm tall; c) the nearest herbaceous plant > 30 cm tall. From a total of 25 points (l00 distance measures per category), composition by stem proportions, of the low windswept canopy was found to be evenly divided between *Melicytus* (45%) and *Schefflera* (42%) with minor contributions from *Fuchsia excorticata* (6%), *Alsophila* (= *Cyathea) smithii* (3%), *Hedycarya arborea* (2%), *Myrsine australis* and *Carpodetus serratus* (1 % each). The mean distance (2.702 m) indicated a density for the canopy trees of 1370 stems/ha. While the basal diameters of their trunks reached up to 30 cm, most stems were multi-leadered and often leaned downslope but with upright branches. Inclusion of 29 sub-canopy woody plants decreased the mean distance to 2.179 m and gave a density value of 2106 stems/ha. This increase resulted largely from a substitution of *Schefflera* (up 12%) for *Melicytus* (down 13%), with minor reductions in *Fuchsia* (2%) and *Carpodetus* (1 %), and an increase in *Hedycarya* (3%). An additional species, *Urtica ferox,* made a minor contribution (1 %).

While eight species were recorded in the herb layer, *Asplenium bulbiferum* (77% of crowns) was the overwhelming dominant and provided almost all of the cover, with small contributions from *Blechnum chambersii* (9%), *Polystichum vestitum* (6%) and *Phymatosorus diversifolius* (= *Phymatodes diversifolium)* (4%), and less from *Asplenium oblongifol-*

FIGURE 2. *Severely grazed plants of* Asplenium bulbiferum *adjacent to site sampled on the lowland talus slope along the south-west side of Secretary Island (site A in Fig. 1). A few of the original fronds r-main (to 1.2 m long) but small regrowth fronds (to 30 cm) now predominate.*

FIGURE 3. *Interior view of slightly modified coastal forest of* Schefflera-Melicytus / Asplenium bulbiferum *which was sampled by the quarter method (site A in Fig.* 1),

FIGURE 4. *Photographic point set up in lowland forest in 1975 to show severe damage to* Asplenium bulbiferum *herb layer (from Mark and Baylis, 1975: Fig. 6) (site E in Fig. 1).*

ium (= *lucidum*). *Pneumatopteris* (= *Dryopteris*) *pennigera*. *Leptolepia novae-zelandiae* and *Lastreopsis* (= *Rumohra*) *hispida* (1 % each). Mean distance for the herb layer (0.554 m) indicates a density of some 32,580 plants/ha of which about 25,100 were of *Asplenium bulbiferum*. In addition to the species recorded, a few Hanes of *Ripogonum scan dens, Rubus cissoides and Muehlenbeckia australis* were present.

The more accessible forest stands in the vicinity of nearby Grono Bay, which previously had supported a similar dense understorey of *Asplenium*. had been severely depleted by February 1975 (Mark and Baylis, 1975: Fig. 6) when this fern had been reduced from a height of c. 1 m to mostly regrowth fronds only 15-20 cm long. This site (site E in Fig. 1) was rephotographed in October 1976, by which time *Asplenium* fronds had been reduced even further, to c. 10 cm long, while three immature plants of *Alsophila* (= *Cyathea*) *smithii* were untouched (Fig. 4). By December 1981, the *Asplenium* fronds at this site were only 3-10 cm long, though they showed no sign of having been recently grazed. The three plants of *Alsophila* had flourished in the interval and are now conspicuous (Fig. 5). In order to follow the fate of individual small plants of *Asplenium,* a vertical photograph covering c. I m2 was taken (Fig. 6) from the top of an aluminium angle stake (height c. 90 cm) installed to mark the tripod position for the general view of this site (i.e. Figs. 4, 5). The fate of *Asplenium* plants shown in this vertical view will be monitored periodically. While they now appear to be young plants they are more likely to be the regrowth from defoliated rhizomes. The condition of the herb layer on this site is generally typical of extensive areas of old debris slopes that surround Grono Bay. Only the dense boulder fields c. 40 m to the north-west of the site being monitored, retain their dense ground cover of *Asplenium* (Fig. 7) because the terrain is difficult even for deer.

The devastation that is evident when Figure 7 is compared with Figure 5 is due to the reduction of *Asplenium*. It is matched in Figure 8 where browsed stumps of *Polystichum vestitum* explain the paucity of the herb layer. More striking, perhaps, is the

FIGURE 5. *The area shown in Figure* 4, *rephotographed in December 1981, showing further reduction in the cover provided by* Asplenium bulbiferum *and five prominent plants of* Alsophila (= Cyathea) smithii *which grow unchecked.*

FIGURE 6. *Vertical view of ground surface from top of stake marking camera position for the photographic point used for Figures* 4 *and* 5. *The numerous* Asplenium *plants are all very small. One heavily grazed plant of* Blechnum chambersii *persists 0.5 m along the tape on its right.*

FIGURE 7. *Area adjacent (40 m N.W.) of that shown in Figures 4-6 where numerous large boulders have discouraged deer despite a dense tall cover of* Asplenium bulbiferum.

FIGURE 8. *A minor depression on a flattish bench in montane beech / kamahi forest at* c. *480* m *above Blanket Bay (site F in Fig. 1) with the open herbaceous layer of chiefly* Polystichum vestitum (c. *one plant per* 2 m^2*) reduced mostly to stumps. Scattered tree ferns of* Alsophila smithii *and shrubs of* Pseudowintera colorata *remain unharmed.*

FIGURE 9. *Subalpine silver beech forest at* c. *880* m *on the leading ridge between Blanket Bay and Mt Grono (site G in Fig. 1) showing collapse of the understorey small-tree layer of Pseudopanax colensoi var. fiordensis after being killed by deer prior to 1975. Compare with Figure 4 in Mark and Baylis (1975) and note that the* Dracophyllum fiordense *stem behind the figure and the dense herb layer of* Astelia nivicola *var.* moriceae *remain intact.*

death and collapse of dead stems of *Pseudopanax colensoi* var. *fiordensis* in areas of subalpine silver beech *(Nothofagus menziesii)* forest where once it formed most of the subcanopy tier. In 1975, these stems were mostly standing though dead (Mark and Baylis, 1975: Fig. 4). Not only has their loss essentially eliminated this layer (Figs. 9, 10) but locally at least, trampling combined with a sparse herb layer has rendered the forest floor prone to sheet erosion and the exposure of tree roots (Fig. 11). It is only the mature bark of *P. colensoi* (both var. *fiordensis* and var. *ternatus)* that has prime palatability (Fig. 12) and, with seed sources persisting in the many inaccessible sites, seedlings and saplings, as yet unattractive to deer, may soon provide the only clue to the former significance of this species in the subcanopy (Fig. 13).

Other highly palatable species that were never

FIGURE 10. *Subalpine silver beech forest at* c. *850 m on the leading spur between The Gut and The Hub (site H in Fig. l) in which the previously dense small-tree layer of* Pseudopanax colensoi *var.* fiordensis *has now collapsed.*

FIGURE 11. *View upslope of area adjacent to that pictured in Figure 10 showing abundant debris, mostly of* Pseudopanax colensoi *var.* fiordensis *stems, together with exposed tree roots and soil which is beginning to wash down-slope.*

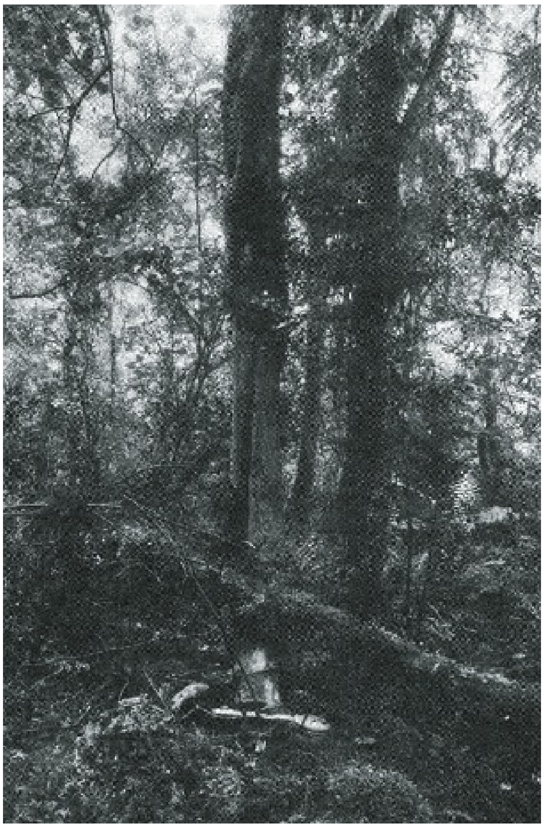

FIGURE 12. *A large stem of* Pseudopanax colensoi *var.* ternatus (c. 35 *cm diam.) forming part of the understorey in lowland beech-podocarp forest at* c. *80 m elevation above Blanket Bay (site 1 in Fig. 1). The bark from this tree readily accessible to deer had been only recently stripped to a height of* c. *1.4 m.*

abundant, such as *Coprosma lucida* and *Blechnum chambersii,* are now quite rare. Common species rarely killed by the present level of browsing are *Griselinia littoralis, Pseudopanax linearis, P. crassifolius, Coprosma foetidissima, Dicksonia squarrosa* and *Polystichum vestitum* (in most sites) but antler rubbing on the bark is usually fatal to *Phyllocladus alpinus.*

Stems of *Pseudopanax linearis* are apt to break when deer try to reach and remove their leading shoots (Mark and Baylis, 1975: Fig. 3). Stem tips of the more supple juvenile stems of *P. crassifolius* in the lowland forest are now being consistently sought

FIGURE 13. *Lowland beech-podocarp forest at* c. *50* m *elevation (near site B in Fig. 1) showing the distinctive fallen trunk of a* Pseudopanax colensoi *var.* ternatus *tree ring barked and killed by deer, together with a sapling, the bark of which has not yet attracted deer.*

by deer. Only rarely do they break, and growth resumes from the uppermost remaining axillary buds. This results in a characteristic distortion of the normally straight stem (Fig. 14) which thereby provides a means of determining the incidence of browse damage to the stem tip. An area adjacent to the track between The Gut and Blanket Bay, where juvenile lancewoods *(Pseudopanax crassifolius)* are numerous (site B in Fig. 1), was selected for a 10 x 15 m permanent plot to describe the present situation and follow the fate of the persisting stems.

Individual stems were located and identified by reference to the distance along (west) and at right angles (north and south) from a 15 m line run through the centre of the plot. Total height of each stem and the heights of any distortions associated with an axillary bud superseding a lost terminal bud were measured. Of the 46 juvenile stems of lancewood occurring within the 150 m^2 plot, five had been killed while all but 12 of the remainder had distorted stems. Four of these 12 undamaged stems, being epiphytic, were beyond the reach of deer while of the other eight, four were among the tallest (> 1.95 m)

TABLE 1. *The numbers of four species of ferns grouped according to the level of browsing by deer in a 20 x 10 m permanent plot in lowland mixed beech-podocarp forest (near site B in Fig. 1).*

Browse	*Dicksonia squarrosa*			*Alsophila smithii*			*Blechnum discolor*		*Asplenium bulbiferum*	
rating	Juv.	Immature	Mature	Juv.	Immature	Mature	Juv.	Adult	Juv.	Adult
Nil	21*	24	9	20	13	18	86	63	60*	4
Slight	—	14	4	0	0	0	0	0	—	0
Severe	—	19	3	0	0	0	0	0	—	6
Moderate	—	12	0	0	0	0	0	0	—	0

* Juveniles of these species were not rated as to browsing damage but were mostly undamaged.

and three the smallest (< 30 cm). The 29 stems that had been browsed had a mean height of 1.16 ± 0.53 m with an average of 2.5 ± 1.03 browsings (range 1 to 4) per stem.*

Dicksonia squarrosa, being another palatable species that is vulnerable before a sufficient trunk develops (Fig. 15), was documented in an as yet little damaged plot, 20 x 10 m (Fig. 16) loca:ed alongside The Gut-Blanket Bay track *c.* 1 km from The Gut hut (near B in Fig. 1).* Here, numerous individuals spanning a range of sizes occurred with other more palatable and non-palatable herbaceous species. In ten strips, each 10 x 2 m, the following categories were noted: *Dicksonia* and *Alsophila* (= *Cyathea) smithii* "juvenile" (maximum frond length < 50 cm, "immature" (trunk height < 25 cm) and "mature" plants (trunks> 25 cm tall), *Blechnum discolor* "juveniles" (trunkless) and "adults" (with trunks), and *Asplenium bulbiferum* "juveniles" (leaves < 25 cm long) and "adults" (leaves> 25 cm long). In addition, each plant was given a subjective browse rating of severe, moderate, slight, or nil. The results are summarised in Table 1. A full species list was compiled for each of the ten sub-sections of the plot*.

Loss of certain aromatic but unpalatable species through bark damage caused by the rubbing of antlers was noted earlier (Mark and Baylis, 1975) and has continued, but several mature trees have also died without obvious damage to their bark. Against the prospect of further losses, two permanently marked plots, each 50 x 10 m, were set up m areas with relatively large numbers of celery pine *(Phyllocladus alpinus)* stems and a spread of size classes. One site is on a low terrace opposite The Gut hut and alongside the track to Blanket Bay (site C in Fig. 1), the second is 910 m in from the coast at Blanket Bay on gently undulating terrain (site D in Fig. 1)*. All individuals were located by their distance either side of a tape run 50 m along the centre of the 10 m wide plot. Size classes adopted were: "seedling" (< 1 m tall), "sapling" (> 1 m tall but < 2.5 cm diam. at breast height) and "tree" (> 2.5 em d.b.h.-actual diameter measured). The

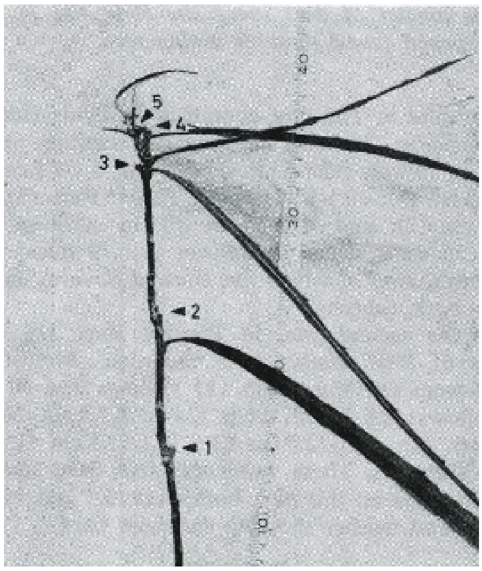

FIGURE 14. *A stem tip of* Pseudopanax crassifolius *showing the distorted apical growth induced by repeated removal of the stem tip by deer. The sequence and location of damage is shown by the arrows* 1-5.

* Details have been filed in the Botany Department, University of Otago and at Fiordland National Park Headquarters, Te Anau.

* Details of location, marking and contents of these plots have been lodged at Fiordland National Park Headquarters, Te Anau, and at the Botany Department. University of Otago.

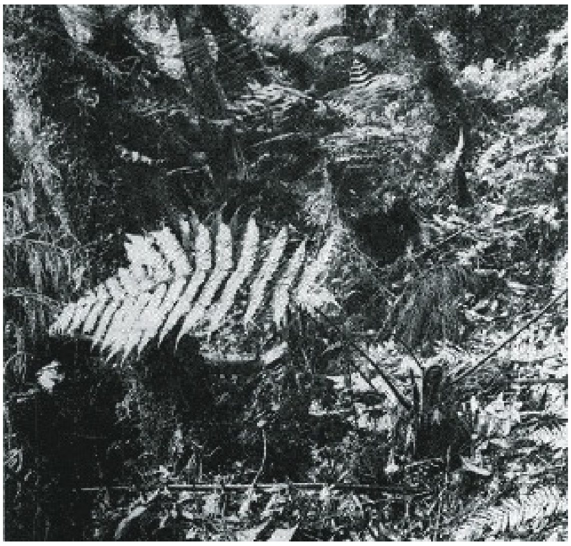

FIGURE 15. *Typical severe grazing damage to a juvenile plant of* Dicksonia squarrosa *photographed within the permanent quadrat set up to study the future impact of deer (near site B in Fig 1). Only one opened frond remains undamaged.*

500 m^2 plot at The Gut contained 81 living stems of *Phyllocladus,* 30 being seedlings, 15 saplings and 36 trees as follows: 2.6-5cm d.b.h. (13); 5.1-7.5cm (7); 7.6-l0cm (3); 10.1-12.5cm (2); 12.6-15.0cm (3); 15.1 -17.5 cm (2); and 17.6-20 cm (6). In addition there were 26 dead stems (7 saplings and 19 trees, up to 15.5 cm diam.) of which five showed obvious damage from bark rubbing.

At the second site, in Blanket Bay, 316 living stems of *Phyllocladus* were recorded. Almost half (155) were seedlings, with 121 saplings and 40 trees as follows: 2.6-5.0cm d.b.h. (24); 5.1-7.5cm (8); 7.6-10.0 cm (4); 10.1-12.5 cm (2); 15.1-17.5 cm (1); and 27.6-30cm (I). There were only two dead stems of *Phyllocladus* on this plot, both trees (3.3 and 14.7 cm d.b.h.) and neither showing damaged bark.

DISCUSSION

We report continuing modification to the forest vegetation of Secretary Island by red deer. Areas which had proven too difficult of access for these animals in 1975, during their first 12 years on the island, are now being affected, despite a concerted effort by New Zealand Forest Service staff to rid the island of deer. We agree with Bathgate (1977) that the degree of modification could still be considered as comparatively slight. Nevertheless, it seems that the present level and type of operation, combining 1080 poison as gel on live foliage baits with ground and air shooting, aided by three huts and a partial tracking system, will not achieve eradication nor even a level of control compatible with the "Special Area" status recognised for it in the management plan of Fiordland National Park. This designation was in recognition of the virgin state of the island's vegetation when it was first described (Baylis, Wardle and Mark, 1963).

A comparison of the deer-free forests of the Catlins region in southeast Otago with the forests of western Otago and western Southland, where deer populations were allowed to reach their natural limit, suggests that the lack of *Pseudopanax colensoi* in the west shows how a once abundant tree may leave no trace (though today its previous abundance in the west can only be inferred). As Veblen and Stewart (1980) relate, the same phenomenon has occurred on Stewart Island. There, an early settler, R. Traill, provided a general description of the Island's forests as he recalled them before modification by deer :hat were liberated in 1905 (Traill, 1965). He also described the observed effects of deer on the sub-canopy tree species and understorey vegetation: "At that time the bush of Stewart Id. had a dense undergrowth of ferns, shrubs and young trees. This growth was so dense that even on dry days in the depth of winter, anyone going into the bush for only a few chains usually got wet to the waist. . . *Nothopanax* (now *Pseudopanax) colensoi* and *Coprosma lucida* were doomed because deer developed the habit of chewing the bark as well as the leaves." While Cockayne (1909) listed *P. colensoi,* together with several

FIGURE 16. *View of forest understorey in the lower right (S.W.) corner of quadrat set up to follow deer damage on* Dicksonia squarrosa. *Photo taken from a position* c. *3 m up the eastern edge of the plot.*

other woody species, as still common in the rata-kamahi-rimu *(Metrosideros umbellata-Weinmannia racemosa-Dacrydium cupressinum)* forests of the island, it is now "relatively scarce" (Veblen and Stewart, 1980).

It is because such losses are too often unsuspected that we have tried to quantify the natural abundance on Secretary Island of species vulnerable to deer. That this can still be done 18 years after the first deer arrived shows that the efforts of the New Zealand Forest Service staff have prevented the population explosion that normally occurs. But there is also clear evidence now of the subtle changes that are caused by selective browsing and of 'the significant loss of ground cover that will follow if deer are driven to penetrate further by an unchecked rise in numbers.

REFERENCES

BAYUS, G. T. S.; WARDLE, P.; MARK, A. F. 1963. Vegetation studies on Secretary Island, Fiordland, Part 1, General introduction, *New Zealand Journal of Botany* 1: 167-70.

BATHGATE, J. L. (unpublished). Secretary Island; the state of its preservation from deer. *New Zealand Forest Service*. Invercargill. 23 pp.

COCKAYNE, L. 1909. Report on a botanical survey of Stewart Island. Department of Lands, Government Printer, Wellington.

MARK, A. F.; BAYLIS, G. T. S. 1975. Impact of deer on Secretary Island, Fiordland, New Zealand. *Proceedings of the New Zealand Ecological Society* 22: 19-24.

TRAILL, R. 1965. Notes on Stewart Island by Mr R. Traill, 1959. *New Zealand Forest Service Protection Forestry Newsletter* 3; 2-4.

VEBLEN, THOMAS T.; STEWART, GLEN H. 1980. Comparison of forest structure and regeneration on Bench and Stewart Islands, New Zealand. *New Zealand Journal of Ecology* 3; 50-68.

WARDLE, P.; MARK, A. F.; BAYLIS, G. T. S. 1970. Vegetation studies on Secretary Island, Fiordland, Part 9: *New Zealand Journal of Botany* 8: 3-21.