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DEER AND THE FORESTS OF WESTERN SOUTHLAND

By JOHN T. HOLLOWAY

As an integral part of the programme of work undertaken by the National Forest Survey, observations relative to the effects of deer upon the "well-being" of the indigenous forests are being recorded. A very considerable amount of information is now on file although it is not yet possible to make any detailed analysis of it. Nevertheless, after paying special attention to this problem during several seasons' field work, a résumé of progress to date becomes advisable. The present communication deals only with the forests of Western Southland and, without going into detail, attempts to sketch out the salient features of the problems involved and to forecast the outcome of certain trends.

It should be emphasised at the outset that the problem is no simple one capable of resolution by a single research worker, for we are dealing, not with uniform forests inhabited by uniform populations of deer but with excessively variable forests in which varying numbers of deer have been acclimatised for varying lengths of time. In Western Southland upwards of fifty distinct types of forest have been recognised; and this for the purposes of forest mensuration alone. A detailed ecological survey would further resolve many of these types into floristically distinct units; and for each unit the reaction of the vegetation to the browsing of deer is peculiar to that unit. At the same time, within any one type of forest, the degree of change in evidence is dependent also upon the level of the deer population and upon the length of time for which the animals have been present.

I. Natural Trends in Deer Population

In any area of virgin forest following the immigration or liberation of deer, there is a well marked series of changes in population density. Initially the forest offers a maximum amount of browse

and the population rises rapidly. Browsing is highly selective and, with increasing population, the preferred food plants are eaten out. The resultant change in the floristic composition of the forest is not necessarily to its detriment for in many cases the preferred food plants are silvicultural weeds. In time, however, and assuming the absence of heavy culling, the level of population overtakes that of available food supply. A period of over-population follows during which the food habits of the deer change rapidly. Many species of plants, previously untouched, are now browsed while the forest is opened up and seamed with deer trails formed by the constant movement of relatively strong herds seeking out the diminishing supply of food plants. Semi-starvation is quickly reflected in the general health of the herds and population falls for this reason and also by emigration. The final, more or less static, level of population is adjusted partly to the renewal rate of the preferred food plants (which itself depends upon the survival of seed sources), and partly to the degree to which the deer can utilise alternative and less attractive browse. Both the rate of population decrease and the final herd strengths are also influenced by the proximity of alternative or seasonal browsing range such as is found above the timber limits or in valley grasslands.

The most apparent damage to the forest accrues during the period of over-population but, following the downward re-adjustment of herd strengths, much of this damage is repaired by the extension of the area occupied by unpalatable plants. The real damage is that which results from the continued browsing of the stabilised herds and this damage is by no means evident in many cases. During the period of over-population many species of plants may be reduced to the point of extinction and their disappearance may be accompanied by local accelerated erosion, but this period is of short duration and, as already stated, the resultant damage may be repaired within a few years. But when, as is frequently the case, the alternative food plants browsed by the reduced and stabilised herds consist of the juveniles and seedlings of major species, then the damage done is serious although it will be less spectacular and may not be apparent to the casual observer. No serious erosion occurs and will not occur until the present canopy trees die.

It is necessary, then, to distinguish carefully between the types of damage or change that take place at the various stages of population adjustment. Equally important is the necessity to appreciate the effects of culling operations upon herd strengths and population trends.

II. Effect of Culling Operations

The effect of culling operations (and the term is used in its New Zealand sense implying the destruction of all deer encountered) varies according to the point in the natural population trend at which it is undertaken. Culling during the period of population increase can only have the effect of prolonging this period and may result in

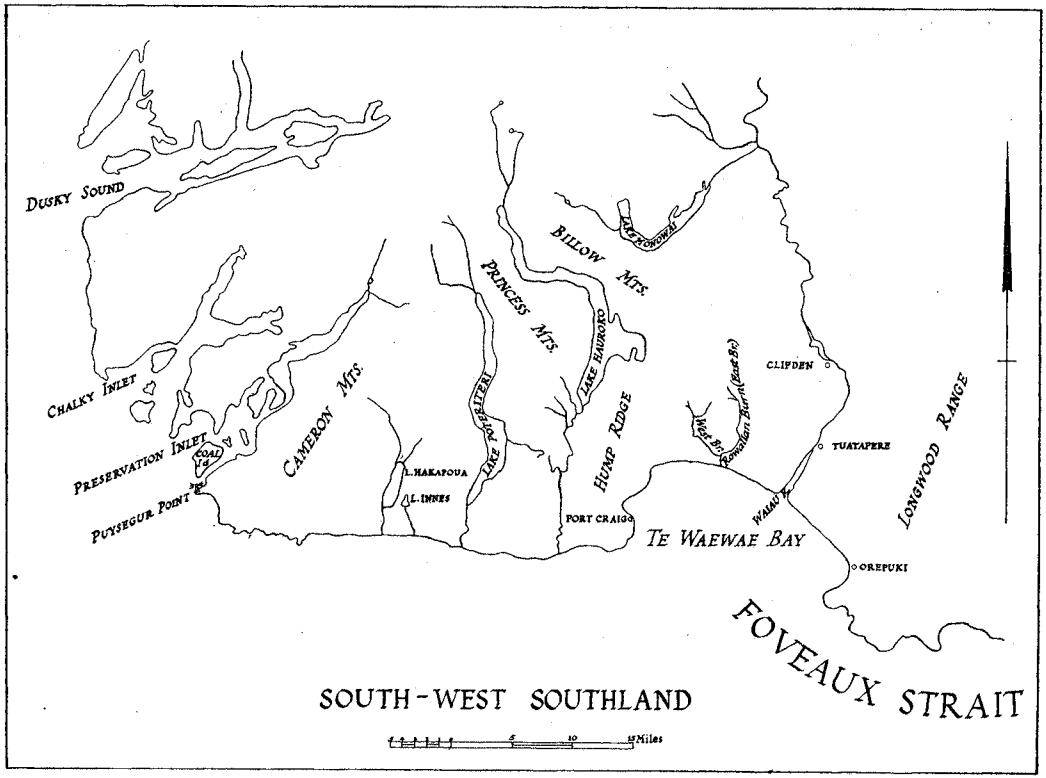
the final stabilised strength of the herds being maintained at a higher level than would otherwise be the case by preventing the destruction, under pressure of population, of the preferred food sources. Culling during the period of over-population may show marked results but in general this is only due to the telescoping of the normal recovery period into a briefer space of time. Culling of the numerically stable herds will have beneficial results but only so long as the operations are carried out systematically and are repeated from year to year. Otherwise the population will recover and again reach or even temporarily surpass the stabilised limits. Any permanent reduction in evidence in herd strengths following sporadic culling is likely to be more apparent than real and to be due primarily to the operations having been carried out at a time when the deer population had already overtaken its available food supply.

Again, before the true effect of culling operations can be assessed the appropriate data must be expressed, not as a gross total of deer destroyed, but as a percentage of total population. This demands the formulation of a reliable method of assessing population density and, at the same time, requires a more detailed knowledge concerning the mobility of the herds and concerning the effect of culling operations in inducing migration. Until this information is supplied, the most reliable method of assessing both total population and the results of culling will be provided by close study of the vegetation. Thus a marked recovery of the more palatable species is sound evidence of a fall in total population below base level. Non-recovery following culling operations indicates a failure seriously to reduce the herds.

III. Population Levels and Trends in Western Southland

In the forests of the Longwood Range the deer population is well below base level. This is largely due to ready access to the forested areas from sawmill settlements and farm lands. The use of the forests for recreational shooting by timber workers and settlers can be considered to have taken the place of normal predator control. Equally important the network of roads, railways and farms which surround the area serves to prevent the immigration on a large scale of deer from the main western ranges. The same consideration holds true for the smaller areas of Island Bush and Woodlaw Forest. Total deer population is low and food plants are present in relative abundance, though these have disappeared or are disappearing from the higher altitude and less frequented areas.

West of the Waiau River to the Hump Ridge and Lake Hauroko available evidence points to the deer population as having within recent years reached a position of stability. Except in the logged areas of former podocarp forest where special conditions obtain, the preferred food plants have been eaten out and present browsing is supplied in the main by the less palatable species. To the north of this area along the Billow Mts., south of Lake Monowai, where culling operations have been carried out within the past few years, a fall in


DUSKY SOUND
CHALKY INLET
PRESERVATION INLET
ROAD
PUYSEGUR POINT
CAMERON Mts.
L. HAKAPOUA
L. INNES
LAKE MONOWAI
LAKE POSITIVE
PRINCESS Mts.
BILLOW Mts.
LAKE HAUROKO
HUMP RIDGE
FORT CRAIG
TE WAEWAE BAY
WAIAU R.
CLIFDEN
TUATAPERE
LONGWOOD RANGE
OREPUKI
FOVEAUX STRAIT
SOUTH-WEST SOUTHLAND
Miles

the population below base level is indicated by the recovery of palatable species beyond the stages reached under a stable population. West of the Hump Ridge towards Lakes Poteriteri and Hakapoua, the population decline following the normal period of over-population is yet in progress or has only recently been completed. Palatable food plants have disappeared and the alternative and less desirable browse is badly depleted. As yet there is no sign of recovery or repair in progress such as is evident to the east of the Hump Ridge where many abandoned deer trails are re-vegetated and there are indications of the spread of unpalatable species.

For the main forest area between the Waiau River and the Hump Ridge and south of the Billow Mts., vegetational evidence indicates that following the liberation or immigration of deer a period of twenty-five to thirty years elapsed before the peak of over-population was reached, that this period lasted for some five to ten years and that over the past ten or fifteen years there has been a gradual reduction, in the main due to westward migration, leading to the present position of relative stability which has to a slight extent been affected by culling operations to the north.

IV. Significant Food Plants and Food Preferences

The following list is by no means complete and includes only those species which are of any considerable significance either in the structure of the forest or as indicators of browsing intensity. The list is compiled as a result of repeated observation of actual browse marks upon stems or twigs. In a few cases past browsing is inferred by the present restriction of the species concerned to epiphytic or otherwise in accessible habitats not normal for those species. Certain species which may once have been present may not be included by virtue of their total disappearance.

Coprosma robusta
Coprosma lucida
Schefflera digitata
Nothopanax colensoi
Nothopanax arboreum
Nothopanax edgerleyi
Griselinia littoralis
Nothopanax simplex
Suttonia australis
Coprosma foetidissima
Carpodetus serratus
Coprosma rotundifolia
Coprosma spp. (small leaved)
Suttonia divaricata
Metrosideros lucida
Weinmannia racemosa
Rubus spp.
Polystichum vestitum
Nothofagus menziesii
Nothofagus cliffortioides
Fuchsia excorticata
Aristotelia serrata
Nothopanax anomalum
Microlaena avenacea
Uncinia spp.
Podocarpus hallii
Podocarpus ferrugineus
Dracophyllum longifolium
Dracophyllum menziesii
Archeria traversii

This list could be considerably extended particularly as regards those species characteristic of high altitude forest and of sub-alpine

scrub and as regards spieces locally restricted to costal forest. It has been arranged in order of food preference and serves as a sufficient key whereby to assess the population level and trend in any new area of forest. Thus if the *Nothopanax* spp. together with *Coprosma lucida* and *C. robusta* are present in relative abundance then it is safe to infer that the deer population is low and that it has never at any stage been high. Heavy browsing of the small-leaved species of *Coprosma* and of seedling beeches, coupled with the absence of *Nothopanax* spp. on sites where they could be expected to occur or where they occur only as epiphytes or as isolated large trees, necessarily implies that the population has passed its peak and that, there having been no culling, it is probably relatively stable. If all small-leaved *Coprosma* spp. show signs of past browsing but seedling (small plants above the level of the surrounding fern) *Nothopanax* spp. are present, then the population has been reduced below base level by culling operations or for some other reason.

Heavy browsing of such species as *Dracophyllum longifolium* or *Archeria traversii* implies a peak population with semi-starvation of the herds. During this period almost any plant may be browsed and the whole forest floor may be bared.

Such observations and deductions must be supported by close observation of the condition of deer trails. Signs of heavy traffic or of disuse can usually be correlated with evidence derived from the floristic lists. The use of the vegetation as a guide and not as the sole criterion is the most desirable approach to the problem. The use of the vegetation in this manner also implies that the observer, as well as being able to recognise the species of plant encountered, and as well as being able to distinguish the marks of browsing, must know also which species should be present on a given site but are now absent. Thus such a list as that given above can only be a guide to a trained and competent observer and would be of little value in the hands of an untrained forest worker. The trained observer will add to and amend the list for himself.

A short list might here be added of species which are never browsed although they may be tentatively nibbled during the peak of over-population or by a fawn.

Wintera colorata
Myrtus pedunculata
Cyathodes acerosa
Leptospermum scopariam
Blechnum discolor
Dacrydium cupressinum
Phyllocladus alpinus

The last two species, and particularly *Phyllocladus*, are extensively barked by antler rubbing. The remaining species in the list are those which, throughout the area under consideration, are extending their range and colonising ground bared during the period of over-population.

Finally it must be emphasised that the present list is accurate for the forests of Western Southland only. In other districts where different species are represented in the vegetation amended or new lists will be required.

V. The Effect of Browsing in Certain Selected Forest Types

It has already been stated that the forests of Western Southland are extremely variable in composition and in quality and that the effect of browsing varies from one type of forest to another. This is partly due to the concentration of the herds in those areas characterised by the greatest abundance of food plants, but it is mostly due to inherently different degrees of stability of the various types of forest. It is not intended here to describe the different types of forest or to expound recent theory (it is hoped to do this in a separate publication at an early date) but it is essential to give a brief outline of certain hypotheses; for it is impossible to understand the full sequence of events unless the natural developmental trends of the various types of forest are understood.

Recent work in this area strongly suggests that major changes in forest distribution have occurred in the recent past and that in certain areas these changes are still proceeding. In general terms the podocarp forests have been displaced by silver beech (*Nothofagus menziesii*) forests and the latter in turn, in certain areas, are being displaced by mountain beech (*Nothofagus cliffortioides*) forests. These changes do not proceed regularly or at an even pace and the pattern of change is liable to distortion by major physiographic or edaphic features. Nevertheless, the pattern can be traced and forest types occurring outside the general pattern display marked abnormalities and can definitely be related to the major physiographic or edaphic features mentioned. The result is that within a comparatively limited area we have stable and unstable podocarp forests, silver beech forests and mountain beech forests together with mixed types over much of the area. Lithologically the region is very varied and soils are derived from unconsolidated siltstones, from limestones, sandstones, conglomerates, granitic rocks, from fluvio-glacial gravels and so on. Topographic features are equally diverse. All these variations are superimposed on the main distributional pattern which, as already mentioned, is itself in a state of flux rendering detailed interpretation a matter of some difficulty.

All that will be attempted here will be to select certain forest types (two of podocarp forest, two of silver beech forest, one of silver beech/mountain beech protection forest and one of mixed podocarp/mountain beech forest) and for each type to trace briefly its major characteristics, to describe the effects of browsing and to forecast its future development. Type symbols refer to Forest Survey type identifications.

Type P.1—This type of podocarp forest is restricted to fluvio-glacial gravel terraces, occurring mainly as a coastal belt around

Te Wae Wae Bay. In character it is essentially an edaphic climax. It is distinguished by heavy stands of good quality rimu (*Dacrydium cupressinum*) with a lesser admixture of miro (*Podocarpus ferrugineus*) and Hall's totara (*Podocarpus hallii*). Rata (*Metrosideros lucida*) where it occurs is of small diameter and good form; kamahi (*Weinmannia racemosa*) is shrubby and present in limited amounts only. The undergrowth can never have been dense and has been radically altered in composition. Scattered trees of *Nothopanax* spp. and *Griselinia* remain but the physiognomic species is now *Myrtus pedunculata*. Browsing by deer is now concentrated mainly on limited amounts of small-leaved species of *Coprosma* and on *Suttonia divaricata*. The forest is well stocked with seedling and sapling rimu and Hall's totara. Juvenile miro, rata, and kamahi are subject to browsing. A small proportion of sapling and pole rimu is damaged by barking, but in general the forest is in an extremely healthy and vigorous condition. There is no evidence of any accelerated erosion but, where the overlying gravels are thinned or removed by the processes of natural erosion exposing underlying siltstones, the podocarps are invaded by silver or mountain beech. This type of podocarp forest is essentially stable and changes resulting from browsing are, from the forester's viewpoint, more favourable than otherwise.

During logging the advance regeneration is largely destroyed. In the absence of deer (i.e. in those areas in close proximity to sawmill settlements or to bush tramways) the second growth consists for the most part of *Nothopanax* spp., *Coprosma* spp., *Weinmannia*, *Aristotelia serrata* and rata, but it is at the same time floristically the richest of any lowland forest type in the region. Indeed, it can be said with confidence that many species of plant persist in these logged areas long after they have disappeared from the virgin forest. At a later stage in the redevelopment of the forest the shrub canopy opens out with the incoming of podocarp regeneration wherever sufficient seed trees remain. Even after the removal of sawmill operations the deer do not return freely to these logged areas on account of the density of the undergrowth, notwithstanding the rich browse available. They will return at a later date when the young rimu can be expected to be damaged by barking.

In areas logged and abandoned soon after logging, as on the coastal terrace lands west of Port Craig, the deer return immediately and find optimum food supplies of the preferred species. In this case the second growth species listed above are heavily browsed, and even rata and kamahi may be reduced to semi-mat plants under one foot in height. There is an immediate incoming of such species as *Myrtus pedunculata*, *Cyathodes acerosa*, *Olearia ilicifolia*, and an increase in the amount of *Wintera colorata*. Regeneration of rimu is generally good and may be prolific, as is that of Hall's totara, although the latter is damaged by browsing of the tips and subsequent infection by the leaf smut *Corynelia tropica*. Miro regeneration is destroyed.

The end effect of heavy and persistent browsing is here to eliminate the prolonged scrub stage in the redevelopment of the forest to a rimu-dominated timber-producing stand, but it should be borne in mind that once the rimu reaches the sapling or pole phases of growth it is liable, in the continued presence of deer, to damage by barking.

This type has been dealt with at length since it offers the only possibility of permanent management of rimu forest in Southland (assuming that land ownership and land use difficulties can be overcome) and is probably closely akin to certain Stewart Island areas.

Type P.3—This type of podocarp forest is characteristically found on hill and ridge crests in predominantly silver or mountain beech areas. It is best developed on the interfluve between the East and West branches of the Rowallan River. It is essentially a relict of formerly more extensive hill country podocarp forests which have been displaced by silver beech invading from the streams upslope. Usually there will be from six to ten large diameter rimu per acre over scattered smaller miro and Hall's totara with heavy irregular rata and kamahi. The undergrowth must originally have been dense except on the drier spurs but has now been considerably modified leaving large *Nothopanax* spp., *Griselinia*, *Fuchsia* and tree-ferns. *Wintera colorata* is frequently abundant and is probably spreading. The disappearance of juveniles of the palatable species has in places bared the ground to such an extent as to induce accelerated soil wash, but such damage is local and is rapidly healed by the spread of *Blechnum discolor*.

The ultimate development of this type of forest in the continued presence of deer cannot be forecast. In the absence of deer it would in time have been invaded and replaced by silver beech. It is possible that continued browsing will open up the stands sufficiently to permit the establishment of rimu regeneration and so reverse the natural trend. Few comparable areas have been logged but it is probable that logging, irrespective of the presence or absence of deer, will lead to the development of a scrub association dominated by old rata and kamahi with marginal invasion by silver beech.

Type B.5—Silver beech/*Weinmannia* forest. In this type of silver beech forest the trees are typically of large diameter, short log length and irregular form. The trees are widely spaced with a very open canopy over an understorey of scrub kamahi. The floor cover is of dense tall *Blechnum discolor*. There are occasional large *Nothopanax* spp. or *Griselinia* and there must have originally been a greater representation of these secondary species. Heavily browsed small-leaved coprosmas are present amongst the fern. It is considered that this type of silver beech forest may represent the overmature phase of the initial crop of silver beech replacing former podocarp forest. It is usual to find one or two old rimu per acre except on certain limestone soils where, however, an occasional defective matai

(*Podocarpus spicatus*) may be present. The natural developmental trend is uncertain. On drier sites it tends to be invaded by mountain beech but there are large areas without a nearby seed source of this species. It is possible that several distinct types are here confused and that development is proceeding along separate lines. In many localities the initial canopy break is approaching but the next stage in the succession is a matter of some doubt. Probably scattered silver beech regeneration will become established amongst the fern in areas where, through a major canopy break, the latter is weakened by exposure. In this case a comparable type of forest will redevelop.

The effect of deer browsing has been negligible apart from the destruction of secondary species which in any case play a very minor role. Their place has been taken by extension of the *Blechnum discolor* ground cover of greater soil conservation value but at the same time a bad silvicultural weed, suppressing all regeneration of commercially valuable species.

Few comparable areas have been logged. Per acre volumes are low and such stands have not been considered merchantable except within recent years. In the few areas of this type that have been milled recently little change is evident. Many cull trees per acre remain forming a partial canopy. *Blechnum discolor* persists but is somewhat stunted in the open. All silver beech regeneration and all secondary species that become established are heavily browsed. The ultimate outcome is largely a matter for conjecture but the invasion of the areas by *Leptospermum* and *Pteridium* is possible. In the absence of deer a comparable type of forest to the poor quality original would have redeveloped unless very expensive silvicultural treatment was given.

Type B.2— The major species here is again silver beech but mountain beech is present in limited amounts particularly on the lower portions of ridges and steeper slopes and along the streams. On the upper slopes there is characteristically an increasing proportion of rimu together with scattered scrubby kamahi. Essentially the type represents silver beech forest which has replaced former hill podocarps, the replacement having proceeded upslope from the streams leaving residual podocarps on the hills, the silver beech in turn now being replaced in part by mountain beech which has become established down the streams and is infiltrating upwards by way of the drier ridges. This type of silver beech forest is an extremely important one. Despite the fact that in competition with mountain beech it will be suppressed over much of the area, yet site conditions are favourable to the fast growth of good quality silver beech timber. The increasing dryness which favours the spread of the mountain beech, at the same time, in the absence of mountain beech, permits the ready establishment of silver beech regeneration after logging by lessening the competition of secondary species of more mesophytic character and by reducing the quantity and size of the *Blechnum*

discolor. In the type as it is now, mountain beech is present in such limited amounts that it could be treated as a weed and eradicated. This type then is likely to be that selected for permanent yield silver beech forest.

It has already been considerably modified by browsing. Indications are that the understorey originally consisted in the main of sapling and pole beech with limited amounts of small kamahi higher on the ridges and an open low shrub tier of *Myrtus pedunculata*, small-leaved coprosmas, *Suttonia australis* and *S. divaricata* with *Wintera colorata* more particularly on the wetter ground. *Blechnum discolor* was, and is, sparse and stunted on the ridges and drier slopes and locally abundant on shady wetter slopes. There were occasional shrubs of *Nothopanax* spp., mainly *N. simplex*. The understorey is now very open, all shrubs bar *Myrtus* and *Wintera* are heavily browsed and much of the ground is bare. Few young beeches have become established over the last twenty years and, despite prolific crops of seedlings, none now survive beyond a few years at which age they are browsed. On the drier and sometimes gravelly ridges there are indications that *Leptospermum*, *Cyathodes* and *Dracophyllum longifolium* are spreading.

No areas in this type have been logged save in the past few years, and in these the ground remains bare or is colonised by fern; but throughout the type there are "accidental experimental areas" where patches of forest were cleared or burned during the course of early survey. Without exception these areas now carry pole beech stands of good to exceptional quality. Where mountain beech seed is available this species outgrows and suppresses silver beech but elsewhere the latter shows good growth rates. On the higher ridges where trig stations were established and the original forest was silver beech with rimu and kamahi, silver beech poles rapidly suppress the kamahi despite the fact that the latter originates from coppice shoots. This is a clear indication of the results that can be expected following logging provided the deer are exterminated. In the continued presence of the deer it is probable that the type area, after logging, will develop to *Leptospermum* heath.

Type M— This forest type is that found at the higher altitudes on the main mountain ranges of Western Southland. It is composed almost entirely of stunted silver and mountain beech, the former on the wetter ground and shady slopes and the latter on steeper drier ground and ridges. There is no timber of commercial value but the forest is of fundamental importance in the protection of the watersheds and in the control of run-off. Associated shrub species are *Nothopanax arboreum*, *N. simplex* and *N. lineare*, small-leaved *Coprosma* spp., *Suttonia divaricata*, species of *Olearia*, *Senecio Dracophyllum*, *Gaultheria* and shrubby Hall's totara. The ground cover is largely composed of mosses, liverworts and filmy ferns with local occurrence of sub-alpine herbs (*Ourisia*, *Forstera*, *Celmisia*, *Astelia*, *Uncinia* etc.).

The effects of browsing have been recorded on some thirty different sites both in this type of protection forest and in the adjacent sub-alpine scrub and herb-field zones, on the Hump Ridge as well as on the Billow Mts. Most of the shrub species with the exception of those of *Senecio*, *Olearia* and *Gaultheria* have been browsed though the *Hebe* spp. are seldom affected. Browsing is concentrated upon the coprosmas, *Suttonia divaricata*, *Nothopanax* spp. and some of the herbs. Space does not permit a full account being given here but I will quote the summary by P. J. Brooke of observations made by him for me in these areas ; and I would here express by indebtedness to him for his careful and accurate observation.

"In low canopy sub-alpine beech forest browsing is confined mainly to secondary species. The floor cover of small sedges, grasses and *Hymenophyllum* is, where space is allowed it between shrubs, left virtually intact. In consequence accelerated erosion does not appear to be taking place. All the erosion seen in this forest type could be attributed to normal processes. Beech regeneration which does not seem to be damaged by deer would be ample to replace natural losses but the shrub tier may in time be almost eliminated.

"In the sub-alpine scrub the effect of deer damage is already apparent. The absence of juvenile individuals indicates that they may have been eaten out almost entirely and the presence in some places of dead shrubs with *Festuca* and other high altitude species replacing them indicates that deer may be responsible for the replacement of sub-alpine scrub by alpine grassland and fell-field. This would explain the fact that the scrub zone is nowhere continuous but is broken up by tongues of grassland extending down to forest level. The alpine grassland has not been much damaged and remains a covering easily sufficient to prevent erosion except that due to the essential nature of the terrain. The herb moor has scarcely been touched by deer."

The above summary relates to work done on the Hump Ridge. Conclusions drawn from the study of comparable areas on the Billow Mts. were :

"In the area covered there are indications that a heavy deer population was removed within recent years." (Culling at or about the period of peak population—J.T.H.) "There are now fresh traces of an occasional animal only. The area consisting of steep ridges of an apparently permeable base rock, normal erosion has taken the form of extensive slips which are deep cut by young gullies." (It is probable that much of the severe erosion here in evidence is due in part to active earth movements along a major fault zone—J.T.H.) "Many of these slips would appear to be of the same age judging from the age of the trees established on them. Some of the slip faces are being held by young pole stands, mainly mountain beech, of an age that would place their establishment prior to the advent of deer to the area. Where the growth of the pole stands has been retarded by

the continued presence of a canopy the undergrowth, including silver beech regeneration, has been heavily browsed and/or trampled and detritus removal is much more rapid. It would appear then that the chief damage done by deer is to prevent the rapid healing of such slips and gullies by the destruction of the plant cover and also by acceleration of erosion by way of tracks, especially on bared rock surfaces."

I would add to these remarks that, although the regeneration of silver and mountain beech is little browsed at or about the timber limits, it is browsed and heavily browsed at somewhat lower altitudes. This zone of browsing is likely to extend upwards as the more desirable food plants are eaten out. The immunity of the beech regeneration at the timber limits I ascribe to the fact that more desirable browse has been available in quantity in the adjacent scrub zone. Ultimately it is possible that the belt of forest from three to five hundred feet below the present limits will fail, with the isolation and later disappearance of the higher altitude forest. This failure will not come gradually and will not be apparent until the decay of the present canopy when the change will proceed catastrophically. In assessing the effects of present browsing in these areas, it must be borne in mind that normal geological erosion is extremely active and great care must be taken that unrelated damage is not charged against the deer. As indicated in the summary of studies made on the Billow Mts., the present effect of deer is to delay or to prevent the healing of the scars left by such normal processes of erosion.

Further, as a consequence of the same causes underlying the major changes that have recently occurred and are still taking place in forest distribution, it is theoretically probable that there has been a retreat in the timber limits from inland towards the coasts and from higher altitudes to lower. This supposition is strengthened by indications of the former existence of extensive forests in Central Otago and in South Canterbury. Such changes also proceed catastrophically, the forest persisting by virtue of what may be termed its own inertia (development of internal climates etc.) until some major impetus towards change occurs, when it is displaced rapidly and finally. In many of these marginal areas, both inland and at higher altitudes, the present forests may be out of harmony with their major environment. In this case the impetus towards change will be provided by the effects of deer browsing and once the forest canopy is broken, the change will be irrevocable. There are indications on the Billow Mts. that this fall in the timber limits has, however, already occurred. There is every evidence of a period of intense erosion having taken place within the past few centuries. The upper alpine grassland slopes are seamed with sharp gullies, slips and slumps, which are now healed under grass. Certain forest types that are to be found in the lowland valleys along the foot of the range appear to be young and of the form likely to be developed on detritus material

spread over the valley floors. Such a period of active erosion could be expected to occur following a retreat in the timber limits where, because the forest originally clothed entirely the mountain tops, a more suitable form of vegetation was not immediately available to replace the forests and stabilise the slopes.

By extension this same argument applies, with equal force, to problems concerned with the destruction and possible re-establishment of the tussock grasslands in the arid portions of Central Otago. It is essential that the possibility of such changes be given serious consideration in all conservation problems whether of forests or of grasslands.

Type PB.2—This final type selected is a mixed podocarp/ *Nothofagus* forest consisting mainly of kahikatea (*Podocarpus dacrydioides*) together with mountain beech with lesser admixtures of silver beech and occasional rimu. Pokaka (*Elaeocarpus hookerianus*) is common as a small tree and in certain localities manuka (*Leptospermum scoparium*) and kowhai (*Sophora microphylla*) may be present. The type is most widely developed along the flood plains of the Wairaurahiri Valley, west of the Hump Ridge. It is therefore within the area where the deer population has only recently passed its peak and maximum "damage" is evident. It is considered to represent former kahikatea swamp lands which have in part been silted up and colonised by *Nothofagus* spp. Surrounding hill slopes are formed of non-calcareous sandstones and accordingly a preponderance of mountain beech seed is available to the comparative exclusion of silver beech. Locally, and as the result of slight headward tilting of tributary streams, the developmental process is reversed and kahikatea is colonising the swampy stream courses.

The natural trend would appear to be toward the establishment of a poor quality mixed silver beech/mountain beech forest. Exceptionally heavy browsing has now destroyed all palatable species originally present. The undergrowth is very open with low, heavily browsed *Coprosma* spp. and *Suttonia divaricata*, and scattered shrubs of *Myrtus pedunculata* and *Wintera colorata*. All beech regeneration has been destroyed, kahikatea regeneration is damaged but small rimu regeneration is untouched. The ground cover of scattered *Blechnum procerum*, *B. discolor* and *Hymenophyllaceae* has been trampled out while *Rubus* spp. have been stripped from their supports and heavily browsed. At first sight the forest appears to have been irrevocably damaged.

But this is not necessarily the case. Continued deer infestation at a reduced population level will prevent the re-establishment of many competing weed species and will prevent the re-establishment of beech. At the reduced population level, however, kahikatea regeneration is little harmed and the possible future of this type of forest in the continued presence of deer is that the normal succession will be diverted and in place of poor quality mixed *Nothofagus* forest

a reasonably good stand of rimu and kahikatea will develop. First impressions may be very misleading.

VI. Conclusion

It must again be emphasised that the above review of the position applies only to the forests of Western Southland. In assessing the effects of animal infestation upon any type of forest, that type must be studied in itself with full appreciation of all local trends in forest evolution and with a full understanding of all local environmental factors. Without such an understanding conclusions drawn are likely to be highly erroneous. No argument based upon examination of one type of forest in one particular locality can be applied in the case of a different type of forest or to an apparently similar type of forest in a different locality.

Studies of the interactions of forests and animals require to be prosecuted over the full range of forest types and from one end of the country to the other. And before the actual position in any area can be accurately assessed the forest itself must be studied in detail and a sound understanding of its origins and evolutionary trends acquired.

Finally, in the field of forest management, such studies are urgently necessary since the deer and other animals are now integral parts of the forest estate. No plan of operations which ignores the part played by such animals can succeed.

Summary

Problems arising out of the acclimatisation of deer in the indigenous forests are discussed, with examples drawn from the forests of Western Southland. The complexity of the problems and the necessity to distinguish carefully between changes that occur in forest composition in different types of forest, in the same types of forest in different localities, and at varying levels in deer population are stressed.

In illustration, the effects of deer browsing on six distinct forest types are described and the future of these types is forecast.

A list is presented of major food plants in order of palatability and the use of such lists in assessing effective deer populations and the effects of culling operations is indicated.