EXPLOITATION OF HIGH PRODUCTION PASTURES IN NEW ZEALAND

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Notwithstanding the ecological fascination and the importance of the exploitation of the several natural communities under discussion in this symposium, none will deny the overwhelming importance to New Zealand of a full exploitation of our great potential for high pasture productivity. There are very few other areas in the world (and all of these are small) where climatic conditions allow similar continued high production pasture growth, and continued outdoor animal husbandry, for the production of high valued milk, meat and wool. In the modern world economy of increasing living standards it is to our obvious advantage to exploit this pasture potential to the full.

In such exploitation of these man and stock-made pastures there are three major inter-related phases of ecological interest. These phases are:—

1. The ecology of the development and maintenance of the pastures themselves, in relation to climate, aspect, soil and fertiliser, animal grazing, and species and strains in use.
2. The ecology of the farm practices of grazing, cropping, fertilisers, and feed conservation to meet animal production difficulties, as well as crop yield requirements.
3. Patterns of farm finance and organisation in their present New Zealand national habitat — with a slight stretch of the definition we can perhaps put this under the broad heading of human ecology in relation to farm development.

NEW ZEALAND PASTURE PRACTICE

There is no need to give New Zealand climatic details here — all that it is necessary to mention is the great value to high production pasture growth of our continued but not extreme soil moisture, moderate temperatures, and adequate light. This appropriate climate is, of course, the climate of sub-tropical rainforest under natural succession, and quite different from the extreme climates of natural grasslands, either those at the cold or at the hot extremes. The New Zealand climate is also very suitable for the continued outdoor husbandry of European breeds of sheep and cattle. Thus in New Zealand we can take full advantage of the vast European background of animal breeding and selection for high productivity in those breeds, as well as gaining from the economies of our own pasture and stock husbandry methods. Compare this with either the many months of indoor feeding in Japan, Europe and North America, or the other extreme of the animal disease and husbandry difficulties in the tropics, plus the paucity of a background of purposeful animal breeding in these latter regions.

Readers will also be well aware of the differences in climate, topography, and soil type within New Zealand. These range from the warm north to the cold south (the latter, however, not quite as cold as Britain), from the wet west to the dry east, and from the heavy gumland clays, to the light soils of Canterbury and to the fluffy pumice areas of the central plateau. Such variability is, of course, the major background for our regional patterns of dairying, sheep for fat lamb or wool, cereal and seed cropping, or forestry. Likewise between the extensive sheep grazing of the steep southern mountain areas, the large sheep and cattle farms

of the back hill areas, and the smaller lowland units for dairying, intensive fat-lamb farming, or the town-milk supply farms near urban areas.

However, overriding this internal variability is the general pattern of New Zealand pasture production based on combinations of clover and grass, topdressing with lime and mineral fertilisers, and all-the-year outdoor grazing. Little or no artificial nitrogen is used on our pastures, and for the most part production is aimed to coincide animal requirements with pasture growth. This, together with the continued pasture growth, and the continued outdoor grazing, and thus the continuous turnover of nutrients in the soil-pasture-animal cycle, keeps feed conservation, with its high costs and losses, at a minimum.

White clover is our most important perennial legume, but red clover, lucerne, strawberry clover, and *Lotus* spp. are also used. The temperate winter also favours the establishment of annual clovers as pioneer legumes on drier soils. Thus suckling, clustered, and striated clovers are useful volunteers, while the higher yielding subterranean clover is sown extensively, and specifically fertilised and managed, in programmes of soil organic matter build-up, and on areas permanently too dry for white clover. The *Lotus* group performs a similar role on wetter areas.

There is no doubt about the tremendous value of white clover in the overall pasture picture of New Zealand. Plant breeding for higher productivity and longer spread of growth has furthered this, and certified New Zealand strains of white clover have about double the productivity of the strains previously available. The annual nitrogen fixation by such white clover in New Zealand, ranges from 200-250 lb. in the colder Southland, up to 400-500 lb. per acre in the warmer northern areas. A clearer appreciation of the value of such clover growth can perhaps be gained from data from Palmerston North, where it was measured that the annual production of a cloverless pasture (without nitrogen but with ample mineral fertiliser) was some 3000 lb. per acre, against 14,000 lb. per acre from a grass/white clover mixture. For comparison, an annual yield of about 6000-7000 lb. per acre and with a much poorer annual spread of growth, would be considered a good yield in Britain. On present costs in New Zealand it would take between £20 and £30 per acre each year to substitute artificial nitrogen for this white clover, apart from the feed value of the clover itself. Such high nitrogen fixation by our clover offsets our very high costs of imported artificial nitrogen. Indeed, it can fairly be said that our clover nitrogen fixing potential is the main basis for our high living standards in New Zealand, and this potential is still open for much further exploitation.

Pasture building, and thus soil fertility and crop yield increase in New Zealand, thus hinge largely around the establishment and maintenance of white clover, and productive companion grasses, by appropriate use of certified clovers and grass, adequate mineral topdressing, drainage, pest control, and grazing to maintain the balance. The programme is relatively simple in principle, but there are nevertheless real practical problems in all phases, such as bloat, facial eczema, ill-thrift, and a continual adjustment of stock and crop to keep pastures in balance between grass and clover, not only to keep direct animal problems minimal, but also for best annual spread of production. Earthworms feature in the cycle as major underground agents for the incorporation of dung and plant residues into the soil, and for the resultant soil crumb — structure building, and the maintenance of clean palatable herbage.

Against this value of our climate in allowing good growth of clover and grass, is its constant and parallel influence on soil nutrient leaching, erosion, and the proliferation of weeds, pests, and disease. Stock grazing and pasture management have thus also to be oriented to control such difficulties. Indeed, quite often stock and pasture have to be deliberately punished in order to control weeds or to provide conditions appropriate for pest control. Likewise, in many steep areas, pasture is best retired for special tree planting and gully control against severe erosion. Pasture species performance can also be affected by our continued outdoor grazing and particularly in the winter, ryegrass, timothy and white clover stand heavy treading much better

than do cocksfoot, Yorkshire fog, *Poa trivialis* and red clover. Thus, as a result both of induced high soil fertility and of the associated heavy stocking, ryegrass and white clover combinations are in general the present upper limit of high production New Zealand pastures. Our latest strains of ryegrass hybrids, and of white clover incorporating greater winter-growing attributes, should continue this trend over at least the bulk of the country, particularly with parallel advances in control of pasture pests.

By contrast to the fertility build-up off good pasture, the rapid loss of soil fertility under cropping is illustrated by the results obtained from an exhaustion trial at Palmerston North. Areas which had been under good pasture for at least ten years were taken each year and continuously cropped in maize, kale, or potatoes. In each year there was a randomised lay-out of combinations of N, P and K (heavy applications) with Italian ryegrass grown each winter between the summer crops. Over the past four years the crop yields (without fertilizer) relative to those obtained directly after good 10-year-old pasture were:

	1st crop	2nd crop	3rd crop	4th crop
Maize	100 (36 tons)	68	70	59
Kale	100 (30 tons)	61	47	40
Potatoes	100 (13 tons)	70	54	34

Fertilizer cross-treatments show that the primary induced deficiency was nitrogen, but mineral (P, K, S and Mg) deficiencies also restricted the third and fourth crops, while loss of soil structure and the resultant poor drainage appear to be the cause of an almost complete failure of the fifth potato crop, even in the highly fertilized plots. Such fertility losses are to be expected from the large amounts of nutrients abstracted by such crops, but the speedy decline in these trials, compared with the very rapid build-up under good pasture, illustrates the very active soil fertility cycle at Palmerston North.

Hill country grazing offers fascinating extremes of the variability of pasture growth and stock management effects, due again to climate and to subsequent stock action. Between sunny and shady faces overall differences in temperature, light and soil moisture are almost as great as the climatic extremes over the whole country. Thus at Palmerston North, sunny faces have a climate not far different from that of Northland, while shady slopes are similar to Southland. Obviously good hill country management must include separate fencing and grazing of different aspects. Hill country grazing is further complicated by the step and stair grazing patterns on each hillside, the animals treading and excreting their manure on their self-made tracks and eating from the riser areas between. There is thus a continual soil fertility transfer by the animal manure, from the riser areas to the tracks, and at night to the camping areas on the warmer ridges. Such fertility differences are clearly marked by large botanical and growth differences, and obviously call for differential fertiliser applications within each paddock. Students of the mechanics of erosion will also appreciate the compensatory effects of these animal manure transfers, and of the terrace-like tracking.

PASTURE AND CROP ON A FARM BASIS

This type of experimental approach, and field observations, show the pattern of pasture development in New Zealand, together with associated animal feeding problems. Possible improvements on some current practices are suggested by a division of New Zealand pastures into 5 broad phases (Fig. 1). The main division is in terms of actual evapotranspiration, phase 1 being all those regions limited by soil moisture to low production, while phases 2-5 are those in the regions not so limited by soil moisture. The boundaries between phases are, of course, not clear-cut.

PHASE 1

Low productivity grass on land of low actual evapotranspiration due to severe climate, soil type, topography or lack of irrigation.

The aim here must be to preserve the cover by minimal grazing to maintain balance between erosion and fire hazards. This

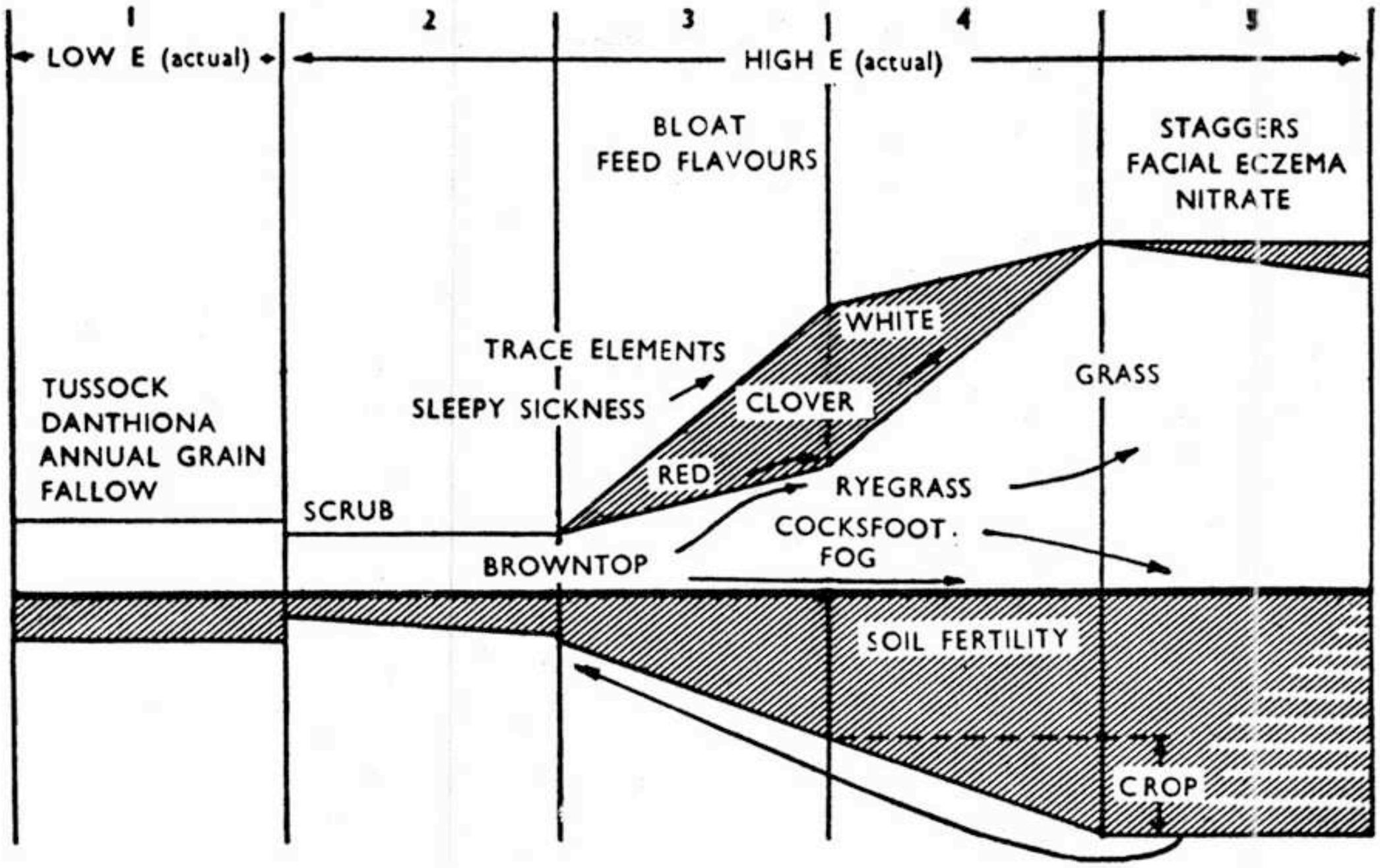

FIGURE 1. *Diagrammatic representation of pasture development, soil fertility and occurrence of some animal problems associated with different stages of pasture development. Annual pasture production is shown as height above, and soil fertility as depth below base line. Arrows show trends in amounts of the species, and the arrow below base line shows transfer of nutrients by feeding or soiling of pasture herbage or crop.*

is not easy in practice because of rapid loss of palatability as leaf and stem increase in age. Grazing control must also include control of rabbits, deer and other pests. Improvement in less severe instances depends on short-season crops, plus appropriate fallow, while the pasture approach is to establish and hold resistant species such as *Danthonia, Phalaris* and cocksfoot, with perhaps an admixture of ryegrass, subterranean and red clover and lucerne.

PHASE 2

Low productivity pasture or scrub on low-fertility soil, with a high potential for improvement through drainage, mineral fertilizers, pest and grazing control, and introduction of legumes and, later, more productive grass species.

Ploughing for land levelling or scrub or weed elimination is an appropriate starting point, but cropping is usually not worth while because of low yields at this stage. Pasture development by oversowing or direct reseeding is more logical. At this unproductive stage animal troubles appear minimal, due to low numbers. However, improvement is impossible without rectifying primary nutrient deficiencies in the animal (e.g. cobalt, copper) as well as plant nutrient deficiencies.

PHASE 3

The improvement from phase 2 *to phase* 3.

This involves the development of a pasture dominated by clover until the soil nitrogen is increased, both by underground transfer, and by animal manure, to a point sufficient for grass growth. Such development is not easy. It is essential to apply sufficient mineral fertilizer, not only to promote pasture growth vigorous enough to compete with weeds, but also to provide for the essential increase in soil organic matter. A current example of this can be seen at the Grasslands Station, Kaikohe. With very heavy initial dressings of lime, P and K, a vigorous pasture developed after only 2 years out of scrub and carries some 8 ewes and lambs on a weed-free sward; but with only light initial fertilizer applications, the carrying capacity is low (2 ewes) and there is considerable re-establishment of scrub and rushes.

On the animal side there are also many difficulties. Because of greater numbers, animal trace-element deficiencies become obvious, while, because of a greater faith in the winter-producing ability of these clover pastures than is warranted, sleepy sickness in ewes becomes a major difficulty. Bloat is prevalent on such clover-dominant pastures, and red clover, subterranean clover and other annuals are all vigorous and even more conspicuous in the pasture than white clover. Feed flavours in milk are also prevalent, as are animal ailments from clovers high in oestrogen content.

It is, however, essential to graze such clover-dominant pastures, mainly to obtain the benefit of the turnover of animal manure, but also to prevent shading of grass. Top-dressing should also be continued to provide sufficient minerals for the grasses at the higher nitrogen level. Control of grass-grubs and encouragement of earthworms are important factors in the transformation to a mixed pasture.

Because of the grazing problems on these clovery pastures, they are often harvested for silage, or ploughed for cropping, or fertilizer may be withheld. Such action will only perpetuate the situation and crop yields will still be relatively low. The endeavour to evade such early clover problems, by leaving clover out of the mixture, or by sowing very heavy rates of grass, are likewise ineffective. The best method is to get active nitrogen fixation by clover as soon as possible, and for this a light grass seed rate, heavy mineral top dressing, and early grazing control are all essential.

PHASE 4

Grass and clover with an increasing proportion of grass, and with steadily improving soil fertility and structure through the added nutrients, plant and animal residues, and earthworms.

There appear to be no animal problems peculiar to this phase, and given appropriate fertilizers and control of insects and weeds, pasture improvement is relatively easy. However, much depends on the strains of plants used and their performance under the local conditions. For example, at Palmerston North it has been shown that both H.1 ryegrass and cocksfoot are susceptible to excessive summer defoliation by stock and/or close cutting for silage or hay. By contrast, skilled winter management is needed to hold a balance between ryegrass and clover and to prevent invasion by *Poa trivialis* or Yorkshire fog. On many farms winter stocking does not keep pace with the improvement of pasture by better varieties, drainage and fertilizer. Also, on many farms endeavours to "autumn save" pasture are carried to extremes, and low winter stocking leads to dominance of *Poa trivialis* and Yorkshire fog which depletes the clover. In general, on such farms the practice has developed of light winter grazing plus heavy summer defoliation, either by cutting or grazing. For most effective development of high production ryegrass and clover, the opposite trend in management is more appropriate — although not so attractive to the eye. A major factor against such lenient summer grazing is lowered palatability, but our latest varieties of ryegrass and cocksfoot offer advantages in this respect. The new machine-choppers for silage, hay and topping, also aid considerably.

PHASE 5

Pastures developed to a high stage of productivity after several years of phase 4, *which are probably ryegrass dominant after continued heavy stocking, and with high soil fertility, particularly in the top layers.*

Productivity is not always satisfactory, however, due to low summer growth and palatability, particularly of perennial ryegrass, and there are also stock-feeding difficulties from the rapid flushes of growth in the spring and autumn. Staggers, facial eczema and some forms of ill-thrift or mineral imbalance appear to be associated with the rapid ryegrass flush on such areas. Many of the past and present efforts of Grasslands Division are directed towards achieving greater palatability and summer persistence of ryegrass in this high fertility phase, and also towards other direct control of such pasture problems. However, the production of grass seed, hay, or silage, or ploughing for forage or cash crops, offer suitable adjustments. Such cropping will not only produce high yields but also, by lowering the soil nitrogen, will again allow clover growth and establishment of a mixed pasture. The fascinating part of such a programme is the organisation of the cropping phase so that the high soil fertility is utilised without reducing it to such a state that the ensuing pasture has again to develop through the excessive clover of phase 3. Ideally the crop would be fed out into areas at phase 3 to transfer fertility there, and thus finish up with the whole farm in phase 4.

Within the above classification are several suggestions for best progress through the various pasture phases. The author is, however, very aware of the many major decisions that have constantly to be considered on the actual farm. Important considerations always in mind in New Zealand include (1) the need to maintain clover in the sward in spite of bloat and other difficulties, (2) the need to maintain adequate leaf cover for maximum photosynthesis, balanced against palatability losses with increase of pasture height, (3) the need for weed control often calling for grazing more severe than appropriate for good pasture growth, (4) the practical difficulties attendant upon the typical New Zealand farm having only one class of stock, thus reducing flexibility of grazing, and thus calling for more mechanical or chemical control of pasture or weeds.

HIGH PASTURE PRODUCTIVITY IN ITS NATIONAL HABITAT

The overall New Zealand grassland picture is therefore one of relative simplicity at a high production level — not the simplicity of the sporadic fire and grazing of the prairie or veldt, not the complication of the stall-feeding, concentrates, and four to six-month growing period of the high production continuous milk supply of Europe, but the simplicity of a single grazing pressure (sheep or cow), the simplicity of a minimal feed conservation requirement, and the simplicity of a minimal demand for direct cash crops which can thus be confined to specialised areas. Further exploitation of this pattern and the provision of better plants and animals to fill in the difficult periods, better fertilizers, fertilizer distributors, and better drainage to strengthen the weaker areas of the variable topography, better pest control, and a stronger integration between pasture, trees, and crops, and all this based on full exploitation of changing economies of capital, machinery, and labour, are the obvious steps in our future grassland economy.

From even such a brief look at the two previous phases, and with a similar appreciation of other countries, it is with considerable confidence that one can again look at our own future pasture prospects. To me these boil down to the fact that there appears to be an increasing demand for our type of product. Such demand will undoubtedly be further increased over the whole East, and especially as Japan and other countries change the emphasis of their own farming, and develop a greater taste for butter, meat and milk, and also change from expensive floor mats to carpets.

By contrast, to fill this gap there are physical production difficulties in most of the present large agricultural producing countries. Although efforts will undoubtedly be sustained to overcome these, the obvious future role for New Zealand is to keep ahead by a full exploitation of our obviously superior pasture production advantages.

Just how best to greatly expand New Zealand pasture development and production, is largely a question of how best to get more of our capital, machines, know-how and labour back from our present urban drift. The technical field problems are relatively easy, but not so are the several economic and ideological differences of opinion. New

Zealand has been developed and developed well largely by the family unit, and the continual trend has been towards smaller and more intensive usage. Undoubtedly such a farming policy has its advantages, but there are also increasing limitations. These are mostly concerned with over-capitalisation with essential but little used machinery, and also capital and labour difficulties are inevitable on small units. General policy in New Zealand is still oriented to the small farm unit, as can be seen for example, in the fact that taxation reliefs for capital improvements are still largely a fixed amount per farmer rather than on a proportion basis. Likewise there is virtually no encouragement legally or by usage, for new capital to be put into farming, except by active ownership, by mortgage, or by Government development and settlement by ballot. And loans to individual farmers have a background of being lost or reduced in slump times! In addition, there has been legal restriction on ownership of more than one farm, or of other absentee ownership. Thus eager-beaver farmers or potential eager-beaver farmers have been dissuaded from expansion.

By contrast, secondary industry, forestry, shops and tertiary industries have been actively encouraged for expansion by protections, and perpetuated by varied and widespread investment alternatives. The normal urban labour drift has thus been encouraged, and even farmers have invested much of their savings, and their sympathies, into towns. A natural and equally serious corollary to this has been the loss of much of our agricultural research and extension personnel, and likewise and naturally, our newspapers are dominantly of urban interest.

To reverse this trend and to develop our agriculture even to keep pace with our general population increase, and living standards, serious consideration should be given to a wider spread of farm ownership, how to encourage and diversify much more capital and labour into farming, and to a flexible farming pattern that will again attract the best of our young agricultural and business abilities. Basically this depends on a clear appreciation of our greater relative advantages in growing good grass, than in most other of our occupations.

THE EXPLOITATION OF NATURAL POPULATIONS*

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As today's speakers have well brought out, one can judge the maturity of a nation by its ecology and its conservation laws. Mankind has been slow during his short history to develop a conscience relating to the biological world he forms part of. Yet what private ethics are to the single individual we may well say ecology is to the nation. The human species lives by exploiting. There is no adverse reflection in this: many of the plants and animals he exploits — like the red grouse (*Lagopus scoticus*) in Scotland and the trout (*Salmo* spp.) in New Zealand — owe their continued and cultivated existence to man's interest in them. The symbiosis consists in his substituting himself for their natural predators and consumers, in weeding out their competitors and jealously reserving to himself the natural increment.

From what each speaker has told us, we may watch the history of man's attempts —

* This paper was delivered as the Chairman's address concluding the symposium of this title at the Society's annual conference at Dunedin.