

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 —

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with greater or lesser success — to reach a balance favourable to his purposes. According to the species, he may achieve this with the use of the best genetic stock, with appropriate nutrition, with control of competition or predation, or by abstaining from wasteful exploitation. With many plants and with those animals he can domesticate he can do all four. With most animals he is fortunate if he can do two or even only the last. Of animals fully cultivated in the sea, I can cite, for example, only one, the oyster. The practice of sound ecology has not arisen overnight, nor lasted for very long in human history. From the accounts we have heard today, I would propose the following Seven Ages in the brief history of Man the Exploiter:—

First, a primitive era of naked exploitation with no thought to ecological consequence; the early era of open slaughter.

Second, a stage early realised by primitive man and communities as necessary to continuing supplies, close seasons and tabus, and restrictions on size and number of individuals taken.

Third, the first "pre-ecological" attempts to husband and manage the species; the well-intended efforts to control predators and to enhance the chances of natural increase, sometimes by introducing new stocks and caring for the young.

Fourth, the realisation after much early husbanding of a species that all is still not well — that, for example, the fish on which the hatchery authorities have spent precious time, money and effort are numerous, but over small, or that restocking red grouse is failing to build the numbers up.

Fifth, the beginnings of true ecology, the intensification of research and the intelligent enquiry as to why things did not turn out as was, on the first face, expected.

Sixth, the results of ecological research applied with the resources of an enlightened society.

Seventh and last, all too seldom reached with any species and with marine species generally manifestly impossible, the provision with minimum exploiting effort of a perfect sustained yield, or viewed another way — perfect conservation. A managed

forest, for example, may be termed sustained which continuously year after year provides a supply of timber right for felling, in contrast to intermittent managing and plundering.

Let me take some examples in more detail from each of these Ages.

First, the era of open exploitation unchecked. We need not, unfortunately, look far for examples, both in past and present history. Some of the animals so exploited have long passed into extinction. The dodo, Steller's sea cow, the great auk, the Chatham Island penguin, the passenger pigeon, and probably in part also the later surviving species of moa, are among these. With many other bird species, cruel inroads have been made, as with the Seychelles industry of eggs preserved in borax, an annual output of 10,000 cases having dwindled to 200. The southern New Zealand stocks of the fur seal were completely wiped out, the industry being past its first flush in only a little over ten years. With the southern right whale, the toll in former days was heavy, the exploiting of females coming into shallow water to calve being ill-judged and disastrous. This whale — a permanent casualty to over-exploitation — has never regained its former numbers in spite of rigorous international protection it now, too late, enjoys.

We find many examples, too, of casualties to smaller-sized but no less economically important species. In our own waters the pilchard population of the Marlborough Sounds has been destructively overfished. The decline of the English oyster must be at least as much due to over-harvesting and lack of replacement or scientific culture (earlier appreciated and put right in the mid-nineteenth century in France) as to the multifarious natural and introduced pests of this mollusc.

In New Zealand forest areas we have seen the reduction of our indigenous cover from 28 to 15 million acres. First came the era of destructive clearing when "one blade of grass was worth two trees", and then the years of wasteful exploitation with the widespread use of indigenous timbers. All this with no scientific State Forest Service until 1919.

Second, the early protective stage of close seasons and restrictions on size and number of catch. This means of conservation must go back even to pre-civilised times. It is a natural and commonsense corrective to the alarming decline of an exploited species and, with some ecological groups, it is in the nature of things all that can be done. This applies pretty generally throughout sea fisheries. It is the level of protection enjoyed by most of the species of whalebone whales under international convention.

The world-wide ranging ecosystem of phytoplankton, zooplankton, pelagic and demersal fish is one that has seemed (at least up till now) astronomically beyond man's power to fertilise or direct. His ecological contribution has been the negative one of limited and rational toll of resources by the adjustment of the size range at which fish may be caught. Action against overfishing has not always had the backing or advocacy of scientific men. By the middle of the 19th century the haddock and flatfish were already in short supply in England. Yet in 1865, T. H. Huxley in an inaugural address to the International Fisheries Exhibition was able to say: "The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery and probably all the great sea fisheries are inexhaustible; that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently from the nature of the case to be useless."

Regulation of catch size may be aimed not only at conservation but at maximum safe exploitation. The ideal to aim at is such a balance between the numbers of fish and the available food supply as to secure a maximum yearly production of fish flesh, that is to say a fast-growing stock. Thus will be possible a high total yield and moreover a high catch per unit effort. The chief symptom of overfishing is a declining yield from increased fishing effort. The progress of our knowledge here is carrying us far forward from the Second Age of catch restriction to the Sixth Age of scientific ecology.

Third, we find the earliest and more naive practice of ecology, the attempt to husband and manage the species by destroying its predators and increasing the supply of its progeny; and *fourth*, the realisation that

this commonsense and sometimes costly assistance to the species may not infrequently turn out ill.

In freshwater fisheries, especially with sporting species, a hatcheries policy has until recently had the centre of the stage. The acclimatisation societies interested in sporting fish have not always realised that the effective upper limit of biomass will be set by the size of the food supply to be shared and not by the numbers of young launched into the environment: where there is a cake of limited size to be eaten, the individual size of fish will tend to vary inversely with the number present. As in America, hatcheries policy — expensive and with much hoped and expected from it — has often been shown to be negligible in its effect on fish yield. We have Thompson writing, in 1941, "In light of our present information, it is not impertinent to enquire which helps fishing more — fish-eating birds or fish hatcheries." We have had in New Zealand insistent and uninformed clamour for destruction of shags as one of the predators of trout. Shags were indiscriminately left out of our protected birds schedules without any proper ecological knowledge as to contents of crops and feeding habits, and alarming destruction was threatened to the stocks of the less abundant species. The spotted shag, for example, is a beautiful and interesting bird, whose mouth structure is adapted exclusively for smaller planktonic food; and probably the only species with a major interest in trout is the black shag. It is an open and interesting ecological question whether such a predator may not manage and conserve stock more effectively than uninstructed human intervention.

A further example of the short-sightedness of much of our breeding policies is given by Stonehouse's mention of the unsuccessful launching of large numbers of young red grouse in poorly husbanded and heavily over-burnt country.

The sub-scientific regulation of pests and predators is being revealed also in our present age of chemical insecticides and pesticides when we look at the ecological principles against which they may offend. Midges, for example, may develop a resistance to dieldrin insecticides after one dosage, driving control measures back upon

the less satisfactory sustained dosage with D.D.T. Chemocontrol gives indeed the most powerful imaginable selective encouragement to those genetic strains subbornly immune to the doubled and redoubled efforts of the sprayers and the poisoners. Here we are ignoring the difference between a density proportional and a density dependent limiting factor, a lesson that should be stamped upon the heart of all who aspire to control pests. In England, we have seen another lamentable outcome of the use of hormone weed-killers along roadside verges with many of the traditional flowering plants — of no economic but of infinite aesthetic and botanic worth — being ruthlessly exterminated. Another defect — of a different kind — attendant on human management of plant populations, has been the virtual elimination over wide areas of England of the cornfield poppy, wild pansy, cornflower and cornfield buttercup, to make no mention of the tiniest and most charming of British rodents, the harvest mouse.

Fifthly, we arrive at the beginnings of true ecology, the investigation by trained ecologists into what went wrong with our previous measures. This must involve ideally a knowledge of the population dynamics of any species we wish to exploit. Today, in fisheries conservation, the outlook of scientists is changing. Fisheries investigations, such as those of K. R. Allen, into stock and crop will indeed illustrate much of the present-day change in outlook in fisheries ecology. We know today that nature — always over-prodigious in securing the replenishment and management of the next generation — hardly ever needs help in getting sufficient recruits launched into the world. Not only in fishes, but even with seabirds, eggs and young may be the most safely expendable age group. In New Zealand, some quarter of a million young mutton birds are every year taken without ill effects upon the stock. The difficulties and the critical period come in juvenile life after release, in avoiding predators, to which the too early release of hatcheries stock may offer a free gift, and in sharing the available food supply. The work of Thorson and the West European school of larval ecologists has shown that not fecundity but freedom from predation and the encountering of a year of adequate food supply has the greatest influence on the

recruitment of adult bottom stocks. Lakes, lochs and inland bodies of water can be fertilised and today frequently are. Even in the seas, we have attempts in oyster parcs at burying bagged superphosphate, so as to allow slow upward seepage through the bottom muds. Fertilisation of even such a limited and land-enclosed portion of the open sea as the North Sea is probably not for foreseeable time a practicable aim. We can, however, in suitable offshore depths raise the mineral-rich lower layers of nutrients by pumping to produce an artificial upwelling. A $\frac{1}{4}$ -horse-power electric motor will move a column of water 500 feet.

The Windermere perch experiment of the 1940's will long supply a case history in applied freshwater ecology. A drastic reduction of numbers was embarked upon for the numerous and far too small-sized population of perch. Wire traps were first used, the "perchines" so caught being canned to find a ready wartime market. Spawn as well was entangled in the traps and lifted out. The total annual catch fell in the late 1940's to one-sixth or one-seventh the original and the size began to improve, though very slowly. The main perch predator, the pike, began now to turn its attention to trout and char, and the next project was to trap pike, and incidentally by the same means, old large trout which are cannibalistic. To restore the previous trout-char character of Lake Windermere must require — as Worthington emphasises — active steps to keep one side of the balance of nature permanently weighted.

In the exploitation of commercial fish, Allen has today stressed that many types such as gadoids and herrings of the sea, or the sunfish and perches of freshwater, are so prolific that there is no need to consider the breeding stock in any way. The approach to economic management may be based on the production not of numbers but of maximum weight of fish. The ideal — aimed at in managed fisheries but never attained — would be to take the entire population when the combined weight is maximal. The object is in practice to spread the catch through the peak of the total weight-age curve, and to do this exploitation must begin before the peak is reached.

In freshwater fisheries moreover, as Allen

tells us, the relationship between growth rate and population density opens up one of the relatively few possibilities of regulating a fishery by managing the fish rather than the fishermen. We can in some small waters so adjust the population density that the optimum catch of fish of the desired size is attainable.

Sixthly, the results of ecological research applied with the resources of an enlightened community, securing with ultimate success the Seventh Stage, a sustained yield and perfect conservation. Of the ecosystems spoken of today, only high production pasture would seem to approach this ideal. As a general rule in a capitalistic democracy, the ecologist does not finally organise the exploitation or run the industry; and the *enlightenment* presents at least as great a political task, as do the ecological findings a scientific one. Sometimes it is necessary, for example, to enlighten the Scottish Landowners' Federation that the production of grouse may not for a given territory be the ideal ecological land use.

Very often, even with the will and agreement to embark on scientific management, the problem is economically intractable and the errors of the past have enduring consequences. In forests, there will be the difficulties as between even-aged and uneven-aged regeneration, and between intensive and extensive management. In part these are the consequence of the long time factor and of the slow pace of ecological history. Animals, where we can economically manage them, have shorter lives and live in smaller compass. In some species, even, one season spoilt may allow a new season's start with a clean slate.

Of aquatic animals, few can be farmed and fertilised and totally cropped. I offer one or two examples: first one may recall the account given by Hickling of the work of le Mair with the *Tilapia* ponds in the Malaccas, fish farming and pig farming interlocked, a beautiful example, given radiant energy and nitrogen, of a closed ecological cycle with a sustained and at the same time easily adjustable harvest, allowing total exploitation at a high productive level. The ponds were manured with organic nutriment run off from the pig pens at a higher level. Growth of filamentous algae and higher

aquatic plants supported herbivorous fish. These in turn could be harvested to the desired amount, or either fish meat or algae could be turned back into bacon by redistributing the harvest to the pigs a few yards up-hill.

We cannot often do such things in the sea. One place, however, where managing and harvesting could be done, and is in many countries well in action today, is in the land-locked estuarine oyster parcs. France since the 1870's, Holland, Italy, even cold-water Norway with great ecological ingenuity, Japan and Australia are today farming oysters upon artificial substrata, but not yet New Zealand. It is fair to say that the ruin of the English oyster industry was hastened by unrestrained and greedy overfishing in the 19th century, with no policy of replacement, as well as by unecological sewage and industrial pollution, the self-introduction of natural pests only lately augmented by settlement competition from our ubiquitous Australasian barnacle *Elminius modestus*, and by well-meant but disastrous pre-ecological attempts to introduce the American oyster, bringing successfully only the American tingle and the slipper limpet. The present impressive scale of oyster research in England may yet be in time to re-establish with enlightened exploitation a now dying industry. Thus we are now able to produce eggs or larvae at any time of the year by temperature regulation of the breeding season. These larvae can be fed on the minute flagellates *Isochrysis*, *Dunaliella* and others. We have reached in England and the United States a similar enlightened knowledge of larval behaviour and spat settlement; and much is known about re-laying and tending the young oysters and — as is possible in the warmer Bay of Biscay, Australia and northern New Zealand, though not in England — we are gaining experience in tending, raking, weeding and harvesting the oyster crop between tide marks.

The New Zealand application of oyster culture will carry with it many economic lessons. We shall probably, as with the enclosure of the common agricultural lands in 18th century England, need to think of the private parcelling out, or licencing, of oyster leases on the foreshore, for which provision already exists under the New Zealand Fisheries Acts. The incentive of a private finan-

cial stake in an individual farm will be found necessary for good husbandry. What is the public concern of the whole State tends to be the final responsibility of nobody. A condition of an oyster licence might well be that the holder should be in receipt of scientific advice and supervision, to improve his stock and yield, his experience so gained becoming available to others.

A notable venture in the farming of fish is Shelburn's recent work at Lowestoft in culturing young plaice, feeding them with *Artemia* larvae and other food cultures, keeping them till past the dangerous predator period of six to eight weeks, then liberating them. The plaice spawns on grounds in the North Sea off the Scheldt, followed by migration northward along the Continental sea coast of Holland, Germany and Denmark. Many years ago Garstang proposed the idea of transplanting by boat larvae caught at the spawning grounds to the richer grounds of the Dogger Bank. In marked Dogger Bank fish, four or five times as much growth was found, giving a highly economic commercial prospect for the shifting of young fish.

Enlightened practice of ecology must raise problems in public ethics. It has been said that man should be allowed to tamper with no species of whose population dynamics he knows nothing. In a world as short of ecologists and as hard pressed for plant and animal resources as we are today, this is a counsel of perfection. Yet there has been

no era of civilisation that has sought to develop a general conscience about man's relations with plants and fellow animals, or about the way we hand on to posterity "this great Entail", the earth off which we live. The Christian tradition would seem never to have squarely faced the question of relations or duties involving the sub-human creation, and when another religion, Hinduism, did this the results were a travesty of enlightened ecology.

Today, as a rich and well-provided State, New Zealand should be spending more on ecology and our schools should be teaching more. These things are as much a part of civics as the relations of man with man. Dr. Sears has with good reason warned us that if we neglect our grassland ecology, the basis of our productive economy, we may have too few resources to allow the luxury of the study of other ecosystems. Above all we must learn and teach that Ecology is an exacting task-mistress and a grudging rewarder. We are not to look for the quick returns expected by the Seychelles authorities of Matthew Ridley and Lord Percy, called out to remedy in five months the ill-effects of a generation's plundering of egg resources.

It will not be agricultural ecology or economic zoology we first foster and study; but rather (without any ulterior economic motive or objective) a humble and wide-ranging concern with plain Zoology and Botany.