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THE INTERDEPENDENCE OF
ANIMALS, CROPS AND
PASTURE

WITH SPECIAL REFERENCE TO SOUTH AFRICAN FARMING.

by

H. D. LEPPAN, B.Sc., Agric. (Toronto) M.Sc. (Cantab.)

Professor of Agricultural Economics.



PRETORIA
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PREFACE.

In recent years the trend in South African farming has fortunately been towards a closer adjustment to natural controls. But since some important maladjustments still require to be rectified, the preparation of this publication was prompted by a desire to assist in giving perspective, however small, to some of those concerned with practical direction.

The orthodox biologist, assuming that I attribute volition to Nature—a credo to which I do not subscribe—will no doubt take umbrage at some of my statements. But in a popular presentation, the latitude I have allowed myself in biological theory is, I think, permissible, for without it the presentation of arguments would have involved too lengthy an incursion into the philosophical.

The task of writing this bulletin has proved pleasurable for two reasons. Firstly, because the conclusions arrived at shewed themselves to be in conformity with the general policy which has been advocated by the Faculty of Agriculture since its inception; namely, the necessity for focussing farming enterprises in the Union on meeting the requirements of the animal and fruit industries; and, secondly, because of the ready assistance given me by my colleagues—in particular, by that rebel against the stereotype in thought, Dr. J. J. Theron.

H. D. L.

The Faculty of Agriculture,
Pretoria University.
21/9/36.

INTRODUCTION.

Farming is first and foremost a business whereby a livelihood is earned directly from living organisms. The existence of these organisms is primarily dependent on the geographical environment, but their numbers and variety are determined by biological interplay, and Nature establishes an exacting relationship not only between the physical environment and the organisms but between the organisms themselves.

Man's lot, in earning his livelihood, is largely that of an intruder whose permanent success depends often on his ability to co-operate intelligently with Nature and sometimes by rebelling against her dictates. In certain things she is implacable—notwithstanding man's prayers the rainfall of a region remains the rainfall of that region; but her adverse moods can often be warded against, as evidence man's ability to control disease. However, throughout Nature maintains her course, even if at times men think they have deflected her from it. In the long run success attends those who keep in step with the purposive old Dame. Aware that she is ruthless in annihilating species who ignore adjustment to her, with her man must yet wrest his livelihood. Herein is to be found the central problem in farming.

Man believes himself to be the lordling among Nature's creations for has she not endowed him with reason beyond other species—to an extent that in some minor things he is allowed to show petulance but is still permitted to exist? But in stern matters she brooks no interference. In these matters she allows the undesirable to commit self-destruction, as witness the civilisations which have disappeared because they failed to keep the balance set between vegetation and climate. If man denudes the soil by allowing his animals to overgraze the vegetal cover she robs him of his livelihood by sweeping the soil from under him.

The key, then, to success in farming lies in knowing what Nature will permit and what she will not allow. Her pattern, for design is part of her, must not be interfered with so far as essentials are concerned. And since her pattern is designed on soil, her foremost decree is that the soil must be in no way impaired. But here, as elsewhere, she showers her favours on those who assist her. Encouragement is to be derived from the knowledge that for thousands of years some civilisations have cultivated their land to their permanent advantage. On the other hand, the pages of history are strewn with the records of those civilisations, who, having rendered their land derelict, have vanished. The reasons for her apparent benevolence and malevolence can only be understood when the nature of the soil is appreciated.

The soil is no inert thing. It is dynamic, ever changing, vital. While it sustains life, it in itself is sustained by life. The framework of sand is clothed with a colloidal complex whose activities give and regulate the flow of nutrients to the organisms. The sensitive balance is due to the extreme sensitiveness of colloidal soil particles to changes in salt content e.g. changes in concentration with increases or decreases in moisture content vitally affect the colloidal state of aggregation. In turn the organisms, during life and when decomposing, stimulate colloidal activity in the presence of water. Broadly speaking, fluctuations in water, associated with conditions of temperature, determine the potentialities of soil to support life.

Basically, moisture supplies are dominant in determining the distribution of organisms found, and, when the biotic complex is undisturbed Nature establishes a delicate equilibrium between the organisms and the moisture supplies in a given region. In arid regions growth is restricted not so much by a lack of nutrients but by the slow rate, owing to an insufficiency of moisture, with which the organism can absorb them. On decomposition of the organisms, the soil is enriched with life-sustaining elements—generally identified with organic matter, e.g. salts, humus and perhaps certain stimulants of the nature of vitamins—sanitating the soil and ultimately establishing a sensitive equilibrium between moisture, nutrients and organisms. This balance is conditioned largely by the „income” and „out-go” of these life-sustaining substances. Almost any disturbance of the soil, such as cultivation, immediately intensifies the „out-go” and restricts the „income.” If by any means, e.g. overgrazing of the vegetation, the additions of elements diminish, then the yield of nutrients and the effective flow of moisture into the soil is seriously interfered with owing to a disturbance in the colloidal complex. In consequence the amount of vegetation which can be supported diminishes accordingly. Concomitant with this change are important physical changes reflected in altered structural features of the soil. The colloidal complex can no longer maintain the optimum granular condition and so undue deflocculation takes place. In this deflocculated state the soil cover is quickly lost through the agencies of wind and rain. Moisture is required by plants not only for the absorption of salts but for other physiological reasons as well.

If, owing to the reasons given, plant growth is restricted then erosion is further aggravated because plants play a mechanical rôle as well in holding soil, and, by obstructing the flow of surface water promote the penetration of rain. The result is a lowered efficacy of the rainfall—a serious situation in view of the part played by moisture in the growth of organisms in these drier regions.

A very different situation prevails in humid regions. With adequate supplies of moisture colloidal activity is maintained at a high level giving abundant growth, which on decomposition adds

large supplies of life-sustaining agents to the soil. Here man may intrude his operations into Nature's processes with a measure of impunity. If his method of farming does not maintain the necessary equilibrium, the productivity of the soil declines only slowly. But, under modern conditions, because of the high yields obtainable, he can restore economically the equilibrium between nutrients and organisms by applications of artificial fertilisers associated with sound farming methods, since in moist areas the moisture factor can to a large extent, be disregarded. In drier areas the use of fertilisers cannot be developed to the same extent as in moist areas because moisture limits come into play restricting the in-take of fertilisers. It is easy to see, then, why some soils in humid regions, where all, even human excrement as in China, goes back to the soil, have been tilled for thousands of years. Here the soils, being moist, are seldom lost through erosion because they are seldom so dry as to become powdered, and moreover, no restriction on colloidal activity through inadequate supplies of moisture is found.

The foregoing discussion serves to show, then, that the balance between organisms and soil is more easily disturbed under arid and fluctuating conditions of moisture than under circumstances where the soil is more or less constantly moist.

The balance set up by Nature, when undisturbed by man, is exhibited in the flora and fauna. Traversing from arid to humid conditions the spare flora found in deserts changes into short grass, then into tall grass, and terminates in the forests of the very humid parts—and, of course, the fauna is closely correlated with the vegetation. The safeguard to the encroachment of the desert lies in the short grass tracts found in the semi-arid country—land in which the balance between soil and organisms is most exacting. It is here that the too intensive farming of land, employing either the animal or plough, works havoc soonest. It cannot be over-emphasised that the soil may be lost even without the plough. In fact some of the worst of eroded land in South Africa has never been tilled—its derelict condition is almost entirely due to over-intensive farming with animals. The urgency for research into veld management problems is obvious.

But many must earn their livelihood from the soil and so are driven to manipulate the forces of Nature. To disturb Nature least man would follow a primitive existence living predatorily on the products of untamed plants and animals. Technically, he would take his place as an ordinary animal of the biotic complex. But with his higher intelligence man's wants are above those of the animal. To satisfy these wants it is necessary for him to procure supplies of foodstuffs above his immediate requirements. He therefore supplements the gifts of Nature by the additional usage of selected plants and animals. Given a surplus in foodstuffs he is then liberated to pursue the fulfilment of his wants other than food.

Among plants and animals are many which do not meet the needs of consumption. In an undisturbed flora it is only a small proportion which is utilised by man or his tamed animals. The collection of these scattered plants is costly in effort and so man finds an economy in energy by selecting and propagating on tilled land the few species he prizes most. By so doing he controls production with regard to quantity, place and, in a measure, to time. By the storage of surpluses he makes provision for the dormant and adverse periods. It should be noted, too, that the plants man uses are selected for their high efficiency in the production of foodstuffs or raw materials for manufacture, and, that the yields are high because these plants are freed from the competition of unwanted plants. Cultivated plants are the product of the climate, the resulting soil and the labour of man.

But in farming certain principles must be followed. The natural process is one in which the nutrients from the soil are incorporated in the plants and finally return to the soil in the form of manure or as the products of the decomposition of animals and plant residues. If this cycle is broken man's existence is maintained with difficulty. Soil exhaustion, which has brought about the undoing of many civilisations, is fostered where the role of the animal in this cycle is overlooked. The most momentous contribution of English agriculture to farming was in the cultivation of crops, particularly hay crops, to cater for the needs of animals during the dormant season. British farmers arrested the exhaustion of their soils by devising means by which more animals could be kept to replenish the soil with the minerals taken out by cropping. At a later stage the use of artificial fertilizers gave to man the means whereby the productivity of many soils could be raised beyond the level set by undisturbed natural processes.

* * * *

The relevance of the above discussion to the theme of this bulletin is obvious. South African land comprises arid, semi-arid and humid areas, in much of which wide fluctuations in the distribution of rainfall are of common occurrence. Regularly, as well as intermittently, most of the soils are subject to widely varying degrees of desiccation. Erosion, then, must always be a menace if adequate precautions are not undertaken in the farming of South African land.

While our present knowledge of natural processes certainly gives meaning to much of what we can see of Nature's design, it is yet too inadequate to be of practical guidance in anticipating the full results of some of man's attempts at collaboration with her. The equilibrium Nature demands is too sensitive to be measured by the scales of present-day laboratories. Our brief sketch will serve, we hope, to give some idea of the complexity of the fundamentals with which farming is concerned. It will be our purpose in the succeeding chapters to shew the disastrous effects to the Union's land that must eventuate if we disregard what we can discern, and, to attempt to indicate how disaster may be averted.

II. SOUTH AFRICAN PASTURES.

All production in farming has its origin in vegetation. But, as previously indicated, the real remedy for soil erosion lies in the control of the vegetal cover. And since the natural vegetal cover in South Africa provides the main source of feed for the animal population, it is obvious that a delicate balance in its utilisation must be maintained—to ascertain which calls for prolonged and intensive research. So far as possible equilibrium must be established between the economic demands on the utilisation of the vegetation and the requirements of Nature for a maximum soil cover to prevent erosion. If, through economic pressure or faulty settlement, land is farmed too intensively—particularly in the drier areas, the vegetation is quickly impaired beyond the danger point to itself and to the soil. Abandoned homesteads standing on ruined land in the United States and elsewhere give tragic evidence of this fact. For the same reason districts in the Cape Midlands have already shewn marked decreases in both animal and human populations—here eroded land supports fewer plants than formerly and the carrying capacity of the soil has decreased correspondingly.

Space will not be taken here to detail the extent of the damage done to South African Soils. Suffice it to say that the deterioration over large areas has been extensive, in some cases irreparable, and if unchecked the generation after this, living in those regions easily subjects to erosion, will have but a meagre heritage in the form of land. The reasons for this deterioration and its threat require to be described.

Before South African land was farmed the relationship between soil, plant and animal was very different from what it is to-day. If an area was experiencing drought the animals no doubt moved to areas where the growth of plants was more active, thus giving the soil of the drought-stricken area an opportunity to retain the essential part of its vegetal cover. With the breaking of the drought the animals moved to plants where renewed growth permitted a certain amount of grazing without loss to the requirements of the soil. But the use of animals in farming quickly changed the relationship between soil, plant and animal.

Even pioneer farming disturbed this relationship because, in order to ensure the safety of his animals, the farmer was compelled to have them herded during the daytime and kraaled at night. Now, herded animals tend to overgraze the vegetation near the kraals and watering places, as well as along the route to the parts of the farm selected for pasturage. By their selection of the more palatable species these plants would tend to disappear and thus Nature's inter-plant relationships were changed, i.e. the botanical composition was altered. The result was that erosion set in, to be aggravated as the animals increased. If droughts occurred, according to circumstances

the farmer and his animals might or might not have moved to other areas. Those compelled to remain over-punished the vegetation by grazing it when, owing to drought, growth was inadequate for the herbage to withstand grazing.

When pioneer farming was gradually replaced by commercial farming the fence and the windmill came into use—two of the most potent factors in the over-intensive farming of arid and semi-arid regions, not only in South Africa, but throughout the world.

Fencing, which, of course, was largely responsible for making commercial farming possible, obstructed Nature's self-regulatory movement of animals. The farmer, too often concerned only with his camped animals, failed to observe the denudation of soil caused by his faulty control of the vegetal cover. It must be remembered that the condition of the animal is frequently no index of the extent to which vegetation, in the initial stages, may be abused. Camps, too, were made with little reference to the specific needs of the type of vegetation they enclosed. Judiciously employed, fencing affords one of the chief safeguards for the proper control of the vegetal cover—but the past use of the fence has unfortunately disclosed a great deal of ignorance. In the past the immediate economy effected in animal management by fencing overshadowed the necessity for care in the use of the vegetation.

The windmill, which, like the fence, may be a blessing or a curse, made possible the close settlement of arid and semi-arid regions in many parts of the world. Without the windmill, the over-intensive farming of these regions would not have come about, nor would the recent history of these parts have been so depressing a tale. The watering-places which Nature places at the disposal of animals are part of her design in keeping the necessary relation between animal and plant. Without water, the short-grass country—the belt round the desert-shrub which acts as a safeguard against the encroachment of the desert—cannot be denuded by over-grazing. But man, in his attempt to force Nature beyond her inclinations, used the windmill in his schemes for closer settlement and so temporarily maintained an animal population beyond Nature's design. In many countries to-day eroded land gives evidence of his folly in attempting to defeat the law of diminishing returns by too intensive farming.

With the best of management not many more animals can be permanently carried in desert-shrub or short-grass country than when it supported only free-roaming animals before man started the farming of this land. The same limitation does not apply in tall-grass or forest country, because of the cultivated crops which may be used as supplemental feed—an aspect to which we shall revert later.

The climate of South Africa, with which the vegetation is closely correlated, varies from Mediterranean in the South West Cape to tropical in the Natal Sugar Belt; from arid country in the Karoo

to humid parts in Natal. In the South West Cape, where grass growth is meagre because of the dry summers, the vegetation, composed chiefly of perennial shrubs, is utilised best by sheep. In a district like Bedford, where the pastures comprise both grass and perennial shrubs—the latter, a bulwark against drought—small stock as well as cattle are employed in farming and can be kept in relatively good condition throughout the year. On the grasslands of a district like Standerton, cattle and sheep are found to do well during the months when growth is active, but are hard put to maintain their condition during the dormant winter months. Fortunately Standerton can grow field crops, for supplementary feeding during winter, with assurance.

The chief shortcomings of South African pastures are to be found in the long periods of dormancy. The long, dry summer of the South West Cape is associated with little growth, and, in the summer-rainfall parts of the Union the dry winter months cause almost a complete cessation of growth notwithstanding relatively high winter temperatures. Intermittent droughts throughout the sub-continent add their quota to the restriction on growth, and, of course, encourage a powdered condition of the soil, favouring erosion.

This brief outline of some aspects of South African pastures brings to the fore two requirements for their utilisation, namely, the necessity in the drier areas for keeping the animal population as low in numbers as possible, and the urgency for devising economic methods of farming in which supplementary feedstuffs—to save the vegetation in times of stress—will play a greater role than heretofore. Without these two shields against the denudation of their vegetal cover, the soils of these parts will not long maintain a reasonable standard of living for those farming them.

In the wetter areas of the country, where judicious cultivation need not cause the loss of the soil, the situation is entirely different. In these parts a balanced farming should be able to cater—in the way of supplementary feed in the form of crops or artificial pastures—for the needs of the indigenous vegetation and the animals.

III. THE HUSBANDRY OF ANIMALS IN SOUTH AFRICA.

The reasons why the animal industry must dominate South African farming need not be detailed here.* Briefly, this is so firstly, because more than 85 percent of the land is unfit for cultivation, being too dry, mountainous, or otherwise unsuitable—it can be utilised only for pasturage. Secondly, the demand, both locally and abroad, is likely to favour animal products rather than grain. Finally, a properly maintained animal industry—since the animals or their feedstuffs can be transported—is less susceptible to the effects of drought than are growing crops which cannot be moved and so suffer the full toll of adverse weather and pests.

To carry out successfully the policy of concentrating on the animal industry will often involve radical changes in the methods employed in farming to-day. The high annual losses of animals, through drought and disease—approximately 500,000 cattle and about 4,000,000 small stock—are themselves an index of the maladjustment of the animal industry to natural resources. But the number of animals which die is not a full measure of the loss to farming, for to these must be added the decrease in production from the surviving animals which have received a setback in development and the loss of soil which has resulted from the destruction of vegetation. Abundant evidence clearly indicates that, with our present methods, a great deal of land is being farmed too intensively—when full account is taken of the impaired sward and the amount of soil eroded. Only with changed methods, employing fewer animals but of better quality, a more rational management of the veld and the judicious use of supplementary feeds, can these areas be farmed at all intensively.

The class of animal farmed also has its bearing on the damage inflicted on the vegetal cover, and so on the soil, because some animals maltreat certain types of sward more than do others. In this respect the goat is one of the chief offenders. The goat feeds on a wide range of plants and will utilise the pasturage on rugged land inaccessible to other classes of farm animals. In certain areas the popularity of the goat has been largely due to the fact that it can survive drought—which it accomplishes by feeding on tall shrubs and young trees—better than do cattle or sheep. In denuding the slopes of shrubs and young trees it contributes to erosion in no mean measure. It is relevant here to point out that the actively growing part in grass is found at the base of the leaf and, in consequence, the removal of the upper part of the blade by grazing does not injure

* This aspect is fully discussed by the writer in his "Agricultural Development of Arid and Semi-Arid Regions: With Special Reference to South Africa" (1928), published by the Central News Agency Limited.

the growing point. It is for this reason that grass lends itself so well to pasturing. In the case of shrubs and trees the growing point is terminal, which when eaten off causes a greater set-back than in the instance of grass. Shrubs and trees, after the grass has been destroyed by excessive grazing, must be looked upon as the last stronghold of the soil. If these are destroyed, and here the goat in some districts is the chief agent, nothing remains to hold the soil, even mechanically. The goat then would do least damage when farmed on grasslands. In many districts where it is to-day popular the goat in fact does most damage.

The various classes of animals shew a differing predilection to edible plants; in consequence Nature's interplant relationships are best maintained where farmers employ more than one class of animal in their farming. In general cattle do less damage to vegetation than sheep, and sheep less than goats. Among the contributory agents fostering the excessive erosion which has taken place on land farmed by natives is the native's partiality to the goat.

Two other features of animal farming, related to soil deterioration, are found in the practices of veld-burning and the disposal of manure.

The merits and demerits in practical farming of burning off the dried, harsh vegetation—of extremely low nutritive value—will not be discussed here. The ultimate effect on the soil, however, is germane to our theme. Parenthetically, it should be noted, that this unpalatable, dry, harsh residuum is Nature's provision for soil protection, since it furnishes a cover for the soil during the protracted period of winter when the soil is in a desiccated condition and thus liable to powder. But all that needs to be said in connection with veld-burning is that because it obviously upsets Nature's provision for maintaining soils, it is a practice which should be avoided wherever possible. Unfortunately it is at present difficult to see how farmers in some localities could dispense with the practice of veld-burning. The position will no doubt be cleared up by future research.

Except in a few parts where the supply of timber is plentiful the burning of manure for fuel, by natives and sometimes Europeans, is general. The cumulative effect over generations of this procedure must be deleterious to the soil since it breaks the natural soil-plant-animal cycle. In the same way the non-utilisation of kraal manure within the locality in which it accrues must adversely affect the veld of that area.

The approach to the proper utilisation of the vegetation is to be found along two main avenues—breeding and feeding.

Stated in short, the type farmed must conform with the nutritional level. In good farming, where supplementary feeds are pro-

vided and where the management of the veld is enlightened, the type maintained can, of course, be "improved" beyond that set by the unaided indigenous vegetation. The past abuse of the vegetation by many of those engaged in animal farming has often been occasioned by the attitude of mind which restricts its compass to the view that the veld, not having been produced by man's efforts, is given gratis to swell profits. Many, too, have adopted farming as an expedient to earn a livelihood—by these, often compelled by economic pressure, the future results, of taking all from the soil without compensation, are disregarded. Particularly by natives, but often by Europeans, the number of animals owned is considered to be of more importance than having fewer animals but of better quality. It is almost unnecessary to point out that this attitude must lead inevitably to over-stocking, resulting ultimately in losses of the soil. In the long run fewer animals, well selected and properly maintained, must give larger profits and more stabilised farming. The temporary financial loss of carrying fewer animals, but of better quality, would often be further offset by the selection of quicker maturing strains.

Had the South African farmer been compelled to stall his animals during winter, as in the case of the Canadian farmer, less would have been heard of soil erosion in South Africa—for then the necessity for the use of supplementary feedstuffs would have been more obvious and the sward would not have been punished beyond its endurance. In the Union the animal is able to survive the comparatively high winter temperatures without being stabled, and, usually is able to subsist on the vegetation during the dormant season. Whatever the reason, economic or otherwise, the fact remains that the provision for supplementary feeding plays far too small a role in our farming. Less than 20 per cent. of our maize is fed to livestock, whereas in the United States nearly 85 per cent. of their crop does not leave the farms on which it is produced. In addition, the South African farmer has been slow to follow the practice of raising steers in the parts less favoured by Nature and finishing them off in the better watered areas where crops can be grown for fattening purposes. The attempt to fatten animals on the natural vegetation alone of some areas has contributed to over-grazing and the resultant deterioration of the soil in these parts.

Until recently South African cropping has not been focussed on the needs of the animals or the vegetal cover, but rather on the production of grain for sale. Had cultivation catered more for these requirements many soils would not have been overtaxed.

IV. THE CULTIVATION OF SOUTH AFRICAN CROPS.

The maintenance of the vegetal cover of the land is all important, and, any increase in our knowledge of veld management will assist very materially in preventing undue exposure of the soil. However, it is necessary to bear in mind that apart from controlling the numbers of animals, in the judicious cultivation of crops is to be found the chief safeguard against the denudation of the soil's cover.

It has recently been said that the use of the plough on South African land should be avoided and that maize and teff are the greatest curses to South African farming. This pessimistic statement is based on slender foundations.

At the outset it must be remarked that approximately only 5 per cent. of the Union's land is under cultivation; that a fair proportion of this lies in the South West Cape where, owing to the drizzling nature of the winter rainfall, erosion does not trouble the cultivator much; that about 1,000,000 acres are under irrigation which also are little subject to erosion; that of the remaining arable land, part enjoys a fairly high rainfall and, if cultivated with discrimination, should suffer little from soil loss. The bulk, then, of the country's arable land, if properly cultivated, need not give rise to fears of erosion. The half-truth to be found in the alarmist statement referred to above concerns some of the land in the drier areas, and to that on ill-chosen sites in other parts. Unquestionably, a great deal of the land now under the plough in the drier areas should never have been cultivated—the same applies to land on steep gradients in other parts. But before proceeding further, the role of the cultivated crop in our farming must be discussed.

The chief function of the crop is to rectify maladjustments of time, which it does by giving a surplus to be stored against some future time when a shortage occurs, or the crop may be grown at a time when required. In both cases the crop—under control, be it noted—may be used to relieve the natural sward. The paramount importance of the field crop lies in the fact that it is under control. Its use may be controlled so as to protect the vegetal cover from being too severely grazed, or it may be used to save the condition of the animal and, at times, even the life of the animal. Looked at in this manner the crop is seen to be vital to the proper maintenance of the animal and the soil. Herein, some justification is shewn for Nature's having endowed man with reason above that known to belong to other species.

Happily, the policy is to-day changing into better directions, but in the past utilisation of our arable land one of the chief faults has been the outcome of general policy—albeit one initially enforced by economic pressure—which fostered the production of crops for

sale off the farm. The reason why this policy came about was largely an outcome of the Anglo-Boer War which badly depleted the animal population. Pressed for cash and waiting for his animals to multiply to what he considered to be the full complement for his land, the farmer was forced to exploit the possibilities of cash crops. Unfortunately an expensive elevator system—not without considerable value for internal trade—was established to facilitate the export of grain. No wonder, then, the South African farmer was unduly impressed and directed his activities to the sale of crops off his land. The result was an impoverishment of the veld, and, because little fertilizer was applied, of his arable soils as well. The pity is that State measures continue to encourage the sale of too large a proportion of the grain off the farms on which it is produced. From the point of view of the soil, the very reverse, i.e. the importation of cheap grain to stimulate the feeding of more concentrates and so to save the veld, should eventually be brought about. Among other aspects, the result of this policy has been to induce many of those farming under precarious climatic conditions to gamble on the production of grain crops, whereas under these circumstances fodder production would not only have been more assured but would have been instrumental in maintaining the animals and in protecting the vegetal cover from overgrazing.

Although now improving, the cultural practices of the past have left much room for improvement. The occurrence of ploughed land on sites and in dry areas favouring erosion is still far too common. Even in the areas of assured production far too little fertiliser is applied. Weed control is poor, and in arranging the sequence of crops little consideration is given to the best order in which they should be grown, so as to combat soil erosion. The necessity for ploughing along contours and for the use of embankments to prevent excessive run-off too often remains ignored. However, encouragement is to be derived from the fact that so much can be done to improve the situation.

From what has been said earlier in this bulletin, it is easy to see why properly irrigated land should not suffer from erosion, and, while the control of alkali on much of this land is still a baffling problem, on the whole irrigated land should remain a valuable resource of South African farming. Not only are the yields high but, the returns being assured, irrigated land is a powerful asset in stabilising farming—if production from these soils is mainly directed towards producing supplementary feedstuffs for animals. The present policy of the Government to assist in the building of small dams is all to the good, for in this way the individual farmer can provide more easily for the needs of his animals and veld. At the moment however, owing to the high prices artificially established for wheat, far too much of the Union's irrigated land is devoted to wheat production for grain instead of crops for stock feeding.

The establishment of cultivated pastures calls for comment. In some of the more favoured areas, work carried out by investigators and farmers, already shews that pastures have an important function to fulfill in our farming. Their proper management often meets the needs for grazing at times when the natural pasturage is deficient, and, some grasses, e.g. Rhodes, not only furnish grazing but provide a yield of hay for winter use as well. As a check to erosion these cultivated pastures are invaluable and it is hoped that in many parts they will be incorporated in ordinary crop rotations. To what extent they can be employed economically in the less favoured areas of the country must rest on future research and practical experience. Certainly, with our present knowledge, cultivated land subject to erosion would be better utilised in this manner than in the cultivation of grain crops whose yields must be precarious and which favour the loss of soil.

Our discussion throughout, it is hoped, has served to show how important the indigenous vegetation and that under cultivation are to the agricultural industry. Research is vital to a full understanding of how these can best be used in farming without deterioration taking place in the soils. Much can be said for the recent trend to concentrate the research of technical officers purely on pasture problems. But unfortunately the recent tendency has at the same time been to neglect the problems confronting the cultivation of ordinary field crops. In view of the enormous bearing that field crops have on soil maintenance, of both arable and uncultivated land, it would be the height of folly to neglect the study of their cultivation. Apart from pasture research, at present too few competent men are engaged on serious agronomic problems. In this regard perspective is at present badly lacking in the Union. So interlocked are the animal and plant industries that it must be apparent that the control of State research concerning production in these branches of farming should be under one head. To treat many of the problems of either independently and without the necessary comprehension of the inter-relationship which must exist between the two, is merely to court the misdirected use of effort and money.

Finally, the question arises as to what land in South Africa may be ploughed without causing anxiety concerning the loss of the soil through erosion? With our present knowledge this question cannot be answered with certitude. Based mainly on empirical data, and subject to many reservations, the writer's credo on the matter is given roughly below.

Nowhere in South Africa should land liable to erosion on steep gradients be cultivated to ordinary crops. With adequate safeguards, e.g. contour ploughing, the proper sequence of crops, occasional terracing, the use of windbreaks, etc., erosion need be little feared on the Union's irrigated land; or in the South West Cape; or on land in the summer rainfall region receiving an average annual rainfall of more than 28 inches. On dry lands west of

the 28 inch isoheyt and in the all-the-year round rainfall region, the use of the plough should be restricted to a minimum, and if used it should be employed only on relatively level land of good texture, protected naturally or artificially from strong winds or the run-off from torrential rains. In order to guard against the deterioration of the soil, cropping should aim throughout at meeting the needs of the animal population. Doubtless it may be found possible, as knowledge from research and practical experience accrues, to cultivate with safety more land than that given in the above estimate. However, with the information of to-day, more caution is required than has been shewn in the past cultivation of soils subject to erosion.

V. SUMMARY AND CONCLUSIONS.

The more salient facts which emerge from the foregoing require to be briefly re-iterated.

1. The relationship between soil, plant and animal is extremely sensitive to change. Any disturbance of this relationship must be effected with the greatest caution, care being taken to compensate for what has been taken away.
2. The past development of South African farming has too often disregarded the necessity for maintaining the soil-plant-animal cycle, the evidence for which is to be seen in parts where the carrying capacity of the vegetation has been lowered through soil erosion.
3. In many parts land has been too intensively farmed—given the methods commonly employed to-day. If the same degree of intensity is to be followed, then radical changes in methods must be brought about.
4. The situation can best be met by farming with fewer animals, but of better quality; by a far greater use of supplementary feedstuffs than has been the case hitherto; and, by improved methods of veld management. In connection with the use of supplementary feeds a note of warning must be sounded. They should not be employed in order to carry more animals—to do so would be to nullify one of the objects in using them i.e. to protect the veld. The vegetal cover in itself is seldom satisfactory for the proper maintenance and finishing off of animals, but by employing supplementary feedstuffs the two latter objectives can be attained as well. In all this it will be necessary to guide practice by research.
5. The role of cropping in furnishing additional feeding will be of extreme importance in meeting the needs of the animal and the soil since it assists in compensating for what has been taken away. Supplementary feeding will obviate the excessive tramping of animals, will enrich the soil, prevent overgrazing of the vegetal cover, and so will act as a safeguard against erosion.

* * * * *

A consideration of the above facts gives rise to certain conclusions regarding some aspects of State policy affecting South African farming.*

* These have been dealt with more fully in the writer's "The Organisation of Agriculture: With Applications to South Africa" 1936) published by the Central News Agency Limited.

As previously indicated, the policy of bolstering up the price of cereals is detrimental to the proper preservation of soils in that high priced grain retards the feeding of concentrates to animals. Livestock well maintained with the assistance of supplementary feed-stuffs would not only enrich the soils with manure but would be less liable to overgraze the vegetation. So far as the soils of the country are concerned, it would be wiser gradually to reverse the policy—eventually to allow cheap grain from abroad free access to our markets.

Much of South African land is being overtaxed simply because too large a proportion of the population is being kept in farming. Under these circumstances the earning of a livelihood precludes a proper adjustment to the natural resources of the soil. Forced to meet his commitments, the farmer is often compelled to attempt to retrieve his position by employing more animals than the vegetal cover of his land will support—this must result in the loss of his soil.

Another economic feature having the same result is to be found in the fact that high land values are out of alignment with the low prices obtainable for farm products. In desperation the farmer here again attempts to save his financial situation by over-farming his land. Unless a white peasant class—undesirable in a country of blacks and whites—is eventually to farm South African land it would be desirable for the State to purchase the land of desperate farmers and to lease it to them, at rentals which can be met at present day commodity prices, over long periods, say, 99 years. In the leases safeguards against carrying too many animals, and so forth, would be stipulated.

The general position would be best alleviated by relieving the pressure on the land by fostering urban activity. In this way those redundant to farming would be absorbed by the towns—to their advantage educationally, nutritionally, medically and otherwise. In assisting urban activity those types of manufacturing which furnish by-products of value to livestock should receive special consideration.

Some of the Union's land, subject to erosion, in view of the disabilities to the human material produced and the soil lost by farming it too intensively, would be better if withdrawn from ordinary farming. This land might be used for extensive ranching or might very profitably be turned into sanctuaries for flora and fauna to attract valuable tourist traffic.

The necessity for giving the native scope for rational development cannot be over-emphasised, particularly at the present juncture when he is to receive additional land. His past farming has resulted in the gross abuse of his soil. It would be the height of folly to allow him to waste the resources of the country any further by per-

mitting him to continue in malpractice. Any expenditure on teaching him improved farming must react to the advantage of the soil.

Finally, it would seem that unassisted legislative bodies are unable to cope with the situation—the present-day requirements for success as the polling-booth do not meet the needs for the retention of the soil. An Economic Advisory Council, to formulate long range policies and to advise parliamentary bodies, would be of inestimable assistance in giving guidance for a sane development of the country's resources. One of the many functions of such a council would be to investigate and to direct research which is essential if harmony in adjustment is to be effected.

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