

## PASTURE IMPROVEMENT POSSIBILITIES IN EFFECTIVE ANIMAL PRODUCTION SYSTEMS

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The term "pasture", "improvement" and "effective animal production systems" as used in the title of this paper may at first sight seem clear and unambiguous. However, lest we flounder over too wide a field some definition and some restriction in emphasis is necessary.

The term pasture is subject to a broader definition which includes all pastoral resources of livestock from the natural arid shrublands through other more productive veld types to the artificially cultivated and irrigated grazings. The narrower definition, which is more commonly applied in South Africa, embraces only the artificial grazing lands and not the natural ranges (veld) (Booyesen, 1967). I read the brief in this paper to be such that I am required to take the broader view. This I will do, but as the theme of improvement implies a goal of maximizing production I will nevertheless give emphasis to systems which are not natural or, rather, to those areas where there is scope for improvement beyond the natural condition. Also in deference to the paper which is to follow I shall confine myself to those areas which receive their rainfall predominantly in summer. However, for the sake of the discussion on opportunities for improvement I shall recognize 2 broad types within the summer rainfall zone – the arid to semi-arid west and semi-humid to humid east (Edwards & Booysen, 1972).

The "improvement" of pastures may mean very different things to different people. The ecologist and conservationist may see the climatic climax condition as the ideal and, therefore, any change in this direction as improvement. Those who profit by selling building sand may have a very different view. However, we have linked improvement to effective animal production systems. While this is indeed entirely legitimate we must at all times remind ourselves that we are dealing with complex ecological systems and that the maintenance of production requires the maintenance of the physical components of the system. Thus for the purpose of this discussion pasture improvement is defined as the development of those *structures* and the implementation of those *practices* designed to produce a better pasture in terms of its capacity to produce livestock products on a sustained basis (Booyesen, 1978).

### Improvement through exploitation, restoration and intensification

The definition of improvement presented above is extremely broad in scope as it includes all processes of management whether the system be geared to exploitation, restoration or intensification. The diagram in Fig. 1 will assist in placing these in perspective.

The word *exploitation* is used here in its wider sense to mean "utilization for ones own ends", and not necessarily implying the detriment of the resource. Man's exploitation of the veld/game system, in the first instance, constituted nothing other than game cropping or harvesting but soon, and usually simultaneously, he introduced domestic livestock and so the processes of domestication began. The veld/game system became the veld/game/livestock system and, in most cases, the veld/livestock system soon followed. The introduction of livestock into the system inevitably implied control by man. Matters such as the development of structures (fences and watering points), livestock numbers and stock movement were subject to operator decision. The execution of these decisions constituted aspects of veld management and when properly applied resulted in veld improvement.

The complexity of the little understood veld/livestock system together with the subjectivity, and often ignorance, of man, the operator, ensured that his decisions would vary greatly and would range from bad to good. Bad veld management leads to veld deterioration and land denudation. Fortunately it is within man's powers to halt this process of deterioration and, in fact, to reverse it. All his activities in this vein we may collectively refer to as *restoration* (including reclamation and renovation) which, clearly, is yet another facet to pasture improvement.

But, man is not only concerned with the maintenance of veld in good condition or in the restoration of veld to a good condition. As the demand for food increases and land becomes limiting, he is forced to use all arable areas for the direct production of human food, to use only non-arable areas for pasture production, and, in these areas, to adopt procedures designed to increase the

# EXPLOITATION

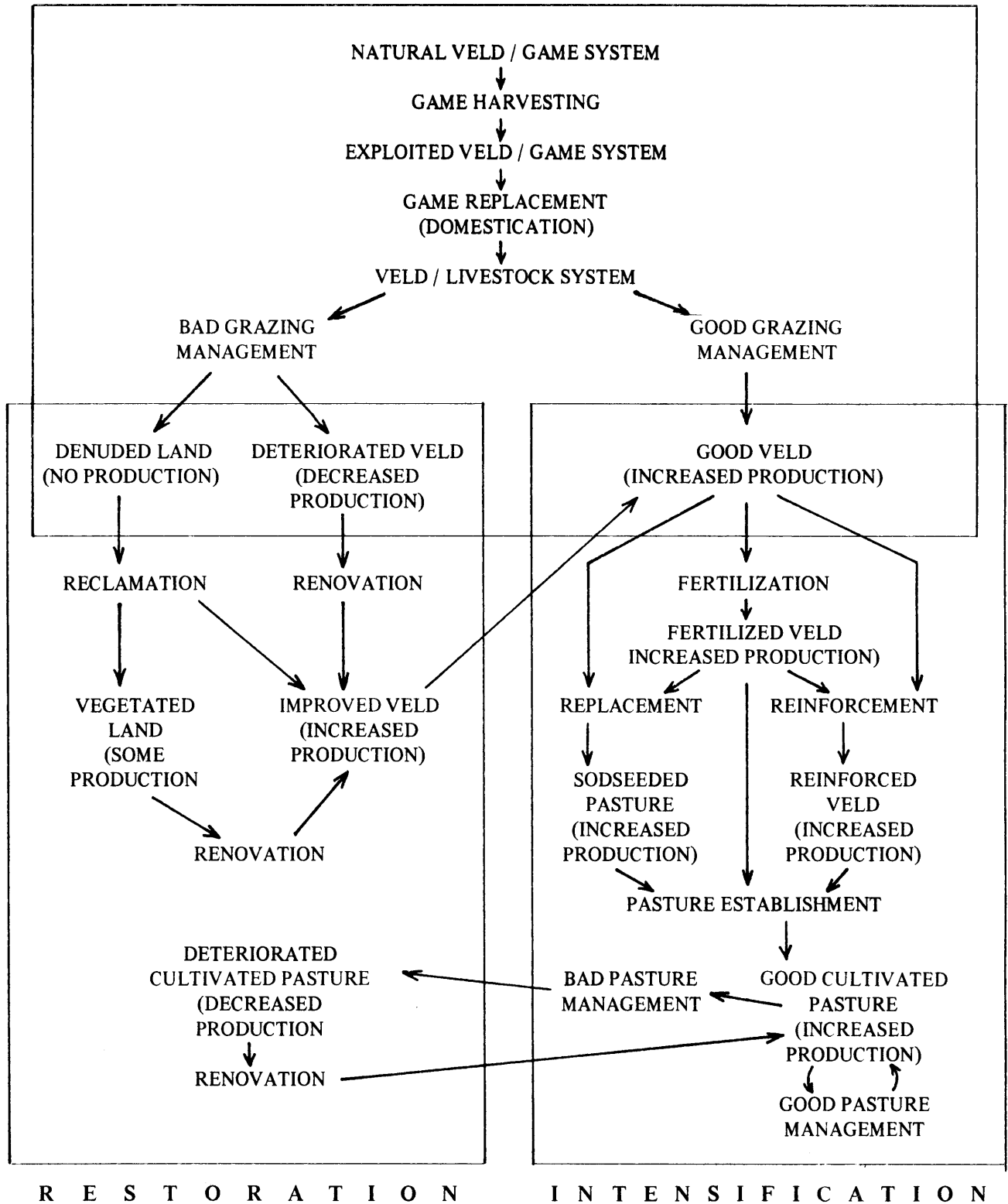


Fig. 1 The processes involved in grassland restoration, exploitation and intensification

productivity of land above that of the natural vegetation, wherever feasible. This process of increasing production per unit area of land is referred to as *intensification* (Booyesen, 1972). In the context of veld and pasture land, the process of pasture intensification refers to the application of practices designed to increase productivity beyond those attainable by the natural veld. In the first instance, the three major procedures involved in pasture intensification are fertilization, reinforcement and replacement. While fertilization may be practised alone, neither reinforcement nor replacement are usually attempted without fertilization. Veld fertilization and veld reinforcement are collectively known as radical veld improvement (RVI). Sometimes partial replacement is also included in this definition.

### The Ecological Perspective

At this point it is necessary to remind ourselves that the grazed pasture is a complex ecological system – an ecosystem – comprising the abiotic physico-chemical environment together with the biotic assemblage of plants, animals and microbes. All these components are both interdependent and interactive. The manipulation of any one has consequences upon the others and, thus, the whole.

In the pasture ecosystem the opportunities for improving the resource and increasing production exist primarily within the confines of 3 areas of endeavour – (i) the manipulation of the physical environment, (ii) the manipulation of the vegetation and (iii) the manipulation of grazing animal. These manipulations aimed at pasture improvement and intensification inevitably lead to a simplification of the biotic components of the system – a herd of cattle replaces the diverse population of game and, the single-species productive cultivated pasture replaces the multiple-species stand of veld. It is vital for the pasture scientist to be constantly mindful that inherent in biotic simplification is the danger of increased susceptibility of the abiotic component to degradation. So as the agriculturalist simplifies the system he must counter the tendency for deterioration by a greater and more sophisticated management input. It is the imbalance of these two things – biotic simplification and management expertise – which is the scourge of agriculture.

While the concept of improvement implies a direction of change it does not set goals or limits. However, a discussion of the possibilities for pasture improvement can be meaningful only if cognizance is taken of the ecological limit for improvement. Clearly, the objective of improvement procedures should be to achieve that limit and not attempt to surpass it. In this context, it is important to identify the factor currently stabilizing the system and address ones attention to the removal of this limitation. If factors such as soil fertility, fire and plant material are limiting production these can be

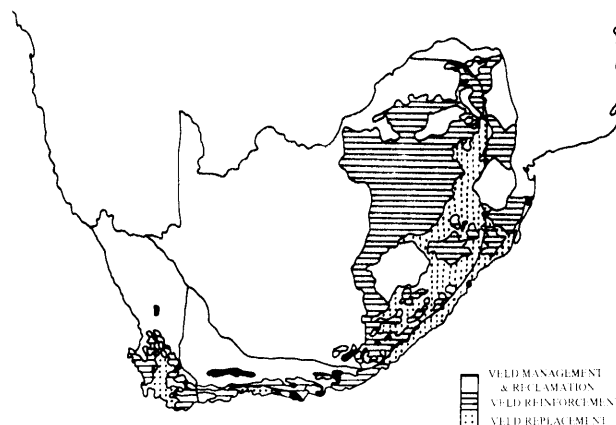


Fig. 2 Grassland potential of South Africa (Edwards & Booyesen, 1972).

readily corrected. However, if climatic factors such as rainfall provide the limitation then improvement is more difficult and the opportunities are much more restricted. Thus we need to deal separately with those areas where the pasture (veld) is the climatic climax and where it is sub-climax due to arrestation by some factor other than climate.

### The Humid Areas with Sub-climax Veld

At the risk of generalization we can say that this region includes the high rainfall regions associated with the Drakensberg range and much of the land east of this great divide (Fig. 2). It is estimated that sub-climax veld constituted about one-fifth of all South African veld and about one-third of all South African grassveld.

The climate in these areas is capable of supporting a vegetation higher in the succession and with more phyto-mass than the existing veld. Usually the veld is grassland and the climate is sufficient to permit the successional development of the vegetation beyond the grassland stage toward a mesophytic woodland or forest climax. Some factor other than climate is preventing the vegetation from further development and the manipulation of this factor is necessary for improvement, intensification and increased productivity.

### Manipulation of physical factors

Fire is commonly the important stabilizing factor in the high rainfall grassland in South Africa. The removal of fire from the system by a firebreak network can be achieved. Protection from fire in time leads to the successional development of higher vegetational stages. This process may certainly, in some instances, represent pasture improvement but usually the higher stages are

composed of tall coarse grasses and woody plants. Consequently, in these areas, removal of fire will only lead to pasture improvement if it is accompanied by the seeding of high producing, good quality exotic grasses.

In these high rainfall grasslands the other factor that sometimes limits successional development and frequently limits productivity is the low fertility of the highly leached soils. The major deficiencies in these soils are nitrogen, phosphorus and potassium, and the primary problems in these soils are low pH and aluminium toxicity. The effect of the application of fertilizers and ameliorants is a dramatic increase in herbage production. However, the species that constitute the sub-climax grasslands are adapted to conditions of low fertility and so, in time, the period of high productivity is followed by an invasion of plant species less acceptable to livestock. Sustained pasture improvement by fertilization can only be achieved if accompanied by the seeding of high producing pasture species adapted to high levels of soil fertility.

#### *Manipulation of the vegetation*

Moving now from the physical environment to the vegetation itself, it is the genetic constitution defining quantitative and qualitative aspects of plant growth that is most likely to impose a limitation on the productivity of the system. In this event pasture improvement involves the replacement of existing plants with others of different or the same species that have been selected or bred for their capacity to produce greater quantities of herbage acceptable to livestock. The importance of plant selection and breeding research programmes to increased agricultural output is well known to all, but the direction of such programmes specifically to pasture improvement in South Africa requires much greater emphasis. The basic requirement is to find existing plants or develop new ones that produce higher yields of better quality roughage and that are sufficiently well adapted to the climatic and edaphic environment to ensure sustained performance. However, because these non-arable grasslands are extensive, and are relatively low producing, these increased yields must be achieved without costly production inputs. Nitrogen is at the same time (i) required for high production, (ii) usually deficient in available forms in these grassveld soils and, (iii) costly. Thus any selection or breeding programme should aim to provide plants that have either a high degree of efficiency in terms of dry matter produced per unit of available nitrogen or, are capable of fixing atmospheric nitrogen. Thus legumes clearly have an important role to play in this context.

Just as we found little advantage in removing the physical limitations to increased yield without introducing into the system plants capable of exploiting the more favourable environment, so too there is little point in replacing

existing plants with others of higher production potential unless the physical limitation to production is simultaneously removed. The simultaneous removal of physical and biological constraints to primary production in sub-climax grasslands is achieved through the practices of reinforcement or replacement.

#### *Reinforcement and replacement*

Both reinforcement and replacement, if properly applied, involve the removal of the physical and biological limitations to production. The difference essentially is whether the introduced plants are intended to augment the natural vegetation or replace it. Both procedures are different to conventional pasture establishment in that minimal disturbance of the soil is a prerequisite.

The exclusion of fire from the system by means of fire-break networks is a feasible proposition and does not present undue difficulty. The procedures for the correction of soil inadequacies with minimal soil disturbance on steep sites does, however, present technical problems. Particularly problematical are those soils that require sub-surface placement of fertilizer and ameliorants in order to effect improvement. For example, liming of the soil in order to overcome problems of excessive acidity and aluminium toxicity is only effective if the lime is placed in the soil. However, even here the problems are not insurmountable. Agricultural technology has provided machines of various kinds enabling these chemical injections to be effected with minimal soil disturbance. Yet there is much more work to be done in improving these techniques.

The introduction of improved plant material (usually seed) into the site also presents mechanical difficulties. The simultaneous requirement of minimum soil disturbance and low cost on the one hand and good seedbed conditions for the seed and good growing conditions for the seedling on the other hand, appear to be discordant. Yet, machines such as the sod-seeder in all its variations, do all these things to acceptable levels and, in addition, place the seed in the soil. Here too the challenge for further improvement in technique is ever present.

When new plant material is introduced into an existing sward (reinforcement) the new plants will establish successfully only if the vigour and competitive ability of the existing plants are reduced. Burning, fertilizing, herbicidal spraying and soil scarification, have all been used in reinforcement programmes toward this end with varying degrees of success. Of course, in replacement the existing vegetation is totally removed. The advantages of replacement, that is, quick and complete establishment of the new highly productive pasture, must be weighed against site vulnerability, which usually increases with great slopes and higher rainfall.

### *The potential and future implementation*

The potential for increased production from sub-climax grasslands through programmes of reinforcement and replacement is great. The areas are large. By some estimates all those areas in the summer rainfall region which can be improved by reinforcement and replacement account for nearly one-third of the land area of South Africa (Edwards & Booysen, 1972). This estimate is likely to include more than the sub-climax grasslands but also the high rainfall climax grasslands. It would not be unrealistic to estimate the potential increase in production to be of the order of five-fold. The prospect for the livestock industry of a five-fold increase in production capacity of the moist one-third of the South African landscape may sound over optimistic. I don't think so but even if that estimate is halved the realization of these goals will be of tremendous significance to the livestock industry of South Africa.

When will these dramatic changes in pasture production take place? Already there are a number of examples where veld reinforcement and replacement have been successfully effected. Why then do the ideas and practices not spread more rapidly? The answer lies in the area of economics. Normal economic forces will dictate the rate of implementation of radical veld improvement and there is little point in attempting to force the pace. We must realize that in the past and at present, farming systems in these humid areas have been, and are still, considerably more extensive than that which the climate is capable of supporting. Therefore, farms have remained far larger than the economic minimum possible with intensification up to the climatic potential. The only meaningful incentive for the farmer to change his practices is the prospect of increased profit. Large ownerships and low product (beef) prices are not conducive to the adoption of capital intensive intensification practices. In due course population increases and rising standards of living will place increased demands on food supplies which in turn will cause a substantial increase in food (beef) prices. Concomitant increases in land values will cause the farmer with the large extensive farm to sell half and to intensify the other half. No amount of persuasion will encourage the farmer to intensify until the economic climate is such that the process is fully justified. Of course, research must continue so that all the answers are available when that time arrives.

#### **The Arid areas with Climax Veld**

Again generalising, these drier regions of South Africa are the plains which lie primarily west of the great divide and constitute the bulk of the South African landscape. The low rainfall imposes a restriction on the successional development and on production. Amelioration of the climatic limitation on any reasonable scale is usually quite out of the question. Thus the climatic restriction

on veld production must be accepted as determining the production limit. However, pasture or veld improvement must have as its goal the attainment of that production limit at all times.

Fire occurs less frequently in these arid areas and rather than being the stabilising factor as it is in the sub-climax vegetation, it is a destructive agent when it occurs. The point being that fire does not prevent the vegetation reaching the climatic climax condition in these areas. Similarly, soil fertility is no limitation to succession or production. On the contrary, the soils in the low rainfall areas of South Africa are generally deep and fertile. Thus by way of broad generalisation it can be said that manipulation of the physical factors does not offer much prospect for effecting the improvement of pasture in the drier areas.

Furthermore, the genetic constitution of the component plants of the vegetation is less likely to constitute a serious limitation to total dry matter production in climax veld than in sub-climax veld. In the drier climax situation growth rate is limited by available moisture and so the replacement of existing plants with others of higher potential growth would have little point. However, there are 2 facets of veld production that could be improved in these areas. These are the seasonal distribution of edible dry matter and the quality of the dry matter produced. There would be much point in attempting to modify through selection, breeding and reinforcement, the season of dry matter production to better suit the needs of the animal. Even here the opportunities are not great, as not only is quality of rainfall a limitation in these areas, but also distribution of rainfall. However, the replacement of the undesirable unpalatable plants of the veld with others both acceptable and nutritive would significantly increase livestock output from these arid areas. If this replacement is to become feasible then the introduced plants must be at least of equivalent vigour, competitive ability, potential growth rate and environmental tolerance as those which are to be replaced.

So while the potential for improvement via reinforcement does exist in these areas the prospects are not exciting. The chances of developing plants with all the necessary attributes is small and even then the degree to which production could be raised is not great.

#### **The Animal Factor in Arid and Humid Areas**

So far the discussion has revolved entirely around the manipulation of the physical factors and the vegetation itself. The other major component of the biota in the pasture system, the grazing animal, has not been discussed so far because it is not appropriately discussed separately for climax and sub-climax situations. Grazing management is a tool of great significance for pasture improvement and the principles are essentially the same irrespective of the ecological status of the veld.

The grazing animal has been one of the most important agents for the degradation and destruction of pasture. What is less well appreciated is that manipulation of the grazing animal through grazing management is an equally important agent for the improvement of pasture. In this discussion then we will not concern ourselves with grazing management procedures for the maintenance of pasture condition and livestock production, important though that may be, but we will consider specifically grazing management for the improvement of pasture. In this context improvement of the pasture means the replacement of plants that are either unacceptable to livestock or of low nutritive value (undesirable plants) by other plants superior in these properties (desirable plants) whether they be native or introduced. In order to achieve this the grazing procedure must do 2 things simultaneously – it must decrease the competitive ability of the undesirable plants to a minimum and increase the competitive ability of the desirable plants to a maximum. How can this be done?

Remember first that the plants constituting perennial pasture are adapted to periodic canopy removal or depletion whether by grazing or other agencies such as fire. Thus, vigour and competitive ability of these plants under grazing conditions is maintained at a high level by periodic moderate utilization.

The vigour and competitive ability of the undesirable perennial can be weakened in one of 2 ways – either by over-utilization or by under-utilization. The best means of achieving the desired result will depend on the species involved. Over-utilization of the undesirable plants can only be achieved if the desirable plants too are over-utilized. The rationale of this as a procedure for effecting pasture improvement is that desirable plants are better adapted to grazing and are less detrimentally affected by heavy utilization than are the undesirable plants. Thus the relative competitive abilities of the 2 kinds of plants change in favour of the desirable plants. On the other hand, under-utilization of the undesirable plants can be achieved at the same time as moderate utilization of the desirables. The philosophy of this procedure in the context of pasture improvement is that under-utilization or non-utilization results in a dense closed canopy, a slowing of growth rate, a decrease in vigour and competitive ability and eventually a moribund condition leading to death and replacement by vigorous desirable plants.

If grazing management is to be effectively used as a tool in pasture improvement the reaction of all component species to various frequencies and intensities of grazing must be clearly understood. There is much work still to be done in this regard.

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