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Source: *Empire Forestry Journal*, Vol. 23, No. 2 (December 1944), pp. 142-159

Published by: Commonwealth Forestry Association

Stable URL: <http://www.jstor.org/stable/42594021>

Accessed: 28-06-2016 08:29 UTC

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SOIL EROSION AND SOIL CONSERVATION IN THE COLONIAL EMPIRE*

By H. A. TEMPANY, G. M. RODDAN and L. LORD

INTRODUCTION

IN 1937 an article by Sir Frank Stockdale appeared in which the position in regard to soil erosion in the Colonial Empire was described and discussed. During the intervening period there has been a marked increase in awareness of the dangers involved and in many places considerable progress has occurred in the application of soil-conservation measures. Interest has been stimulated by the action of successive Secretaries of State for the Colonies who have repeatedly drawn the attention of Colonial Governments to the matter. In 1938 Mr. Ormsby Gore (now Lord Harlech) addressed a circular dispatch to Colonial Governors in which attention was invited to the question and the importance stressed of according to soil-conservation measures a prominent and permanent place in the policies of Colonial Governments. Particular emphasis was laid on the point that such measures should not be regarded as purely the concern of the specialist Departments of Government but as a major policy having a direct bearing on the welfare of the communities.

To assist Governments, the resources of which were insufficient to embark on conservation projects, the provision of grants from the Colonial Development and Welfare Fund was contemplated. Since then the matter has been kept under constant and continuous review. Notwithstanding the events of the war, interest has markedly increased, and although developments have been to some extent impeded by the necessity for deflecting man-power for military duties, causing the depletion of agricultural and forestry staffs and of available labour, nevertheless marked progress has been made.

Probably the most important advance is the growth in popular appreciation of the dangers inherent in erosion and the need for active steps to conserve the soil. This is not confined to the more highly developed sections of the communities, since in parts of Africa there is now considerable and increasing erosion consciousness among native tribes. Coupled with this has been the growth of appreciation that conservation practices should not be regarded merely as remedial measures undertaken to counteract a specific danger, but that the need is for the evolution of systems of husbandry that will maintain and enhance the natural fertility of the land in which measures to ensure the conservation of the soil find their appropriate place. In large tracts of Africa, for example, there is increasing need for the development of intensive systems of farming to replace the methods of shifting cultivation and extensive ranching which have hitherto been widely prevalent and under the stress of increasing population pressure can no longer suffice to maintain, let alone to raise, the level of subsistence. Obviously no one system of husbandry can be laid down which is universally applicable; modifications will be needed to meet the varying conditions of soil and climate and these must also be adapted to the needs and the ways of life of the cultivators and pastoralists themselves. In each locality, therefore, the primary necessity is to ascertain by experiment the system best adapted to the conditions and thereafter to secure its adoption by cultivators by precept, example and, if need be, by a measure of compulsion.

A good deal of progress has been made in devising systems of mixed farming suited to varying conditions in which both crops and live stock play their part and by incorporating therein methods designed to counteract the dangers of erosion. It is, of course, uneven and the advances are not necessarily correlated with the gravity of the problem; for example, erosion is a grave menace both in East Africa and in parts of the West Indies, but for some time past the degree of awareness of the danger and progress with counteractive measures have been much greater in the former region than in the latter, although in the West Indies apprehension of the position has greatly increased of late years.

The general position in the dependencies was discussed in Sir Frank Stockdale's article referred to above; for convenience of reference it may here be said that the most widely prevalent form of erosion is sheet erosion, but in places extensive gullying also occurs, whilst in drier areas wind erosion is a serious menace. The chief contributory causes have been excessive deforestation, cultivation of lands which by reason of their steep slope should not have been opened for cultivation at all, unsuitable methods of cultivation, lack of provision for dealing with surplus run-off, the growth of crops conducive to erosion without adequate cultural safeguards, lack of protection from wind and excessive concentrations of live stock, especially during dry periods, leading to overtrampling and consequent soil loss.

* This article appeared in the *Empire Journal of Experimental Agriculture*, Vol. XII, No. 47, July 1944. (University Press, Oxford.) It is of such interest to foresters that permission has been obtained to reproduce it in full. For this permission acknowledgment is made to the authors, especially Dr. Tempany, the Editors, Dr. Tripp and the University Press, Oxford. It was felt that the activities of the Agricultural, Veterinary, Forestry and Engineering Departments, in co-ordination with the Administration, are so closely and rightly blended in the work of Soil Conservation, that any extracting of portions of the article which described the forestry side of the activities alone would have told only a partial story. The article shows clearly that, while soil erosion is one of the most serious problems which the Colonial administrations have to tackle, during the last few years there has been greatly increased appreciation of the position, and in spite of the engrossment of all Governments in the war effort, considerable progress has in fact been made.—EDITOR.

The most severe cases of damage from erosion have occurred in the East African Dependencies and in the High Commission Territories of South Africa. In West Africa the position is considered to be somewhat less serious, although in certain areas, notably in the Northern Territories of the Gold Coast, parts of the northern and eastern provinces of Nigeria, and parts of Sierra Leone, sheet erosion with some gullying is extensive. In the West Indies the position varies greatly, but erosion is very serious in some of the more mountainous regions of these island dependencies. Erosion is also an extremely serious matter in parts of Palestine and Cyprus.

The measures adopted to counteract erosion naturally vary to some extent according to conditions; they may be classified as follows: (a) agricultural, (b) forestry and (c) engineering. Under (a) are comprised contour ploughing and planting, rotational strip-cropping, the use of grass strips and live wash-stops, the making of contour drains and wash-stops, the planting of wind-breaks to check wind erosion, restriction on the cultivation of those crops specially conducive to erosion, the use of cover crops and mulches, the control of grass- and bush-burning, and the improvement of pastures, combined with the introduction of rotational grazing and, where necessary, the reduction of stock. Under (b) are comprised the establishment of forest reserves and the closure to cultivation of threatened areas coupled with their reforestation; such areas may include hill-tops, steeply sloping lands, gullies and river catchment areas. An ancillary activity is the establishment of plantations of suitable trees for the provision of fuel and timber supplies for the use of populations. Under (c) are comprised the construction of contour bunds and terraces, the construction of stops and dams for the checking of gully erosion and the construction of works to deal with excessive run-off, as well as the maintenance of roadside drainage, neglect of which is often a cause of gullying. With this is combined the provision of additional water supplies for live stock and human consumption, thereby reducing excessive concentrations of live stock during dry seasons and its attendant overtrampling and erosion, and the reclamation of swampy areas by drainage, thereby increasing the land area available for cultivation in situations least liable to erosion.

In addition, the removal of part of the population in densely populated areas and their resettlement in other localities where land is more plentiful may be undertaken.

Experience tends to show that, so far as is practicable, it is good policy to reduce to a minimum any works for the direct control of erosion which have the character of major engineering operations, and to replace them, wherever possible, by operations carried out by the cultivators themselves, since it has been found that where such works are carried out by direct government agency in the first instance it is difficult to arouse the interest of native cultivators and to induce them to assume responsibility for their subsequent maintenance.

In the subsequent pages the position in the various dependencies is described. The various sections have been revised by the agricultural authorities of the territories concerned and the information presented summarizes the position at the present time.

EAST AFRICAN DEPENDENCIES

Kenya.—The two main developments have been the institution of a special Soil Conservation Branch and the promulgation of the Land and Water Preservation Ordinance and Rules. The Soil Conservation Branch was instituted at the beginning of 1938 as a branch of the Department of Agriculture to perform advisory and experimental work and to supervise and carry out conservation schemes in European and native areas. The Land and Water Preservation Ordinance and Rules, promulgated in 1940, gave wide powers for the protection of the resources of the country. A Land and Water Conservation Committee was appointed in 1941 to advise the authorities empowered under the legislation to deal with the natural resources of the colony and protectorate. In addition the Control of Grass Fires Ordinance was enacted in 1941 with the object of lessening the effects of grass-burning on erosion. New and more comprehensive rules under the Land and Water Conservation Ordinance were promulgated in 1943.

Soil-conservation measures may be classified as follows: (1) the prevention of erosion on arable and grazing land at present in good condition; (2) the reclamation of eroded areas; (3) the preservation of watercourses and water supplies; and (4) afforestation.

The primary aim is to achieve conservation by means of a sound system of mixed farming in all areas suited to this type of agriculture.

It became evident in 1939 that the pace of erosion was accelerating; the outbreak of war resulted in further deterioration owing to the withdrawal of personnel for military service. Since then there has been a further realization of the dangers and progress has been made with conservation measures, but the urgent demand for the production of foodstuffs for war needs has resulted in further acceleration of erosion. In 1941 in the European-settled areas of Trans-Nzoia, Uasin Gishu, Nakuru, Koru and Naivasha, 630 miles of broad-based and 750 miles of narrow-based terraces were constructed, and work was also undertaken in native reserves, District Agricultural Officers and trained instructors being provided for part- and full-time work. The total length of variable grade and level contour lines set out by the Soil Conservation Service during 1941 was estimated to be at least 2200 miles. Shortage of staff, tractors and oxen prevented full advantage being taken of the awakening of Europeans and natives to the evils of soil erosion. In the Central Province also considerable progress was made with the construction of narrow-based terraces, the planting of live wash-stops and of grass on eroding land, the closure of eroded hill-sides to grazing and cultivation, and the construction of dams. At the end of 1940 narrow-based terraces had been constructed on 70,000 acres and live wash-stops on over 17,000 acres in this province. Live wash-stops are only partially effective in that they do not dispose of excess

run-off, and during the year narrow-based terraces were constructed on approximately 14,000 acres and over 200 grassed drainage-ways were established. Other measures included the establishment of grass paddocks, the closure of considerable areas of grass land to stock for part of the year; the protection of river and stream banks and the planting of indigenous trees in the heads of valleys.

Terracing was begun in North Kavirondo, Nyanza Province, in 1941, following the establishment of live wash-stops and contour banks in 1940. In Central Kavirondo banks and trenches have been constructed to control erosion over 44,000 acres of cotton cultivation. The closing of certain grazing areas has not, however, proved successful as the resultant concentration of stock in adjacent areas has accelerated erosion. In the Coast Province the construction of narrow-based terraces on hill-sides has been undertaken. A demonstration area was closed to grazing in the over-grazed and badly eroded foot-hills around Msau, and the Local Native Council has agreed to the gazetting of certain areas as native forest reserves and to the afforestation of areas unsuitable for cultivation or grazing. Surveys of agricultural and living conditions in native areas are being carried out to provide data for long-range planning.

Uganda.—In Uganda also considerable progress has been made. By 1939 it had become evident that a soil-conservation policy could not be confined to anti-erosion measures but involved a modification of the agricultural system of the country associated with general plans for rural betterment. A Development and Welfare Committee was set up in 1940 under the Chairmanship of the Chief Secretary, the membership of which included the heads of the Agricultural, Educational and Health Departments, with a Rural Development Sub-Committee comprising the heads of the Medical, Agricultural, Veterinary, Forestry, Geological and Public Works Departments, the Heads of Provinces and three unofficials. This Committee co-ordinates all programmes of rural development, so ensuring the full co-operation of all departments concerned.

The following broad lines of anti-erosion policy have been laid down:

- (a) Prevention of the extension of semi-desert conditions in the north-eastern areas of the protectorate to the agricultural and pastoral areas in the south.
- (b) The counteraction of the effects of overstocking in grazing areas by the organization of rotational grazing, the provision of additional water-supplies for stock, and the establishment of cattle markets for the sale of surplus stock.
- (c) The development of a more rational land-utilization policy, aimed at removing from arable cultivation areas unsuited thereto, and planting to trees for the provision of village timber supplies.
- (d) The evolution of a sound system of cropping which ensures the restoration and preservation of the crumb structure of the soil and the maintenance and enhancement of soil fertility.
- (e) The institution of Crown and Native Administration Forest Reserves.

The carrying out of this programme has largely devolved on the provincial and district teams, which comprise representatives of those departments concerned with development.

(a) and (b). A policy for demarcating dry and wet season grazing grounds in the semi-arid district of Karamoja in the Eastern Province has been drawn up, combined with early controlled burning, clearing to prevent the spread of tsetse fly southwards, and the reservation of areas as Crown Forests. In Teso in the Eastern Province the demarcation of pastures for a simple form of rotational grazing has been widely adopted with satisfactory results, and the local Native Administration Councils have co-operated very heartily in the measures. Throughout the Protectorate much attention has been paid to the provision of additional facilities for watering stock, with the object of lessening stock concentrations during dry weather. The construction of dams and impounding reservoirs is proceeding rapidly, particularly in Teso, Lango and Karamoja districts. In Teso ten dams had been completed at the end of 1942; in Lango ten dams had either been built or were in course of construction. Eighteen impounding reservoirs were completed in Masaka, Ankole and Karamoja districts by the Geological Survey Department. An extensive programme for the provision of bore-holes has been in operation for some time and has proved most successful in improving village water-supplies. The organization of stock markets, following successful disease-control, has succeeded not only in reducing the stock concentration in dangerous areas through the sale of surplus and "scrub" animals, but has also achieved a definite and important change in the outlook of the African. The stockowner to-day now appreciates the monetary value of his stock and is forsaking the old idea of *quantity* and looking more and more to *quality*.

The increased sale throughout the country is also reflected in the marked increase of meat consumption, with consequent benefit to the African dietary and nutrition. It is interesting to note that sale in organized markets alone rose from 42,431 cattle in 1938 to 130,048 in 1942. The estimated annual slaughtering in the Protectorate is in the region of 350,000 head of cattle and 630,000 goats.

(c) In 1941 the area of Crown Forests was increased by 380 square miles and Native Administration Forest Reserves by 14 square miles, permanent fuel reserves were increased by 600 acres and windbreaks established over 5½ miles in Kigezi, whilst large distributions of planting materials of Eucalyptus and other timber and fuel trees were made. Early controlled burning was carried out over a total area of 1500 square miles in the Eastern and Western Provinces.

(d) One of the first lines is the encouragement of a more rational use of live stock with stall feeding for manure-making purposes in thickly populated areas, and controlled grazing of resting strips and communal pastures elsewhere; it is recognized that the key to soil conservation in most areas is the maintenance of the crumb structure of the soil, and that this can be achieved

by laying down arable lands to grass periodically and the development of strip-cropping. To elucidate the details, numerous experiments are in progress on the establishment and management of grass leys and on the incorporation of cattle in the system of land management. Remarkable success has attended these methods in various parts of the Protectorate; in Teso it is estimated that 90 per cent of the land under annual crops is now strip-cropped with narrow grass strips interposed between the cultivated contour strips. In Mengo and other parts of Buganda in the vicinity of Lake Victoria the control of erosion is practised by the establishment of strip wash-lines planted in elephant grass (*Pennisetum purpureum*); over 8000 plots were so planted in Mengo in 1941 and 6000 plots in Masaka were bunded; in the badly gullied area around Kampala many hundreds of gullies have been stopped by the Native Administrations working in association with the instructors of the Department of Agriculture.

Some areas have been selected for intensive demonstrations in rural reconstruction. Steps have also been taken to ensure that soil-conservation measures are fully observed in Government-operated cultivation. Badly controlled drainage from roads is at times a cause of serious gully erosion, and special attention is paid to this question by the Public Works Department, whilst in the Eastern Province and in Buganda rules have been drawn up for the guidance of Native Administrations in making their own roads so as to minimize the risk of damage to adjoining lands.

Vigorous propaganda directed to spreading information concerning the dangers of erosion and the means of counteracting it is carried out through the medium of the vernacular press, and by lectures and talks. An inter-departmental conference on rural betterment was held in 1941 at which the position and progress in regard to anti-erosion measures were exhaustively discussed. It can in fact be said that there has been a very general awakening of public opinion to the dangers of the position throughout Uganda, and that control measures are being very actively prosecuted, despite difficulties arising from the war.

Tanganyika.—This was one of the earliest territories in East Africa to realize the dangers of the erosion position, and for some time past Native Authority Rules have been in operation in the majority of districts to enforce soil-conservation measures and to control the damage done by indiscriminate burning of bush. In 1938 an instruction was issued to all heads of Government Departments concerned with land utilization, and to all District Officers, that the adoption of planned measures for the control of erosion was an integral part of the policy of the central Government.

Considerable progress has been made and certain of the Native Administrations have very actively collaborated in carrying out control measures. Limitation of staff and especially the drafts on man-power arising out of the war have handicapped efforts, and there is need for additional trained African personnel, who are essential for making and maintaining contact with the cultivators and their chiefs and leaders. Nevertheless the position cannot be regarded as unsatisfactory, having regard to the special difficulties.

The measures adopted include contour banking and ridging, the planting of contour hedges and windbreaks, the demarcation and protection of exposed hill-tops, steep slopes, river sources and river banks, the control of grass-burning, the amelioration of soil conditions by manuring combined with the development of mixed farming, the demarcation and establishment of forest reserves, the introduction of simple deferred grazing schemes, and the reduction of the numbers of live stock by encouraging sale. The provision of water supplies, especially at the periphery of overpopulated and overstocked areas, so as to allow more even distribution of population and live stock is an outstanding requirement.

In some areas the practice of organizing tribal "turnouts" of labour for conservation measures has made considerable progress and is now a well-recognized procedure.

Latterly there has been increased collaboration between the Departments of Agriculture, Veterinary Services and Forestry in conservation measures and the services of the botanist attached to the Veterinary Department have been available to advise on the work of the three departments throughout the territory. This has resulted in a number of comprehensive schemes being put forward jointly by the three departments. In certain districts teams of African agricultural instructors have been organized for continuous work on conservation, and as more staff becomes available operations on these lines are being extended.

Considerable areas have been protected in some degree by contour ridges, broad-base terracing and the re-alignment of ridges and hedges. Thus on the slopes of Kilimanjaro upwards of 60,000 acres in arable cultivation have been demarcated and protected by contour banks; in Sukumaland and in the Central Province progress has also been made. In the Usambara mountains 50,000 acres of native land have now been protected by live contour hedges. Many hundreds of small gullies have been planted up with elephant grass and sisal in Mwanza district. In Moshi terracing equipment acquired by the Department of Agriculture was employed in terracing operations on farms cultivated under maize.

An extensive programme of conservation works by tribal "turnouts" has been laid down for the Central Province, including the badly eroded Kondoa area, Dodoma and Singida. The schemes aim at the control of erosion on 5,000,000 acres of pasture and 1,000,000 acres of arable land within 10 years; some small progress has already been made there, but a real attack on the problem must wait until after the war.

In the Sukuma district of the Lake Province it is estimated that as much as 300,000 acres of grazing are now annually reserved during the rains for dry-season use, and an even greater acreage is under some measure of grazing control in the Central Province.

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Some 1200 hill-tops have been closed to cultivation at various points and approximately 215,000 acres declared as additional forest reserves. Concurrently there has been extensive distribution of the planting material for reforestation, upwards of a quarter of a million young plants having been disposed of by the Forest Department in 1939-40. In Mwanza district alone, for instance, between 700 and 800 acres were planted with *Cassia siamea* in 1942 in communal village plots.

A considerable number of dams of varying size for the provision of water for stock have been constructed. In the last four years fourteen dams have been dug in Shinyanga and two in Mwanza district.

There has been some improvement of farming standards in many parts of the territory, especially in the Lake Province, where the use of cattle manure is extending. The campaign for the increased production of food crops has emphasized the need for better farming methods combined with soil-conservation measures.

Marked progress has been made with schemes for the marketing of stock surplus to the carrying capacity of the land through the extension of local cattle markets. The sale of cattle by native stock-owners has now reached the impressive number of 250,000 a year, which is more than double the pre-war figure; a large proportion of these animals is being purchased by Messrs. Liebig's for their meat-preserving plant in Kenya.

The eradication of tsetse fly is closely linked to soil conservation since in certain areas the relief of congestion of human and live-stock population is dependent on reclaiming adjacent fly-infested land. In reclaimed areas it is important that the land rendered available shall not be ruined subsequently by overstocking and defective husbandry. In the solution of this problem the Departments of Agriculture, Veterinary Services and Tsetse Research are collaborating.

In other areas of the Territory where rainfall is higher but stock population less dense, the problems are less urgent, but nevertheless progress is appreciable, although less spectacular. In the mountainous areas centred on Rungwe mountain and the Livingstone mountains natives are showing increasing interest in soil-conservation measures. The excellent indigenous system practised by the Wamatengo tribesmen of the Songea district is being fostered and extended where possible.

It can be said that whilst the need for much more extensive operations is urgent, nevertheless the problem is now well understood and, despite difficulties arising from the war, progress has continued.

Northern Rhodesia.—Northern Rhodesia is some 290,000 square miles in extent and has a population of about 15,000 Europeans and 1,400,000 natives. There are large tracts of low fertility, and tsetse fly is prevalent over wide areas. Widespread soil erosion is not likely to occur, but serious situations have arisen locally owing to excessive concentrations, relative to the carrying capacity of the land, of man and live stock. Most of these concentrations are, naturally, an indirect result of European occupation. Over the greater part of the territory the rains are confined to the months of November to April inclusive and vary from 20 in. in the extreme south to 60 in. in the extreme north-east. Active measures for the checking of erosion have so far been confined to the maize-belt of the Southern Province, the Abercorn and Isoka districts of the Northern Province, and to the Fort Jameson and Petauke districts of the Eastern Province. There are, however, other areas in which soil impoverishment and soil erosion will receive attention as soon as circumstances permit. In the three areas in which work is in progress conditions, and consequently the remedial measures adopted, differ widely.

The maize-belt of the Southern Province lies on the more fertile and accessible land bordering the only railway. It is occupied by European and native farmers and, being "fly"-free, carries a large head of cattle. Several European farms have been contour ridged in recent years and interest in this form of protection is increasing. In the native area the opportunity for the sale of surplus maize and the introduction of the plough have led to the cultivation of greatly increased acreages and, with the abandonment of the traditional system of bush fallows, to soil impoverishment and erosion. Three agricultural stations serve this vitally important area which, from its soils and geographical position, affords an opportunity of developing farming as a business rather than as a mere means of subsistence. Field works consist of contour ridges and grass strips, and some 25,000 acres of garden had been protected by these means by the end of 1942. Soil impoverishment is being tackled by the introduction of a four-course rotation in lieu of continuous maize cropping and by the use of manure and compost. This is a much slower process than soil protection by departmentally constructed field-works, and although it is realized that, ideally, the two remedial lines of action should be taken simultaneously, the need for protection *per se* is such that its pace must not be restricted. The adoption of improved farming methods is steadily spreading, and the present policy will at least ensure that there is land left on which to practise them.

The "chitemene" system of finger-millet culture is traditional over the plateau of the Northern Province. It involves the annual lopping of trees over a large area to provide branches for burning on a relatively restricted patch in which millet is subsequently sown without cultivation. The system obviously demands a large area of woodland per family. In native reserves of Abercorn and Isoka districts the population was too large for safe adherence to the traditional method, and insufficient interval between cutting cycles caused deforestation. In these districts 213 village areas have been demarcated within which annual loppings are now conducted on a 15-20-year rotation with fire-protection of the recovering woodland. At the same time the gradual

development of subsidiary gardens cultivated by hoe is proceeding with a view to increasing still further the carrying capacity of the land. Such gardens are protected by contour banks.

In the Eastern Province most of the land was formerly owned by the North Charterland Explorations Co., and the large native populations of Fort Jameson and Petauke districts were confined to inadequate reserves. Devastation, unparalleled in Northern Rhodesia, resulted. The estate was, however, acquired by Government in 1941, and steps were taken immediately to dilute the population of the reserves by orderly settlement of the new land.

Following a soil and vegetation survey, areas estimated to be capable of supporting the population of each village were demarcated in advance of settlement, and cultivation blocks were laid out, separated by contour strips of vegetation in which cultivation is prohibited. By the end of 1942 new areas had been settled by 156 villages comprising 18,000 inhabitants. The work is proceeding and will take some years to complete. Meanwhile soil-conservation work has been started in the original reserves. The traditional system of mound cultivation is particularly conducive to heavy run-off and erosion. A change to ridge cultivation on the contour is being introduced with the additional protection of departmentally constructed storm drains at suitable intervals. There is also much need for improved agricultural methods, including the use of all available manure, but the most urgent matter is the rapid dilution of the population in order to give improved methods a chance.

Nyasaland.—Soil-conservation measures are the responsibility of the Agricultural Department working in close collaboration with the Forestry, Veterinary and Administrative services. In 1937 an Assistant Conservator of Forests was seconded for duty as Soil Conservation Officer for a period of three years, and as a result of his investigations the Government in 1939 issued a circular directing attention to the dangers of soil erosion and laid down a policy for the conservation of the land. The measures recommended included controlled early burning as a first step in the control of bush fires; the preservation of natural vegetation on the banks of streams and steep hill-sides; cultivation of contour ridges instead of on mounds (with checks in the form of silt pits or low mounds constructed between the ridges); manuring and rotation of crops; prevention of run-off from higher areas by drains and by banks, or belts of vegetation across the top of the gardens; and the rotational grazing of pastures.

It was recognized that in six regions of the protectorate erosion had reached such an advanced state that immediate measures for control were needed. Assistance was sought from the Colonial Development Fund and in 1940 a free grant of £16,500 was sanctioned to defray the cost of anti-erosion measures.

Throughout the protectorate there has been a general change-over to ridge cultivation. The ridges are laid out on the contour, and on the steeper slopes they are "boxed" or tied by smaller ridges running at right angles to the contour ridges. The continuance of these measures, supplemented by the burying of waste vegetation, is generally advocated, but a permanent soil-conservation programme must have as its major objective a reorganization of the village lands and the introduction of strip-cropping with periodic laying down to pasture. Such a reconstruction of African village life presents many problems, and to study these problems an area was selected, and an "Administrative Unit" was set up to carry out the initial survey. The first unit was formed in March 1941 to operate in a selected area in the Cholo district, with an officer of the administration in charge, assisted by representatives of the Agricultural, Forestry, Veterinary and Medical Departments. The programme included the closing to cultivation of all steep slopes, the planting of lines of bamboos to demarcate these areas, the redistribution of land remaining open to cultivation, and its protection by ridge terracing and contour ridging. It is believed that the work of this unit will point the way to satisfactory methods of combating soil erosion throughout Nyasaland, and it is hoped to establish spaced administrative units in all districts. Uncontrolled immigration has resulted in over-population in Cholo, the density amounting in some places to as many as 600 or more per square mile. Schemes are under consideration for controlling immigration and for the resettlement of the population of the more congested areas.

A Soil Conservation Officer was appointed early in 1942 and an Assistant Soil Conservation Officer in December 1942, and these officers are now engaged in surveys of areas considered suitable for settlement to relieve the pressure on some of the overcrowded and badly eroded lands.

In North Nyasa the Misuku Land Conservation Scheme entered its fifth year in 1943 and cultivators are beginning to realize the benefits derived therefrom. It is hoped that in due course they may be trusted to maintain conservation measures with no more than ordinary supervision.

Forest reserves have a profound bearing on soil conservation and over 5000 village forest reserves have been established under the control of the village headman. The Veterinary Department is carrying out a policy of gradual de-stocking of those areas where over-stocking is threatened.

It can be said that although progress has been to some extent retarded by the war, nevertheless marked advances have been made. There is general awareness of the dangers, and a noteworthy degree of collaboration between departments of Government and the Native Administration Authorities in conservation operations.

Somaliland Protectorate.—The greater part of the country is semi-arid and the beneficial effect of the scanty rainfall is much reduced by desiccating winds. Agriculture is carried on at between 4000 and 5000 ft., but at least 90 per cent of the people are pastoralists and graze their flocks and herds on the vast plains. Owing to the scarcity of water the human and stock populations are tied to the wells, except for comparatively brief periods after the two rainy seasons when they migrate to outlying grazing areas.

Such a state of affairs leads to excessive pressure on the vegetation in the vicinity of the wells, and this is frequently shown by complete denudation of the ground-surface and the resultant removal of surface soil by wind and water. In the open woodland country, overgrazing and tree-cutting combined are giving rise to windswept sandy wastes, and it has been estimated that 10 per cent of the country is devoid of all vegetation.

Even in the plateau area soil erosion is far advanced, and much of the rainfall runs off the hard surface and is lost. It has, however, been proved that most of this area is not beyond man's power of saving, and before the war the value of deferred grazing was abundantly proved and the protection of catchment areas and watersheds recognized as a first essential in any programme of improvement.

In the cultivated areas the Somali was, before the outbreak of war, beginning to recognize the benefits of terracing, contour grass-strips and contour cultivation. Under the stress of war deterioration set in, but in 1942 a survey of the grazing areas was made and recommendations designed to ameliorate the conditions are under consideration. It is hoped that in this connexion a general protectorate grazing-plan may be formulated and accepted.

Zanzibar.—Soil erosion is not an acute problem in the Zanzibar Protectorate, as the live-stock population is comparatively small and there are no undue stock concentrations; the principal crops are tree crops, the planting of which is in itself an anti-erosion measure when properly carried out. Much of the highest land is planted with cloves, and a considerable part of the remaining land is under coco-nuts. In areas where cloves have died out through one cause or another there are indications that soil erosion might become a serious problem if cloves and coco-nuts were replaced by annual crops, unless protective measures were undertaken.

At places a little gully erosion has taken place, notably on Masingini Ridge. The remedial measures first undertaken consisted of the planting of lines of banana and Tephrosia, but this was not completely successful and in 1940 the construction of contour terraces and the planting of trees and grass on the higher slopes of the catchment areas was begun with more satisfactory results.

In all areas where erosion is likely to occur the advisability of restricting the cultivation to the lower slopes and of strip-cropping is being impressed upon plantation owners.

Under the pressure of shortage of imported foods large areas are being put under food crops by unskilled cultivators, and although ridging along contours is enforced wherever possible, there are considerable areas where lack of ridging and absence of strips occur. There is also too great a proportion of cultivated to fallow land, which is inevitable under present circumstances.

SOUTH AFRICA—HIGH COMMISSION TERRITORIES

Basutoland.—Soil erosion has long been observed in the lowlands of Basutoland and by the middle of last decade it had assumed very threatening proportions. The Commission appointed by the Secretary of State for Dominion Affairs to inquire into the financial and economic position of Basutoland called attention to the matter in its report (published in 1935) and expressed the view that the amelioration of conditions in this regard was a matter of urgency if the economic future of the country was to be safeguarded. It recommended the preparation of a scheme to be financed from Imperial funds for dealing adequately with the matter.

The main cause of sheet and subsequent gully erosion is the uncontrolled run-off of storm-water from the overgrazed lower slopes of the mountains and the hills in the lowland areas of the territory. Sheet erosion is evident in all cultivated areas, particularly in the lowlands, and gully erosion has destroyed most of the lowland valley bottoms. It is clearly shown by the complete ecological survey carried out in detail all over the country and from subsequent investigations by experienced Forest Officers that the ecology of the country proves that Basutoland has never carried a forest cover. This, coupled with excessive overgrazing of Basutoland's fine pastures, permits of heavy run-off, which has removed millions of tons of soil from the territory. As a result of the Commission's report a sum of £160,000 was made available, under the Colonial Development Act, to carry out soil-conservation measures, which included the planting of trees.

It was realized that a campaign of this nature must involve considerable interference with established agricultural practices and some disturbance of the normal way of life. Accordingly immediate steps were taken to educate native opinion to appreciate the need for protective measures and to accept the methods proposed. This was done by means of propaganda, explanation and demonstration. A strong lead was given in the matter by the then Paramount Chief, who readily co-operated and asked that anti-erosion measures should be inaugurated on his own land.

Demonstrations of the methods of soil conservation were started in 1935 and large-scale operations in 1936. The measures adopted comprised the laying out of contoured, broad-based terraces and the introduction of ploughing along the contour, the construction of earth-dams to check gully erosion and provide additional water supplies for stock, combined with the planting of grass and trees to stabilize contour banks and to assist the silting up of gullies, and the fencing of the banks of dams and of plantations to prevent damage by live stock. To carry out the work a soil-conservation section of the Department of Agriculture, consisting of seven qualified agricultural officers and a civil engineer, was constituted under the charge of the Director of Agriculture. It was provided with the necessary survey instruments, terracing equipment including tractors and graders, etc.

Combined with these measures there must be improved methods of agriculture based on the introduction of mixed farming in place of the existing system. It is considered that the maintenance of crumb structure in the soil should be the aim and that this can only be maintained

by suitable agricultural methods. To assist in popularizing improved systems of agriculture three mixed-farming demonstration units have been inaugurated.

As the capacity of soils for absorbing and holding water is a first necessity in the prevention, particularly, of sheet erosion, and as the lowland soils in the territory had been depleted of humus or organic matter, it was essential to make available as soon as possible all the kraal manure for this purpose in the territory. All manure had been used as fuel for domestic purposes, and to overcome this abuse the extensive planting of trees was necessary. Furthermore, apart from reserves of fuel, protective forest belts were necessary in badly eroded catchments and on badly eroded hill-sides. Therefore the planting of trees was prosecuted from the inception of the scheme. Recently on the suggestion of the High Commissioner an all-out tree-planting campaign was instituted, and it is hoped to secure the planting and establishment of some 2,000,000 trees per annum for the next ten years, with the dual object of providing protection to the land and also rendering available supplies of firewood, thereby reducing the use of cattle manure as fuel.

By the end of 1942 nearly 100,000 acres of eroded land had been efficiently dealt with by the soil-conservation organization in the lowlands with strikingly beneficial results, and some 9000 acres had been dealt with by the use of grass strips in the mountain areas where the soil is far more fertile and incipient gulying is not so prevalent. It is evident that the use of these grass strips on the richer soils where incipient gulying is largely absent provides a cheap and relatively efficient means of checking sheet erosion. But in the light, sandy soils of the lowlands where gulying occurs to an excessive degree, contour terrace-banks, whether light or heavy depending upon conditions, must continue as the chief means of stabilizing the soil. By the end of 1942 122 dams had been constructed and the water supplies thus made available have naturally assisted in preventing the destruction of pasture by tramping out.

The considerable measure of success which has already attended these operations has only been possible through the support of the Paramount Chief and the tribal authorities which, as a result of a policy of effective propaganda and explanation, is fully forthcoming. The policy has been given a legal basis by the issuing of a series of twelve orders under the Native Administrative Proclamation setting out the cardinal points which must be observed in conservation operations in tribal areas.

Bechuanaland.—Sheet erosion and desiccation are widespread in many parts of the eastern portion of the Bechuanaland Protectorate below the Kalahari escarpment and, particularly, in the river valleys which flow east from the escarpment. A certain amount of gully erosion also occurs. Erosion is caused in Bechuanaland by over-concentration of live stock in the vicinity of the limited number of water supplies available; hence the destruction that has taken place in the river valleys. Cultivated fields, particularly those lying in the river valleys, like the general pasture land in the valleys, have also suffered from sheet erosion. The overgrazing in the valleys has endangered the life of the pasture on which the economic life of the inhabitants depends. The tramping out by stock has in places been so severe that tracts of country have been denuded of vegetation.

The provision of additional water-supplies to permit of the removal of live stock from the valleys is the principal measure which will check the present erosion. Therefore the provision of additional water supplies is regarded as the principal project in Bechuanaland, and to this end a grant of £139,000 was secured from the Colonial Development Fund to cover a five-year water-development plan, commencing in May 1936. The first object was to supply domestic water-supplies in tribal reserves and to develop water-supplies in grazing areas, many of which had hitherto been useless owing to lack of water. As the work has proceeded, there has been a progressive dispersion of stock from overcrowded areas with the consequent reduction of tramping out and the evils attendant upon it. By the end of 1940 a total of 142 water-supplies had been provided. The continued provision of water-supplies to maintain the live stock and combat soil erosion practically ceased at the outbreak of war, and only very minor work of this kind has been carried out since that date. The provision of additional waters may be termed the provision of life-blood to this territory, and the continued destruction of pasture will carry on until this work can be resumed when boring apparatus, etc., once again becomes available.

A further measure introduced to preserve the territory was the prevention of veldt fires, and the position in this connexion improved rapidly as a result of the development of greater tribal control. Controlled burning is at times necessary to prevent devastating fires due to accumulated dry herbage, and the great object was to prevent fires occurring in the areas where water had been provided, water that made available reserved grazing. Unfortunately in 1941 fires were widespread, owing to the population being preoccupied with recruitment for the African Auxiliary Pioneer Corps at a time of the year when winds were high and the pasture dry. But there is little doubt that, with the provision of further water supplies and the gradual betterment of pasture- and fire-control measures, the destruction by fire will decrease.

The Forest Department, which came into being at the end of 1939, is making a study of trees suitable for providing protection against soil erosion and for the supply of building and fuel timber for the people. Generally speaking, the territory, unlike Basutoland, is well provided with timber, except in close proximity to the big native towns or villages, such as Serowe with 30,000 inhabitants, where the trees have been cut down for building purposes and firewood. The Forestry Section will endeavour to deal with this aspect when, from experimental plantings, sufficient data are available to know which types of trees will exist under the semi-arid conditions obtaining in the protectorate.

Swaziland.—As in the other High Commission Territories, soil erosion occurs in Swaziland largely as the result of overstocking in certain of the Native Reserves, the concentration of too great a number of cattle at certain dipping tanks, and unsatisfactory cultural practice. Sheet erosion is fairly widespread and gully erosion occurs in a few places.

The most important anti-erosion measures so far undertaken have been :

(a) The construction of an additional fifty dipping tanks, made possible by a grant of £5000 from the Colonial Development Fund.

(b) The construction of dams for the provision of additional water supplies for live stock. This work, which began in 1938, was made possible by a grant of £16,000 from the Colonial Development Fund : £2000 of this sum was available for anti-erosion measures in cultivated fields and to check gully erosion. By the end of 1940 a total of seventeen dams had been constructed, and in 1941 the dam-construction programme was placed on a more satisfactory basis, since when this work has proceeded steadily, augmented by a further grant which will permit of the provision of a minimum of sixty water-supplies.

(c) At the Aird Government Farm good results have been obtained from planting Napier grass in strips on the contour. Not only do these strips act as a safeguard against erosion by stabilizing the soil, but they supply a large quantity of fodder for stock. As a result of these experiments, and after much propaganda, this work has now been extended on a fairly large scale in certain of the Native areas and has found favour for use on European-owned lands. In one Native area nearly 10,000 acres have been permanently safeguarded by the use of strips of Napier fodder grass, and individual natives are using this system in various parts of the territory. Progress continues, but can be much accelerated when additional staff becomes available.

Where serious gullying has occurred the worst instances have been dealt with by establishing contour banks and drains.

WEST AFRICA

Gambia.—Soil erosion is not a serious problem, though some movement of the sandy soil takes place after heavy rainstorms. A series of orders made by Native Authorities in the protectorate prohibit the burning of growing grass, and bush land to be used for farming purposes must be burned early. A Forest Commission submitted a report in 1940 dealing with the protection of existing forest and the reforestation or cultivation of economic trees on denuded areas, but no comprehensive soil-conservation policy has yet been formulated.

Early burning is advocated in order that regrowth may afford a measure of protection before heavy rains fall, and this is meeting with success. Both the flat and the ridge-and-furrow systems of cultivation are practised in the Gambia ; in the latter, the desirability of making the ridges across the slope is impressed upon the people. Emphasis is also laid on the value of cattle manure and compost, thus leading to more intensive farming and aiding soil conservation.

A scheme to extend greatly the cultivation of rice on the tidal flats will shortly be put into execution. This, if successful, will transfer a certain amount of cultivation from the less fertile dry lands, but there is no problem of land hunger in the Gambia, or of serious erosion of uplands as in Sierra Leone. The dearth of timber has been aggravated by war-time needs, and the establishment of a Forestry Department as a part of the work of rehabilitation is now under consideration.

Gold Coast.—Primitive farming methods are leading to soil degradation in the Northern Territories. Recent changes in the economic and social life of the people aggravate the damage resulting from shifting cultivation, uncontrolled grazing and annual grass fires. In the coastal areas, where the population is dense and large tracts of forest have been cleared, erosion is also evident.

No separate organization has yet been set up to deal with soil-conservation problems. The subject is dealt with by the Departments of Agriculture and Forestry, and, although the operations are still largely in the experimental stage, a number of measures have been inaugurated. The area of Forest Reserves established up to 31st March, 1943, totalled 6940 square miles, but with the exception of 1088 square miles the reserves lie in the forest zone, where erosion is not a major problem. In Ashanti the Native Authorities issued orders in 1938 forbidding the cutting down of forest for planting new cacao farms. In the northern savannahs rules were made in 1938 to control grass-burning.

In the northern territories, particularly in Zuarungu and Bawku, sheet and gully erosion occur ; the prevention of grass fires and the increased use of farmyard manure constitute the most effective conservation measures. Planned migration from over-populated areas is also under consideration. Mixed farming as a substitute for shifting cultivation has been experimented with and developed since 1937. The planting of shade trees and windbreaks in the cacao-belt is another accepted line of attack.

The active co-operation of certain Native Authorities in conservation measures has been secured, as instanced by the orders mentioned above. From 1938 to 1942 1,130,000 trees were issued to farmers for planting, and the greater proportion of them were planted as shade trees for cocoa, a few shelter-belts also being established.

No large-scale measures can be expected until after the war, but in the meantime useful data are being collected which should enable a larger programme to be adopted as soon as supervisory staff is available.

Nigeria.—Soil degradation and erosion are taking place over much of the savannah country in Northern Nigeria and also in the more densely populated areas of Southern Nigeria.

Insufficient staff has prevented the establishment of an organization designed specifically to deal with soil conservation, but a considerable amount of work has been done by the Department of

Agriculture in improving agricultural methods, and by the Forestry Department in the establishment and protection from burning of forest reserves. The Public Works Department are also co-operating by controlling excessive run-off from the roads and by abolishing the clean weeding of road edges. Provincial Welfare and Development Boards are taking an interest in soil conservation measures.

A promising and constructive line of approach is the extension of the cultivation of rice, wheat, onions, sugar-cane, and other suitable crops in the swamps and marshy valleys, with the object of relieving the pressure on the over-farmed uplands.

The clearing and farming of steeply sloping land have in places been prohibited, the areas thus released being used for fuel and timber reserves. Communal forest areas have been established to prevent the indiscriminate cutting of timber and scrub for firewood.

In Southern Zaria work has been started to test the possibility of farming the rich soil of the thickly wooded and steep-sided valleys without either laying the seeds of serious erosion or increasing the incidence of sleeping sickness among the population.

Other measures include contour ridging, broad-base terracing, the planting of natural fallow grasses such as *Andropogon gayanus* and the planting and preservation of economic trees. Propaganda to enforce the Burning of Bush Order is also being intensified.

In the more northerly districts of low rainfall, where wind erosion is of pressing importance, measures include the planting of shelter-belts, the establishment of line-fences and grass strips or bunds between the fields.

A start has been made with the rehabilitation of "bad lands"; measures include the digging of shallow contour trenches and the planting of hardy indigenous species of grasses and other plants, those which first appear in ecological succession on this type of impoverished soil being selected.

It will be seen that anti-erosion work is still largely in the experimental stage, but valuable knowledge and experience are being accumulated which can be applied after the war when staff conditions admit.

Sierra Leone.—A pernicious system of shifting cultivation has degraded the soil in the upland regions of the western and southern parts of the territory. Degradation is progressing rapidly, and erosion is now severe on the hills and slopes, the position in the Colony hills being particularly bad. The demand for farming land is insistent and nearly all of the original forest has been destroyed. The first requirement, therefore, is to exclude shifting cultivation on hill-slopes, and in consequence the policy has been adopted of endeavouring to relieve pressure on the uplands by encouraging the cultivation of river flats and valley bottoms, which by lowering the demand for upland farms will facilitate the declaration of forest reserves on the hills and slopes and the replanting of denuded areas with suitable forest trees.

To implement this policy extensive surveys of tidal and swamp lands have been carried out by the Department of Agriculture. An experimental station for work on rice cultivation was opened at Sembehom towards the end of 1938. Farmers were granted loans to assist them in felling the mangrove. The scheme, though on a small scale, was highly successful. In the first two years over 1000 acres of virgin land were taken up. In the next year more than 1000 additional acres were cleared, and with increased provision of funds to assist planting, rapid development can be expected.

To assist developments an Irrigation and Drainage Engineer was appointed in 1940, the cost being met from a grant under the Colonial Development and Welfare Act. A preliminary survey by this officer showed that upwards of 500,000 acres existed in the tidal coastal area which could be reclaimed for cultivation, and it is believed that a similar area exists as inland swamps. The Irrigation and Drainage Branch was expanded in 1942 and a scheme approved for the reclamation of 50,000 to 60,000 acres of swampy land during the next five years at a cost of £303,000 (including free plant), funds being provided by a combined grant and loan under the Colonial Development and Welfare Act.

Further proposals are under consideration for establishing water control over some 300,000 acres in the Southern Province (Bum-Kittam area) of potential rice lands; concurrently, proposals have been made for reforestation in badly denuded upland areas. Forest legislation was enacted in 1942, and the collaboration of the Native Authorities has been secured in a plan for demarcating declared areas as forest reserves. A framework of shelter-belts and forest reserves was laid down in 1940; nurseries of forest trees have been established by the Native Authorities under the guidance of the Forest Department, and by 1941-42 7500 acres of protective forest had been demarcated.

It can be said that the seriousness of the problem is now fully realized, and measures to counteract the evil are being energetically pursued.

St. Helena.—St. Helena is a small island with a total area of 47 square miles. The coastline consists of high perpendicular cliffs, above which the ground rises in fairly steep slopes to ridges in the middle of the island that are broken by narrow valleys and fissures descending to the sea. The rainfall is moderate, but varies considerably in different localities. At one time it is reputed to have been covered with forest, but most of this has been removed.

Erosion is a serious problem, due mainly to the effects of the strong trade winds following indiscriminate deforestation, uncontrolled pasturing of goats, donkeys and sheep, and bad cultivation practices on exposed areas.

The island was visited in 1939 by Sir Frank Stockdale, who directed attention to the position and made recommendations for dealing with the question as a part of a policy of general agricultural rehabilitation. Funds for the execution of this programme were provided through a grant

from the Colonial Development and Welfare Fund, and a start was made at the end of that year, an agricultural officer being specially appointed for the purpose. Since then there has been appreciable progress. The measures have aimed at the regulation of grazing, the protection of pasture lands by fencing, the reduction of the number of uncontrolled goats, reconditioning and reafforestation of denuded areas, the improvement of cultivation methods by the use of manure, and the establishment of terraced and contoured cultivation.

Legislation has been enacted "to make provision for the preservation and protection of the soil and for the control and improvement of crop production and live stock". With the powers provided goat-ranges have been defined and the number of goats on the island have been considerably reduced. Much effort has been expended on propaganda to make the inhabitants aware of the seriousness of the position, and with encouraging success. Stall-feeding of cattle, donkeys and goats is extending. Already there has been a marked improvement in the herbage in areas where grazing is prohibited, and cultivators are beginning to adopt improved methods of cultivation. A start has been made with the planting of trees in protected areas, and it is intended to give increased attention to the provision of forest protection so soon as circumstances permit. Although the position remains grave, there has been already an appreciable improvement, and given continuity of the existing policy the outlook is not unhopeful.

EASTERN DEPENDENCIES

Ceylon.—The serious nature of the soil-erosion problem in Ceylon has been recognized for some years. This is particularly true of tea and rubber estates, which occupy the hilly land in the regions of high rainfall. The introduction of ground-covers on rubber estates dates back to the "twenties", but on tea estates the immediate practical disadvantages and objections to anything but the old practice of clean-weeding were more obvious and weighty, and it is but recently that the maintenance of a cover of selected soft weeds has become at all general.

Although a ground-cover is regarded as the most satisfactory first line of defence in preventing erosion, in that it anchors the soil and increases its absorptive capacity, the importance of other soil-conservation measures is not overlooked. Large estates have, from the earliest times, provided drains across hill-sides, but these were formerly dug at a relatively steep gradient. In more recent years the practice has been to construct the drains on the contour or at a slight slope and to provide catchment pits at intervals, so that any surplus water is led from the land in a silt-free condition. Stone terraces constructed on the contour are also extensively used where stone is available and, where the land is not too steep, earth excavated from drains is consolidated into "bunds".

The research institutes for the three major economic crops, tea, rubber and coco-nuts, have taken the lead in encouraging soil-conservation measures by investigations and demonstrations. The Department of Agriculture fills a similar role for the village agriculturist and is responsible for carrying out the policy laid down by the Ministry of Agriculture and Lands.

In 1937 an officer of that department was appointed in a part-time capacity as Soil Conservation Officer to make a special study of the subject. Early in 1939, however, he was seconded for other duties, and unfortunately the emergency conditions arising from the war situation prevented the resumption of his soil-conservation work. He was able, however, to submit a report containing definite recommendations for the better conservation of water and soil in Ceylon, which are likely to form the basis for legislation. In 1939 the Central Board of Agriculture accepted the report of a special Soil Conservation Committee whose basic recommendation was the constitution of a statutory body to be termed the Soil Conservation Board. The Central Board also recommended the early framing of a comprehensive Soil Conservation Ordinance, but this has had to be held in abeyance during the war.

The only form of compulsion which has so far been exercised is in respect of land opened under the Rubber (New Planting) Ordinance of 1938. All persons exercising rights under this ordinance are obliged to adopt certain minimum prescribed measures for the prevention of erosion. Advice and financial assistance are given to small-holders in the execution of the necessary work.

Ceylon is fully alive to the importance of conserving her soil. Considerable progress has been made in the adoption of protective measures, whose value is based mainly on empirical observations. Had it not been for the war a more detailed study would have been possible and legislative action taken.

Hong Kong.—Both Hong Kong island and the New Territories offer a picture of bare hill-sides which have been heavily eroded in past years. Cultivation is almost entirely confined to the valley bottoms and the lower slopes of the hills in the New Territories. An extensive programme of reafforestation on hill-sides had been embarked upon by the Hong Kong Government with a view to providing the protection so badly needed and rehabilitating the denuded soils, as well as for providing some supplies of fuel and timber. The work had been in progress for a number of years prior to the Japanese occupation and had already shown some substantial results; it was being steadily extended. When peace returns no doubt it will be resumed.

Malaya.—The position presents some similarities to that in Ceylon, although there are some differences. Until recently agricultural development was confined to the lower lands and little attempt had been made to open up the mountainous region of the centre of the peninsula. Shifting cultivation has never been a serious problem. Development was mainly in rubber, and in the earlier days clean-weeding without any safeguards against erosion was the usual practice. Extensive erosion had appeared early in the second decade of the twentieth century; this was followed by remedial efforts by the planting body, which first took the form of contour bunding and silt pitting, and was later followed by the planting of cover crops and the establishment of natural

covers with selective weeding. A further source of difficulty was insufficiently controlled mining for tin, which led to extensive erosion with much gullying in places, coupled with silting rivers and consequent flooding and damage to cultivated areas through the deposition of silt. This condition was remedied by the application of much more strict control of mining operations.

The opening up of the mountainous area and the establishment of tea plantations after 1930 gave rise to a fresh series of problems, but these have been dealt with in the light of experience in Ceylon and other countries, and by 1941 the situation was well in hand.

Much work was done by the Rubber Research Institute of Malaya with a view to ascertaining the most suitable methods of erosion control in rubber plantations, the results of which were extensively applied. On small holdings the position has never been serious, since peasant cultivators of permanent crops such as rubber and coco-nuts have never practised clean-weeding in the manner formerly current on estates; this has served to check any tendency to erosion, and the only annual crop extensively planted is swamp rice, which does not conduce to erosion.

Towards the end of the period 1920-30 a serious situation was beginning to arise on lands cultivated in pine-apples in the southern and central part of the peninsula. At the time of the Japanese occupation this was being closely studied by the Department of Agriculture on the pine-apple experiment station in Johore, with a view to working out economic methods of obviating the danger.

Erosion is also a serious matter on the mountain slopes of the densely populated island of Penang.

Until 1930 no special organization existed for dealing with soil conservation, but in that year a standing central committee was appointed by the High Commissioner to investigate and advise on the problem, with sub-committees to advise on the technical, administrative and legal aspects of the question. Evidence collected by this body showed that the position had considerably improved of recent years; a certain amount of damage was still occurring where bananas had been planted on unsuitable sites whilst the position on pine-apple plantations and on Penang Hill was serious.

Mauritius.—Soil erosion is not a serious problem; over 90 per cent of the cultivated land is in normal times cultivated in sugar-cane, a crop which affords excellent protection against losses by erosion, whilst the system of cultivation employed, which includes long ratooning and the careful preservation of sugar-cane straw on the land, further assists in the process. The forests of the island are also well protected, and the Forest Organization is among the oldest in the Colonial Empire. There are considerable Government-owned forest reserves, and control is exercised over privately-owned forests. River reserves are maintained by statute for a prescribed distance from the water's edge on all major watercourses. As a result, notwithstanding the mountainous nature of the country and the erodible character of the soil, a high standard of protection against erosion has been achieved.

As a result of the war it has been necessary to plant a much larger area than usual in food crops, with corresponding reduction in the area under sugar-cane. It remains to be seen whether this will have any effect on the erosion position.

Seychelles.—This group of small islands is predominantly mountainous. In some of them, and particularly in Mahé, the principal island, a narrow coastal belt of more or less level land surrounds the granitic mountain massif and from this the land slopes steeply up the mountain side. Cultivation extends far up these slopes in many places, and there has been considerable removal of the forest cover. The annual rainfall averages 90-100 inches and its distribution is somewhat erratic. Under these conditions severe erosion has occurred on the exposed slopes.

A free grant was made from the Colonial Development Fund for the three-year period 1935-37 to further the work of reforestation of degenerated areas, and some 450 acres were replanted. Schemes for terracing, irrigating and generally reclaiming these badly eroded and worked-out slopes are now under consideration; and financial assistance to carry them out is being sought under the Colonial Development and Welfare Act.

Aden.—In southern Arabia the rainfall is in general too low for an efficient natural vegetation to cover the slopes and act as a check on run-off. Only by the efficient use of all sources of water, particularly flood water, can cultivation continue. In these circumstances an effective system of soil and water conservation forms an integral part of traditional cultivation, and although there is a constant movement of the soil from the slopes to the flats, efficient run-off control results in comparatively little silt-laden water reaching the sea. Soil erosion occurs where flood waters are not controlled, and in some areas overstocking has led to soil degradation.

Wind erosion is a factor of importance in the alluvial areas, such as on the coastal plain, where it affects areas which have been withheld from cultivation for long periods. In such situations desiccation of the soil is followed by wind erosion. The remedy is, of course, to irrigate such soils and bring them back into cultivation.

The agricultural staff is at present very limited, but some measures to improve the position have been possible.

The general view is that efforts to effect soil conservation should be directed to the maintenance and extension of the present system of flood control. The districts of Abyan, Beihan and Ahwar, which depend largely on a system of flood-water irrigation, have been selected as areas for improvement. In past years flood waters have gone to waste owing to local insecurity and impoverishment, which resulted in the neglect of the deflectors and canals required for flood control. During the past two seasons active measures have been taken to remedy this state of affairs following an improvement in political conditions, and by a system of advances to cultivators

willing to undertake the restoration of their irrigation systems. Such flood-water control works must naturally go hand in hand with increased production measures.

On the Audhali plateau a system of advances for farmers willing to improve or sink wells or recondition terraces has proved successful, and particular interest has been stimulated in areas where political difficulties have in the past caused neglect of such opportunities for the improvement of the natural resources.

MEDITERRANEAN DEPENDENCIES

Cyprus.—The need for soil conservation has been recognized in Cyprus since ancient times, and the art of terrace-making has been handed down by cultivators from generation to generation. Considerable areas are, nevertheless, in an advanced state of erosion, brought about by extensive and continued removal of forest growth and excessive and unrestricted grazing. The necessity of conserving the forests has been recognized since the British occupation in 1878, and legislation has been enacted from time to time to control grazing by sheep and goats. In approaching the problem the Department of Agriculture has aimed at devising control measures consonant with established agricultural practices. Attention has been given to the contour planting of annual crops, vines and trees on erodible land; the encouragement of tree planting on land which is too poor or too steep for field crops, and the protection of field boundaries and drainage beds. This has been combined with propaganda directed to make the farming community erosion-conscious, and the establishment of demonstration areas and gully reclamations and forest-tree planting on steep hill slopes. By the end of 1941 a total of eighteen soil-conservation demonstrations had been established. As a result soil-conservation measures are now being undertaken to an increasing extent by farmers on their own properties, and many applications have been received for Government assistance to this end. In 1942 a grant of £5000 was made from Colonial Development and Welfare Funds to assist the carrying out of soil-conservation measures in agreed areas. Much of the land under the control of the Forestry Department lies in the mountains, the slopes of which are steep and at times precipitous and subject to heavy rains; where forest protection has maintained a reasonable cover a precarious balance exists, but in many places forest fires, heavy grazing and fuel-cutting have upset the balance, and progressive erosion has occurred. Soil-conservation measures have been kept prominently in view in recent reforestation operations. In 1941 a grant of £210,000 was made from Colonial Development and Welfare Funds to provide for reforestation, and this has enabled the Forest Department to undertake a large programme of reforestation, which includes special protective measures to ensure soil conservation. The latter include the planting of protective strips combined with the construction of contour trenches or contoured stone bunds in forest areas where erosion is specially liable to occur.

Simultaneously steps have been taken to curtail or eliminate the grazing of goats and other live stock in forest areas. By the end of 1942 all lawful grazing had been eliminated from the most important forest areas of the southern range of mountains. This release of certain forest areas from excessive grazing produced an immediate and most remarkable improvement in the natural vegetation and natural regeneration of tree species. It is now obvious to all that the total clearance of grazing from forest areas is a necessary preliminary to allow the restocking of the forests to proceed economically. Forest grazing is still only under control in limited areas and there is much to be achieved before this question is satisfactorily settled. By the end of 1942 grazing had been eliminated from practically the whole of the mountain forest areas with an accompanying remarkable improvement in the natural vegetation. As a part of this policy there has been a considerable strengthening of the forest staff.

These moves have been accompanied by a considerable quickening of public interest in forestry questions. A Cyprus Forestry Association has been formed which has organized an Arbor Day and Tree-Planting Week on an island-wide scale, and has imparted a considerable impetus to tree-planting on privately-owned lands.

Reforestation received some set-back owing to the heavy demands for timber for military purposes in the mid-eastern area, and also owing to the extremely heavy demands for wood fuel to tide over the war period of very limited importations of mineral fuel. It is hoped that the permanent effects of this policy will not be excessive, though it has resulted in much overcutting for the time being.

It cannot yet be said that public interest in Cyprus has been aroused over the subject of soil conservation, but certain branches of Government are now well aware of this evil, though it yet remains to draw up and apply long-term plans of action that would arrest and correct soil erosion. The visit of Dr. W. C. Lowdermilk, Chief of the Soil Conservation Service of the U.S.A., in 1939 did much to initiate thought on soil-conservation problems in Cyprus.

Malta. Although the island contains a high percentage of rocky, uncultivable land, the problem of soil erosion can hardly be said to exist to-day in Malta. Considerable tracts of fertile soil are to be found in the valleys, and, behind the numerous stone walls, which have been erected to free the land of rock, to prevent soil erosion, and to provide shelter for the crops from strong winds, there have been created—often by the transport of soil—small enclosed and terraced fields which are intensively cultivated. Soil is very precious in Malta and is efficiently husbanded.

Palestine.—Palestine is a continental country with an extreme type of Mediterranean climate. Over the greater part of its area the natural vegetation of forest and scrub was long ago destroyed to make way in classical times for agriculture of a conservative type which later gave place to wasteful practices of haphazard cultivation and extensive grazing. The remaining vegetation on steep slopes and the terraces which held up the soil of the hill farms were gradually destroyed, and the hills consequently denuded of soil. Stream-beds in the plains were filled up by transported

gravel and silt, and the resultant formation of swamps was accelerated by the building-up of sand dunes following the destruction of the vegetation on the coastal strip.

Prior to the war civil disturbances and financial stringency made it impossible to initiate any major schemes of soil conservation, but the value of terracing was demonstrated in the nurseries and stations of the Department of Agriculture, whilst two small schemes were inaugurated by the Department of Forests for the control of erosion by afforestation and the protection of the natural vegetation. Work on the control of sand-dunes was started at Gaza, and investigations were made into the growth of certain hardy species on eroded sites. Interest in erosion problems and remedial methods and awareness of its dangers were stimulated by the visit in 1939 of Dr. W. C. Lowdermilk, who spent many weeks visiting eroded sites.

A Soil Conservation Board under the chairmanship of the Conservator of Forests was set up by the Government in 1940. Discussions of the Board and their inspections of eroded land revealed the need of new legislation for the control of erosion as a prelude to any effective action. Terracing on agricultural land in the hills was extended during 1940, aided in some places by Government loans, and efforts were made to encourage contour ploughing. In May 1941 the Flooding and Soil Erosion (Prevention) Ordinance No. 12 of 1941 was passed by the Palestine Legislature. The High Commissioner was empowered to declare regions threatened by erosion to be Special Areas in which the cultivation of crops, the pasturing and passage of domestic animals, and the cutting and removal of vegetation could be regulated or prohibited as circumstances required. The first Special Area to be declared was at Tiberias to the west of the Sea of Galilee. During 1941 one section of this area was trench-terraced at Government expense. It is intended to proceed section by section until, in the fifth year, the whole of the Special Area will be closed to grazing and subjected to soil-conservation restrictions. The work of the Board during 1941 also included the preparation of plans for the control and utilization of sand-dunes, the framing of a proposal for a long-term scheme of regeneration for the Nablus-Tulkarm Valley, and the investigation of the problem of grazing.

Lack of control over grazing is stated to be by far the most important cause of flooding and soil erosion in Palestine, and the formulation of a grazing policy is under consideration. The construction of new terraces on cultivated hill-sides started in certain localities during 1941, and large demands were made on the Government Nurseries for the issue of trees for windbreaks and other purposes. Owing to the war overcutting of local vegetation has inevitably continued, but, on the other hand, the realization of this fact has led to increased provision of funds for planting in Forest Reserves.

In 1942 a second Special Area comprising 14,000 acres of loose sand-dunes south of Jaffa was declared with the object of bringing the dunes under control and preventing further damage by sand drifts to adjacent lands. Grazing is to be regulated and suitable grasses planted to bind the sand.

Special attention was paid to propaganda and education in 1942, in order to take advantage of and to stimulate the obvious interest of many sections of the population in soil conservation.

Trans-Jordan.—Soil erosion in Trans-Jordan is widespread and has become more evident in recent years. It is due to the destruction of forests (which has been progressing for centuries), to overgrazing, to improper methods of cultivation, and to the failure of the peasantry to maintain the ancient terraces on the hill-sides.

The rapid, natural increase in the population during the last 20 years and the consequent need for additional cultivation and larger flocks has to a certain extent accelerated the process of soil erosion. The effects of this pressure of population are now, however, taking a form which is not entirely evil in relation to the problem. In the first place, the damage has become so evident in places as to compel the most conservative or feckless landowner to take stock of the situation. In the second place, the urgent need for additional land for cultivation is driving the cultivators to repair ancient terraces and to terrace new hill-sides.

The chief measure employed to combat soil erosion is to obtain, in the course of land settlement, and register as state domain, areas of land which are forested or which are suitable for afforestation. Once the land is state domain, the prevention of detrimental practice is simplified. By the end of 1942 510,981 dunams* of land had been secured in this fashion.

The reafforestation of parts of these areas was begun before the war, and 11,000 dunams were fenced in and planted with Aleppo pine and acorns (*Quercus aegilops*). Since the war fencing material has become unobtainable and the work of replanting has had to stop for the time.

Three officials of the Department of Lands received a course in forestry and the control of soil erosion in Palestine, and are now explaining to the Trans-Jordan people the benefits of terracing and contour ploughing. There is evidence that their work is having effect.

WEST INDIES AND AMERICA

In the British West Indies the gravity of the position varies considerably in different dependencies. Soil exploitation in the past has led in some parts to serious erosion; but in recent years the dangers have been brought prominently to notice. Considerable efforts have been made to devise an agricultural policy which will increase crop yields and assist the conservation of natural resources, and as a part of this policy simple measures of soil conservation are being advocated. In consequence there has been a considerable increase of public awareness of the change; owners and occupiers of land are beginning to realize that there is much they can do to lessen soil erosion, and members of the legislature are conscious of the duty which the present generation must hold for the future of the land.

* 4 dunams=1 acre

In the Bahamas, Barbados, Bermuda and British Guiana soil erosion is not serious. The arable lands of *Barbados* are normally almost entirely devoted to sugar-cane, a crop which of itself provides considerable protection, whilst the practice of planting in cane-holes affords protection against wash. In the hills of the Scotland district erosion occurs and is serious in some areas, mostly on land of small agricultural value. Experiments were started in 1941, with funds provided under the Colonial Development and Welfare Act, to ascertain effective means of studying erosion of the steep hill-sides in this district; a survey has also been carried out with a view to afforestation and rehabilitation of the area involved.

In *Bermuda* the hill-sides are normally covered with trees and grass; arable cultivation is restricted to level or slightly sloping ground; and the limestone soil is very porous. The soil structure and the extensive use of windbreaks prevent erosion by high winds. Isolated cases of severe erosion by water occur where hill-sides are cleared for cultivation or where they are overgrazed by live-stock. In general, however, erosion is on so limited a scale and the territory so small that it is possible for the Department of Agriculture to note the places where it is liable to occur in serious form and to advise landowners as to measures necessary to check damage.

In *British Guiana* there is no soil-erosion problem on the frontal lands, which are cultivated with sugar-cane and rice. The ranching lands of the interior are so poor in fertility that overstocking is nowhere apparent. Promising experiments on the improvement of pasture are in progress at Ebini.

British Honduras.—Over the greater part of the country soil erosion is not serious. Even on fairly steep, abandoned clearings the rate of regeneration of forest growth is so rapid and vigorous that serious soil losses do not occur. The policy of the local Department of Agriculture is to introduce improved methods for the intensive cultivation of comparatively small areas of land, rather than to permit shifting cultivation of larger areas; this policy has been promoted by means of demonstration loans for rice production, and a guaranteed price for agricultural products. Satisfactory progress in the development of "settled" agriculture has also been achieved on communal farms established in relief of damage due to hurricanes and locusts; it was found that the settlements continued after the cessation of the payment of relief money.

The transitory nature of forest exploitation leaves little impression on the vegetation, and erosion occurs only on extraction roads cut on steep slopes. For long-term concession these roads are protected from erosion by cross ditching. A topographical map of the colony is in preparation from aerial photographs and it is proposed to use it for the reservation of protective forests on steep slopes and of productive forests on land unsuited for agriculture. Some sheet erosion is caused by shifting cultivation in regions of high rainfall and on the Mountain Pine Ridge, but it has not yet been found possible to carry out any soil-conservation work.

Jamaica.—Soil conservation received but little attention until recently, although the topographical and climatic conditions as well as the single-crop system of agriculture that everywhere prevails are highly conducive to erosion. The rapidly increasing density of the population requires that the productivity of the land (much of which is steeply sloping) should be maintained at its maximum if a reasonable standard of living is to be assured to the inhabitants, and it is now becoming realized that Jamaica cannot afford any further losses of top soil.

To arouse popular attention effective propaganda has in recent years been carried out by the Department of Agriculture, the Department of Education and the Jamaica Agricultural Society, and, since the start of the war, large-scale demonstrations of soil-conservation methods have been carried out by the Food Production Board. Results have been so successful that the Agricultural Society has recommended the enactment of legislation to compel the adoption of soil-conservation measures. But work is still in the experimental stage, and much investigation will be necessary before the most suitable methods of treatment are evolved for the various soil types and different climatic conditions.

Progress has been made, and a series of simple and practical instructions in conservation methods, which cultivators themselves can apply, has been published in the *Journal of the Jamaica Agricultural Society*. The measures recommended include the natural establishment of terraces by the packing of stones on walls along contours, the planting of grass strips along contours, strip-cropping, the use of mulches and catch crops and the construction of contour drains on heavy soils in areas of high rainfall. So far visible progress is not very great, but interest and attention have been aroused and more rapid development is to be expected. The soil-conservation campaign will not be fully effective, however, until the accumulating fertility of the demonstrations is seen to produce superior yields of crops. The work has been facilitated by the acquisition of several estates for use as agricultural training centres to relieve unemployment.

Forestry activities have increased following substantial grants from Colonial Development and Welfare Funds. The worst sections of 10,000 acres of degraded land in the catchment areas of important rivers have been acquired for afforestation under the Taungya system, anti-erosion practice being enforced. New roads through forestry plantations are laid out, drained and protected to avoid gullying.

Leeward Islands (Antigua, Montserrat, St. Kitts-Nevis and the Virgin Islands).—Soil erosion is a serious problem and the effects of past negligence are plainly seen. In *Antigua* erosion in sugar-cane cultivation is more prevalent than was previously thought possible, and a system of contour banking is now being devised. Soil losses in peasant cotton and food-crop cultivation are considerable, particularly on hill-sides. A substantial increase in cultivation on steep hill-sides has occurred in recent years, mainly as a result of peasants extending cotton-growing in view of the

favourable market, and for the increased production of food, which resulted in serious soil erosion. Good headway is being made, however, mainly with lines of khus-khus and Guatemala grass, and the anti-erosion demonstration plots on hill-sides are now, after four years, giving yields greatly superior to the unprotected lands.

During 1941 a Forestry Ordinance was enacted which declared all forested lands to be forest reserves within which the felling of trees is forbidden except under permit. Powers also exist under the ordinance for the reservation of denuded areas to allow of natural regeneration. This law has checked the deforestation of the hill-sides, which has been marked during recent years.

In *Montserrat* erosion is a serious and urgent problem. The principal export crops are sea-island cotton and tomatoes, both of which may cause serious soil erosion when grown on sloping lands without proper protective measures. The position is most serious on the higher lands where steep slopes have been denuded of their natural vegetation. Comprehensive proposals for dealing with the problem were made by the Inspector-General of Agriculture, including the appointment of additional agricultural staff and the establishment of centres for investigating and demonstrating conservation methods. Planters are taking an active interest in the work, and it can now be claimed that most land in *Montserrat* is ridged on the contour.

In *St. Kitts* conditions are naturally favourable to erosion: much of the land is steeply sloping, the soil is light and friable, and the rainfall fairly heavy. The lower slopes of the island are mainly under sugar-cane, which has preserved most of the land on sugar estates where anti-erosion measures are practised to some extent. Marked sheet erosion, however, occurs on lands between the upper limit of cane cultivation and the lower limit of the forest belt, which are given up to labourers' food plots, and conservation measures are necessary. Appreciable progress has been achieved during the past two years. Contour cultivation has been adopted by several sugar estates in *St. Kitts*, and many managements and overseers are now equipped with road-tracers. The use of pen manure for the maintenance of soil fertility is still the practice on all estates, and the Central Basseterre Sugar Factory returns all residues and surplus bagasse to cane producers for application to the land. Satisfactory progress has been achieved with contouring the Fahies and Sadlers settlements. Experiments of the Matengo (Lake Nyasa) pit-system have been laid down. Two instructors were appointed to assist peasants regarding anti-erosion methods on the upper provision lands.

In *Nevis* soil erosion is not a serious danger. Much of the sloping hill-lands are uncultivated and carry a heavy cover of vegetation, whilst the presence of numerous stones and boulders reduces erosion risks. Contouring with dry-stone walls is the simplest method of checking soil-wash under *Nevis* conditions, and this system has been evidently adopted by cultivators, who are largely of the peasant class. Contour cultivation by peasants has increased in recent years and more attention is being given to the maintenance of soil fertility. The Agricultural Department gives assistance with the laying down of contours on allottees' plots on Government land-settlement areas.

Trinidad and Tobago.—In *Trinidad and Tobago* soil erosion in varying degrees of severity has been going on for many years. The problem, if recognized, was shelved, but the stage has now been reached when energetic measures are essential for the welfare of the islands. The need for erosion control has been stressed in the report of the *Trinidad Agricultural Policy Committee* recently published.

It is mainly insidious sheet erosion that is variably affecting both sloping ground and flat alluvial lands. In addition, clay soils within wet areas are subject to land-creep and landslip. In the Northern Plain the effects of erosion are not spectacular, though every flooding rainstorm exacts its toll of surface-soil and the watercourses of the Oropouche and Caroni drainage systems are silt-laden throughout the wet season. In the Central Range land-creep and landslip movements are seen to some extent. In the hilly sugar-cane lands of the Southern Plain soil erosion has been enhanced by ploughing with heavy tractor-drawn implements, and the forest and cacao lands of the eastern and southern parts of the plain also show some sheet erosion; a large-scale demonstration (44 acres) of contour planting of sugar-cane has been laid down.

The Southern Range and Cedros Peninsula are mostly under forest; the loose sandy soil which covers their greater part erodes rapidly when exposed by tree-felling and burning.

Erosion in *Tobago* at present is important chiefly in the Castara and Mason Hall districts. Within the Windward cacao belt intensive erosion during the sugar-cane-growing era has effected considerable profile truncation in the hilly igneous rock soils that had originally developed under forest.

Soil conservation in *Trinidad and Tobago* has not yet been systematically practised, and the co-operation of planters and landowners is essential in any attempt to stop further degradation.

As a result of the report by the Lands Advisory Committee on the western foot-hills of the Northern Range the sum of \$60,000 was provided in the 1942 Estimates to acquire 806 acres in the Caura Hills for the purpose of soil conservation. This is only a small part of the area necessary to protect the natural resources of soil and water in the Western portion of the Northern Range. Stringent measures have also been taken to tighten up fire-control, particularly in the Northern Range.

Windward Islands (Dominica, Grenada, St. Lucia, St. Vincent).—The degradation of soil on cultivated slopes of land subject to high rainfall is the most complex problem of agriculture in the Windward Islands. The most serious consequences are to be seen in *St. Lucia*, where a heavy intractable subsoil is exposed within a few years of cultivation without anti-erosion mea-

sures; eroded land is then lost to agriculture almost indefinitely. In Dominica where the greater part of the island should be maintained in forest, the problem is not acute because of the sparsity of population. The most spectacular forms of soil erosion occur in St. Vincent; fortunately, however, the subsoil rapidly weathers and eroded lands are quickly brought back into a productive condition. Landslides, extensive gullying and wash-aways in the high-rainfall areas regularly cause extensive damage to property, highways and sometimes to life itself. The local Departments of Agriculture, especially those of St. Vincent and St. Lucia, have made considerable progress during the last two years both in awakening the public to the dangers of soil erosion, and in obtaining a good response from planters and small cultivators. The principal measure is the contour planting of grass bunds. A dual purpose is attained by the planting of Guatemala grass by the stock-owners, and the use of khus-khus grass where straw-plait cottage industries are developed. In St. Vincent they have passed the "contouring" stage, and strip-cropping is the vogue. In the dry island of Carriacou, the ill-effects of soil erosion have had greater social consequences even than in St. Lucia.

A great deal of research on soil-conservation measures is needed in all the main ecological areas of the West Indies. Provision has been made for this in proposals which have been submitted jointly by the Principal, Imperial College of Tropical Agriculture, and the Inspector-General of Agriculture, for the centralization of long-range research. At the same time there are some simple practices which can be safely applied in every colony. It is claimed that Departments of Agriculture have made much progress; agricultural officers and producers have profited by their early but not serious mistakes. The main obstacle to further advance has been shortage of tyres and petrol and, in some colonies, the demand for labour on important defence works. In all the islands of the British West Indies provision has been made by the Comptroller for Development and Welfare for financial assistance to carry out the programmes of soil conservation.

Falkland Islands.—The Falkland Islands consist of a group of two large and about 200 small islands. They contain a series of sloping plains traversed by mountain ranges, their total area is about 4600 square miles, the soils are poor and the climate is colder on the average than that of the British Isles, although the annual temperature range is less. The annual rainfall is about 30 inches. The islands are constantly swept by high winds. There are no forests and but few trees, the main vegetation being poor native grass and sedge. The only agricultural industry is sheep-raising, which is practised on rather primitive lines.

Water erosion does not occur to any appreciable extent, but considerable wind erosion takes place in a few localities where excessive grazing and burning have so weakened the turf that the top-soil is blown away; damage has also occurred in certain areas where drifting sand has buried pasture vegetation. The worst effects are seen in coastal areas where uncontrolled grazing has killed the Tussock Grass (*Poa flabellata*). Some wind erosion occurs on dry ridges typically covered with goose-grass (*Aira praecox*) or on those locally known as diddle-dee ridges.

The erosion is not rapid, and may be prevented by fencing, so that grazing may be controlled, thus permitting the re-establishment of Tussock Grass in the coastal areas and the development of Brown Top (*Agrostis tenuis*), *Poa pratensis*, White Clover (*Trifolium repens*) pasture on the ridges.

Drifting sand can be controlled by planting marram grass or the native sand grass. Some attempts to improve matters by systematic grass-planting were begun in 1920. Later the matter received increased attention mainly with the object of improving the grazing and the low stock-carrying capacity of the grazing areas. In 1938 a visit was paid to the colony by Mr. W. Davies, of the Welsh Plant-Breeding Station, the cost being met from funds provided under the Colonial Development Fund Act. In his report Mr. Davies indicated lines which would probably be effective in improving pasture conditions, and recommended extensive trials of certain methods of pasture improvement and the introduction of various grasses. Work has since been in progress in accordance with his recommendations.

DEPENDENCIES IN THE WESTERN PACIFIC

Fiji.—Little damage from soil erosion occurs in the alluvial flat land of Fiji, but sheet erosion does take place on the undulating and high lands where the system of agriculture adopted by the Indian peasant is to cultivate one crop until the soil is exhausted and then move to another piece of land. No measures are taken to conserve the soil. The Fijian, on the other hand, shifts his cultivation at frequent intervals and seldom clean-weeds his crops. Though not commendable, it does allow of a fairly quick regeneration of vegetation. Soil erosion also arises from the indiscriminate burning of grass and reed lands. Efforts have been made by the Department of Agriculture to demonstrate soil-conservation measures on their own demonstration farms and at provincial and other school farms. Eighteen such demonstration centres were started in 1939. The work has been continued since then, but its scope has been restricted owing to the preoccupation of the department with the campaign for the extension of food production.

In 1940 a Native Land Trust Ordinance was enacted which requires lessees of native land to apply and maintain such measures to check soil erosion as may be prescribed, and prohibits the clearing and cultivating of very steep slopes and stream banks.

Increasing attention has of late years been paid to the prevention of grassland burning in the dry zone. Propaganda has been undertaken pointing out the dangers of erosion and indicating simple preventive measures with the object of awakening public interest and preparing the way for a more intensive campaign as soon as circumstances permit.

CONCLUSION

Although soil erosion remains one of the chief agricultural problems with which the Colonial Empire is faced, it is a striking fact that notwithstanding war conditions there has been a marked gain in popular appreciation of the serious nature of the position, coupled with appreciable advances in the devising and application of soil-conservation measures. It cannot of course be said that anything approaching a satisfactory solution of the problem has yet been achieved, but the fact that so much advance has been capable of attainment in the midst of the anxieties and preoccupations of war appears to hold out hopes that with the return of peace the way may be open for achievements on a larger scale.

An important factor has been the provision of funds from the Imperial Treasury through the Colonial Development and Welfare Fund for carrying out soil-conservation measures; equally important has been the tendency towards improved collaboration between the various agencies of Government concerned with the different aspects of the question and the growing measure of popular support for policies directed towards conservation.

ACKNOWLEDGMENT

Acknowledgment is made of the assistance given by Directors of Agriculture and Directors of Forestry who supplied information and revised the sections for their respective territories in addition to providing the photographs with which the article is illustrated.

(Received 28th February, 1944)