EROSION AND CONSERVATION, WITH PARTICULAR REFERENCE TO THE NATAL COASTAL BELT

By G. C. DYMOND.

The progressive erosion of the earth's surface by uninformed and sometimes wanton destruction of the soil's top-cover, with the resulting disturbance of nature's delicately balanced but perpetual hydrologic cycle; the erosion of low lands and the silting up of reservoirs through the deforestation and over-grazing of uplands; the general non-contouring of farmlands; the increasing defertility and decreasing moisture-holding power of soils through mechanical replacement of animals and their humus potentials; the export of food and the increasing diversion of soil products to industry, with the resulting non-return of the mineral salts and the natural manure therefrom; increasing populations and the general avoidance of nature's fundamental law of return of all animal and human waste products; soil exploitation through our irrational systems of land tenure—have provided in our time a world problem of such immediate urgency, that even politics and big business must recognise and act on the acknowledged fact, that the very survival of man at even his present density per square mile of arable land is at stake.

No. 1.—Indigenous bush destruction and subsequent erosion on the banks of the Tugela River. The Indian settler (right) has moved on from the bare eroded patch on the left. This process is repeated until there is no more land left to cultivate.

There appears to be a general misconception that the area of the world's potential arable lands is practically endless. According to Dr. Bennett[1] this is far from the truth. He says: "Only about 11 per cent. of the earth's total land area is capable of cultivation now or in the immediate future. At present the other 89 per cent. of the world cannot furnish man with the necessities of life." If this is true, then the following statistics[6] on portions of the 11 per cent. of productive lands available, become deeply impressive.

Erosion in U.S.A. in 1934.

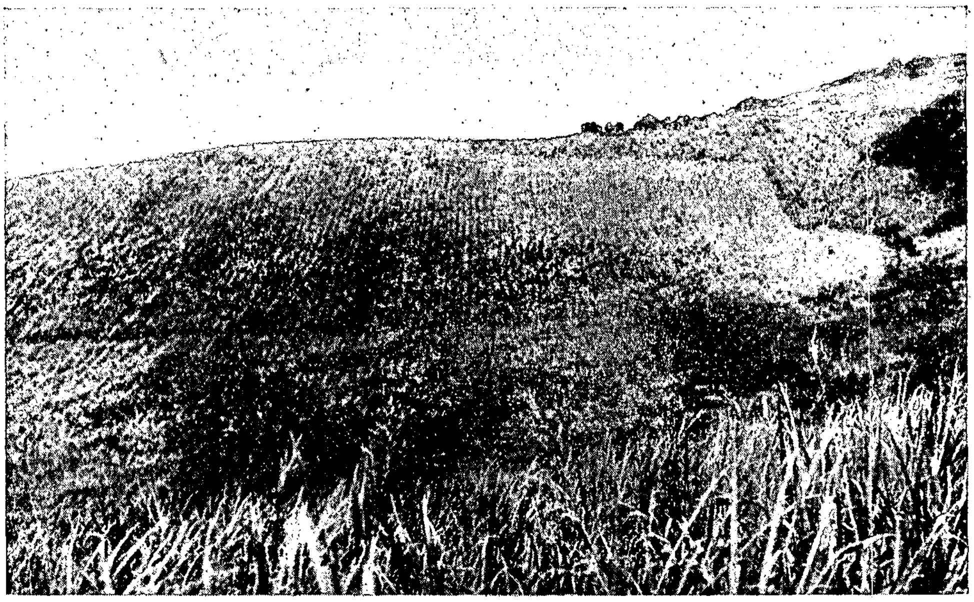
All top-soil gone	14 per cent.
Half to quarter top-soil gone	42 per cent.
Little erosion	14 per cent.
No erosion	30 per cent.

How do these figures compare with statistics available in Natal? The following is an accurate survey of an area of 113,177 acres between Boesmans and Bloukrans Rivers in Natal by Pentz[4]:—

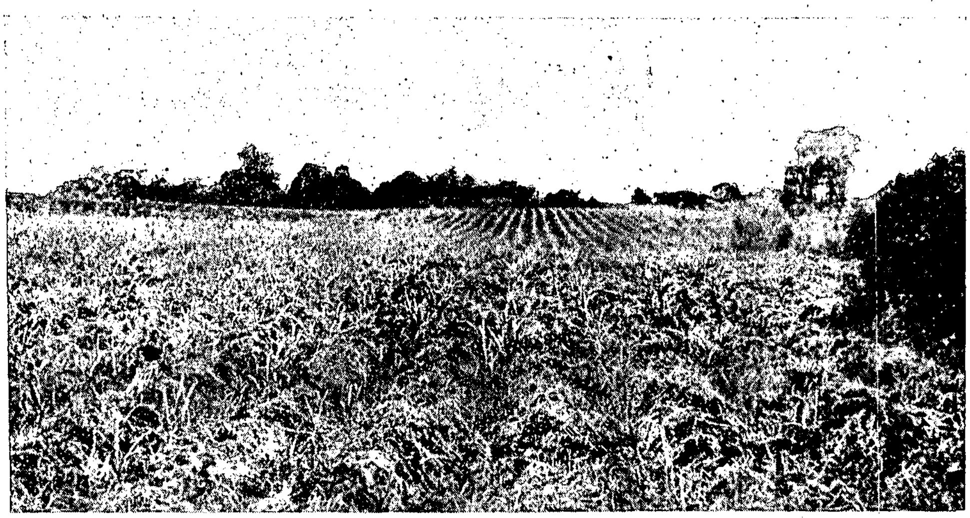
	Acres.	Per cent.
Area completely eroded to rock and shale...	21,699	19.1
Sheet eroded and overgrazed hillsides...	37,465	33.1
Cultivated, badly eroding areas	15,251	13.4
Area in fair condition	38,762	34.4
Total	113,177	100.0

EFFECT OF SLOPE.

To what extent does this gloomy picture apply to the sugar-cane crop, which is one of the best soil-holding and potentially soil-building crops in the world? A casual glance through the sugar belt shows that the good planters are apparently holding their lands, but a detailed examination exposes the fact that the percentage of properly contoured fields is lamentably low; that up-and-down planting of hillsides and slopes is quite common and that this practice is general among the Indian and Native small-crop gardeners fringing the sugar lands. In 1937, the late Alfred Townsend[5] presented the only paper up to now on soil erosion in the sugar belt. He said: "The agricultural and pastoral lands are our heritage, held by us in trust, and they should be cared for scientifically and handed down to future generations in a healthy productive condition. Is this being done to-day? My observations lead me to the opinion that we are guilty of much neglect. As an example," he continued, "the Verulam hill on the Durban side was leased by Indians in 1870. Heavy crops of mealies were produced in the first years, but to-day the land has become unproductive. This I attribute to continued erosion of the soil surface due to incorrect agricultural methods." To-day there are many more Verulam hills fringing the sugar belt. Mr. Townsend asked for erosion experiments to be carried out and a general investigation made under the direction of an experienced technical officer. That was eight years ago. Since, nothing has been done, and as there appears to be extremely little data on the effects of erosion factors on sugarcane crops, the following general statistics from overseas are of comparative interest. In the U.S.A. it has been found that with every inch



No. 2.—Cane field planted up and down a steep hill.



No. 3.—Cane field planted up and down a slope which could easily have been contoured.

No. 4.—Cane field ploughed on the contour.

of rainfall per hour on a sandy loam, the erosion loss of soil increases with the increase in slope as follows :—

Slope (fall).	Soil lost in pounds per acre.
4 feet in 100 feet	200 lbs.
8 feet in 100 feet	1,000 lbs.
16 feet in 100 feet	25,000 lbs.

From these figures, it is obvious that all steep slopes should be left under a cover of grass and that the slope of lands for ploughing should not exceed 4 feet in 100 feet.[2]

EFFECT OF COVER CROPS.

The rate of erosion with various cover crops has been worked out in New Zealand.[6] With a slope of 3 feet in 100 feet, the tons of soil eroded per acre per year is estimated to be as follows :—

	Tons eroded per acre per year.	Number of years required to erode 7 inches of soil.
Fallow 8 inches deep	42 tons	24 years
Blue grass	6 cwt.	3,045 years
Wheat	9 tons	100 years
Rotation	3 tons	368 years
Maize	15 tons	50 years

It is probable that sugar planters will rate their crops with the blue grass lands of New Zealand and consider that 3,000-odd years are good enough, without going in for all the trouble of remaking their farms on the contour principle. There is, however, another factor which should appeal—a factor which has not been explored, nor sufficiently emphasised when soil conservation is discussed—and that is the conservation of rainfall.

RAIN CONSERVATION AND ITS EFFECTS.

The amount of such conservation is naturally dependent upon the degree of slope and the condition and absorptive power of the soil. R. M. Gorrie,[3] in a paper on Indian soil conservation, writes : "Fields which, owing to steep slope or a hard-baked fallow surface, fail to absorb a reasonable amount of rain water, are bound to be the first to show crop failures. Contour trenching and ridging has the effect of adding many inches to the quantity of rain absorbed by the ground and the flora in the immediate neighbourhood of each trench, and often for many yards downhill from it, show a quite obvious ecological improvement."

The actual loss of rain from similar land under different cover has been determined in New Zealand.[6] The slope is not mentioned.

Natural bushland.	Stumps.	Maize.	Lucerne.
2.8 per cent.	70.0 per cent.	30.0 per cent.	2.2 per cent.

In the U.S.A. the figures given are :—

No vegetation.	*Vegetation.*
Run-off 16 per cent., causing a loss of 16.75 tons of soil per acre.	Run-off 0.3 per cent., a loss of 0.027 tons of soil per acre.

To what extent the conservation of rainfall might be achieved by the proper contouring of the farms in the sugar belt is unknown, but the statement by Dr. Bennett[1] that "conservation farming in the U.S.A. has resulted in an average increase in crop yields of 20 per cent," is worthy of notice; for if this could be achieved in sugar it would mean the growing of each quota on a smaller acreage, thereby releasing land for long fallows, other food crops and the keeping of more animals, which are an essential factor in the maintenance of soil fertility.

Dr. Bennett[1] says : "Essential crops of grain, vegetables, potatoes, cotton and soya beans are being produced at a rate one-fifth greater on conservation-treated farms than on untreated farms. This figure is a minimum. Frequently crop increases are much higher—40 per cent., 50 per cent. and more." Surely such statements by an eminent authority are worth trying out in our sugar lands of Natal.

THE HYDROLOGIC CYCLE AND THE SPEED OF RUN-OFF WATER.

The hydrologic cycle is nature's constant cycle of water evaporation and precipitation. What happens in between ?

When rain falls, a portion of the water evaporates before reaching the earth's surface. A further portion evaporates from the vegetative cover, which further breaks its fall and so alleviates the pounding action of the raindrops.

The portion that reaches the soil is partly used by plant roots in the process of growth and is largely transpired again into the atmosphere. A similar transpiration process takes place in the animal kingdom. Another portion of the water absorbed by the soil becomes evaporated in the top layers before it sinks to deeper layers, or becomes absorbed by the roots of grasses, shrubs and trees. These amounts depend largely on a number of factors, such as the physical structure of the soil, the temperature of the soil and the air above it.

The water which sinks deeply into the crust of the earth's surface feeds the underground water supplies, reappearing in the form of springs or boreholes; and, lastly, a portion of this water reaches the ocean by way of underground springs and streams. From the ocean and from surface pools, marshes, lakes and rivers the final evaporation of the hydrologic cycle takes place.

Considering this natural equilibrium, it is obvious that any derangement of the factors, such as the essential plant cover, will upset the balance of the hydrologic cycle, causing an acceleration of the speed of the run-off, which is the principal factor in water erosion. This speed of flowing surface water is obviously determined by the land slope, the condition of the surface—sun-baked or thatched by an impervious dead vegetative cover—the surface spread and the obstacles, that are placed in the way.

In order to control these factors and so combat soil erosion by water, the points to be aimed at are well stated by Dr. J. C. Fick.[2] He says :—

(a) "An increase in the cohesion and resistance of the soil against the water flowing over it. This can be obtained by maintaining the humus content and good structure of the soil and by keeping the vegetation growing on it in a healthy, luxuriant and dense condition.

(*b*) A reduction of the speed of run-off water—

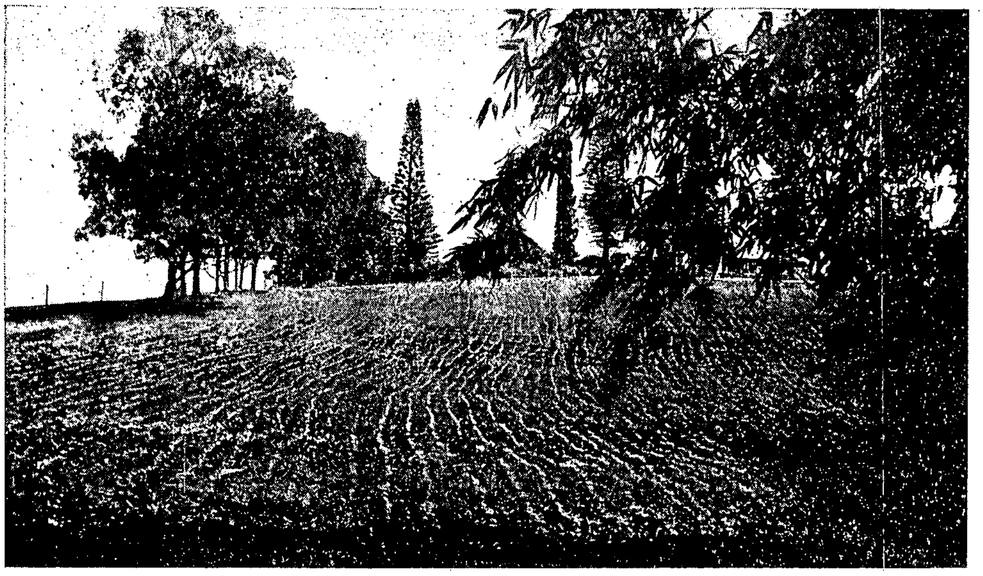
(i) by an increase in the number of obstructions, so that energy may be expended in overcoming them;

(ii) by increasing the length of flow;

(iii) by inducing the water to flow in numerous small streams and to prevent them from converging into large streams along distinct courses."

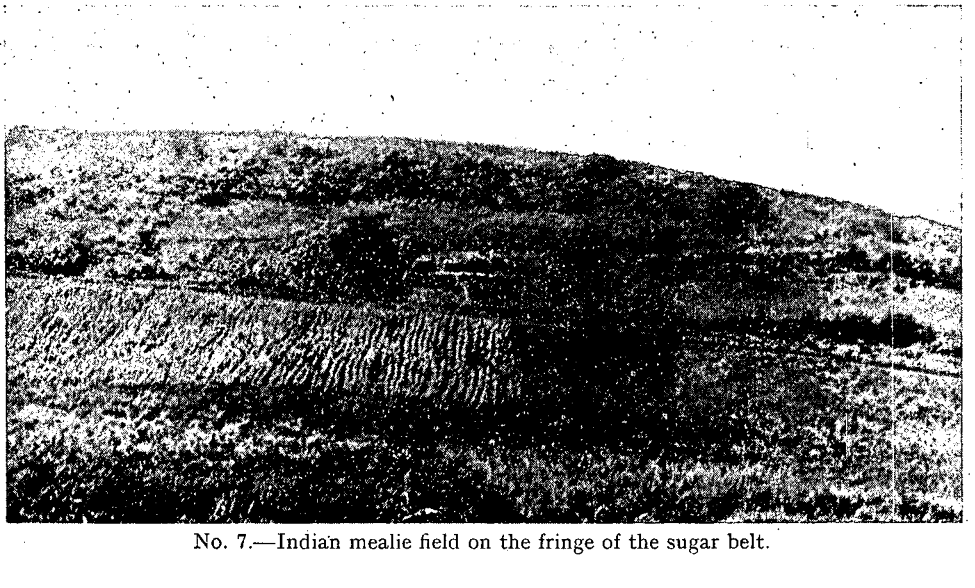
In a nutshell, all this demands a healthy dense vegetation and, in the case of ploughed land, the surface must be irregular and ploughed on the contour. Such a surface, especially in the light sandy types of soil, should only be exposed to the action of wind for the shortest possible time, otherwise sheet erosion occurs. This condition results from the ploughing of large areas and the enforced delay in planting owing to an extended period of dry weather. Methods to avoid this are tied up with labour shortage, length of the cutting season and the consequent out-of-season planting which has become such an unfortunate practice in more recent years. Here the work of Dr. A. McMartin in prolonging the germination period of setts by preventing infection of the exposed ends, should prove of great assistance in allowing a "plant as you plough" programme to operate independent of the weather conditions.

These are the general principles which must be applied in any land conservation programme. There is another—afforestation. In the sugar belt most of the natural bush has gone. Forested streams have been denuded of their natural trees and bush and put under the plough. The result has been the drying-up of these natural springs and streams and the eventual establishment of gullies and dongas, which are the sign-manuals of eventual widespread erosion.



No. 5.—A crop of beans planted up and down a slope.

No. 6.—Indian market garden on leased town lands.



No. 7.—Indian mealie field on the fringe of the sugar belt.

In Mauritius, the Government owns all the streams and vegetative cover for 100 feet on either bank of every stream and river. It is a pity that this wise national legislation was not copied and enforced not only in Natal, but over the whole of the Union. Every farm should have its woods and spinneys and in the stock districts isolated trees as well for sheltering animals.

MECHANICS OF CONTOURING.

Few farmers have the necessary mechanised equipment for contour ridging and ploughing. The question is a national one and can only be achieved by concerted Government and Provincial action. This war has witnessed the production of vast quantities of mechanical machinery for the moving of earth, the digging of trenches and tank traps, the preparation of air-landing fields and so forth. It has also witnessed the training of many thousands of expert mechanics, who can handle these bulldozers, road graders, heavy ditching ploughs and earth scoops; all of which, the men and the machines, can be employed directly after the war in a national scheme of contouring and terracing the large areas of the world's surface, which is in peril through erosion. South Africa can learn from New Zealand, who, through their Compost Club, have suggested that all organised bodies, the Women's National Council Institutes, Federations and Guilds, Chambers of Commerce, Rotary, Churches, Teachers' Unions and associations of all kinds, should pass resolutions calling on the Government to plan and begin organising this work at once. We have in this country the beginnings in the National Veld Trust.

THE DIVERSION OF FOODSTUFFS TO INDUSTRY.

There is one other subject I wish to touch on, and that is the increasing diversion of foodstuffs to industry. It was estimated that in 1930 New Zealand exported £50,000,000 worth of primary products, consisting of 250,000 tons of meat; 70,000 tons of wool and 140,000 tons of butterfat, thereby costing the country 460,000 tons of surface soil or 40 square miles of soil one inch deep. Added to this exploitation of a country's wealth of basic fertility comes Chemurgy—chemistry plus power.

In New Zealand the human consumption of wheat in one year is approximately 6½ million bushels. One automobile factory uses the same quantity of this essential food over the same period. The world is faced with malnutrition and slow starvation. Which will win—essential food for the people, or industrialization for the few?

Turning to sugar, we have a different picture, for sugarcane is the only crop in the world whose food product takes practically nothing from the land, *provided* its essential by-products are returned to the soil from which it came. Sugar is the product of the air and the sun, with an infinitesimal amount of mineral salts derived from the soil. Its normal by-products are cane tops, trash and roots, bagasse, filter cake and molasses.

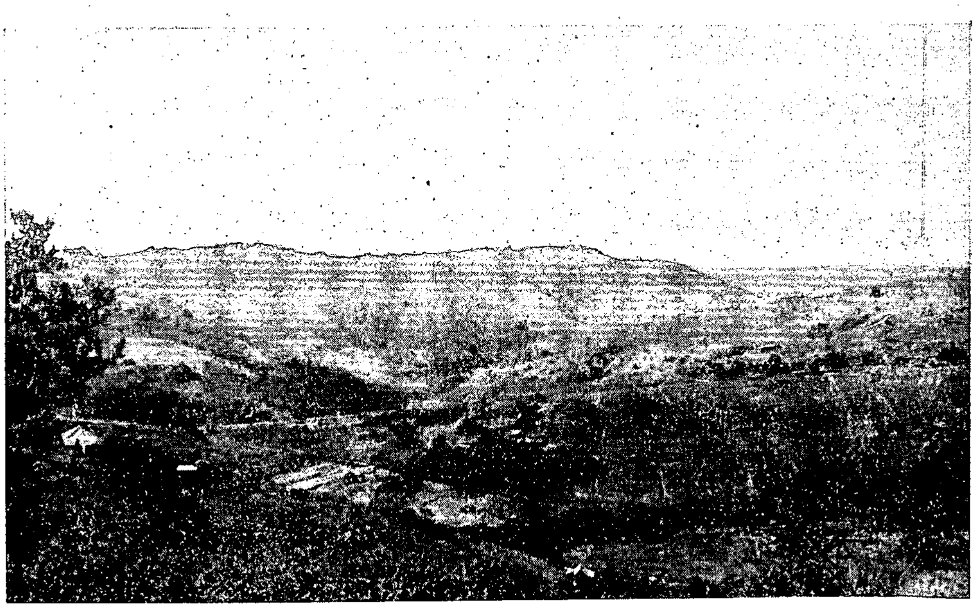
Cane trash and bagasse are burnt. Molasses is exported away from the sugar factories and, after fermentation, its by-product is destroyed or pumped into the sea. Only filter cake is returned to the land. The potential agricultural values of these sugarcane products have been exhaustively assessed in many papers presented to our Association, with the exception of bagasse, which has only been considered in terms of its B.T.U.'s.

Due to the high fibre content of cane grown in Natal, improved steam saving and raising efficiencies, some sugar factories have been faced with an embarrassing amount of surplus bagasse—embarrassing because of fire hazards and the difficulties of removal and storage. Such surplus bagasse has a potential agricultural value, whether it be used as a surface cover between the cane rows or is mixed with the filter cake or composted. An analysis of such an accumulated surplus gave the following results:—

	White. Unde-composed.	Brown. Partially decomposed.	Deep brown to black. Decomposed through heat.
Moisture per cent.	47.6	65.2	69.2
Calculated on dry substance:	per cent.	per cent.	per cent.
Loss on ignition	96.8	96.2	97.0
Ash	3.2	3.8	3.0
Nitrogen	0.25	0.28	0.28
Total P_2O_5	0.05	0.05	0.05
Total K_2O	0.07	0.07	0.07

On a crop of 5,400,000 tons of cane, these figures represent the following quantities, on the assumption that the total bagasse were available for other than steam-raising purposes:—

	Tons.	Tons per 1,000 tons cane.
Tons organic matter	912,600	16.9
Tons ash...	3,240	0.6
Tons nitrogen	270	0.05
Tons total phosphoric oxide	49	0.009
Tons total potash...	65	0.012



No. 8.—The non-contoured Indian gardens at Durban's back-door.

This bagasse, when composted with filter cake, animal manure and household refuse, yielded the following comparative results :

	Moisture.	Per cent. loss on ignition.	Per cent. ash.	Per cent. N_2.	Per cent. total P_2O_5.	Per cent. total K_2O.
		On dry substance.				
Bagasse compost .	67.0	43.2	56.6	1.2	1.8	0.6
Springfield compost	72.3	47.9	52.1	1.9	1.6	0.6
Filter cake	72.1	74.2	25.8	0.8	2.0	0.4
Karroo manure ...	10.0	40.3	59.7	2.0	1.0	3.9
Karroo manure ...	19.1	49.8	50.1	2.1	1.0	3.9

The actual food and the potential power and fertility values of the sugarcane crop are limitless. The application of soil conservation principles will increase the yielding power of our sugar lands, thereby enabling other essential food crops to be grown in a food-starved world. The conservation of normal by-products are sufficient not only to maintain a high level of fertility for sugarcane, but for other less fortunate crops and for an increasing number of animals per farm as well. There are enormous animal food values in cane tops, which represent approximately 486,000 tons each season; there is power and a limitless supply of raw material for Chemurgy in surplus cane. As food and a source of fertility and power the sugarcane crop stands alone.

References.

[1] Bennett, H. H.: Hold Your Ground. Free publication by the U.S. Office of War Information.

[2] Fick, Dr. J. C. (1944): The Abuse of the Soil. S.A. Interest Group (I.M.C.). Hortors Ltd., Cape Town.

[3] Gorrie, R. Maclagan (1944): The Place of Mechanised Equipment in Indian Soil Conservation. Jnl. of the Royal Soc. of Arts, No. 4681.

[4] Pentz, J. A. (1940): Soil Erosion Survey of Reclamation Area in Natal. Science Bul. No. 212.

[5] Townsend, Alfred (1937): Soil Erosion—A Problem Confronting the Sugar Farmer. Proc. S.A. Sugar Tech. Assoc. **11,** 139.

[6] Watkin, E. A.: New Zealand and her Trees. Compost Club publication, Auckland.

No. 9.—A hill of surplus bagasse of great potential humus value.

The PRESIDENT referred to the first illustration which was, he said, a scene he had often looked at with interest. As you came down the hill you could see the whole slope with the virgin bush on one side followed by a patch just cleared, the cultivated garden, abandoned land badly eroded and older eroded land with the thorn bush establishing itself again. He wondered whether the final closing in of the thorn bush would restore the fertility of the soil again.

Mr. DYMOND pointed out that although a few thorn bushes were growing in the abandoned area he felt sure that as both water and sheet erosion were taking place the gullies would win.

Dr. DODDS said that soil erosion should never be lost sight of in the sugar industry or anywhere else. Sugarcane cultivation was not particularly subject to soil erosion. The sugarcane was a good cover crop with an extensive root system, and the fact was that the land, especially where cane was not burned, was very seldom exposed to the weather and erosion effects of rain and wind. Nevertheless erosion was possible if the lands were not properly contoured. If our lands were to maintain their relative immunity from soil erosion this fact should be impressed on the industry, and the necessary implements for contour cultivation should be obtained if not already available in sufficient quantity.

The PRESIDENT said that the late Mr. Townsend originally brought this subject before us, but nothing had been done. It was hoped that now, with public interest so much more concentrated on this subject, this paper would mark a new beginning, and that something concrete would be done before the lamentable conditions which already existed in other parts of the country were reached here.