SOME ASPECTS OF EROSION OF FARM LANDS.

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With the realisation that the end of our virgin land is now definitely in sight, we in New Zealand are becoming more interested in the problems of land deterioration and soil conservation. Among other questions we seek to learn what part soil erosion plays in the deterioration of some of our farm lands.

The following remarks are baaed largely upon observations made on some of the clay hills of North Auckland - land formerly clothed in forest and now largely covered with pasture and scrub.

Erosion under Forest.

Erosion is the process whereby the land is gradually reduced to sea level. Under the native forest cover, streams, by down-cutting, over-steepen the valley sides, and adjustments generally take place by mass movements, such as slips. Everywhere throughout the for-at hill lands, arcuate scarps indicate the sites of former slips. Another process whereby the slope of the hillsides is reduced is that of soil creep. On steep slopes the soil and mantle of rock-waste gradually creep down hill tending to carry with it the vegetative cover.

A continual struggle appears to take place between the erosive force3 which tend to subdue the landscape and the native vegetation which tends to preserve the hillsides unchanged. The forest and its attendant litter layers absorb much rainfall. Thus the run-off is low and so impeded that it has little power to erode. The roots of forest trees anchor together the top and subsoils. On the steeper hillsides the curious curved lower trunks of the trees with their deeper roots trailing uphill evidence the forest's efforts to remain anchored and the forces tending towards the down hill creep of the soil. Under these conditions erosion proceeds slowly; ground bared by slips has time to be invaded by vegetation before another slip appears; bare rock has time to weather. Only in the most precipitous situations is erosion able to outpace the soil-forming processes and the growth of a vegetative cover.

Silt removed from hill lands in this way is carried down by the streams and spread over the lower-lying flats, but here, too, the process is comparatively slow. Only in time of flood is the process of deposition temporally able to outpace the process of soil formation.

Changes brought about by Farming.

With the coming of the farmer forests are felled and burnt; the hillsides sown in grass, and thus begins the process of changing a forest soil into a grass soil. Every plant modifies the soil beneath it, and when grass displaces forest it immediately commences to modify the soil until what was originally a forest soil becomes a typical grass one. The litter layer of the forest disappears and a grass humus layer forms below the surface of the mineral soil ; but where the grass cover is incomplete this is poorly developed, and much bare ground is exposed. The strong roots of the forest trees are replaced by the finer and generally shallower roots of the grassrs. The surface soii becomes more compact.

By far the greatest change, however, is the change in the soil moisture status. Under the grass cover less rainfall is absorbed causing increased run-off and wider fluctuations in the moisture content of the soil. With more water passing over the surface of the soil, sheet erosion becomes important wherever the soil is unprotected by vegetation. In dry periods the soil becomes more parched than it had normally done under forest cover, anti cracking of the ground becomes more prcnounced. The alternate wetting and drying of the soil, with its seasonal cracking and swelling, weakens the soil mantle and tends to speed up the process of soil creep and slipping.

Under the forest cover slipping was slowly taking place. Indeed the shape of the hills themselves was due largely to the forest. However, a hillside in balance under forest is not necessarily in balance when clothed in grass. The soil tends to move into the valleys more quickly, forming easier slopes which can be grass-control led. This causes the upper slopes of the hills to become steeper. More bare rock is exposed and the run-off further increased. The scars we see disfiguring the steeper hillsides are thus seen to be due to the acceleration of the process normally taking place as part of the erosion cycle under forest. The cause of this acceleration is due to our interference with the plant cover.

Owing to the increased run-off, streams draining the hill land, flood more frequently, and alluvium is deposited more rapidly over the low-lying flats. At first the alluvium is largely derived from the hill topsoils, but as the erosion of the hills continues and the flooding of the streams increases, the flats are covered with coasar and less fertile alluvium.

Chief Types of Erosion Observed.

The chief types of erosion observed were sheet and slip erosion.

Sheet Erosion is the removal of a thin, more. or 1 ess uniform, covering of soil during rains producing run-off. To the casual observer there is nothing very spectacular to be seen - just a general impression of deterioration. Soil with a close cover of pasture grasses is effectively protected from this type of erosion but where the ground is bared, e.g. after a for'-st or scrub burn, or when the pasture is open, allowing of much bare ground, this type of erosion attacks the uppermost and most fertile layers of the soil. The practice of continued burning of second growth and roughage is one of tha chief causes of deterioration by sheet erosion.

There is another aspect to be considered. Unless the grass cover is kept continuously the process of forming a grass soil, is delayed and there is no steady progress towards the desired permanence. To alternate scrub and fern growth with grass upon a hillside is somewhat akin to rotating crops. The turf cover is weak and parts of the grass humus already built up are eroded away when exposed after a burn.

Slip Erosion is the moving down the slope of large blocks of soil. Ths topsoil may slid? over the subsoil or both the topsoil and subsoil may slide from off the weathered rock material below, or else all these horizons may together slid? from off the undecomposed rock.

On the clay hills of North Auckland slipping appears to Se of two kinds. There i s ashallow slipping which appears to be tha accelerated form of the normal soil creep that. takes place under forest. The soil, weakened by the cracking and swelling in wet and dry periods, and being no longer supported by the roots of forest trees, tends to move downhill at a *greater* rate. During dry summers rainwater flows down the cracks until

it reaches an impervious horizon when it percolates downhill sometimes reappearing at the surface lower down the slope. Water entering in this way lubricates the subsoil above impervious horizons and induces slipping. In some places the hillsides are covered with shallow slips induced in this way. Where. there is a strong and complete grass turf more rainwater is absorbed and the ground does not crack so readily, but where the grass humus layers have either not been built up or have been removed by sheet erosion the ground cracks badly and shallow slipping quickly takes place.

The larger slips, however, do not appear to bear much relation to the type of grass cover. As already stated, they are the accelerated phase of the slipping process normally taking place under the forest cover. Bollowing the destruction of the forest, the weathered rock mantle is weakened by the greater moisture fluctuations. Hence these slips appsar at their worst some years after the forest has been felled and especially when an exceptionally vet season follows an exceptionally dry one.

They nearly all move forward on impervious horizons over which ground water is seeping. At the back they leave steep arcuate scars on which are exposed the underlying decomposing "rock and *it* is this back portion of the slip that is most difficult to grass. The slipped portion moves forward and downward to form the toe of the slip. On some slips. the grass covering of the toe is preserved largely intact but in many places the excessive run-off from the bare ground at the back of the slip, quickly cuts the toe into channels.

Erosion Control.

From a consideration of the foregoing, a few general principles in erosion control emerge* Any agricultural practices tending towards the strengthening of the pasture cover, e.g. seasonal spelling and the sowing of turf-making grasses, minimise the danger of erosion and assist in the formation of a permanent grass soil. Those practices which tend to weaken the cover such as over-grazing and the frequent use of fire to control second growth have the opposite effect.

For permanent grassland however our hillsides must be in balance with the grass cover and there are many grassed hillsides which are so out of balance that great changes must follow their continued grassing.

Where the soil is underlain by rocks that weather slowly and are low in plant foods the steeper and most unbalanced slopes will tend to become more and more infertile until. their production becomes very slight indeed. Even if we do manage to grass the slips we must realize that each time a slip occurs a certain amount of bare rock has been exposed and much of the soil surrounding is left in a shallow and infertile condition. Whe re the underlying rock weathers more rapidly to produce a fertile soil this does not apply. What we need is more knowledge as t o thelimits of slop.5 on each soil type which we can grass with some hope of permanent success.

The most obvious solution of the problem, and it is one that is practised by many progressive hill country farmers, is to grass the slopes that seem capable of being grass controlled and to leave the more intractible parts to the native vegetation. Land farmed in this way certainly presents an appearance of permanence and beauty. Moreover, it is the method adopted by some of our early settlers from Bohemia, men who probably brought with them a tradition of hill land farming.

There is, however, no set cure-all for erosion, each area needs to be studied in the light of its own special conditions. Even were we satisfied that, in the longrun, we could with certainty grass a watershed, we must remember the farmer on the flats downstream. It is Imperative to him that the flooding of his land be controlled and the only way to do this satisfactorily is to decrease the rate of run-off upstream. We must consider whether grass as a cover reduces this run-off sufficiently. Added to this is the question of water conservation, which is outside the scope of this paper.

Since these difficulties have been brought upon us by our interference with the vegetative cover it follows that the only satisfactory form of control is a vegetative one. This is in accordance with the experience overseas. In the United States of America and elsewhere, purely engineering control has been tried and found wanting.*

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* E.S.Clayton, Soil Erosion, Extract Agr.Gazette N.S.W.1937.p9.

DISCUSSION,

E.B. Levy:

Mr. Taylor has opened up a very important grassland problem. It looks as though on some of our hill land we will have to retreat a little way. Anyhow whether we have done all that we might have done in the past from a grassland -point of view to prevent what Mr. Taylor has shown us remains yet to be seen, and I feel that it is important in regard to our hill lands to have *some* idea what can be grassed and what should be left to go back to forest. Mr. Taylor; I am sure you will agree, must be heartily congratulated for bringing this subject before the country and we thank him very much for bringing it before the Grassland Association.

H. Woodyear-Smith:

I agree with the Chairman that Mr. Taylor should be heartily congratulated on the material that he has presented us with this morning. Mr. Taylor has dealt with North Auckland conditions and there is *no* need for me to touch on that point in that district, but it occurs to me to wonder how many of us have studied this question of hill country farming. It has not been given the same degree of thought as the lower country has. These pictures we have seen this morning show a rather deplorable state of affairs on some of that hill country in Morth Auckland, but it would be difficult at this stage to suggest necessary remedies. *One* wonders what the position is regarding the hill country in other parts of New Zealand and whether there is any relationship between soil erosion and the amount of production on some of our hill country areas. Does the nature of soil erosion have anything to do with our enormous annual bill for repairs through floods, silting and dis-location of public services? It is interesting to note that in the last four years there have been one hundred and seventy reports of major floods in the Dominion whereas thirty-five to forty years ago there was nothing like that number of floods anywhere in the country over a period of four years. It was assumed that during the last two years - 1936-1938 - that the bill for repairing, clearing railways, clearing slips, repairing roads, bridges, amounted to something like three quarters of a million pounds, but that did not take into account the damage that was done to hill country pastures or loss of stock. We have only to refer to some of those workers on erosion overseas to find that the position is really becoming very terrible indeed. In America soil erosion is a serious problem, also the same applies to North Africa and today in South Africa they have large areas of deteriorated lands which was attributed to soil erosion. It might be said that this process that you saw on the slides and the film are natural ones. So they are in a sense but they are man induced in many cases. It would be a serious thing to this country, although it is such a wonderful grassland Dominion to allow our hill country areas to virtually become man made deserts. Mr. Levy in those wonderful slides he showed last night showed quite clearly in Austria and Switzerland that -people on the hillsides had throughout produced a type of farming that was suitable for holding their soils in place and one noticed the forest covering slopes somewhat like that picture and slide that Mr. Taylor showed when a 'crank' tried to conserve his soil, It seems that these questions are not fully understood and I think that Mr. Taylor has opened up wonderful avenues. We used to think that surface sowing would favour the position in many cases. Should we use fertilisers to overcome the' difficulties or f-arming and

stock manipulation. Those things we do not know and it would be interesting to hear from any of the people here if they have any suggestions to make along these lines.

E. A. Madden:

I would like to congratulate Mr. Taylor on his paper. I think it has opened up a very big subject. I think also the matter Mr. Woodyear-Smith mentions should be investigated and we should sow seed over these slopes. The regrassing of slopes in Taranaki has done much to prevent a certain amount of run-off. It is debatable whether trees, forest, actually do stop much of the surface run-off, I have been told that in our New Zealand forests for a very dry forest requires only 1" of rainfall to wet it thoroughly, One does not see that there is very much hope of having the country in forest there is much hope of preventing erosion.

F. R. Callaghan:

Mr. Taylor has brought up a number of useful new points. I think it is worth paying some attention to the type of country, say, the geological formation of the actual action of the soil and the character, and the rainfall. In the Waipu District the picture showed a contrast with the Hokianga District. I think there is a difference of soil in the two districts, In Waipu the grass grows under much more difficult conditions than in the Hokianga District, i would like to hear from Mr. Taylor some remarks on wet country erosion, where you get hard fern and scrub. i would like to hear the part fern and scrub played where established at Waipu, It would seem that poor ground which it seems to be very seriously affected with soil erosion.

Prof. Riddet:

I feel that the auestion of soil erosion, the question of land utilization in New Zealand, the question of grassing are of vast importance to the welfare of our country and future, Perhaps we are less conscious in this country of soil erosion. I was especially interested in the attention being given to the question in the United States of America, Travelling through those devasted areas it was terrible to see how the people there suffer. They do suffer enormously. In Great Britain we are firstly impressed by the great number of trees which we see, They are employed as shelter. This shelter has not merely grown up. It is the foresight of the farmers and they are benefi ting from the results. We are living in a country of very high rainfall, a country subject to all types of erosion. We pass through places which have been settled for a number of years and we find most of the forest cut out, We find that the old settlers had the foresight to plant something in its place. One of the wide differences one sees between here and overseas is the enormous difference of shelter , for no attempts have been made to protect our soil and I join with others in congratulating Mr. Taylor in drawing attention to this important point.

N.H. Taylor: I do not know that I have very much to say. With regard to Mr. Madden's points here again is useful work in bringing our attention to the fact that we do not really know whether run-off under forest or under ground is greatest. At the same time I think the general statement that the run-off under forest is less than under grass is substantially correct, but at the same time I agree with Mr. Madden , as I said in my paper erosion has always been going on and we have got to carefully measure the increased erosion that man has caused, Prof. Riddet mentioned the amount of

suffering abroad that is being caused. I might venture to say that there has been not little suffering in New Zealand. I think if we meet some of the families that have come from those parts of New Zealand, that are now sadly deteriorated and abandoned, we will hear quite a tale of suffering from them, We have in the past been inclined to pass by those areas and say that it is a bad farmer, but in many cases he has done his best.
