Papers on Erosion Control, Soil Conservation and Watershed Management to International Forestry Meetings

Sadao OGIHARA

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Proposal

(1) Considering it too broad and abstract, deliberate discussions are desirable to be made to formulate a more concrete and realistic definition of "watershed management. This problem has been discussed and is still being discussed even in USA, who was the producer of this term together with "conservation".

(2) It is necessary to make efforts to establish a set of principles of "soil and water conservation", the definition of which has already been made clear.

In dealing with the above two problems our efforts should be directed from the standpoint of a working party in Asia Pacific Forestry Commission, FAO.

Suggestion

1. Definition of watershed management

In Report on the Development Center on Watershed Management India 1957, "Watershed management" is explained as follows:

Watershed management implies that all usable land has more than one use and of those several uses, the production of water is one. The object of watershed management is to meet the problem of land and water use not in terms of any one resource but on the basis that all resources are interdependent and must therefore be considered together. It includes the concept that what one man does to his land within the watershed may have a considerable effect upon the management and productivity of the land belonging to a neighbor.

From this we understand the idea of watershed management. But as regards the definition of watershed the above explanation is still indefinite; Does this watershed mean a large river basin such as the object of TVA or DVC? Moreover, when we intend to treat this problem as an item in forestry program, a more specific and concrete

* For the Working Party of Watershed Management.

definition of our watershed is desirable. Otherwise, the discussion would be too extensive and conflicting with other fields such as agriculture, water engineering, city planning, etc.

In doing so, it is suggested to begin with the understanding that

there must be the difference between our watershed management and overall development of a river basin, and

that

the former is a part of the latter.

2. Point of discussion

(a) Definition of watershed

Our watershed is a part of large river basin taken as a unit for watershed management. As long as it is dealt with in forestry, the watershed should naturally be closely related to forest and range management. Accordingly, the watershed in question is that which was originally covered with forest and where forestry has been and is a principal type of land utilization. Grazing land, as managed in most cases by forestry agency, can be considered simillar to forest. Arable area developed afterward is another member of the watershed.

In short, our watershed is specifically defined as:

(i) that, from the standpoint of land utilization, where forestry, grazing and or arable land uses are predominant,

(ii) that, in regard to location in a river basin, which is located mostly in the upper reach,

(iii) that, in regard to topography, which is comparatively steep, mountainous or at least hilly.

(b) Object of management works

How a unit watershed is managed affects the condition of the whole river basin. Therefore, each unit watershed should be managed in such a way as to contribute ultimately to the benefit of the whole river basin to which it belongs. At the same time it is required that land use and water production in each unit watershed are managed profitably and durably for its own sake with due consideration for the interdependence of all resources.

Here a question arises as to which the first object of a unit watershed management is. Is it for the sake of individual unit watershed or for the sake of the whole river basin? As for very productive unit watersheds their increased production plays an important part in the economy of the whole river basin. On the contrary, poor watersheds can contribute to the whole river basin only in such a way that they do not produce flood water and harmful sand and debris. Thus, the type of management differs according to the condition of watershed. These are the reasons why we find difficulty in giving a simple and concrete definition of the object of watershed management.

But, if we review the foregoing sentence referring to productive unit watersheds, we

notice that the productivity can not be expected without the stabilization of soil. Now, let us remind the term "soil and water conservation". Soil is a resource which is basically important and can be used as a representative of living resources growing on it. Water is also a valuable resource indispensable for living things and the demand for it is increasing rapidly with the development of modern industries. Both of soil and water, when they move in exessive volume, cause disasters. Shortage of water brings about drought. Soil movement is desirable to be as slow as the pace of normal erosion.

Soil and water conservation can be applied to both productive and unproductive unit watersheds as the most basic principle of management. It is reasonable to suggest soil and water conservation to be taken as a simple but basically important definition for the object of works of the watershed management.

General Paper to Fifth World Forestry Congress

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I. General description of forestry erosion control

1. Introduction

Japan has many special features in her natural as well as social conditions. High mountains in small area cause rivers torrential and wild in nature. Moreover, the country is known for her terrible typhoons, earthquakes and volcanic hazards. The above facts tell that the people of Japan have long been greatly suffered from natural havocs as landslides and floods.

Unlike those of America and other continental countries most of erosion disasters of Japan have been brought about by the downstream basins' being covered with sand and debris from the headwater areas. The eroded sites themselves which locate high up in the mountains are almost neglected. The farm land and urban centers in the flat land have more economic value than the forested land in the mountains. Damage to the flat land is usually overestimated, while damage to the forested land is underestimated. Large scale civil engineering projects such as levees and high check dams attract the attention of thousands of town people, but few are aware of the inconspicuous but essential part that forests play in soil conservation and flood control. Whenever Japan has suffered from serious flood inundations, the public has demanded that the forests be given more attention. But as the floods are forgotten, the public turns its interest to more immediate issues.

The repeated flood disasters caused by the reckless destruction of forests during and after World War II and the visits of typhoon almost every year have awakened the people of Japan to recognize the importance of forest conservation. Thus, the govern-

ment budget for forest restoration and conservation has become larger year by year together with the increase of that for public works for the safeguard of national lands.

2. Erosion control works

The modern method of erosion control, though its principle was introduced from European countries, has gradually become peculiar to Japan until there appeared many projects in Japanese type. As a whole, the work of preliminary constructions of check dams and bed sills is first carried out in the lower reaches of wildrivers. This work is carried out mostly by engineers of the Ministry of Construction.

Then, the work begins on the denuded slopes of the mountains where gullies have been formed. At this stage, Forestry Agency of the Ministry of Agriculture and Forestry takes over the direction of operations. Besides, upper parts of wild rivers, i.e., small tributaries are also controlled by foresters. The principle, "more small dams than one larger dam" is observed in this case, since the principal objective of check dam is not to keep large quantities of eroded materials but to decrease the slope of stream bed so as to mitigate the erosive force of torrent in order to attain the ultimate objective of stabilizing the bases of mountain slopes facing the stream.

As soon as the preliminary process is accomplished, the work on denuded hillside is carried out. The first step to be taken is grading and smoothing of the uneven features of denuded slopes. After grading, small horizontal terraces are built at a vertical spacing of 1 or 2 m. The soil excavated in building terrace is left at the site in the form of staircase and is held together with sod wall which covers rice straw to improve the soil condition. The dimensions of these sods are about $20\times30\times5$ cm; they are collected in neighboring areas and used to hold the steps, which are thus faced with sods both at the front and on the top. The step is about 0.3–0.4 m in height and 0.3–0.6 m in width.

Where the sod is lacking, brush or even stone wall is used as a substitute, following the principle "use proper materials easy to get from neighboring areas". The purpose of step construction is to make a good local condition of soil and also to furnish a foot step convenient for tree planting. When the slope is not very steep and the mantle of soil is rather deep, Miscanthus stocks are set along the front edge of the step work. The work has been put in practice throughout Japan with success. But it is to be noted that this method of hill-side recovery is not favorable for the place where the soil is lacking in cohesion under the influence of heavy weathering and frost in the ground. In such place a method of covering the ground surface with fascine and straw is recommended.

Tree seedlings are planted with spacing of about 0.5 m on the step.

3. Vegetative control

A. Tree planting

On slopes of less than 25 degrees, with fairly regular features, and rather deep soil,

trees can be planted without any special supplementary works. Ordinarily, however, the objective of planting can better be attained on the stabilized ground surface by some engineering works mentioned above. Tree species used for erosion control should be suited to geological and climatic conditions of the working site. Planting should be done soon after hillside works are completed or at the same time the terracing is done. The trees have to mature against surface soil movement. The planting should definitely be done in seasons favorable for germination and rooting.

Planting of shallow-rooted species, such as alders, is preferable in order to stabilize ground surface as quickly as possible. Then deep-rooted species, such as pines, should be planted to replace the shallow-rooted species. When this is done the first planting can be utilized as fertillizer to the second. Erosion control planting should be conducted with closer spacing than usual because of the low survival percentage. Seedlings should be trimmed a little more heavily than usual in order to keep a balance between transpiration and absorption of water. After planting, the young trees must be tended carefully and fertilized to supplement shortage of nutritions in denued areas. Calcium super-phosphate and ammonium sulphate are effective. Ash and chicken droppings are used very widely.

Effective trees for erosion control are:

(1) Pinaceae: Evergreen deep-rooted tree. Owing to a few lateral roots, it is not effective in preventing surface erosion but is very effective in combining surface soil layer and bed rock. Mature trees have great commercial value besides the function of erosion control.

(a) Aka-matsu *(Pinus densiflora)*

(b) Kuro-matsu *(Pinus Thunbergii)*

(2) Butulaceae: Has vigorous reproductive power. Grows under adverse conditions and has a good soil building root system.

(a) Yama-hannoki *(Alnus incana)*

(b) Yashabushi *(Alnus firma)*

(c) Hime-yashabushi *(Alnus pendula)*

(3) Salicaceae: Widely used, because of vigorous sprouting power.

(a) Bakko-yanagi *(Salix Bakko)*

(b) Inukori-yanagi *(Salix integra)*

(c) Yamanarashi *(Populus Sieboldii)*

(4) Leguminosae: Most of leguminous plants absorb nitrogen in the air. Widely used for poor land improvement, because of hardiness against infertility and dryness.

(a) Hagi *(Lespedeza bicolor var. japonica)*

(b) Nise-akashiya *(Robinia pseudoacacia)*: Originated in U.S.

(c) Nemu-no-ki *(Albizzia Julibrissin)*

B. Grass covering

As a preliminininary measure, grass covering is sometimes very effective on slopes where surface erosion is severe. Most grasses can grow on less fertile soil than trees.

Their roots, although small and fine, have vigorous thriving power and quickly stabilize ground surface. Grasses most commonly used for erosion control are:

Kaya	*Miscanthus sinensis (Gramineae)*
Itadori	*Polygonum cuspidatum (Polygonaceae)*
Medo-hagi	*Lespedeza juncea var. sericea (Leguminosae)*
Kawara-yomogi	*Artemisia capillaris (Compositae)*

Many other kinds belonging to the above-mentioned families are suitable for ground surface fixation.

Most grasses are sown, except Miscanthus which is stock planted. Sowing grasses in mixture is effective, because they utilize space in both soil and air according to different degrees of development of root systems and stems above the ground. Large quantities of seeds should be sown because germination and survival percentage are less on exposed areas in need of moisture.

After World War II Kentucky 31 Fescue and weeping love grass were imported from U.S. and have been tried in many places throughout Japan with success.

II. Current problems in forestry erosion control

1. Recognition of forest influence against natural disasters

One of the most serious problems we are now facing in forestry erosion control is the fact that here in Japan extraordinary heavy rains often cause landslides on steep mountain slopes despite of good forests. A landslide results in not only the production of mud and stone flow but also drifting timber which increases the destructive force of flood. Most river inundations are attributed to damming-up caused by the drifting timber at bridges. It is true that our people have believed that forests furnish absolute protection against natural disasters including soil erosion and flood. However, several instances of destruction of fertile forest land have disproved this belief and even an opposite criticism has risen among intelligent people. The Japanese people are now more scientific in their views and no longer accept old belief with blind faith.

Recently our foresters, particularly concerned with erosion control, recognize definitely the margin of erosion control power of forest as follows:

a. A forest is almost absolutely effective against surface erosion.
b. It is relatively effective against shallow erosion occurring in soil layer occupied by tree root system.
c. It is non-effective against deep erosion having a plane of rupture in a depth beyond the reach of tree root system.

As regards the deep erosion it might happen that a forest gives an unfavorable influence in allowing the soil to absorb excessive rainwater which is one of the most powerful causes of landslide. Cynically the forested area in danger of deep erosion is the site where we can expect a useful function of water control. We must, therefore,

remember that the collapse of the forested land brings about threefold disadvantages: the decrease of water conservative function, the production of harmful mud and stone flow together with destructive drifting timber, and the loss of forest resource. Here, the importance of prevention of forest destruction is well convinced. "An ounce of prevention is worth a pound of cure" is true and should be put in practice in the future.

Nearly one hundred percent of our forestry erosion control was concentrated to repairing or restoring of denuded forest areas. However, a few years ago, a work of precautional character was begun under the name of "Precautional Forestry Erosion Control Work, aiming at protecting sound forest areas from natural disasters, especially the attack of extraordinary heavy rains. The principal operations of this work are the construction of check dams in order to stabilize the bases of steep forested area as well as the construction of outlet channels to drain excessive surface runoff and control the infiltration to the minimum. The new work has been paid greater attention and given more fund year after year. At first, the project was started chiefly in national forests but it has gradually been extended to prefectural and private forests.

2. Characteristics of vegetative control

In Japan the natural conditions such as geology, topography and climate necessitate carrying out a considerable amount of structural works in order to assure successful vegetative works. Although the complete cover of all mountainous areas with green is the the ultimate objective in forestry erosion control it will not be realized without the aid of structural works and even the completed green cover will be destroyed for lack of structures. It is natural that in upstream areas the vegetative work takes a major part and the structural work is of subordinate character, just as the reverse relation is observed in downstream areas. Here we must notice that there is an essential difference between the above two works from the standpoint of working practice. Under the highly developed mechanization of today any structural construction can be completed in a comparatively short period, if sufficient fund is available. One can see a good example in "Sakuma" Dam, one of the largest hydro-electric power reservoirs in our country. It was estimated to take at least ten years for the completion of this dam construction. But practically it was built up in only three years with the help of U.S. enginees and machines.

The vegetative work is not so simple. We can plant seedlings on thousands of acres in a few weeks if the planting fields are ready for and sufficient material and labour are supplied—that means the monetary background. But this can not be said to have attained the final objective. Because we can not expect the function of erosion and water control until the planted seedlings mature. Usually it takes several ten years. With respect to water conservation the soil condition improved under good forest cover is regarded much more important. The above reasons tell that it requires many years for the completion of a forest building. Moreover, trees are very weak against natural

havocs when they are young. Forest building should be hastened in non-disastrous periods. When peaceful weather continues for years many people are apt to forget the misery of disasters and to regard the tree planting a slow and tedious enterprise. But one must be convinced that a stabilized climatic condition gives the greatest opportunity for seedlings to be grown up rapidly and vigorously.

Considering the difficulty of long term weather forecast, we come to a conclusion that the quickest way to complete the establishment of forests strong enough to control erosion and flood is to begin tree planting today and to continue it steadily and constantly with proper tending and care including prompt aid to planting when they are damaged by unexpected natural disasters.

3. Ten year plan of erosion and flood control

Last year 1959 was an epoch-making period in our history of disaster. Typhoon No. 7 of August 14 and No. 15 of September 26 caused flood damages in several mountainous districts in central part of Main Island. Moreover, the latter brought about a record-breaking high tide in "Ise" Bay which caused the loss of nearly 6,000 lives and the devastation of the industrial center in Nagoya City and rice fields developed recently along the bay. The high-tide disaster was so great that the inland floods were made dim to general people of Japan.

Now let us compare flood disaster with tidal disaster. Naturally the damage is severe when a high tide attacks a developed and densely populated seashore. But, the occurence of disastrous high tide is much less frequent than that of inland floood. The flood occurs at least once every year. As regards the total amount in a considerable length of time the flood damage exceeds the tidal damage. After Typhoon No. 15 various opinions arose for the need of a strong measure of natural disaster prevention in the future. Some insist upon the urgency of seacoast protection, while others support the importance of flood control. Government listened deliberately to the advices of scholars and specialists as well as politicians. As a result, Ten Year Plan of Erosion and Flood Control (including high tide prevention) was established and pushed forward among policies for the fiscal year of 1960. The cost of this work is estimated at 1,050 billion yen which corresponds to 67% of the total of national budget for 1960.

We pay respect to the government attitude for its far-sighted decision in planning the counter-measures for typhoon disaster. Erosion and flood control is given a greater weight despite the fact that the people concentrate their sympathies to the tidal damage they witnessed last year. In all works precautional measures are stressed together with restoration work. We sincerely hope this ten-year plan will be materialized in full.

4. Development versus conservation

Development and conservation have been regarded as being contradictory to each other. It has often been the case that accessible resources are likely to be improperly

used, which leads to devastation. But the intentional misuse of land and resources is strictly prohibited in the principle of real conservation. The accessibility necessary for resource development is also of great value from the point of view of conservation. However careful we may be, we cannot be entirely free from natural disasters. Some misfortunes may happen despite our sincere efforts.

It is desirable to repair devastations while they are slight. In doing so, a constant watch for changes in the resource situation is required, and the development of a road network is the only way to achieve success. The works of repair or prevention can be carried out more smoothly and economically where we have easy access to the area. We know that in remote watersheds there are many naturally created devastations on a large scale, producing harmful surface runoff, together with sand and debris. Their adverse conditions cannot be improved, for lack of accessibility. The development of virgin areas is important not only for the increase of available resources but also for the repair of natural devastations which have been untouched until the present time.

Without mankind, there is neither development nor conservation of natural resources. If the principle of conservation is faithfully observed, the development of accessibility will do us a favor in two ways: the exploitation of new resources and the transformation of idle land into productive land through human conservation activities. Now our experts in forest road construction and erosion control are going to work together with full understanding of the interdependence between development and conservation of forests.

Summary for lecture

When we discuss the forestry techniques in erosion control, it is necessary to recognize the preventive function of forest against erosion. Erosion on steep ground is classified into two types: (1) "Shallow Erosion"—in other words, "Surface or Sheet Erosion" including "Gully Erosion"; (2) "Deep Erosion"—or "Massive Erosion" such as landslide or landcreep.

On rolling lands seen in continental countries like America, India and others, where the surface erosion is dominant, the establishment of forest cover is the major part of erosion control works. But, in small and mountainous countries, among which Japan is a model, the problem is not so simple.

It might seem unusual to most of you, if I say that the forest is not almighty in erosion control. But it is true in our case, because under heavy rains deep erosions often occure on steep slopes in spite of good forest conditions. Good forests require soil layers of certain depths, even when they exist on steep slopes. When these soil layers absorb exessive amount of rainwater, they become susceptible to slide. Unfortunately a landslide of forested area results in not only the production of mud and stone flow, but also drifting timber which increases the destructive force of flood, causing collapse of river banks and damming-up at bridge sites.

However, it is also true that if there is no green cover on a steep slope, the surface erosion is severe even under a little rain due to greater rate of surface runoff, and that if it is covered with a dense forest, the surface runoff is controlled, causing little surface erosion so long as the forest holds its position.

Here we have to find out some way to protect steep forested areas from massive erosion. This is the very problem we are now confronting. Practically, it is difficult to know beforehand which forest site will slide under the next rain, because the geological episodes take much longer and more complicated intervals than those of human. There are great many forested sites seemingly dangerous. To carry out precautional measures for all of such areas requires a huge amount of expenditure.

From the above relation, we recently revised the principle of erosion control on steep slopes as follows: (1) The planting on denuded areas should be carried out as in the past or rather more extensively, if the fund is sufficient; (2) Add to this, proper engineering measurses should be taken in order to protect steep forested slopes from massive erosion. In doing so, it is wiser and more economical to begin the works from steep slopes facing main streams and then proceed to upstream of tributary areas.

In short, "Protect forests in some cases and expect their greater effects in land preservation and water conservation." The erosion control works, especially engineering constructions, require accessibility to the spot in order to carry out works smoothly and economically. In this view the watershed development and conservation should go together.

Paper to the Thirteenth Congress of International Union of Forestry Research Organizations, Vienna, September 1961

The role of forests and engineering structures in the control of flood and erosion (Japan)

Abstract

To countries with small area, steep mountains, erodible soil and heavy rains, flood disasters are fatal. Forest, though not absolutely effective, has acted as a powerful mitigator of the flood energy by controling flood water as well as sand and debris.

In Japan even a small scar on forest area affects the harmful energy of flood. Our ancesters were forced to keep their watersheds green to lessen flood damages, and this effort is considered one of the reasons why we are now enjoying one of the most green territories in the world.

But, with the increase of population followed by the development of downstream area, the increase of flood damage has been accelerated. Now we have to take measures to prevent or at least to minimize harmful runoff and erosion, which were formerly

regarded as unavoidable. The necessity of the supplementation by structural measures should be thoroughly understood in the future plan of flood and erosion control. It should be so, even when the plan is made for forest area by foresters.

1. Review of erosion control history

Japan is a world famous museum of disasters, which is easily understood from her peculiar environments. Disastrous causes are many and severe. Moreover, sensibility to disasters is sharp. Topography is steep; geology is unstable; climate is capricious; in addition there is also rapid increase of population and land development. Among various natural disasters the flood has been the most furious tyrant. But it should be remembered that this might have not been so, if without a great mumber of elements such as sand and debris. Forest has been a most popular yet effective defender against flood. It controls the amount of flood water as well as its followers.

Nevertheless, the author believes that Japan is one of the most green countries in the world. It has ever been so since long ago. In the feudal era destructions of some forests had been recorded in some places. Restorative works against forest denudation, however, were faithfully carried out, because even a small wound exerted a harmful influence on people in the watershed. The enthusiasm of Japanese people for planting trees together with caring of the existing forests has left to us the present green territory we are proud of.

Let us review an important event in erosion control. During the latter part of the feudal era and the earlier part of the modern era of our country there occurred a pretty large amount of artificial forest destruction in various ways due to successive civil wars, rapid development of public works, etc. This resulted in frequent occurrence of flood damages. The new government made efforts in forest restoration, as suggested by Mr. Drehk, a consultant engineer invited from Holland. But the traditional measure of vegetative control was not sufficient enough to protect fast growing farming, industrial and urban areas along big rivers from flood hazards.

It was very fortunate for us that at the end of the 19th century the structural way of flood and erosion control was introduced from Europe. Levees were strengthened and heightened along the lower parts of rivers. Check dams were built in mountain streams. Thus, the administrative system of flood and erosion control was established. Since then the river improvement works including mostly levee construction became over estimated and favoured with ample funds. But recently, especially after World War II, the predominance of the river improvement works showed its weakpoints in ultimate control of flood inundation and produced many elevated rivers. General public demanded the necessity of erosion control works again. Now the flood works and the erosion works are made to go in good balance. Consequently, in the erosion control plan the vegetative measure and the structural measure are paid equal attentions.

2. Vegetative versus structural measures

In many countries especially those in great continents the establishment of forest may be the principal work in erosion control. But in small or narrow countries with unfavorable environments, among which Japan is an example, the necessity of supplementation by structural measure is absolute. There, under torrential rains the collapse of some forested areas is inevitable. In many cases forestry techniques of erosion control do not attain successful results without some engineering structures.

Examples are landslides and landcreeps. The former is a sudden downward movement of ground mass on a steep slope. The latter is a gradual movement of clayey soil body on a relatively gentle slope. Both phenomena are very common in our country. They occur regardless of forest condition. The direct cause of these happenings is the supply of exessive water into soil. Surface water drainage and slope base fixation are suggested as precautional measures to stop landslide or creep. A check dam is one of the most effective measures, when a slope faces a down cutting stream. For a landslide of very large scale we have to prepare a debris basin at some point in the stream route.

Another example is hillside repairing works. Though there is no danger of landslide, there is still surface erosion troubling the growth of planted tree seedlings. Terraces or step constructions are required to secure rapid greening.

Nevertheless, the above-mentioned statement does not lessen the importance of the vegetative measure. Because the area of lands suffering from surface erosion is much greater than the area of sites causing massive erosion. Moreover, the latter would suffer from more severe surface erosion if not covered with vegetation.

Now it is suggested that the vegetative measure and the structural measure may be developed together in countries having natural conditions similar to Japan. However, it is important to understand an essential difference between these two measures from the standpoint of practical work. Today, when mechanization is much developed, any structural construction can be completed in a comparatively short period if sufficient fund is available. Our civil engineers are building numbers of large dams, power plants, high ways, etc. at an astonishingly quick pace in many ragged mountain areas, overruling topographical and geological difficulties.

On the contrary the vegetative work is not so simple. We can plant tree seedlings on thousands of acres in few weeks or less if the planting fields are made accessible and sufficient material and labour are supplied, in other words, the financial background. But the completion of planting on a large scale is not the final object, because young seedlings can not display the function of erosion control. We have to wait at least several ten years until the seedlings are grown up to forests of considerale sizes. If we expect water conservation function of forest soil, we have to wait longer. It is wise to hasten forest building in non-disasterous periods, because infant trees, like other living things, are weak against natural enemies.

When favourable weather continues for a long time, most people are apt to forget the misery of disasters and to regard the tree planting a slow and tedious enterprise. But one must be convinced that the ordinary climatic condition provides a great opportunity for tree seedlings to show a rapid and vigorous growth.

Considering the difficulty of long term weather forecast, we come to a conclusion that the quickest way to complete the establishment of forests strong enough in erosion and flood control is to begin tree planting today and to continue it steadily and constantly with proper tending and care including prompt supplementary planting when hurt by unexpected natural disasters.