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THE HOLDING AND RECLAMATION OF SAND DUNES AND SAND
WASTES BY TREE PLANTING.

BY H. P. BAKER.

ORIGIN OF DUNES.

By a dune we mean a low hill of drifting sand usually formed on the sea-coast or shore of large inland lakes. Along the sea-coast the movement of the tide, the flow of which is more rapid than the ebb, tends to carry sand beyond the action of the waves, where it is caught by sea winds and carried up the beach to be piled in dunes and hills.

If the land winds are of greater frequency, duration or strength than the sea winds, the sands left by the retreating waves will be constantly blown back into the water, but if the prevailing air currents are in the opposite direction, the sands soon will be carried out of the reach of the highest waves and will be transported continually farther and farther into the interior of the land unless obstructed by high grounds, vegetation or other obstacles. So long as the sand is kept wet by spray or by capillary attraction it is not disturbed by air currents, but as soon as the waves retire sufficiently to allow it to dry it becomes the sport of the winds and is driven up the gently sloping beach until arrested by stones, vegetation, or other obstructions, and thus an accumulation is formed which constitutes the foundation of a dune. By successive accumulations they gradually rise to the height of 30, 50, 60 or 100 feet, and sometimes even much higher. The dunes once deposited are held together and kept in shape partly by mere gravity, and partly by the slight cohesion of the lime, clay and organic material mixed with the sand; and from capillary attraction, evaporation from lower strata, and retention of rain water.

In working through the sand hill country of western Nebraska, and through the dune region of the Columbia river it was an interesting thing to find that the sand of the dunes or hills was always moist a little below the surface. Even with moisture present strong winds instead of adding to the elevation of the dunes sweep off loose particles from their surface, and this, with others blown between the new-forming dunes build up a second row of dunes, and so on according to the character of the wind, the supply and consistence of the sand and the face of the country. In this way is sometimes formed a belt of sand dunes irregularly dispersed and varying much in height and dimensions and often times many miles in breadth.

DUNE MOVEMENT.

The rapidity with which dunes move inland varies from a few inches to a number of feet annually, depending upon the force of the wind and the location of the dunes with reference to interior obstruction. Studies have not been prosecuted to a sufficient extent in this country for us to make any definite statements as to rapidity with which dunes along our sea-coast or inland are moving, but observations made during an average season lead us to believe that depending upon the severity of the winds our dunes have about the same rate of movement as those in France and other countries. Bordering the Bay of Biscay in Gascony, France, there is a belt of sand dunes which vary in width from one-quarter to five miles, and cover an area of about 250,000 square miles. Where these dunes are not fixed by grass and a group of trees they advance eastward at a mean rate of about sixteen feet per year. Marsh says:

"It is not known historically when the dunes began to drift, but if we suppose their motion to have always been the same as at present they would have passed over the space between the sea-coast and their present eastern border and covered the area of 250,000 square miles in fourteen hundred years."

EXTENT AND WORK OF MOVING DUNES.

From written records it is known that these dunes have buried extensive forests, fields and villages; changed the course of rivers, and the lighter portions of the sand carried from these dunes by the winds, even while not in sufficient quantities to form sand hills have turned lands formerly fertile into sterile stretches. Along the coast of Jutland in Denmark, the dunes, in the course of two or three centuries, have moved several miles inland covering forests and villages. In our country the drifting dunes have done immense damage upon Cape Cod, in the southern half of Long Island, on the coast of New Jersey and along the Pacific coast from the mouth of the Columbia river southward to Golden Gate Park in California. Small but active areas of dunes along the eastern shore of Lake Michigan and along the valley of the Columbia river in Washington and Oregon have also caused much damage by covering railroad tracks and encroaching upon fields and cities. Along the Snake river division of the Oregon Railway & Navigation Company's line, as much as from \$5,000 to \$8,000 per year has been spent in keeping the tracks free from sand. At Riparia on the above division large railroad shops and other buildings were moved away to prevent their covering by rapidly moving dunes. The Pere Marquette Railroad which skirts the southeastern shore of Lake Michigan, has spent considerable money in keeping their tracks free from encroaching sand. There have been several railroad wrecks in the country, of more or less importance, as a result of sand being blown over tracks during severe storms. A wreck near The Dalles, Oregon some six years ago caused considerable loss of life and property. Injury to forts along the Atlantic coast from moving dunes has caused the War Department to call upon the Scientific Bureau of the government to aid them in keeping back these dunes from the immediate location of the forts.

ORIGIN OF INLAND SANDS.

The sand plains which lie in the interior portions of the different continents are either derived from the drifting of dunes or are deposited by floods or are sea-beds uplifted by geological upheaval. The inland sands are generally looser, dryer and more inclined to drift than those of the sea-coast where the moisture and atmosphere of the ocean keeps them always more or less damp and cohesive. After a thorough study of the sand dune region of eastern Washington and the Columbia Valley, it was found that the origin of this sand was an old inland lake or sea-bottom known geologically as Lake Lewis and Clark which covered portions of eastern Washington and Oregon and was perhaps a continuation of old Lake Bonneville. The Columbia river flows through a portion of this old lake bottom, and during the annual period of high water, which occurs in June, large quantities of the sands of this bottom are carried into the river and deposited on flats all along the Columbia as far down as the mouth of the Willamette river. The sand plains in the Lake States and in Kansas and Nebraska are the result of the gradual upheaval of old lake or inland sea bottoms.

SAND AREAS FORMERLY COVERED WITH VEGETATION.

That these extensive areas of sand plains and coastal dunes have in the more or less remote past been covered with vegetation has been proven by scientific investigation. In accounts of investigation in the Nebraska sand hills Doctor Bessey states that at one time these hills were partially if not entirely covered with forest growth, and gives evidence to prove his statements. Doctor Dwight, an early president of Yale College, who traveled extensively through New England in 1800, states that his investigations of the sands of Cape Cod led him to believe that they were formerly almost completely covered by natural vegetation. French scientists state that the million and a half acres of land of the sand plains in southwestern France were formerly covered by a dense forest.

The unfertile and waste conditions of these sand dunes and plains today is due to many different influences and conditions. Annual fires, started either through natural causes or by man have had much to do with their present conditions. In a large measure the thoughtlessness and selfishness of man in destroying the forests has brought about the dune formations and these tremendous areas of sand-wastes are constantly on the increase. The fact that these dunes and plains have been covered with a forest growth and are in parts now so covered, gives us strong evidence that the problem of holding the drifting sands and planting them with forest trees can be solved though it take years of patient labor and considerable expense.

EARLY EFFORTS AT HOLDING OF DUNES BY PLANTING OF GRASS AND TREES.

Running back for centuries we find accounts of attempts to hold drifting dunes to prevent the destruction of fertile lands back of them. In Egypt before the Christian era the Pharaohs built great walls along the edge of the plains on either side of the valley to prevent the sand from

blowing down upon the fertile fields and orchards, along the Nile. The Dutch people since European history began have planted and cared for the dunes along their coast and influenced the formation of others because these dunes keep back the sea from their homes and fields. The first authentic accounts of successful holding of dunes is that of the work on the southwest coast of France, back of which lie extensive sand plains called the Landes. As early as 1778 the French government sent an engineer, Baron de Villers, to the dune region of Gascony to study the conditions and prepare plans for the work of reclamation. The system which he proposed and partially put into execution is, with a few alterations, the same as that in use in most European countries today, and the same that we will probably use when extensive work begins in this country. In justice to Denmark, let us say that under the guidance of its engineer Reventlof, the government began successful work upon the dunes at about the same time as in France, and rather peculiarly about the same system was adopted. The fact that climatic conditions are much more favorable in France than in the countries to the northward has made the final success of dune planting there much more evident. The system proposed by de Villers and later perfected by engineers Chambrelent and Bremon tier was the formation of a littoral or protective dune just above high water mark; the planting of this with sand binding grass and a final planting among the grass of seed of the maritime and other pines.

As soon as the protective dune is formed naturally or artificially the planting of beach or marram grass (*Ammophlia arenaria*) or other valuable grasses is begun. The method of planting is very simple and with good management and careful supervision the formation of the dune is kept under perfect control. The beach grass grows vigorously, putting out fresh rootlets at the nodes as these become covered, thus holding the sand as effectively as a brush fence or palisade. The grass is put out in tufts of four or five plants each at a distance apart dependent upon the rapidity of sand accumulation. Care and attention in preserving this density, and immediately repairing any damage is all that is requisite in the preliminary holding of the dune.

PLANTING OF TREES NECESSARY FOR THE RECLAMATION OF DUNES.

After the formation of the protective dune comes the work of planting trees in its lee. In Europe the usual method in planting the dune to trees is to cover the surface of the same with brush arranged like slates on a roof and held down by throwing on a shovel full of sand here and there. The seeds of maritime and other pines are then sown with seeds of hardy shrubs like the cytissus, which shade the young pines for the first few years of their growth. As has been shown the planting of grass or other herbs is absolutely necessary for the tentative holding of the moving sand, but every student of the question finds that forest trees must be planted to bring about final reclamation. In the Report of the Harbor and Land Commissioners of Massachusetts for 1896, the chairman of the commission who made thorough investigation of the Province Lands, says:

"It is obvious that the work of planting with beach grass must be first, and that this must be followed up by planting shrubs and trees of rapid growth, interspersed with those of slow growth before the labor of planting shall be complete."

Mr. A. S. Hitchcock of the Division of Agrostology in bulletin 57 of the Bureau of Plant Industry, entitled "Methods used for Controlling and Reclaiming Sand Dunes", writes:

"The reclamation is most permanent when the dunes are covered with forest; hence forestation is the ultimate aim wherever possible."

The director of the Central Experiment Station at Ottawa, Canada, was sent abroad in 1901 by the home government to investigate dune planting for the purpose of planting and reclaiming the shifting sands of Sable Island off the eastern coast of Canada. After making thorough investigations in France, Holland and Denmark, he reports that trees must be used if permanent results are to be obtained.

Mr. John Gifford, in writing of the dune region of France, says in part:

"By the formation of these dunes in Gascony 1,625,000 acres of land were made productive and today this region is a health resort. They have demonstrated fully that there is no better way of fixing shifting sands or reclaiming sweeps and removing pestilence than by forest planting."

The methods of planting and reclaiming used in Gascony are practically the same as those used all over Europe and in northern and southern Africa. While conditions and circumstances in the United States are very different, yet the general problem is the same and the work in Europe forms a splendid basis upon which to outline the work here. Their long list of successes cannot be other than an incentive for the commencement and successful completion of the holding and planting of sand dunes along our coasts and rivers and the reclamation of the immense tracts of sand hills, sand barrens and sand plains, which constitute parts of a number of our states.

DUNE RECLAMATION IN THE UNITED STATES.

The work of planting and holding dunes and sand wastes in our country has been very limited and is still in the experimental stage. At Cape Cod as early as 1826-38 planting of beach grass was made by the government and the town of Provincetown at a cost of \$28,000. Constant care was not given this planting and the poorer class of fishermen and laborers cut the sod and removed woody growth until the dune lands reverted to their original conditions. Only now with renewed efforts is the work beginning to be successful. Along the coast of Long Island and New Jersey a few scattered attempts have been made to hold the dunes, but nothing of importance has been accomplished. A little planting of grass has been done at the mouth of the Kalamazoo river, but the work was not continued and now conditions are even worse than they were before this work was started. Perhaps the

most successful work has been done in Golden Gate Park at San Francisco. Here the dunes were extensive and were gradually moving towards the city. Experiments were made with planting barley and some of the lupines, but success only came when the beach grass was introduced. A large number of trees have been planted and the most satisfactory are the Monterey pine and the Monterey cypress, which are native to that immediate region, and several species of eucalyptus and the Austrian wattles (*Acacia latifolia* and *A. laphantha*).

THE FUTURE IN DUNE RECLAMATION.

Wherever the dunes exist in this country there are numerous native grasses and other herbs which are well suited to preliminary planting, and there are also numerous conifers and a few broad leaf trees which have a high value for the reclaiming of the dunes. Investigations seem to show that such conifers as the white pine, jack pine, loblolly pine, Norway spruce and Austrian pine where not subjected to severe salt winds are adapted for planting on dunes and sand plains of the eastern states. Through the Pacific and Columbia river country such conifers as the bull pine, sand pine, Monterey pine and Monterey cypress are valuable for planting.

On inland sandy lands such as the sand hills of Nebraska, the experimental planting of forest trees has been much more extensive and satisfactory, and the Forest Service is convinced that a very large per cent of the so-called absolute waste lands of the west can be reclaimed and made to grow forests of coniferous trees. The work will require the expenditure of considerable sums of money and years of patient, persistent work, yet the outcome cannot be other than success and that a financial one. The same and worse problems and difficulties have been met and solved by European foresters. We can profit to a certain extent by their experience and accomplish what they have accomplished in a much shorter time.

The great need at present in this sand dune work is a definite knowledge of the dunes as they exist in this country. We must have more accurate knowledge of the origin of the sand which is forming a certain group of dunes, of the processes by which the dunes are being formed, of the amount of plant food which the sand contains, of the moisture in the sand and its source, and lastly and of most importance, of the flora of the dunes the herbs the shrubs and the trees, so that we may judge as to what grasses and trees can be most successfully planted. From this knowledge it will be comparatively easy to plan as to where the sand shall be held, whether in the form of a protective dune or at the place of its origin, and what methods of work will be most practical.