EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN NO. 121—JANUARY 1904.

Agricultural, Botanical and Horticultural Departments.

AGRICULTURAL DEPARTMENT.

A. M. TEN EYCK, B. Agr., Agriculturist.

Renewing Washed and Sanded Lands.

"THE floods of the spring of 1903, by far the most disastrous in the history of the West, covered a territory of more than 2,000,000 acres; they wiped out property approximating $40,000,000, and took nearly a hundred lives."* When the great flood occurred (May 28 to June 5), practically all crops were planted and growing, wheat was headed, and the first crop of alfalfa was ready for the sickle. The waters covered the land for from three to eight days, and on some poorly drained fields remained for weeks, preventing the replanting of the land that season. On well-drained lands, where the water was not deep and remained only two or three days, crops were not usually destroyed. Even alfalfa survived under these conditions. But on all of the lower river bottom, not only were the crops destroyed and great damage occasioned by the loss of farm products, damage to buildings, the washing away of fences, etc., but many fields were permanently damaged by the washing away of soil and the gouging out of great holes by the rushing water. The sand from these washouts and from the washing of the river banks and the cutting of new channels was often deposited over fertile fields further down the stream, so that

*Senator J. R. Burton, in *North American Review*, October 1903.

throughout the valley of the Kansas river and its tributaries considerable areas of land were left covered with white sand from a few inches to several feet in depth.

DEPOSITS OF MUD. Over large areas which were covered with backwater or where the current was slight there was left more or less of a deposit of mud. The covering of mud served to destroy crops which otherwise might have escaped destruction by the water alone, and often because of the sediment or the slow draining and drying of the soil some fields could not be replanted last season. Plate II is an example of such a field upon which a corn crop was destroyed, while plate III shows an alfalfa field which received a deposit of mud from three to twelve inches in depth. The photographs from which these cuts were made were taken July 16, forty days after the waters had receded; yet at this time the land was too wet in many places to drive a team over without miring.

Aside from making more certain the destruction of the crops and perhaps throwing the fields out of use for the season, the deposits of mud are likely to prove beneficial to the land by increasing the fertility and improving the texture of the soil. When a thick mudcovering has been made the land should be plowed deeply, so as to mix the old soil with the new soil and bring someof the old soil up to the surface. The soil bacteria which are considered so essentialin fertile soil because of their action in making plant-food available are likely to be more or less lacking in this new deposit, and thus the mixing of the new and the old soil is essential in order to spread them ; also, the deep plowing and mixing of the sediment with the coarser soil will tend to improve the texture or physical condition of the soil.

DROWNED LANDS. On low lands and on poorly drained fields stagnant water remained for weeks and even months during the hot summer weather. As these lands are drained and brought under cultivation again the soil will perhaps not produce well for several years. Some of the soluble plant-food has been leached out of these lands. The soil has been settled and puddled, so that it will take some time, assisted by good tillage to reestablish a proper physical condition and good tilth. The bacteria in these soils have perhaps been largely destroyed by the long continued flooding, literally *drowned out,* and it may be several years before they again multiply in such numbers as to maintain the supply of available fertility necessary for a productive soil. A good way to treat such land will be to seed it to grass. The land should be thoroughly drained at once, if this has not been done already. As soon as the surface is in a fit condition disk or plow shallow; later, when the land has become drier, plow deep and leave the

soil loose and mellow for a time. If the plowing was done in the fall or winter, grass may be seeded next spring; otherwise it will be better to plow as soon as the soil is in a fit condition in the spring, leave the land fallow during the summer, cultivate with the Acme or disk-harrow occasionally, and seed to grass early in September,

If the land is fairly well drained and not too low, a mixture of orchard-grass, ten pounds, meadow fescue, eight pounds, *Bromus inermis,* six pounds, with one or two pounds of Red clover, per acre, will make a good pasture, For hay, sow three times the quantity named of one of the above grasses, with two pounds of Red clover. A mixture of orchard-grass, *Bromus inermis* and Redclover will often make an excellent hay meadow. On low, wet lands a mixture of redtop, fifteen pounds, and Alsike clover, two pounds, per acre, will make a good meadow or pasture. Alsike clover may also be properly substituted for Red clover with the other grasses on the drier land, and a small amount of *Bromus inermis* and perhaps orchard-grass mixed with the redtop may often prove valuable, especially for pasture, when seeded on the wetter lands.

WASHED LANDS. Where the surface soil was largely removed but no great amount of deep washing occurred, the land may perhaps soonest be reclaimed and made productive by seeding legumes and grasses, but a little different plan should be followed than that described for "mudded" and "drowned" lands. Not only have the bacteria and soluble plant-food been largely removed from washed fields, but the richest part of the soil, containing the humus, has been removed. The subsoil or the subsurface soil remaining is sure to be relatively poor in humus, although the supply of mineral plant-food may be sufficient to produce good crops. Perhaps some of the fertile surface soil remains; at least, the top part of the washed soil will doubtless be richer in humus and contain more plant-food than the deeper soil. Therefore the ground should not be tilled deep, but shallow plowing or even disking the surface will prepare a more suitable seed-bed than deep plowing. The grasses mentioned above as being adapted to fairly well-drained soils, and perhaps alfalfa, can be successfully seeded on washed lands which contained enough available plant-food to start and establish the young plants. The seeding should preferably be done early in the spring.

If the washed land is too poor to start grasses, or if it is desired to continue the use of the land for cultivated crops, it will be necessary to build up the humus of the soil by the application of stable manure, by green manuring, or by the growing of annual legume crops. A good coating of well-rotted manure disked into the ground will much improve the seed-bed for the planting of legumes and grasses and

other crops. If no stable manure is at hand, the field may be prepared by shallow plowing or disking early in the spring and given a light seeding of oats, barley, or emmer. This crop should be plowed under rather shallow for green manure, about the last of May, and the ground subsurface-packed if possible, or at least well tilled with a harrow, disk, or Acme harrow, and reseeded with cow-peas, planted in close drills or sown broadcast at the rate of four to six pecks per acre. The cow-peas may be cut for hay if they make a rank growth, or, better, the crop should be plowed under before it becomes too rank and mature, and the land immediately reseeded to oats, which should be left as a cover crop during the winter. This land may now be in a fair condition to grow a crop of corn or seed down to grass, or the green manuring may be repeated again the next season, as the judgment of the farmer may direct.

For badly washed areas in which the top soil has all been carried away and the surface has been left rough and broken, as shown in plates IV, V, and VI, little can be done.

After a few years the soil of such areas will become weathered and more fertile, when, by scattering grass seeds, they may be turned into pastures.

SANDED AREAS. The sanded lands are the most extensive and perhaps the hardest to reclaim. Some of the land replanted last season was covered with a light coat of sand. Where the layer of sand was not so thick but that the lister placed the corn in fertile soil beneath the sand a good crop was secured. The cultivation during the season mixed the sand with the good soil, and little trouble is likely to be caused by the sand where the depth of the deposit did not exceed two or three inches. Deep plowing on such fields will more thoroughly mix thesand with the soil and give a more uniform texture and bet. ter tilth.

The problem of how to get rid of the sand is a difficult one on those fields in which the covering is six inches to several feet in depth, The sand was often left more or less in drifts by the water, and during the summer the conditions have been made much worse by the winds. When the sand is not more than six or eight inches deep, it may be possible to turn it under and bring up the good soil by plowing very deep. With a strong sixteen- or eighteen-inch plow, four to six horses ought to turn a furrow ten to twelve inches deep. If a plow could be constructed with a larger, longer mold-board than the ordinary plow, capable of elevating the earth twelve to eighteen inches high, it might be used to deepen the furrow of the ordinary plow. It would be possiblealso to construct a gang so that one plow, with a high mold-board, set at a lower level, will follow the other plow in the same

furrow; but with the ordinary plow it is not practicable to attempt to plow more than one furrow deep, as the earth cannot be elevated, and will simply fall back to the bottom of the furrow, which will be left mellower but little deeper than it was by one plowing.

It may be profitable, on valuable land and on small fields, to use the spade with the plow, and by digging trenches, bury the sand and bring the good soil to the surface. In some instances where the sand lies in deep drifts it may be practicable to haul it off the field with scrapers or pile it up in large mounds.

When the sand is buried or mixed with the soil, the question arises as to the effect which it may have on the texture and fertility of the soil and in the production of crops. The effect which the sand has on the soil texture will depend upon the character of the soil and the coarseness of the sand. If the original soil was heavy and compact, a light dressing of sand may improve the texture and increase the available fertility, but if the soil was already sandy, the addition of more sand will tend to reduce the fertility and produce a coarser and more open texture, unfavorable to the holding of soil moisture and to the root growth of plants.

To improve the physical condition of the soil and prepare a proper seed-bed, such fields should be thoroughly firmed and packed by the use of a subsurface packer or similar tool; but even with thorough preparation lands in which the sand has been buried or mixed with the soil by deep tillage are not in a condition to seed at once to grass, but had better be planted with corn or other cultivated crops for a few seasons, or the system of green manuring described under "Washed Lands" may be profitably employed, especially if the soil is light, and lacking in humus. When land has been plowed very deep and the subsoil has been brought to the surface, the land is not likely to produce well the first season, because the raw soil must weather and decay and the bacterial growth must be reestablished before a sufficient supply of plant-food can be made available to meet the requirements of the crop.

In case the covering of sand is too deep and too extensive to be subject to any of the methods of treatment suggested, it may be practicable to hold the sand and attempt to hasten the building of it into soil by means of soil-binding grasses and legumes, discussed in another part of this bulletin, or doubtless in some cases it may be more profitable to leave nature undisturbed in her sturdy efforts to renew the soil and replant the sanded wastes.

SEED TO GRASS LANDS WHICH ARE APT TO WASH. Perhaps the greatest permanent damage to farms resulting from the flood was caused by the washing away of the soil. Thousands of tons of fertile valley

soil were swept away from many fields. Some of this soil was deposited again on other fields, but much of the fine sediment and all of the soluble plant-food was swept into the Missouri and thence onward to the sea. The sanding was also the direct result of washing.

It was observed that the cultivated fields were the ones which were cut up by the water, while lands which were in grass and alfalfa were not usually damaged by washing. Grass or alfalfa served as a protection to the land, and although the crop itself may have been destroyed, the loss of the crop was small compared to the protection afforded by the crop to the soil.

Only a small fraction of the land in the valleys damaged by the flood was seeded to grass or alfalfa and often the fields were tilled and planted with annual crops almost to the river's edge. A large part of the low-lying land in the river bends and bordering the river might profitably be kept in grasses or alfalfa much of the time, thus insuring protection to the soil in case floods should again occur.

CROPS AFTER THE FLOOD. Plate XIII shows a field of sorghum cut for fodder on the farm of Mr. Fred Moehlman, in Moehlman bottom, south of Manhattan. This field was planted about July 20. Corn planted after the flood made an excellent growth of stalks and usually matured a good crop of ears. Many fields of Kafir-corn also matured seed, while sufficient sorghum and Kafir-fodder was produced throughout the flooded districts to provide roughage for wintering the stock.

BOTANICAL DEPARTMENT.

H. F. ROBERTS, M. S., Botanist.

Sand-binding Grasses.

ONE important matter to consider, for owners of sanded lands which are too deeply covered to be successfully handled in an agricultural way, and in which an accumulation of humus is an essential preliminary to its subsequent use for agricultural purposes, is the introduction of what are known as sand-binding grasses. A grass, to be a "sand-binder," must be, first, a perennial, and must have the habit either of sending out creeping stems below the ground, from which the aerial shoots come up, or of sending out runners above the surface of the ground, or both. As a matter of fact, the true "sand-binders" spread prevailingly by underground stems or rootstocks. By this means the plant secures for itself greater protection against drought and the scorching heat that often prevail in summer-time on the immediate surface of sanded areas. The buffalo-grass, although it sends out runners which in the course of a single season will extend from a foot to a foot and one-half out from every side of the parent plant, is not adapted to sandy regions, and is not available therefore for the present purpose. It must further be remembered by farmers, that if they undertake to plant sanded land with sand-binding grasses, it must not be done primarily with an idea of getting immediate financial returns from the grasses themselves. While there are some sand-grasses, such as the sand blue-grass, that are available for hay, most of them have such tough and wiry stems and such hard, coarse leaves that they are not at all adapted to hay purposes, and others, such as the one above referred to, are not in the market. It is also the case that sand-grasses do not commonly form a close turf on the soil, but cover it in rather loose and open fashion, which of course means a small yield of hay per acre.

The real value of sand-binding grasses lies not in what they may yield of themselves for pasture or forage, but in their ability to hold the sand in position and keep it from drifting, and to lay the foundation for an agricultural soil by the accumulation of humus. While there are a number of species of sand-grasses, there are comparatively few, the seeds of which are a commercial article. Foremost among these should be placed the beach-grass or marram grass, *Ammophila*

arenaria (L.) Link, commonly sold as *Ammophila arundinacea.* This is a perennial grass, spreading by underground stems, growing from two to four feet high, with long, coarse leaves and a narrow, spike-like flowering head from five to six inches long. This grass is extensively found on the sandy seacoast region of the Atlantic, as far south as Virginia, and is also the common grass found covering the sand dunes along the Great Lakes, notably on the eastern coast of Lake Michigan. It is of no fodder value. Its seed runs in weight fifteen pounds to the bushel and sells at about forty-five cents per pound, or 100 pounds for about $40. The seed should be sown in the spring, either drilled or harrowed in, and the ground covered with brush to hold the seed in place until the young plants have gained a start. The usual method is to transplant already established sods, and by this means large areas of dune and beach land have been planted in Europe and along the eastern coast of the United States; but inasmuch as *Ammophila* is not likely to be found accessible already established, it will be necessary to start an area of young plants as above indicated, for further transplanting.

Next, perhaps, to *Ammophila arenaria,* among those grasses the seed of which is commercially available, is *Poa compressa* L., the Canada blue-grass. This is a small perennial grass, with slender, wiry, flattened stems, growing from six inches to one and one-half feet high, and found in waste places generally, scattered over the northern United States. It also propagates by underground stems, and does well on the poorest soils. Unlike the *Ammophila,* it is a valuable pasture grass, and if once well established it will prove of some worth in itself, beside being, in addition, very valuable as a sand-binder. It is, however, not likely that it will take hold at the outset in loose sand as readily as the beach-grass. It is therefore recommended that beach-grass be used first to fix the soil before the other is sown.

The two grasses above given are the only ones which this department feels absolutely justified, from observation and experience, in recommending for immediate use. There are a few others among the fescue grasses, such as Hard fescue *(Festuca duriuscula),* Sheep fescue *(Festuca ovina),* Red fescue *(Festuca rubra),* and Slender fescue *(Festuca tenuifolia),* and lime-grass *(Elymus arenarius),* which may or may not prove valuable here, in connection with the Canada blue-grass, and it is planned to use them during the coming season in an experimental way on sanded lands in this vicinity.

In connection with the grasses, it is desirable, as soon as possible, to start legume plants of species which will endure hard conditions. The sanded lands, being notably deficient in humus at the surface, and consequently in compounds of nitrogen, so essential as plant

food, it is especially desirable to introduce those plants which are known to be nitrogen gatherers. The legume family, including such common and well-known plants as alfalfa and the clovers, represent this family; but neither alfalfa nor the common clovers will make a "catch" in very loose, sandy ground. The sand vetch (*Vicia villosa)* is a biennial legume which cannot be too highly praised as a nitrogen gatherer. It does well on poor, sandy soils, forms a cover of thick, matted stems a foot or so high, and self-seeds liberally. It is recommended that sand vetch be sown next spring, mixed with rye, at the rate of one bushel to the acre. The price varies according to the market, but fifteen cents per pound may be taken as a fair average price.

If the vetch and rye mixture be started first, it may then be possible to sow Canada blue-grass broadcast in the fall.

HORTICULTURAL DEPARTMENT.

ALBERT DICKENS, M. S., Horticulturist.

Trees for the Sanded Areas.

IN MAKING plans for utilizing land which has been damaged by floods, the forest-trees deserve careful consideration. There is little question as to the success of trees in such locations, and but little as to their ultimate value. Land that is so badly sanded as to require manuring before it contains sufficient humus to support crops of grass and grain will support some species of trees. One great advantage in planting such soil to trees is that when once started the danger of blowing is obviated. In growing grain or fodder crops upon such land, there must be for many years the danger of its blowing badly, which is certain to injure its value very considerably. The particles of organic matter in various stages of decomposition are, when partially dry, very light, and certain to be blown away if exposed to the wind. Experience in farming sandy land has taught that severe blowing reduces fertility to a very marked extent. In planning for the use of such land, the factor of certainty is much greater with tree crops than with annual crops. Practically all of the flooded land is so low that tree roots will reach the strata of constant moisture in a very short time, which in itself insures certain, and, in most cases, rapid growth. The protection of the land from blowing is one of the necessary factors in improving it, and trees will do this more certainly than any other crop.

In many cases, where a deep deposit of sand has been made, there is danger of the land being badly washed by high water. A volume of water which would have occasioned little damage prior to the great flood of last year would now probably cause considerable washing of the banks, and a growth of trees along and near the bank would to some extent lessen this danger.

The principal objection to planting forest-trees as a crop is that considerable time must elapse before any part of the crop can be marketed. In the case of the flooded areas, this objection is certainly less forceful than in case of good farm lands, for, with much of it, any crop secured will be a light one and return at best but small profits. In view of the facts that flooded lands must be carefully handled in order to improve their texture and fertility, and that considerable time

must elapse before they can be expected to return even a fair profit, and as the success of trees in similar locations and conditions is a matter of common observation, it seems probable that in many instances the growing of trees is the best use for such land.

The selection of species for planting is a matter of importance, for though all trees are good, some are much better than others and more valuable, but as a rule the more valuable are slower to reach marketable size. Post production may be regarded as giving the quickest returns from forest-tree plantations, and catalpa *(Catalpa speciosa)* and Black locust *(Robinia pseudacacia)* may be expected to produce good posts in less time than any other trees grown in our climate, These species, however, succeed best in fairly rich soil and would be better adapted to locations where good soil has been covered with sand than to deep deposits of sand. The locust borer, *Cyllene robinice* works such havoc in Black-locust plantings as to almost exclude Black locust from the list.

The Osage orange (*Toxylon pomiferum)* is rather slower in growth, but furnishes posts which in most localities bring the highest price, It seems to be similar to the catalpa in soil requirements. The Russian mulberry *(Morus alba)* is another post tree, probably ranking next to catalpa in rate of growth, but requiring more care to produce markctable posts. The length of time required to produce marketable posts varies with conditions, season, and soil, a good average probably being—catalpa eight years, mulberry, ten years; Osage, twelve years. All renewreadily from coppice growth, and in each case the second growth furnishes posts in less time than the first.

Whenever trees planted for posts make but poor growth during the first season or two it is good practice to cut them back to the ground, which nearly always results in a strong growth. On land that is deeply covered with sand it is probable that the more-rapid-growing trees will give better results. The cottonwood *(Populus deltoides* or *P. monolifera)* is believed to be the best tree of this class. Young trees are easily secured from cuttings or natural seed-beds along the rivers, and transplant very readily. Many tracts of the flooded land are now thickly covered with young cottonwood trees. The seed was ripe soon after the flood, and the wet sand and soil provided the best of seed-beds. In most cases good growth was made during the summer. Plate XIV shows a tract that seemed to be bare sand when the waters receded early in June. The young trees, mostly cottonwood, with an occasional willow, stand very thickly, and made growth varying from two to seven feet, averaging probably between four and five feet. Plate XV shows a clump of these young trees. Where the land has been planted by natural means, it is questionable if any better

use can be made of such land than to allow the trees to stand. Within a few years the stronger trees will outgrow the others, thinning will take place naturally, the land being, indeed, natural forest land. A great deal might be done in such plantings by thinning the trees, giving the stronger a better chance to develop. In five or six years the poles would more than pay for the thinning.

Plate XVI shows a growth of cottonwood on a bank of the Kansas river. The present owner of the land states that when he bought the property, about fifteen years ago, it was a thicket of young trees, probably five or six years old, Examination of the trees recently cut shows twenty annual rings. The trees vary considerably in height and diameter, some of the largest, those near the edge of the grove, measuring slightly over 100 feet in height, twenty-four inches in diameter at the ground, and eighteen inches twenty feet from the ground. What was considered an average tree was cut November 5, showing twenty annual rings and measuring seventy-five feet in height, seventeen and one-half inches in diameter at the ground, and fourteen inches at nineteen feet, where it branched, and containing about twenty-five cubic feet of cord-wood in the top and limbs. Many of these trees will now make fair logs for sawing, and if left standing will increase in size for a number of years.

The demand for low-grade lumber suitable for packing cases, apple and potato barrels is growing. The average of prices obtained from dealers is twenty-two dollars per thousand for selected stock, sixteen dollars per thousand at the mill, ten dollars per thousand on the stump. The following prices obtained December, 1903, from S. N. Higinbotham, dealer in wood, shows the market value of cottonwood compared with other species: Cottonwood, $3; red elm, $4; hackberry, $5; maple (soft), $3; walnut, $4; oak, $5; box-elder, $3; hickory, $5. It would seem that at such prices for timber and fuel, the cottonwood is not to be despised. Where land is to be planted, it is advisable to plant cuttings from the trees of strong, straight growth.

The Carolina poplar *(Populus deltoides,* var. *carolinensis*) has not been so long or so widely grown, but seems to be hardy, equal to the best cottonwoods in vigor, and more uniform in growth. It grows very readily from cuttings. The results of plantings of these and other species of trees are recorded in Experiment Station Bulletin No. 120.

Explanation of Illustrations.

PLATE I. The flood at its height, looking east from Bluemont, north of Manhattan, across the valley of the Big Blue, and down the valley of the Kansas. The pumping station of the city water-works, the Blue Valley branch of the Union Pacific railroad, and the channel of the Blue river, with a strip of timber on the east bank, are shown in the foreground, while beyond is a broad expanse of water as far as the eye can see. The channel of the Kansas river lies in the background to the right, the hills to the left, across the valley of the Big Blue, are about six miles distant.

PLATE II. A quarter-section of land on the farm of Fred Moehlman, in Moehlman bottom, south of Manhattan. A crop of corn on this field was destroyed by the flood, and on July 15, when this picture was taken, the field was too wet to cultivate, and some of it was still under water.

PLATE III. An alfalfa field on the farm of Chas. Rosencutter, in Moehlman bottom. This field was covered with a deposit of mud from three to twelve inches in depth, and the alfalfa was totally destroyed. The ground was too wet to plow on July 15, and no crop was grown on the field last season.

PLATE IV. A washed area on the farm of John Dempsey, one and one-half miles east of Manhattan, showing soil removed and the field badly cut up by the water. This particular washout covered about four and one-half acres in the middle of a cultivated field.

PLATE V. A nearer view of a portion of the above washed area, which gives a better idea of the washout. The pit shown was more that ten feet deep.

PLATE VI. On the farms of James Allingham, Wm. Allingham, and Mrs. Martha Finley, in Allingham bend, south of Manhattan, some sixty acres were destroyed by the washing. Plate VI shows one of these washouts, which was about 100 yards wide, 400 yards long, and 20 feet deep at its greatest depth.

PLATE VII. This is a view of the new channel of the Kansas river which was cut across Allingham bend, south of Manhattan, during the flood. The new channel crosses the farms of the parties mentioned above, also the farm of Mrs. Emma H. Bowen. This channel is 40 to 130 rods wide and over a mile in length. The body of water to the right is the old bed of the river.

PLATE VIII. After the flood—on the farm of Harry Deibler, east of Manhattan, The clump of trees to the west is what remained of a fine young orchard. Before the flood the house now seen in the distance stood in the edge of the orchard. The debris is largely ties and steel rails, the remains of the Rock Island railroad, which bordered the farm on the south.

PLATE IX. A sanded area of about ninety acres on the farm of Gus Carlson, in Moehlman bottom. The sand was several feet deep in places, and was beginning to blow and drift about with the wind. This view was taken July 15. A scant vegetation was struggling up in places where the sand deposit was shallow, and over a part of the area a thick growth of young cottonwoods was starting. Hundreds of acres of this once fertile and beautiful valley were rendered useless by this covering of sand.

PLATE X. A sanded area of about sixty acres, on the farm of G. E. Spohr, also in the Moehlman bottom. The man standing in the excavation is Mr. Spohr, who, by digging at different points, estimated the depth of the sand on this area to vary from one to five feet.

PLATE XI. An orchard which was destroyed by the flood, on Mr. G. E. Spohr's farm. In this orchard of twenty-three acres, some thirteen acres of trees were washed down, covered with sand and debris, and destroyed.

PLATE XII. A bur-oak stump on the roadside, east of Manhattan, showing how the soil was washed from the roots by the forming of eddies in the current. Many trees in orchards and groves and along the river banks were washed out or injured in this manner.

PLATE XIII. A crop grown after the flood. A field of sorghum, on the farm of Fred Moehlman, in Moehlman bottom. This was planted July 20 and made an excellent crop of fodder.

PLATE XIV. A tract of land that seemed to be bare sand when the waters receded, early in June, but in November was thickly covered with cottonwoods and willows.

PLATE XV. Clump of young cottonwoods that have grown up on land flooded in June.

PLATE XVI. A growth of cottonwoods about twenty years old, on the bank of the Kansas river.

ACKNOWLEDGMENT.

The photographs from which the cuts shown in this bulletin were made were taken by Dr. S. C. Orr, of Manhattan, who does much work of this character for the Agricultural College and Experiment Station, and spares no effort to produce the best possible results.

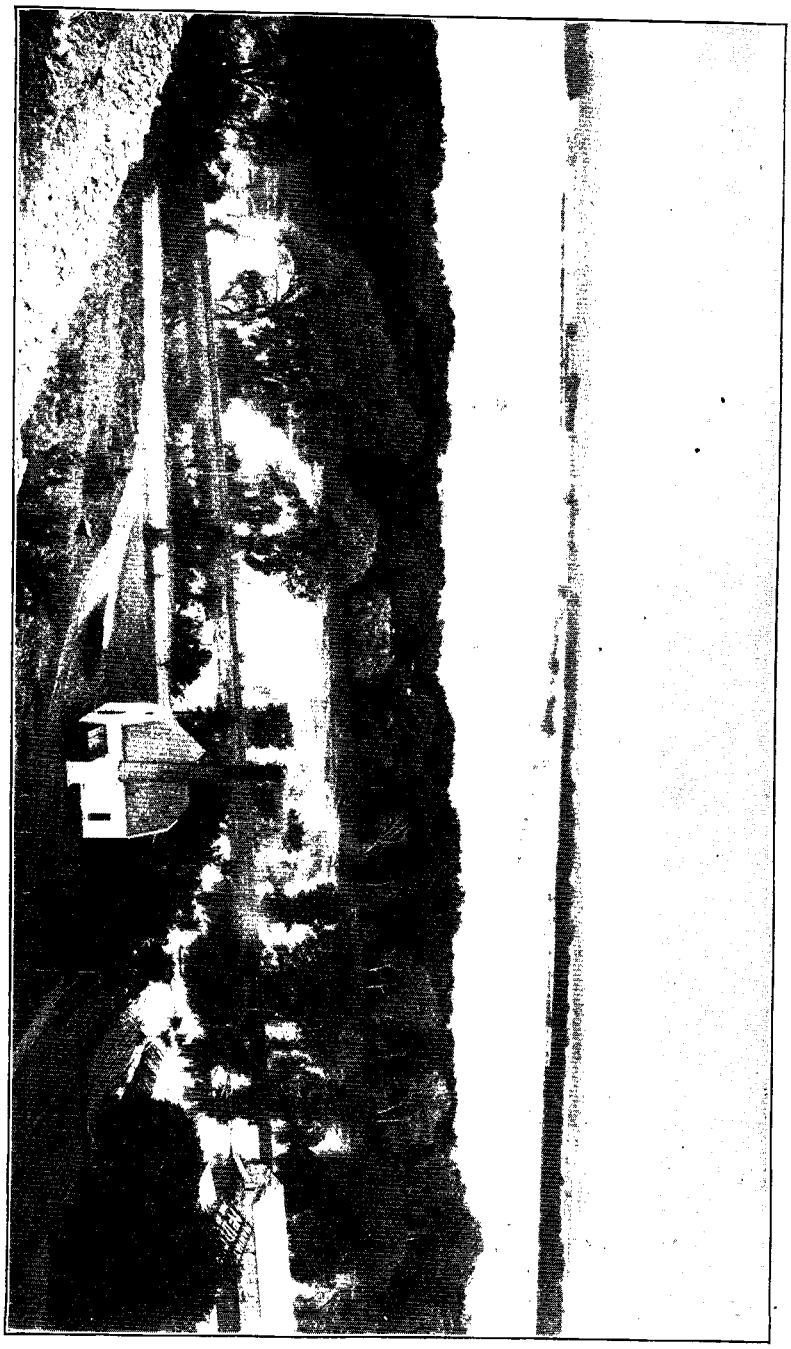

Plate I.—The flood at its height. Looking east from Manhattan.

Plate II.—A corn crop destroyed and ground still too wet to plant, forty days after the flood.

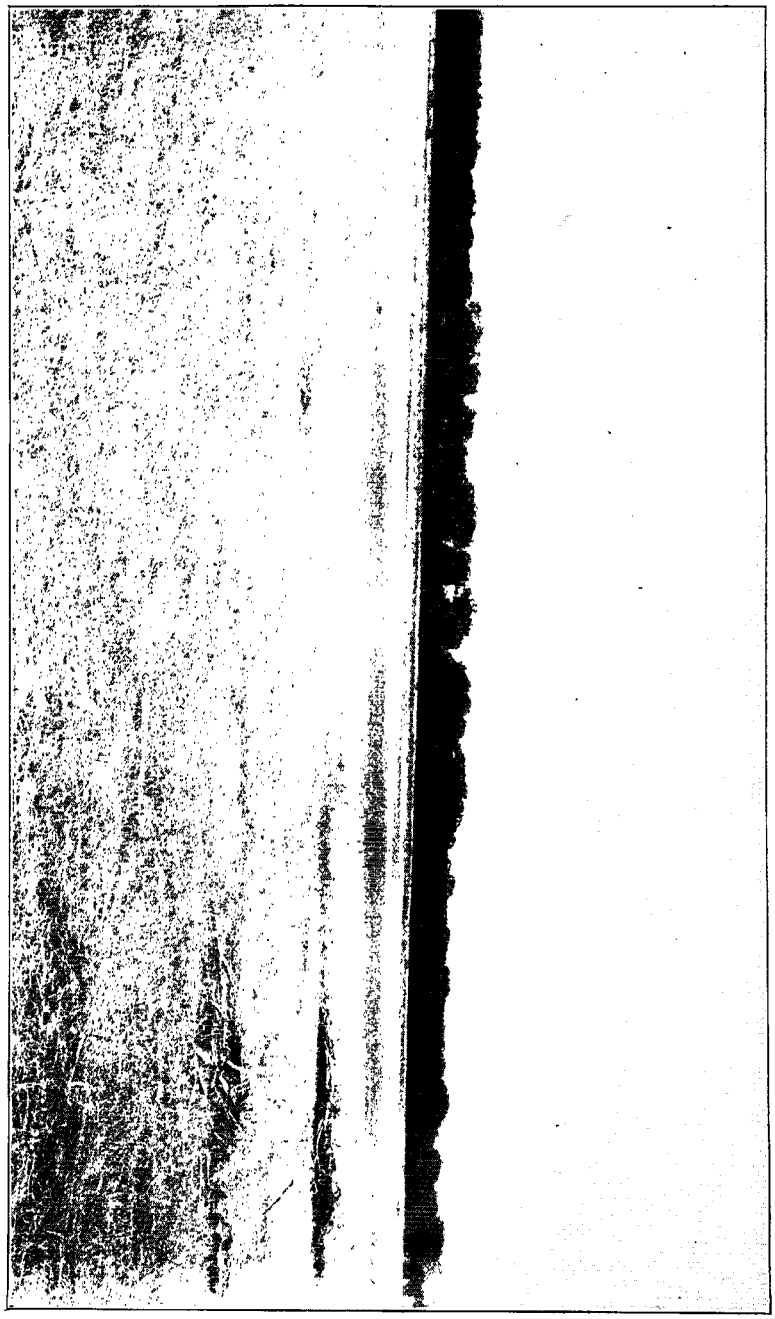

Plate III.—An alfalfa field covered with a deposit of mud three to twelve inches thick.

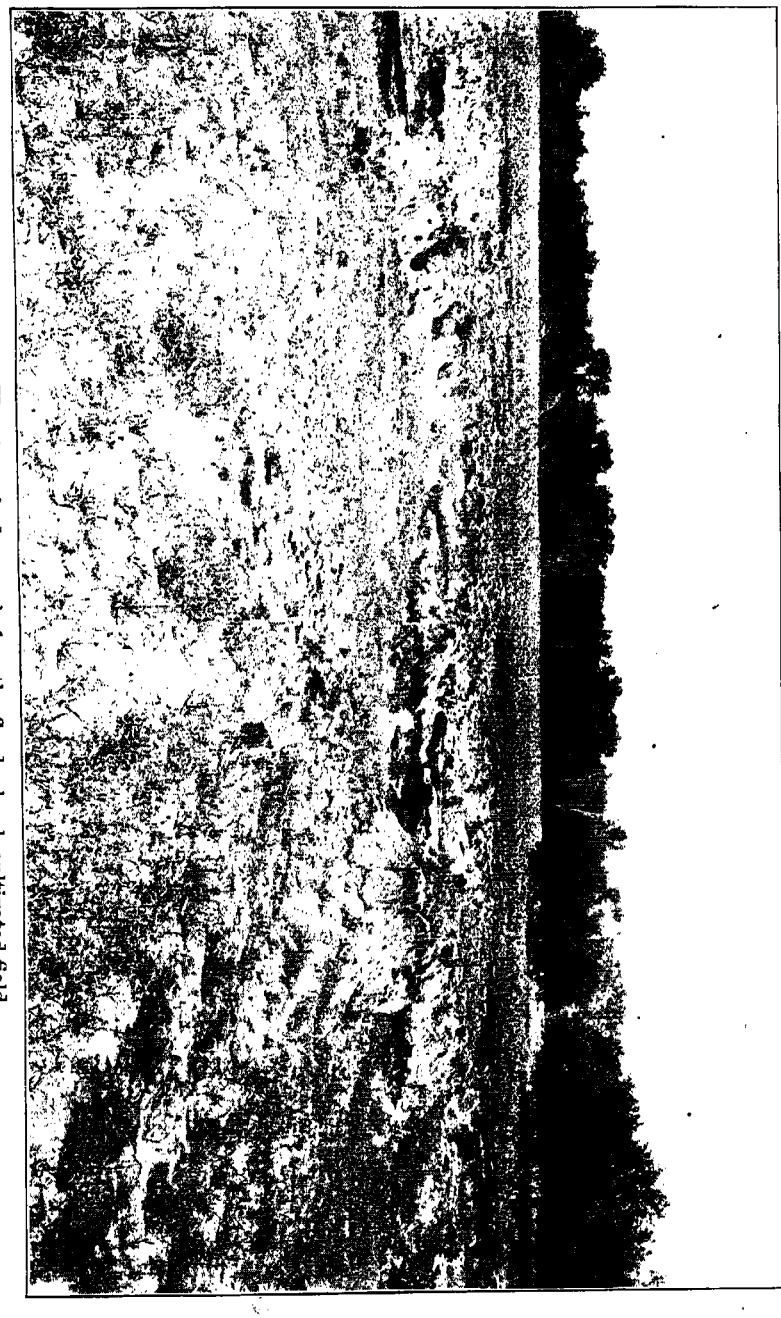

Plate IV.—A washed area; before the flood a level, cultivated field.

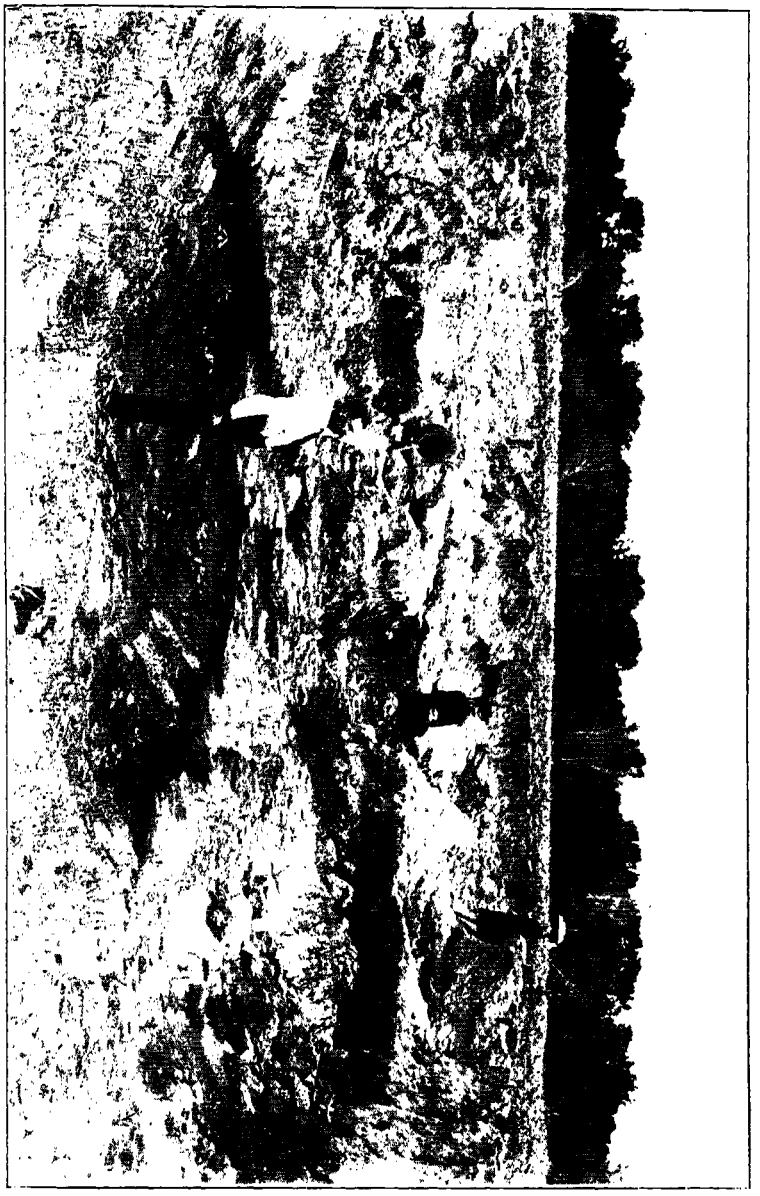

Plate V.—Showing the depth of excavations.

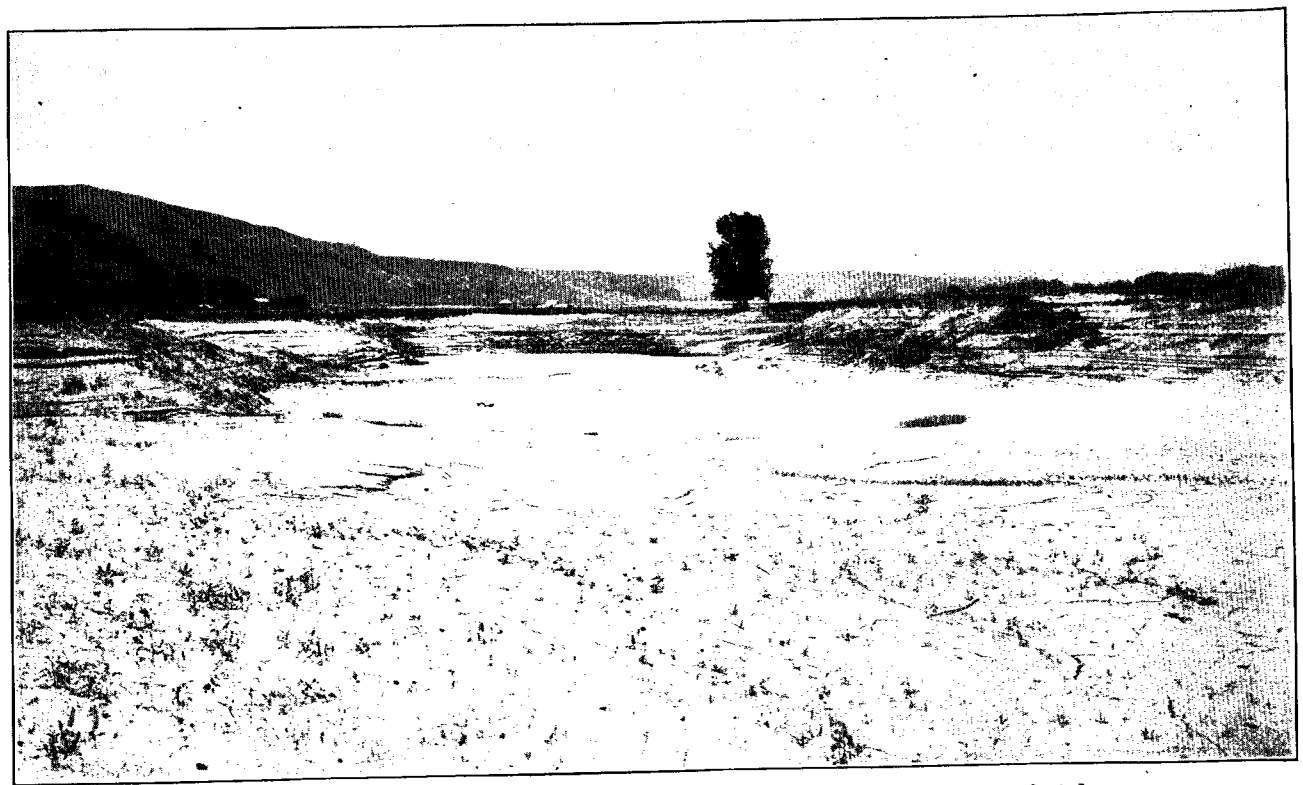

Plate VI.—A big washout. This hole was more than an acre in area and twenty feet deep.

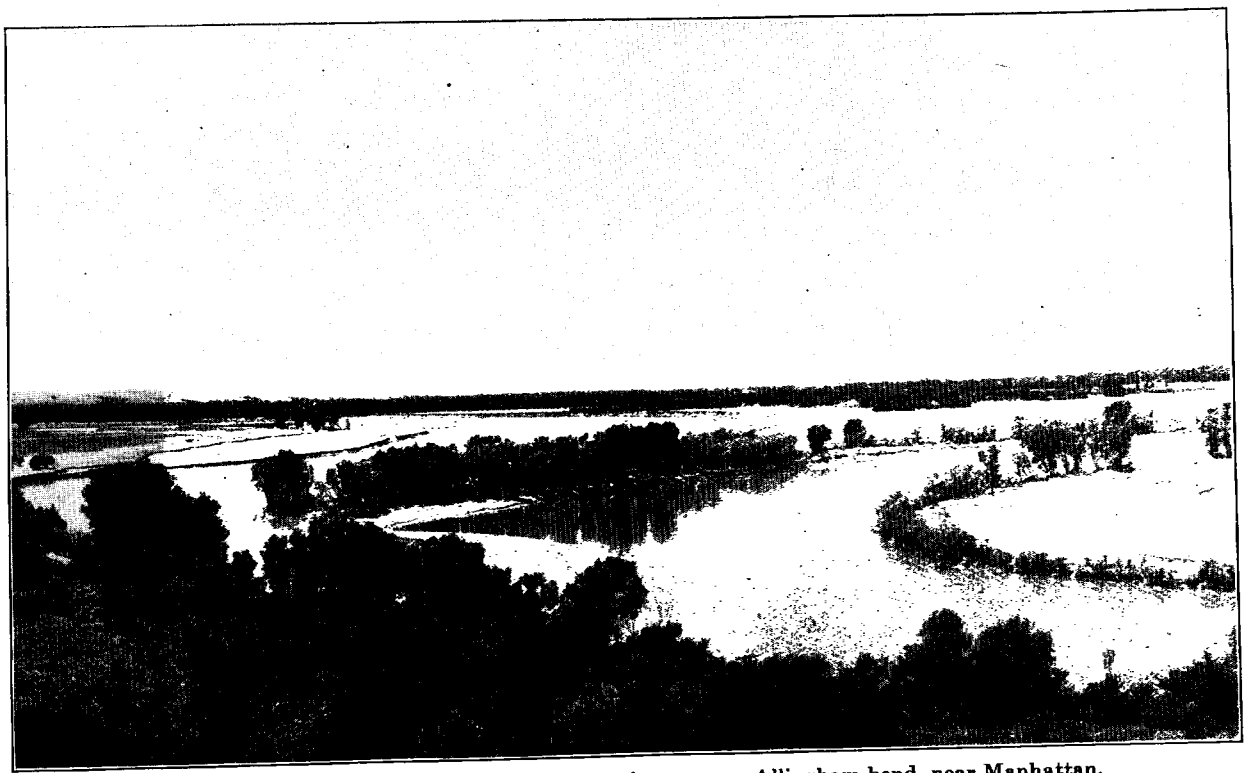

Plate VII.—The new channel of the Kansas river, across Allingham bend, near Manhattan.

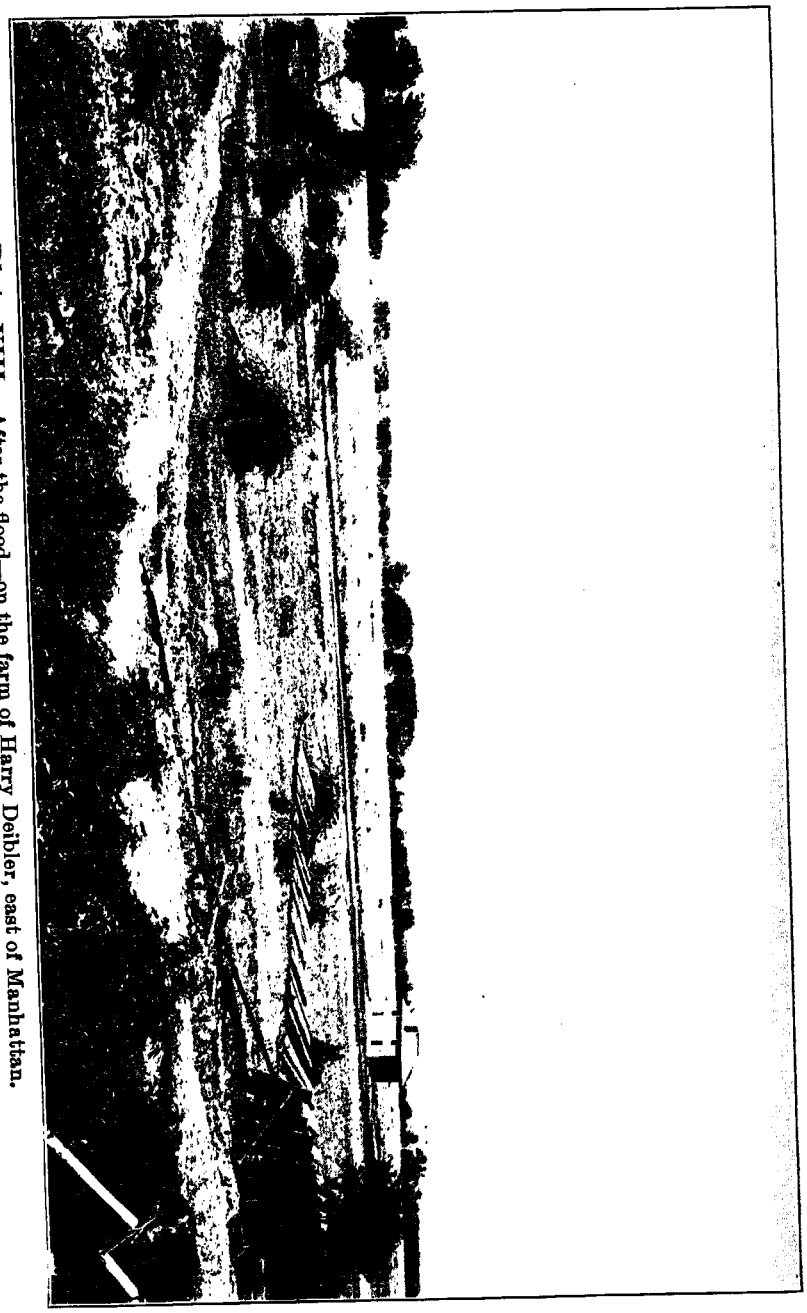

Plate VIII.—After the flood—on the farm of Harry Deibler, east of Manhattan.

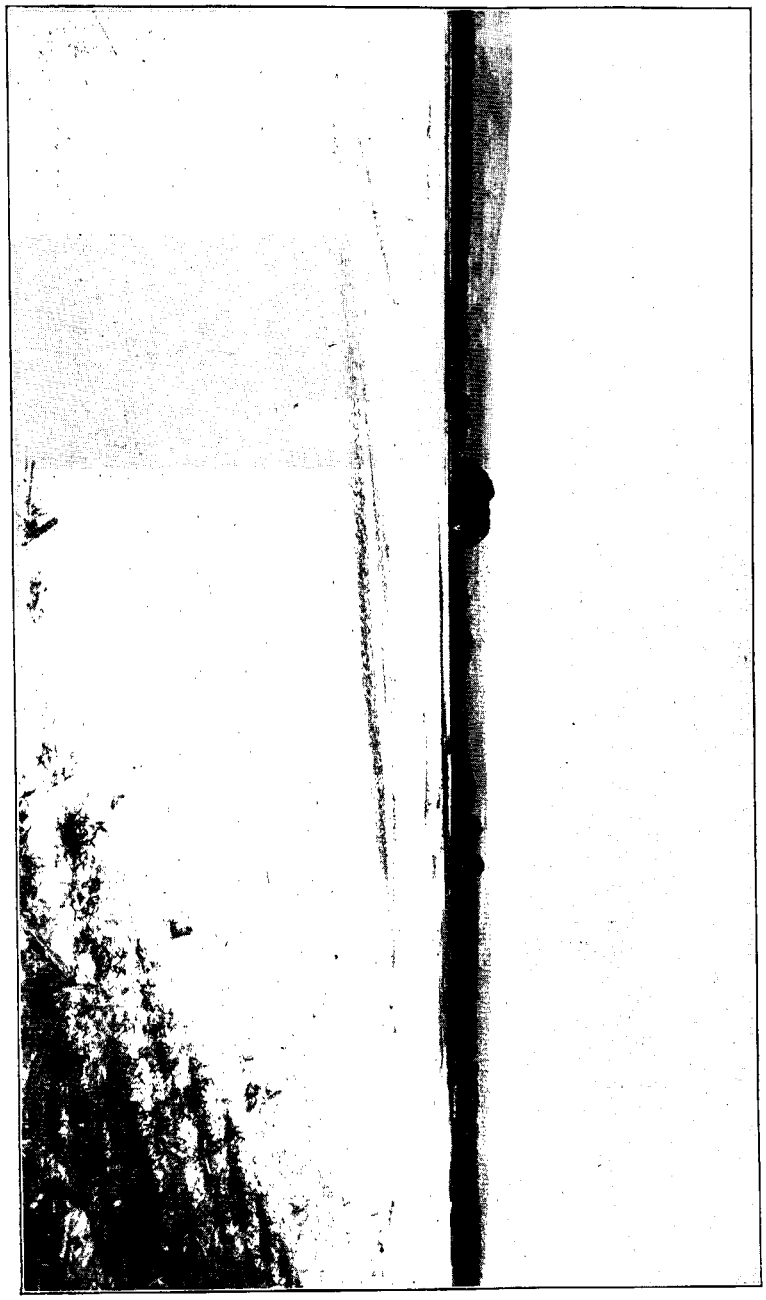

Plate IX.—Ninety acres of once fertile farming land covered with sand.

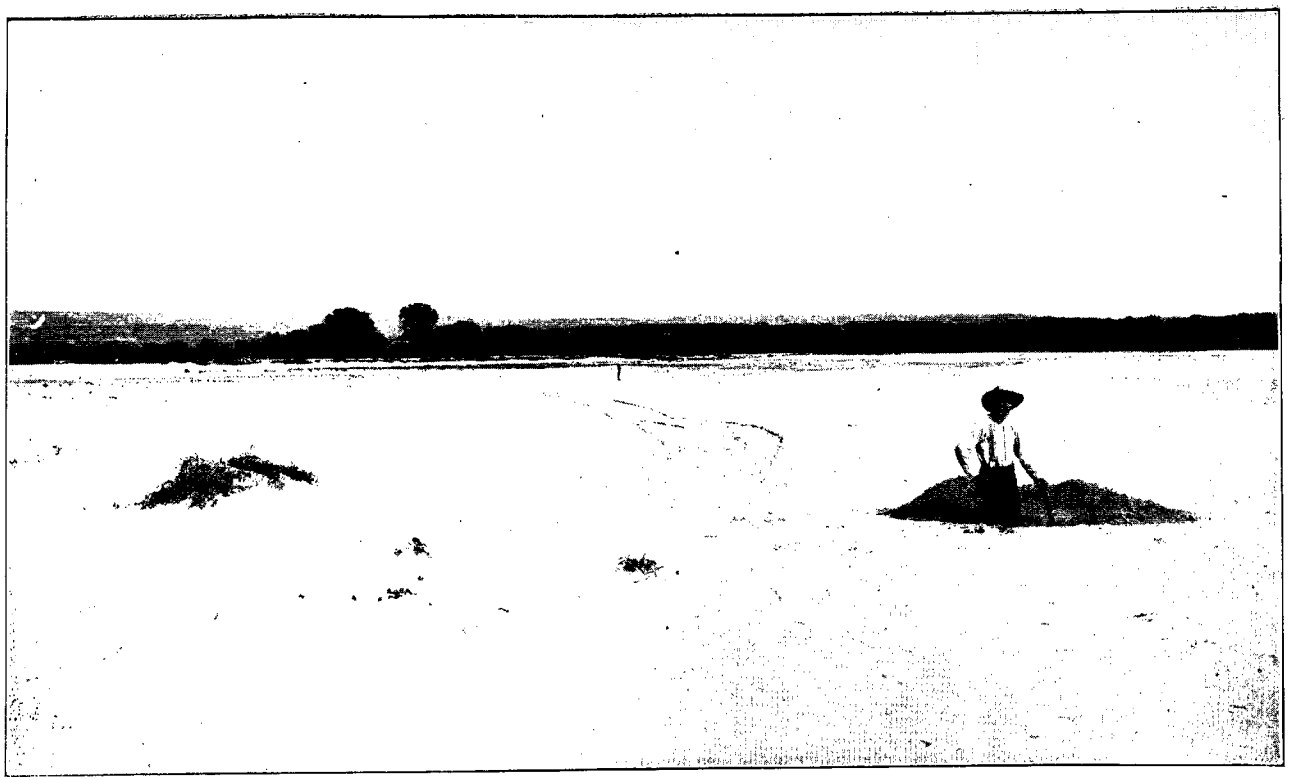

Plate X.—A sixty-acre field covered with a coat of sand one to five feet in depth.

Plate XI.—Mr. G. E. Spohr's apple orchard after the flood.

Plate XII.—A bur-oak stump, as left by the water.

Plate XIII.—A crop of sorghum grown after the flood.

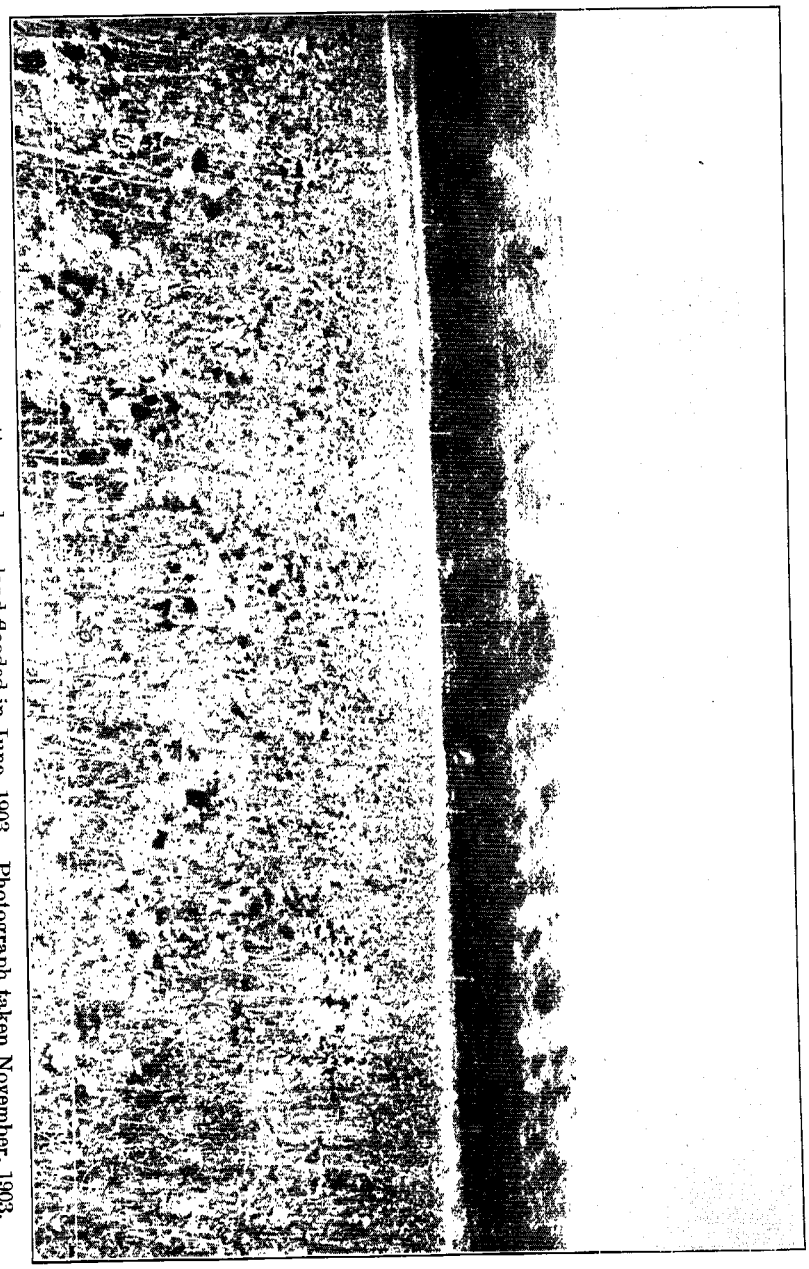

Plate XIV.—Growth of young cottonwoods on land flooded in June, 1903. Photograph taken November, 1903.

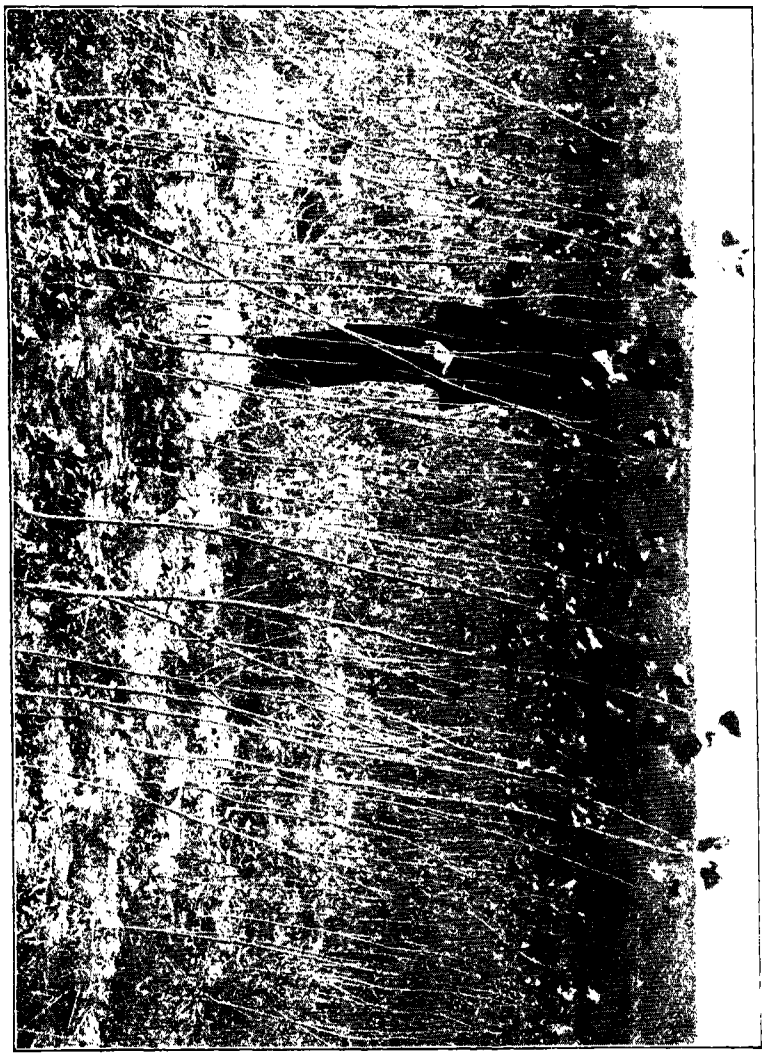

Plate XV.—Clump of cottonwoods on land flooded in June, 1903. Photograph taken November, 1903.

Plate XVI.—Grove of cottonwoods on Kansas river bank, about twenty years old.