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UTILIZATION AND CONTROL OF AQUATIC RESOURCES OF OHIO.*

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In attempting to present the matter of conservation of the resources of our State, I realize that the problem is so large that even to discuss one phase of it is more than I can expect to do, but the importance of the matter is such that I desire to contribute what I may in this direction. While the aquatic resources have been perhaps less recognized than the ordinary resources in agriculture and mining, we cannot question their close relation to other lines of development, and especially in agriculture a most important relationship exists. Considering the aquatic resources by themselves we must include the phases of aquatic dependence for agriculture, manufacture and commerce, and a careful examination of the problems will show that these are most intimately blended, and in reality mutually serviceable.

In arid regions the term "duty of water" is used to indicate the service that water should perform, and this term might be used with reference to our aquatic resources, but perhaps we may speak in a broader sense of the service of water as a recognition of its utility in all the varied activities of our commonwealth. We must appreciate its necessity in agriculture, its importance in furnishing water supplies in cities for domestic purposes and for power and for navigation, and in short its constant use in all human activities. Taking the state at large, we have approximately forty inches of rain-fall each year, and this represents a certain amount of basis for the numerous activities

*Read before the Ohio Academy of Science at its conservation session, Nov. 27, 1908.

of the state, just as essential and permanent an asset as the soil itself. Unquestionably a large amount of service is derived from this body of water. It is, I believe, equally certain that an immense amount of this resource is going annually to waste, and that by its proper utilization the wealth of the state could be very greatly increased.

While it is not my purpose to go into detail regarding all phases of this problem, I may call attention to the service of water in connection with agriculture, where we have a large amount of utilization, and where there is perhaps less of necessity for changes in method of operation. For service in production of crops it is necessary that the annual rain-fall be absorbed in the soil, that a certain amount be retained for support of plant life during intermittent periods of dryness, and to a large extent this is met in the ordinary methods of culture, especially in connection with systems of tile drainage which are now largely in vogue. The practical necessities in preservation of soils is admirably stated by Professor Chamberlain in a recent article in Popular Science Monthly,* which I take the liberty to quote:

"The key to the problem lies in due control of the water which falls on each acre. This water is an asset of great possible value. It should be the habit of every acre-owner to compute it as a possible value, saved if turned where it will do good, lost if permitted to run away, doubly lost if it carries also soil values and does destructive work below. Let us repeat the story of its productive paths. A due portion of the rainfall should go through the soil to its bottom to promote soil-formation there; a due portion of this should go on into the under-drainage, carrying harmful matter; a due portion should go again up to the surface carrying solutions needed by the plants; a due portion should obviously go into the plants to nourish them; while still another portion should run off the surface, carrying away a little of the leached soil matter. There are a multitude of important details in this complex of actions, but they must be passed by; the great features are clear and imperative."

It may be noted in passing that this service of water by no means affects its further service in other ways, but that the more complete the retention of the soil, the more equal the distribution of the flow, the more perfect is its availibility for other purposes. My understanding of the effect of tile drainage is that it provides for the greater absorptive power of the soil, so that a larger portion of the rainfall goes into the soil, reducing the surface wash, providing for the retention of organic matter, and regulating the outflow.

With regard to the utilization of the waters of the state for power, it appears that there is opportunity for an immense development. There are hundreds of sites where some considerable amount of water could readily be impounded, and power for electric-lighting and running of machinery be developed on a large

*July, 1908, Vol. LXIII, p. 5.

scale. There are many other localities which have such power in a smaller degree for the running of small local plants in various industries.

This feature is also closely associated with the greatest utility of water in irrigation and navigation, as the retention of waters during flood periods is the evident means of prolonging the periods in which irrigation or navigation is possible. This problem is essentially an engineering problem, and I would like to present some quotations from the report of an engineer who has evidently given this problem a great deal of study. His paper entitled "The Mississippi River Problem" while covering the whole Mississippi River drainage, is in large part a discussion of questions pertaining to Ohio, and it seems to me distinctly appropriate in this connection. It certainly fits in most perfectly with any efforts toward the retention of our own rainfall, its utilization and the reduction of flood damage within the state. He says:

"The solution by building a series of reservoirs in the head-waters of the chief tributaries appears to be the cheapest and most certain remedy for all these difficulties. By the construction of reservoirs the excess of water which produces flood stages could be impounded and held up with these important results: Excessive and destructive high-water stages could not occur, while, on the other hand, by regulating the discharge from the reservoirs, a more even flow of water could be maintained at all times, eliminating to a large degree the losses from diminished water supply, reduced power and fouling of streams incident to the low stages of late summer and early autumn. As soon as the irresistible rush of flood waters is stopped the sapping and caving of banks will be reduced to a minimum, with the efficiency of revetments increased many fold; finally, cutting down the flood volumes means a great dimuintion of the amount of sediment carried, and a marked alleviation of the sand-bar evil. The reservoirs would, moreover, eliminate floods from the whole system, not merely from the lower course. The prevention of the annual flood damage in the Ohio would in itself be worth the entire cost of the reservoirs, yet until the work of control is carried to the headwaters no relief can be secured for that populous valley.

"The solution by head-water reservoirs, of all proposed plans, has probably provoked the most discussion—on the one side, those who regard it as impossible, or, at least, highly impracticable; on the other side, those who consider that it is not only feasible but at once the only proper remedy. It is admitted by every one that the topography of the country about the head-waters of the Mississippi system is especially well adapted to the construction of retention dams and reservoirs. The arguments advanced against this plan, though admitting this condition of favorable topography, maintain that sufficiently large reservoirs could not be constructed and made safe or, in other words, they would, through danger of bursting, be a constant menace to the whole valley below the retaining dam. Again it is urged that if this plan were adopted, the building of reservoirs would have to be done on an enormous scale, since destructive floods often result from local conditions, such as a swollen tributary superimposed on an already swollen river. This necessity for a widely extended system of reservoirs, it is further claimed, would involve such tremendous expense as to make the adoption of the plan impossible. Most of these supposed objections are still based on a report made to Congress nearly fifty years ago, and, whether good or bad arguments then, there is no question that they do not apply now."

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*Tower, W. S. "Popular Science Monthly," July, 1908. Vol. LXIII, p.13.

"It is flying in the face of cold facts to contend any longer that reservoirs to retain the flood waters can not be built, or not without danger to the entire valley below. The Ohio floods of 1907, the most disastrous for more than two decades, were due to an excess of water estimated at 23,000,000,000 cubic feet. To hold every drop of that excess discharge would have required a reservoir only a little more than half as big as the Pathfinder irrigation storage reservoir on the North Platte River in Wyoming, or one-third of the size of the reservoir in the Salt River project in Arizona. The Engle dam on the Rio Grande, a hundred miles north of El Paso, Texas, will impound about 120,000,000,000 cubic feet of water, equal to one-sixtieth of the total annual discharge of the entire Mississippi system, or more than five times the quantity of water causing the most destructive Ohio flood in a score of years. These reservoirs are being built by the government at a cost of about $4,000,000 for the Pathfinder dam, $5,300,000 for the Salt River project and $7,200,000 for the Rio Grande reservoir. Furthermore, it is expressly stated by the Reclamation Service that the Wyoming reservoir and the Engle dam will absolutley control the worst floods which the North Platte and the Rio Grande have ever known, the latter of these streams having been a notorious offender in flood damage. The mere fact of being able to retain the flood waters in impounding reservoirs can no longer be denied, nor can the claim of danger from breaking dams be now advanced as a valid argument against this system. This government is most assuredly not spending millions in reclamation projects and encouraging thousands of people to take up irrigated lands if there is any remote likelihood of having homes, property and lives wiped out in floods from bursting reservoirs.

Granting, then, that the reservoirs are feasible, there still remains the question of expense in constructing the number necessary to place one or more in each of the most important tributaries. Estimate the expense most generously, letting each one cost a third more than the Engle dam above El Paso, and the total figure then is less than what has already been spent on the Mississippi system. But there is another important factor to be considered—the tremendous possibilities which lie in the development of water power from each reservoir. The question of furtue motive power for industrial purposes, as the coal supply decreases, is a problem which must soon be met in this country, and probably will be solved by the use of water power either directly or through electricity. In fact, even now, water rights are being rapidly acquired and developed on every hand, as the advance guard of the change that is to come. A sample of what a storage reservoir will do can be seen in the case of comparatively small irrigation project at Minidoka, Idaho, which will develop about 30,000 horse power per year. Renting this power at the very low figure of $10 per horse power per year would pay for the entire Minidoka project, reservoir, irrigation-canals, gates and all, in six years. The amount of power generated by the Mississippi system is variously estimated high and low, with 60,000,000 horse power per year as an intermediate figure. Much of this amount is not directly available, but granting on a conservative basis that a series of impounding reservoirs would develop immediately 2 per cent of that amount, there would be 1,200,000 horse power to be turned into electricity and distributed to factories. A purely nominal rental would be ample enough to repay in two or three decades the entire original expense of the system, besides a good income on the investment. The reservoir system, however, must be intimately associated with forest conservation as a vital factor in regulating surface drainage and in checking the amount of soil erosion which supplies sediment to the river.

The proper building of reservoirs in the headwaters, therefore, offers what no other plan can possibly offer: it promises effective regulation of river stages and water supply for all time to come, removing entirely the liability of destructive floods, checking the erosion of banks and preventing much of the formation and shifting of sand bars and the pollution of water which the presence of sediment means. At the same time it provides a way of actually paying for itself in short order, aside from all idea of the savings to shippers and river interests in general which would be in excess of the cost. The importance of this latter consideration is emphasized best by a brief comparison with the system now being followed. The levee-revetment system, as mapped out, calls for an expenditure of $60,000,000 for its completion. From the engineers themselves comes the statement that the average life of a levee is not over twenty years, which means this and no more; in two score years, at the most liberal estimate, the present system, completed, will have disappeared entirely and a new series of levees constructed at the cost of another $60,000,000 will have taken its place, with conditions then no better than they are now. Considered solely on their own merits from the standpoint of control afforded, the present system has nothing, and the reservoir plan has everything, to recommend it.

"In order to bring the river route to its highest possible degree of efficiency, it would be necessary to combine the reservoir system with a straightened course for the lower river, by which combination every evil would be removed and absolute control for all time would be insured. The reservoirs would make it possible to regulate the flow of the streams, preventing both floods and very low water, and at the same time, through developed horse power, pay for the improvements. The corrected or straightened course would shorten the route and effectively put an end to caving of the banks with all the difficulties arising from it at present. Together the reservoirs, with the necessary forest conservation and corrected course, would remove the sand bar problem—the one greatly lessening the actual amount of sand carried into the river, the other giving the current increased power to sweep its own channel clean."

While it is probable that some of the advantages claimed may not be entirely realized, especially in the case of extreme flood there is, it appears to me, so much of virtue in what this author claims that it should be given great weight in any general plan of flood control. It appears, however, that such a method should be strongly re-enforced not only by the conservation of forests and thickets on uplands and hill sides in the head waters of streams, but that the stream valleys should, to as large an extent as possible, be planted in willow and other moisture loving shrubs or trees, which serve as a natural check to the stream currents and therefore retard the flow and serve to distribute it through a longer period of time.

There is another phase of the subject, and the phase which appeals directly to me. That is the biological side of the problem of utilization of water. While this phase seems to have been largely neglected, it appears to me that it is worthy of fully as much consideration as the utilization for power or navigation and particularly in connection with its bearing on flood control. The neglect of this phase is probably due to the fact that in our ordinary processes of culture we have come to consider water in excess as undesirable and make efforts to eliminate it rather than to conserve it. For the culture of our ordinary crops it is, of course, true that an excess of moisture is detrimental, and tile drainage combined where possible with irrigation is a natural remedy for this condition. There is, however, no question that beyond this we have in water areas a source of production which is very extensive, and which, were it brought under the proper system of cultivation, would furnish a great source of wealth. We are all familiar with the rank growth of swamps and lowlands, and can readily appreciate that for certain kinds of vegetation a constant or even excessive supply of water is in no degree detrimental. There is however, in addition to the evident growth, an enormous development of microscopic life familiar to the biologist, but practically ignored by those unfamiliar with aquatic life.

"Some of this becomes apparent as green scum or as floating masses when its growth exceeds the capacity of the aquatic animals to consume it. Sometimes these minute algae become a great source of annoyance in water supplies if for any reason their multiplication is unchecked, since they give offensive odors and taste to the water.

"It has been estimated that the rate of development in some of these organisms is such that the possible progeny of one individual would suffice to fill all the waters of the globe in less than a week.

"This is significant to us here simply as showing the enormous possibility of these organisms in utilizing water and air in the formation of vegetable substance, which substance may, with proper utilization, be transformed into fertilizing agents for the production of valuable plant crops or into animals having direct commercial value. To understand this process, let us consider for a moment the relations existing among aquatic organisms. The algae may be considered among the more simple and these develop with only water and air or the other inorganic contents of water, but they furnish food for an innumerable host of microscopic animals such as amoebae, rotifers, etc., and these in turn are fed upon by others, such as microscopic crustacea, which again form an important part in the diet of young fishes. These when grown, or after furnishing the basis of food for other larger species, may reach our tables as human food. This, however, is but one line of transformation, as we have fishes of very different habits utilizing different kinds of aquatic life as food.

"Where the life taken from the water does not balance the production, or where this product is not drained off into the sea, the accumulation of organic debris forms at the bottom a mass of richest organic matter, which by its decomposition may in a large part result in marsh gas, and in this form escape into the air. * * *

"We have in America practically no established system of cropping our water areas. * * * Something has been accomplished in fish culture in some sections, but even here the full utilization of the resources of a body of water are but poorly accomplished. A few sporadic efforts have been made here and there in the culture of frogs and turtles, but how many of them with such attention to the subject as to warrant the term culture?" * * *

The farmer who drains and cultivates an acre of swampy land on his farm gains that much additional space for his ordinary culture and for a time at least it may be unusually productive as it contains the accumulated organic debris of years, but would it not be far greater wisdom to dredge out occasionally a portion of this accumulation to spread upon higher ground and keep the acre as a source of fertilizing material for the years to come. This seems all the more desirable when it is remembered that this basin must collect quantities of the finest and most fertile parts of the soil washed from the higher ground. Moreover, I hope to show that there is good reason to expect that the acre can be made so productive over and above this function of conserving fertility that it will be worth more in water than it could be as cultivated land.

> What is needed in the matter of utilization of our great tracts of marshy or swampy land is some such systematic study and the development of some such adapted system as is in progress of development in the systems of "dry farming" in the arid or semi-arid regions of the west—a system which will intelligently conserve and utilize our heritage of water, not throw it ignorantly away and reduce our uplands to a condition of sterility."*

There are certain resources among the natural inhabitants of aquatic areas, and a few of these may be enumerated to advantage. First perhaps in general recognition is the fish industry which in many localities is a quite important matter. In large part, however, the fish industry is carried on without particular regard to the methods by which the largest available crop could be secured, and except as efforts are made to save and rear eggs of certain species and to regulate the capture for certain seasons, no systematic plan is in practice by which the crop may be regularly grown and harvested, so as to provide for perpetuation. In many localities, especially in swampy areas, the growing of frogs, turtles, ducks, geese and musk-rats is sufficiently recognized to indicate that these are all capable of a much greater cultivation, and there can be no question that a systematic study of the means of culture and adaption to the best localities would result in productive crops. Aside from these there are several species of fur-bearing animals, especially the beaver, otter and mink, which in wilder tracts might undoubtedly be grown with profit. In streams and ponds where the native species of clams used to abound, there unquestionably could be established a productive industry in the growth of these animals for pearls, and as a basis for the button industry. While not yet developed, there is, in all probability, a great latent resource in the aquatic plants which might be used for the manufacture of paper. Some of the species that are native here seem likely to furnish an excellent fibre, but if not, the introduction of other species, especially the Japanese paper plant, might establish a most important industry and serve to relieve in part the drain upon the forest areas which are being consumed in the manufacture of paper. Willows and other rapid growing semi-aquatic trees might also be utilized in this direction, as well as for their influence in checking the outflow of flood waters.

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*Osborn, Pop. Sci. Monthly, July, 1908, Vol. LXIII, p. 85-87.

It is estimated in a recent article in the National Geographic Magazine that Ohio contains 1250 square miles of swamp, or, in other words, 800,000 acres, and this area is now practically unused except perhaps to some extent as a hunting ground, but without control or regulation regarding the protection of certain species further than is given by the general laws regarding the killing of game. That this area could be profitably converted into a permanent water area for the retention of rain-fall, and by a system of canaling made into cultivable land or water, seems certain. Estimating the capacity of such an area we would have for one foot of water nearly thirty-five billions of cubic feet, or for two feet of increased depth nearly seventy billions of cubit feet, which, if compared with the previous estimates as to the excess of outflow responsible for serious floods, will seem to have a very direct importance. If it be recognized that this area could be kept in water, and at the same time produce valuable crops, the advantage of preserving this resource will be apparent.

It seems, therefore, that the general policy for the conservation and utilization of water which is a very constant element in our state wealth, should be that of retention and culture for various crops, rather than a rapid discharge by drainage applied to all swampy land. This is perhaps the main point involving a radical departure from present policies, but this is of immediate importance since there are constant efforts in the drainage of existing swamps, and once these swamps are drained, a re-establishment of the conditions for retention of water will be very difficult, if not impossible.

To the engineer a drainage scheme is perhaps the most attractive, since it presents definite possibilities in the disposition of water, but from the biological standpoint the retention of water seems far more important. Ohio already has a distinct start in the direction of reservoirs in the Grand, Lewiston and Licking reservoirs, which are bodies of considerable size. Although designed originally in connection with the canal system of the state, they are capable of serving for other purposes without in any degree affecting their value for the original purpose. Abundant sites exist in the state for the construction of additional reservoirs, largely in the valleys which are not of great value for other purposes, and which in the aggregate would furnish a large capacity. The Columbus storage dam containing 1,600,000,000 cubic feet with the present thirty-foot dam occupies a river valley which was practically unused and of slight value for agricultural purposes. A number of such reservoirs suitably located and properly controlled, while nor sufficient to entirely prevent flood conditions, might certainly aid greatly in preventing the excessive flood conditions that result from the immediate outflow of all surplus water, and also serve largely in the improvement of navigation.

They could also be used in suitable localities for extensive systems of irrigation, and finally for the cultivation of aquatic crops. Such crops, although at present problematical, have, I fully believe, a most important promise of wealth.

Considering, then, the quantity and regularity of our water, the extent of the utilization it is already given, and the possibilities in development for irrigation systems, power, and navigation, and especially the possibilities of development for production of important crops, it is no extravagance to claim that it stands as one of our greatest sources of wealth, and merits and demands thorough scientific investigation that these resources may be conserved, developed and utilized to their fullest extent.

In summing up these different factors it seems that the greatest utility of our water supply and its most effective control may be secured with the combination of a number of different methods, but not by depending upon any single one. The following may be offered as suggestive:

First, the levee system serving to narrow and raise a river channel, can serve only to jeopardize the lives and property of the river valley and should be resorted to only in particular cases and in connection with other means of flood relief.

Second, the establishment of as many reservoirs as possible, in the head waters of the smaller tributaries to the larger streams and the utilization of such reservoirs not only for power and as a reserve for water supply, for irrigation and navigation, but also as a basis for the growth of aquatic plants and animals, the cultivation of which should be a subject of careful experiment.

Third, the exhaustive study and development of reforestation wherever this can be done to advantage, and especially the protection of thickets and brush land along the slopes leading to the river bed.

Fourth, the preservation and regulation of all extensive swamp areas which can be made to contribute to water retention in the head waters of the river tributaries.

Fifth, the extensive planting of marsh grass, willows, or any other plants which flourish in the river bottoms, as a means of checking the flow to the streams during periods of excessive rain.

Sixth, the utilization of the river flood plains reached by higher floods for crops which are least affected by over-flows of river water and which provide an opportunity for the spreading out of excessive water and serve also to catch and hold the river silt which forms a most important addition to the soil's fertility.