POTHOLE AND POND CONSTRUCTION

Value

Some form of pothole construction has been tried on state-owned wildlife areas in almost every management district in the state. These constructions range from simple blasted potholes to more sophisticated runoff ponds. Although runoff ponds in the strictest sense are not true potholes, they serve many of the same objectives and are included in this section. The principle objective of these constructions was to provide territorial sites for breeding waterfowl. On the Pine Island Wildlife Area their value as water holes for upland birds and mammals was also considered important. Certainly the greatest return on potholes in terms of waterfowl use can be expected in areas of high waterfowl density where territorial sites are at a premium. In areas of very low density there may not be sufficient waterfowl to fill the additional habitat created by the addition of potholes. In such locations potholes may be only partially utilized. It may take a considerable period of time before breeding waterfowl populations build up so that all portions of this newly created habitat are fully utilized.

Evans and Black (1956:53) found that on the prairie of South Dakota all types of potholes are of practically equal value. They stated, "The small temporaries are of no value through most of the year, but acre for acre of water, they are the most valuable type during the critical breeding period. The large permanent areas serve a number of functions in duck production through a much longer period, but do not have as high a value during the breeding season. Furthermore, as water levels, weather and duck populations fluctuate, the birds vary their use of the habitat, further equalizing the long-term values of the different types."

They also point out that the main value of small potholes is to allow the breeding pairs to disperse and maintain a measure of isolation from other birds of the same species. It should not be construed that a pair of birds use one pothole to the exclusion of all others, but rather a series of potholes will be used and defended against intrusion. However, other birds may use the same pothole or potholes when they are unoccupied by the original pair. There is considerable overlap in use, therefore, and any one pothole may be used by several pairs at different times during the day. Evans and Black (1956) noted a single pair of birds using seven different potholes as part of their home range.

Mathiak (1965), working on the Allenton Wildlife Area found that nesting blue-winged teal used from 5 to 10 different potholes in one day and mallards used only 2 to 3. However, when several pairs of mallards were present as many as 8 potholes were used.

Construction and Costs

Most potholes dug on state wildlife areas in Wisconsin were either rectangular or square in shape. Bottom contours were trepezoidal or wedge-shaped (Fig. 8). Exceptions to the rectangular shape are found on the Ackley Wildlife Area where "V" shaped and circular ponds were constructed. Circular ponds contained small loafing islands. Some of the larger farm ponds constructed by the Soil Conservation Service were also circular and contained an island. Wedge-shaped bottoms provided shallow edge for puddle ducks despite fluctuations in water level and at the same time provide a maximum surface area of water during drought periods. In the more fertile southern part of the state this shallow edge construction should probably be modified. Increased edge depth would prevent rapid encroachment of the open water area by cattail.

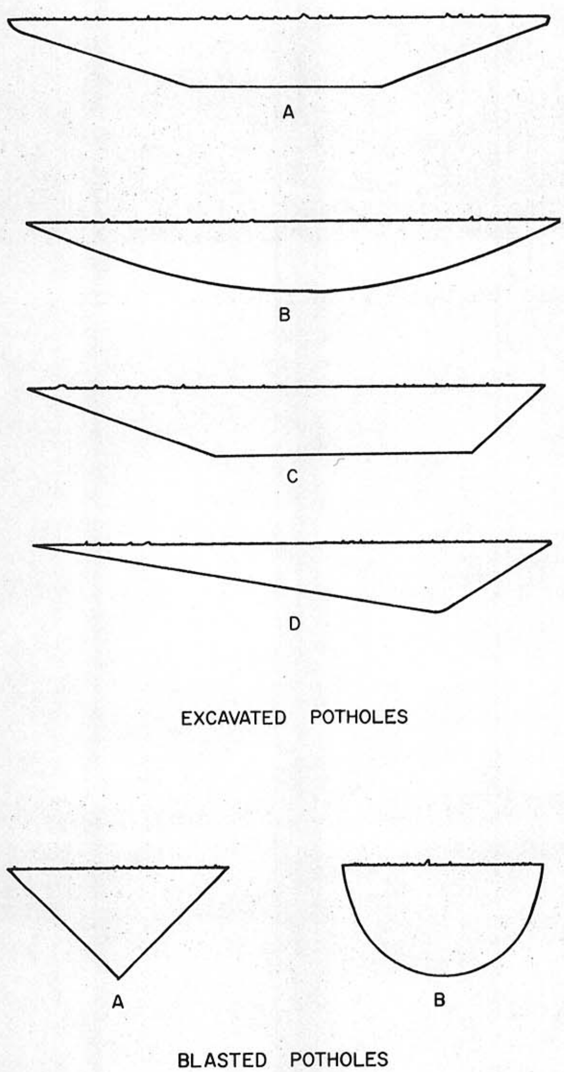

Figure 8. Variations in longitudinal profile of bottom contours for constructed potholes.

Circular bulldozed pothole with resting island in center (Antigo District).

"V" shaped bulldozed pothole (Antigo District).

Hammond and Lacy (1959) who pioneered in pothole construction believed that on their study area the optimum size of potholes was 20 to 25 feet wide and 40 to 75 feet long with a water surface area of 500 to 2,000 square feet. They recommended that the pothole have one or two gradually sloping edges so that there could be some use of bottom foods by dabblers. They did not feel that it was necessary to level spoilbanks. Increases in size within the above range gave a proportional increase in use. They recommended 150- to 200-foot spacings between potholes. Potholes should have a depth of about 4 feet and a berm should be left between the spoil pile and the water to reduce silting. Pattern of pothole arrangement should be in block form and well within the daily pair travelling range from a marsh and large breeding and brooding pond. On their area this was 1/4 mile or more.

Detailed cost and use figures for pothole constructions in Wisconsin were not always available. Use was seldom recorded in sufficient detail to be of value except in certain instances where some form of study was actually made. However, available costs ranged from $77 per acre-foot to $923. This included construction by blasting, dragline and bulldozer. Compared on a per acre-foot basis, bulldozing produced the cheapest construction, but on the per pothole basis, blasting was by far the cheapest form of construction. This indicates that if many very small potholes are to be constructed, blasting is the most economical form of construction, but if fewer and larger constructions are wanted, bulldozing would prove to be more economical providing conditions are right for using this type of equipment. The average cost for all forms of constructions was $435 per acre-foot of water produced. It is difficult to compare operations since there were no figures available to indicate how much earth was moved to create an acre-foot of water. If the pothole or pond is created in a natural depression, less earth must be moved than if the pond or pothole was located on level terrain.

Hammond and Lacy (1959) reported that pothole costs are about one-half the cost of level ditching. They found that the cost per breeding pair when prorated over a 30-year period ranged from 45 cents to $1.43. Level ditching ranged from 81 cents per breeding pair to $1.43. These costs varied with the size of the construction and the type of equipment used.

Types of Construction Used on State Management Areas

Blasted Potholes

Blasted potholes have been widely promoted in this state and no detailed descriptions of construction techniques are necessary since they were well covered in a recent Department publication (Mathiak, 1965). One of the first attempts at pothole blasting (42 ponds) was made by Dreis (1963) on Hay Creek Wildlife Area in Dunn County. Using 189 sticks of 60 percent ditching dynamite, a hole approximately 20 by 40 feet and 4 feet deep was constructed. Cost of explosives were estimated at $29 per pothole. Shortly thereafter Mathiak (1965) introduced the use of

ANFO (ammonium nitrate fuel oil mixture) for pothole blasting in Wisconsin. Since it is considerably cheaper, it has supplanted the use of dynamite.

A 50-pound charge of ANFO will cost about $3.00, complete with detonating charge, fuse and cap and will produce a circular hole 19 to 35 feet in diameter depending on the soil and water conditions (Mathiak, 1965). Bottom contours vary from cone to bowl shape and depths range from 30 to 72 inches in the ponds measured, but they may be greater. Since pond sizes show such extreme variation due to soil characteristics, it is difficult to predict pond sizes in advance from area to area or even within the same general area.

Pothole blasted with ammonium nitrate (ANFO) (Eldorado Wildlife Area).

Ammonium nitrate costs only about 1/10 as much as dynamite (42 cents/lb. for dynamite and 4 cents/lb. for ANFO) and is quite safe to handle and store. There is little doubt that if blasting of this type is to be done, ammonium nitrate is the best choice of explosives. Mathiak (1965) estimated that pond depths require 2 years to stabilize before accurate depth measurements can be made. A disadvantage of the blasted pond is that the edges are extremely steep, sometimes almost perpendicular. In loose soils this causes sloughing in and silting and is probably less attractive to waterfowl than is the dug pond which can be constructed with gradual slopes that provide shallow water for puddlers and an edge that may have good loafing spots.

When water levels drop a foot in a blasted pond with a conical bottom, the surface area of the pond shrinks appreciably and the decreased water area is then surrounded by a fairly steep bank. Since any bird using the pond would have its visibility obstructed by the steep pond edges because of the small confined water area, there is a strong possibility that the ponds would not receive much use during periods of low water level. However, Mathiak (1965:14) noted that a pair of teal were seen in a pond which had a water level that was 3 feet below the surface, so apparently birds do use them even under extreme conditions. Mathiak believed that in this instance the birds had established a territory before the water levels receded and they simply continued using it even though the water levels dropped.

Shearer (1960) found that in stock pond dugouts, waterfowl use increased as the ponds filled with water and cover increased. However, it appears that dug ponds do provide water areas that are usable for longer periods of time during low water conditions. During a dry fall, if jump shooting is expected, the blasted ponds may be completely unusable, while dug ponds, due to their flatter bottom contours and greater surface area, may still have usable water available for waterfowl.

If we consider blasted potholes strictly in relation to waterfowl breeding activity then their value greatly increases. In the spring and early summer, during a normal year, most potholes will be filled with water and there will be no problem with steep edges restricting visibility. There is little doubt that they will be used as territorial sites. In this case, their relatively small size should not be objectionable. Because of the low cost involved, areas of good waterfowl use could inexpensively be saturated with many small potholes that could conceivably increase waterfowl breeding use considerably. Mathiak (1965:19) reported excellent use by mallards and blue-winged teal of 44 blasted potholes in semidry portions of the Horicon Marsh Wildlife Area.

Blasted potholes in a variety of locations computed from measurements by Mathiak (1965:16) ranged from .0013 acres to .0025 acres for those constructed with 50 pounds charges of ANFO, and from .0015 acres to .0029 acres for the 100 pound charge. Blasted potholes constructed by Dreis (1963) were approximately .018 acre in surface area as computed from his dimensions, which was 9.4 times larger than the average pothole constructed by ANFO using a 50-pound charge, or 7.5 times larger than a hole constructed with 50 pounds of ANFO in wet peat, but at a cost that was 9.7 times larger. Labor costs for dynamiting are much larger than for ANFO because of setting multiple charges. According to Mathiak's (1965:16) table of averages there may be no advantage of using 100-pound charges of ANFO over 50-pound charges in wet peat. A gain of a few inches in depth was cancelled out by a decrease of 1 foot in diameter. From this it would appear that experimenting with various size charges at each general location would eliminate wasting ANFO through the use of unnecessarily large charges.

Blasting potholes on a per acre-foot basis may be more expensive than other forms of pothole construction, but when figured on a per pothole basis it is far cheaper than any other type of construction. If only limited funds are available for construction this may be the only way of putting water on an area. Since pothole volumes vary considerably with soil types and water content of the soil, it is difficult to predict exact costs on a per acre-foot basis.

<u>Bulldozed Potholes</u>

Bulldozed potholes ranged in cost from $77 per acre-foot to $721 per acre-foot. Spoil was spread and leveled as it was removed during bulldozing operations and final leveling was kept to a minimum. Conditions must be dry enough to allow efficient operation of the 'dozer. The high cost figure of $721 per acre-foot of water was caused principally by poor operating conditions. Extremely wet soil caused the 'dozer to become bogged down and cost figures went almost 4 times the average cost for this type of construction. Under such conditons a dragline would probably have been much more efficient. The cheapest bulldozed pond was a 1.44-acre pond costing $110 per acre-foot. A series of 10 ponds of varying size was bulldozed at an estimated cost of $87 per acre-foot, but these were constructed by cleaning out some natural depressions and are not really comparable since less spoil was removed than would have been if they were constructed in flat terrain.

Bulldozed pothole (Eldorado Wildlife Area).

On Crex Meadows Wildlife Area the objective was to re-establish natural potholes in the upland depressions which had silted in through the years and to again make them available for waterfowl use. The spoil was used to increase the amount of tillable acreage adjacent to them. About 5-1/4 acres of usable cropland were added by this process. Ten potholes ranging in size from .09 acres to 1.28 acres and totaling 3.55 acres were constructed with a D-7 bulldozer. They averaged 2 to 2-1/2 feet in depth. Loafing islands 15 to 20 feet in diameter were built into some of the larger potholes. Cost for the 10 potholes including leveling and seeding the edges was $310. Since pond contours may vary it is difficult to make a per acre-foot estimate but it probably was about $87.

Pothole constructed on the Crex Meadows Wildlife Area for breeding waterfowl.

The estimated useful life of these potholes is 25 years. Since the potholes are surrounded by cropland, waterfowl use was extremely heavy during migration. As many as 500 geese were seen at one time on or around the potholes. Heavy deer use was also noted. A good comparison between the size of the pond or pothole and its relationship to per acre-foot costs can be found in comparing costs for 19 fractional-acre potholes and those of a single 1.44-acre pond constructed on the same area during the same operation. The 1.44-acre pond cost only $110 per acre-foot of water constructed while collectively the fractional-acre potholes cost $279 per acre-foot of water. Per acre-foot costs increased 15 percent for the small potholes which had a collective surface area of only 1.16 acres.

Dragline Constructions

The average cost for dragline pothole constructions on state management areas where data were available was $435.33 per acre-foot of water constructed, although costs ranged from $222.22 to $750.00 per acre-foot of water. Cost figures were influenced considerably by weather and operating conditions. All costs were for actual construction. They did not include final spreading of the spoil or seeding of the banks. Under conditions of very wet soil there is no choice but to utilize a dragline or blast potholes since a bulldozer cannot operate efficiently. However, Hammond and Lacy (1959) found that 'dozer or tractor and scraper work could be half the cost of dragline work under favorable conditions.

It does not pay to move heavy equipment into an area for construction of only a few small potholes. Small potholes can be constructed more cheaply by blasting since moving time between potholes greatly influences the cost of constructing potholes with heavy equipment. This is especially true of dragline constructions. Larger ponds cost less on a per acre-foot basis with heavy equipment than do small ponds. Cheapest dragline pond construction recorded in this survey were two ponds, 1.6 acres and 2.0 acres. The cost was $222.22 per acre-foot of water.

Pothole Use

Allenton

On the Allenton Wildlife Area 27 potholes were constructed by dragline. They averaged 20 x 50 feet (.002 acres) in area and 4 feet in depth at a cost of $16 per pothole. Mathiak (1965) reported that duck use of the area greatly increased after pothole construction, since little or no open water was available prior to construction.

Horicon Marsh

Eleven potholes were dredged by dragline in semidry sedge-grass bog on the Horicon Marsh Wildlife Area at a cost of $22.72 per pothole. Pothole sizes varied from 15 feet by 60 feet (.02 acre) to 30 feet by 60 feet (.04 acre) in area. Average depth was 4 feet. Each was located on the edge of a low cattail swale, although the excavated portions were actually in sedge-grass bog. Surrounding sedge-grass meadow offered excellent nesting cover and the potholes provided open water. Lack of open water had limited use of this area by breeding waterfowl before pothole construction. An area of low utility was converted to one of high use.

Because the potholes were located on the edge of cattail swales, unlimited muskrat food was available and the 'rats responded by making fairly heavy use of the potholes. Water of insufficient depth in the swales had precluded much muskrat use of the area before pothole construction. However, in dry summers the potholes lost all their water and 'rats were forced to move out before winter unless fall rains restored water levels. This, of course, made for intermittent use by muskrats, but it did provide early spring and summer range and some muskrat litters were produced during normal years.

Checks made during spring and early summer of the first year after construction indicated that the 11 ponds were used by breeding pairs of blue-winged teal, mallards and shovellers. It was estimated that there was a minimum of 11 blue-winged teal pairs using the potholes. If each observed pair or lone bird represented a possible brood, then a minimum of 11 blue-winged teal and 2 mallard broods and 1 shoveller brood could have been produced on the potholes during their first year of existence. Some predation on duck nests was noted in the area, but there is nothing to indicate that predation should be any greater here than it is in any other waterfowl nesting habitat on this marsh.

Heavy deer use on the potholes increased as marsh water levels decreased leaving the potholes as the only source of open water in the vicinity. Raccoon sign around the pond edges was common so it is apparent that the ponds received multiple use by a variety of wildlife.

If we prorate construction costs over an estimated useful pothole life of 20 years, the cost per pothole per year would be $1.13. Hammond and Lacy (1959) estimated that this type of construction had a productive life of about 30 years. If we prorate costs over a 30-year period, this amounts to 75 cents per pothole per year. On the basis of 14 observed breeding pairs for the 11 potholes the costs per breeding pair per year would be 59 cents. Pair use was minimal in this check since the checks were begun after the peak of the mallard breeding activity. Include muskrat, deer and other forms of wildlife and the per unit cost for wildlife use becomes extremely low. In general, this pothole project can be considered highly successful. An area of very low waterfowl productivity was converted to good waterfowl breeding habitat and other wildlife use was increased.

Of course, this does not mean that all areas will respond in a similar fashion to pothole construction. Horicon Marsh is a highly productive area having a high potential for heavy use by breeding waterfowl. If bird use on a marsh is normally low it may take a relatively long time for birds to expand into this new habitat and fully utilize it, but if bird use is good this type of construction may encourage more of the temporary spring migrant population to stay and breed on the area. Broods produced on the area will be encouraged to return to breed because available habitat is expanded. Their tendency to spread out and use other areas will be minimized.

Other Areas

Detailed observations of waterfowl use on pothole constructions in other parts of the state are not available for comparison. The 35 potholes on Oconto Marsh were checked for one summer, but results are rather inconclusive. These potholes were constructed by dragline at a cost of about $30 per pothole. They were approximately 33 feet square (about .02 acre), 4 feet deep, and spaced 75 to 125 yards apart. They were constructed in a sedge-grass marsh. Oconto Marsh has Green Bay to draw on for breeding birds. However, during the first part of the breeding season relatively few birds were observed on adjacent water areas. There was a period when half of the breeding birds on the marsh appeared to be concentrated in the potholes, but these birds were in relatively small numbers. Peak counts on the potholes represented about 10 breeding pairs, and there was a possibility that some of these were reflushed birds. Since the breeding bird population on adjacent water areas was rather small and the total bird use of the potholes was low, the overall sample size is too small to properly evaluate. However, there is little doubt that these potholes did make a contribution to waterfowl production on the marsh since breeding birds were making use of semidry marsh which would have received little or no use without the potholes.

Weekly observations of breeding pair use were made on 12 potholes blasted along the semidry edge of the Eldorado dike. Peak use on one day was 16 pairs of birds on the 12 potholes. Of these, 14 pairs were blue-winged teal and 2 pairs were shovellers. Shoveller and blue-winged teal pairs often shared potholes. However, simultaneous use of the same pothole by 2 pairs of blue-winged teal showed rather surprising tolerance between pairs of the same species on such small potholes. Observations throughout the breeding season indicated that there was a minimum of 21 pairs of ducks using these 12 potholes during the season. They included 14 pairs of blue-winged teal, 2 pairs of shovellers, 3 pairs of mallards and 2 pairs of green-winged teal. Lone birds were considered as members of a pair.

Birds were first noticed using the potholes on April 27 and no birds were observed after June 29. Although water remained in the ponds throughout the summer, there was a conspicuous drop in water levels during July and August until fall rains again filled the potholes. Waterfowl used after the breeding season was minimal. However, it is obvious that potholes had filled a requirement in the breeding habitat and from this standpoint could be considered successful. It should not be inferred or expected that potholes of this type will be as heavily utilized in all parts of the state. Where breeding waterfowl populations are low it may require a number of years to build up a sufficiently high population to obtain 100 percent use on a dozen potholes. If other important requirements such as food and larger water areas for brooding are lacking this breeding habitat may never be completely used.

More evaluations of pothole projects in all types of areas are needed before the total contribution of potholes can be properly assessed. However, according to information presently available, this type of habitat manipulation does contribute to breeding bird use.

Runoff Ponds

These are essentially small impoundments but are usually located on upland sites. They are constructed by plugging natural drainage courses with short dikes or large gullies draining off upland slopes. The watershed must be large enough to supply and maintain levels of the resulting pond. Runoff pond dimensions will vary with the size and contour of the site, but for multiple acreage constructions they are cheaper to construct than other types of ponds since the principal part of the construction is the short dike and emergency spillway. If a water control structure is desired, construction costs will increase proportionately. Although a control structure is not a necessity, some means of drawing down the pond to remove undesirable fish or turtles, to make repairs, or to control vegetation is desirable. Since ponds of this type average an acre or more in size they usually can be developed into very satisfactory waterfowl brooding ponds. If the surrounding area is maintained in grass cover and scattered small potholes are added, a good waterfowl nesting and brooding unit can often be developed.

Runoff pond construction is essentially the same as that of the Soil Conservation Service farm pond with modifications to meet local needs. Bradley and Cook (1951:257) based small impoundment construction which depended on runoff water on the following criteria: (1) at least 20 acres of drainage area is required for each acre of water impounded; and (2) structural design is based on a water flow covering a 50-year frequency.

Addy and MacNamara (1948:62) pointed out that watershed requirements for runoff ponds are extremely variable and depend on rainfall, topography and land use. They say, "In some instances, 20 acres of pasture or cropland is sufficient for one acre of pond and in other cases 100 acres of woodland or brush land will be needed." Since watershed requirements vary with local conditions it is desirable to seek Soil Conservation Service assistance while still in the planning stage, before construction begins. A pond constructed on too small a watershed will fail to fill and may dry up during the middle of the summer, while a pond constructed on too large a watershed will require more expensive dikes and control structures to handle the peak flow, unless part of the flow can be diverted.

Two runoff ponds were constructed on the Eldorado Wildlife Area. A 2-1/2-acre pond with a maximum depth of 5 feet at the level of the emergency spillway was built with a D-11 bulldozer and a 12-yard carry-all. The watershed involved was 200 acres. Work was done by the Town of Eldorado road crew using their equipment at $14.50 per hour. Total cost including shaping of the dike was $550. No doubt equipment rental costs were below what could be obtained commercially. The average depth of this pond was 2 feet and it cost about $110 per acre-foot of water at full pool.

Another pond of this type also built on Eldorado had a total estimated area of 5 acres. It was constructed on a 450-acre watershed at a cost of $1,424 which included dike shaping. This pond had a maximum depth of 11 feet at emergency spillway level. Since the average depth was 3 feet it cost about $285 per acre-foot of water at full pool. A state-owned D-4 cat and a 9-yard carry-all was used for most of this construction with additional time and equipment furnished by the Town of Eldorado for the finishing. These ponds at the time of survey, although just completed and only partially filled with water, were already receiving use by ducks, geese, deer, raccoon and many shorebirds. They will undoubtedly have utility not only for aquatic wildlife, but also for upland birds and mammals as well.

Ott Pond, a runoff pond in the Eldorado Wildlife Area.

Brood Areas

In most wetland areas where potholes will be constructed, larger water areas or streams are usually close by which can serve as brooding areas for birds which breed and nest in the vicinity of the potholes. If a brooding area does not exist, one should be constructed. Just what constitutes a brooding area is a matter of opinion, but it should be large enough to supply food and escape cover for the duck broods until they are large enough to fly. Size, within reasonable limits, is probably not as important as the availability of food and escape cover and the permanence of the water. Evans and Black (1956:45) stated, "Once the eggs have been hatched the home range breaks down and the hen and brood, with a set of requirements and preferences different from those of the breeding pair, go off on a trek of their own."

The distance a brood will move to a brooding area may be considerable. Evans and Black (1956:41) recorded a 2-1/4-mile move for a blue-winged teal brood before they were 2 weeks old. They believed that movements of a mile are easily made. Brooding areas of 2 to 5 acres were more desirable to broods than larger areas. Cover in brooding areas was found to be of great importance for escape of the broods. They stated, "Observations of brood behavior have indicated that the selection of brood-rearing habitat depends on the availability of a means of escape from predators. This may be furnished by cover sufficient to conceal the brood but not so dense as to restrict the movements of the young. On the other hand, a means of escape may be provided by open water of sufficient size and depth that broods can dive to escape their enemies." They found that dabbler broods commonly used areas as small as 1 acre and as shallow as 5 inches provided good escape cover was also present. Areas without cover were used if they were at least 20 inches deep and 5 acres in size.

All Ackley Wildlife Area impoundments were drawn down completely during the summer of 1966 and the only water that remained was in two small disconnected pools near the structure of the Wicke Flowage. Their combined acreage was less than an acre. A blue-winged teal female maintained a brood of 5 young on one of these pools until they reached flight stage. They were observed only on the one pool and did not seem to move off until they were able to fly. When disturbed they disappeared into the dense stands of bulrush which covered the low areas adjacent to the pothole. Little or no water was present in the stands of bulrush. No submergents were present in these potholes and other food plants were not in evidence, although bulrush did fruit heavily later in the summer. What the ducks were eating was a matter of conjecture but it may have been principally invertebrates. Good crops of *Daphnia* were noted at various times. This would indicate that brooding needs can be quite minimal. However, ponds of an acre or more should provide sufficient edge and emergents encouraged in portions of the shallow edge waters will provide escape cover.

Pondweeds and other food plants should be planted or encouraged. Submergents not only provide food directly, but also increase the invertebrate population in the pond. Snails may increase greatly if good stands of submergents are present. Gurzeda (1964:31) found that submergents with the greatest leaf divisions or surface area harbor the largest crop of invertebrate animal life. In this respect muskgrass and water milfoil are of special significance.

Evans et al. (1952) noted that mallard broods may move up to 2 miles overland. However, the greater the distance a brood has to move to brood water the greater is the likelihood that mortality will occur. It therefore seems advisable to make provisions for a suitable brood area close to the potholes. Brooding areas can be provided by several different types of construction:

1. Blasting or dredging

2. Level ditching

3. Runoff ponds if topography of the land is suitable.

Multiple charges of 50 pounds of ANFO spaced at 15-foot intervals will make broad shallow ponds with only a slight ridge between the points where each charge had been located. (Mathiak 1965)

There are times when level ditching might be more advantageous than pond construction for providing brooding areas. Long ditches like streams and rivers can certainly provide brood area and at the same time serve as firebreaks so that controlled burning can be practiced to manage the cover adjacent to them for nesting habitat. Blue-joint and sedge meadows lend themselves very well to this type of management. The ditch is better constructed meandered or zig-zagged since it provides more concealment for birds than would a straight ditch which allows unlimited visibility from one end to the other. It also offers more territorial sites for breeding pairs if it is broken by curves. Mendall (1958) states that the greater the number of zig-zags in a ditch the greater the use.

If water tables are subject to large drops during the summer the ditch should probably be fairly wide (30 feet or more) to overcome the effects of exposed vertical edges of the ditch which may be unattractive to waterfowl. A wider ditch probably would provide greater security for the broods. If occasional depressions measuring about 10 feet in diameter and about a foot deep are carved in the bog so that they are continuous with the ditch the growth of emergent aquatics will provide escape cover for the broods. Bradley (1960:30) reported that "An individual small marsh can be made more productive when adjacent lowlands can be dug out or small draws blocked to give supplemental spring breeding units. The cost benefit ratio can be very favorable." This type of construction can be used for runoff ponds that, when properly constructed, can serve as brood areas.

Pothole Diversity

Where a number of ponds are being constructed on an area some thought should probably be given to diversifying their depth and edge cover. Addy and MacNamara (1948:12) stated, "Ponds of varying depths with a diversity of vegetation and open water will attract a greater variety of ducks." Puddlers desire water depths of 18 inches or less while the diving ducks prefer deep water ponds. Since most of the better marshes in the southern part of the state are too shallow to fully meet diving duck requirements, the construction of deeper multiple-acre runoff ponds in the vicinity of these marshes might increase breeding populations of divers such as redheads and ruddy ducks. These ducks already utilize some of these marshes to a limited extent.

In the larger brooding ponds, emergent escape cover for broods should be developed in the shallower areas which are best suited for such growths. Addy and MacNamara (1948:12) pointed out that, "With small ponds, vegetation is the principal escape cover, whereas with large ponds the open water serves also as an effective means of escape and is preferred by some species, particularly diving ducks."

Evans et al. (1952:45) concluded that managing waterfowl breeding habitat in regions of small water areas is dependent upon "the maintenance and proper interspersion of pothole types, each to serve its own function".

If we are attempting to duplicate prairie pothole conditions for breeding pairs through the construction of potholes and ponds, then we should also be striving for the right type of interspersion of cover and pothole types. Evans et al. (1952) also noted that breeding pair use was greatly influenced by pothole size. They stated that river duck pairs in the prairie pothole regions showed the greatest per acre use on areas of 0 to 0.5 acre while diving ducks preferred 2 to 3 acres of water. Most, if not all of the potholes constructed in Wisconsin so far are well within the optimum size range of the river or puddle ducks. Construction of more deep runoff ponds should certainly improve waterfowl use by providing a better interspersion of water types and cover.

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