Artificial nesting structures for the double-crested cormorant. No. 126 1981

Meier, Thomas I.
Madison, Wisconsin: Wisconsin Department of Natural Resources, 1981

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ARTIFICIAL NESTING STRUCTURES FOR THE DOUBLE-CRESTED CORMORANT

Technical Bulletin No. 126

DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin
1981

COVER—*Cormorants on the George W. Mead Wildlife Area in central Wisconsin have readily accepted artificial nesting platforms as a substitute for deteriorating natural nesting habitat. The number of breeding pairs has increased from 28 at the beginning of this study to 223 in 1981. Photo by Bruce Bacon*

ABSTRACT

Natural nesting habitat for the double-crested cormorant *(Phalacrocorax auritus)*, consisting of flooded dead timber, has become limited in the midwest portion of the United States. Population trends have followed this decline in habitat and today the species is classified as endangered in Wisconsin. Artificial nesting structures, consisting of a pole with platforms, proved to be a successful substitute for natural nest sites on the George W. Mead Wildlife Area in central Wisconsin and thus provided an excellent method for rehabilitating deteriorating natural rookeries. Platforms constructed with a lath surface, with additional perching space provided, were the most successful of the four platform designs tested, and received high use by cormorants and great blue herons. Cormorant production on artificial platforms was generally greater than that in natural nest sites.

Guidelines for construction and placement of artificial nesting structures are presented to assist land managers in their restoration efforts.

ARTIFICIAL NESTING STRUCTURES FOR THE DOUBLE-CRESTED CORMORANT

by

Thomas I. Meier

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DEPARTMENT OF NATURAL RESOURCES
P.O. Box 7921, Madison, Wis. 53707
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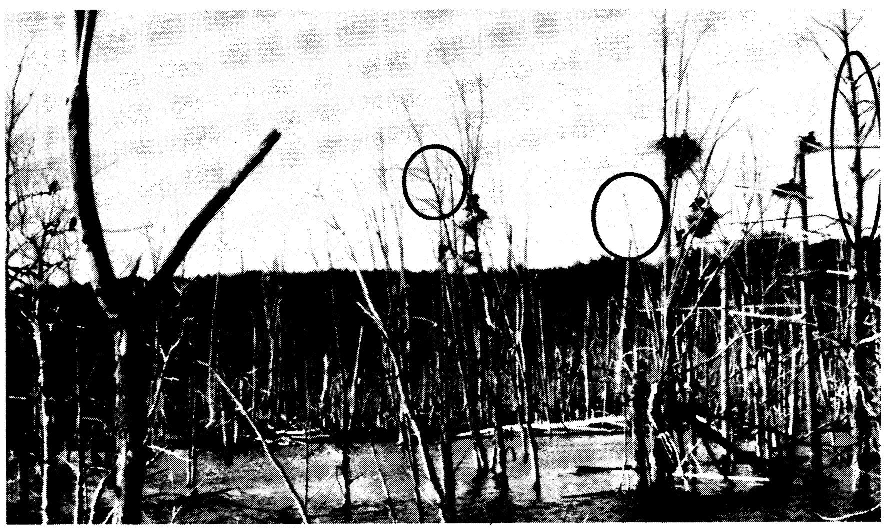
INTRODUCTION

The double-crested cormorant *(Phalacrocorax auritus)* nests primarily in flooded dead timber over most of the midwest, although several rocky islands in lakes Michigan and Superior have been inhabited by colonies in the past (Anderson and Hamerstrom 1967). A common nester in most parts of Wisconsin in the 1940's, the cormorant is classified today as an endangered species (Wisconsin Department of Natural Resources 1979). Population declines attributed to habitat deterioration and human disturbance resulted in only a few scattered colonies in the southwestern and western portions of the state by the mid-1960's (Anderson and Hamerstrom 1967). The cormorant is also endangered in the neighboring states of Illinois (Illinois Department of Conservation 1978) and Michigan (Michigan Department of Natural Resources 1980) and is threatened in Minnesota (C. Henderson, Minn. Dep. Nat. Resour., pers. comm.).

Cormorants often nest in company with other species. Anderson and Ellis (1966) reported the association of cormorants with great blue herons *(Ardea herodias)*, black-crowned night herons *(Nycticorax nycticorax)*, common crows *(Corvus brachyrhynchos)*, and gulls and terns.

Cormorants in the central Wisconsin Lake DuBay colony nested with the great blue heron. Knudsen (1951) reported approximately 400 nests of both species in 1949 and documented a decline to approximately 250 nests in 1951. The rookery is now extinct, due primarily to the loss of nesting trees. High pesticide levels produced significant eggshell thinning and may have contributed to the decline of this colony (Anderson et al. 1969).

Cormorant nesting habitat materialized in the Lake DuBay area in 1964 when areas adjacent to the Little Eau Plaine River on the George W. Mead Wildlife Area (Mead) were flooded. During the decline of the Lake DuBay colony, cormorant and heron use of newly flooded areas on Mead was not uncommon (Anderson and Hamerstrom 1967). The last recorded nesting year of 1966 for the DuBay colony was followed by nesting of cormorants and herons at Mead in 1967; it is possible that the Mead colony is a product of



Due to the deteriorated condition of natural nesting trees cormorant and heron nests are continually lost during stormy and windy periods. The photos above taken before and after a storm demonstrate this phenomenon. Two nests located in the far right portion of the lower photo represent additional nests built on artificial platforms as a result of loss of natural nesting habitat.

The heron nest (left) typifies conditions in the rookery at the beginning of the study. Built in a precarious site, it will most likely come down during the breeding season.

the Lake DuBay colony. The cormorant population at Mead expanded at an annual rate of approximately 25% since 1968. By 1974 an established rookery of 28 cormorant and 75 great blue heron nests existed.

When this study was initiated in 1974, the flooded hardwood timber that provided the nest substrate for the Mead colony was deteriorating at a rapid rate and the future of the colony looked dim. The existing nesting trees were expected to disappear by 1980. Similar deterioration of nesting habitat has occurred throughout the midwest. On the Agassiz National Wildlife Refuge in Minnesota, for example, deterioration was so advanced in 1967 that cormorants were nesting on the ground or on floating mats of vegetation (Cline and Dornfield 1968). Habitat deterioration has also occurred for the osprey *(Pandion haliaetus)* and the everglades kite *(Rostrhamus sociabilis plumbeus)*, both endangered in their respective states of Michigan and Florida.

Artificial nesting structures for the osprey (Postupalsky and Stackpole 1974) and artificial nest baskets for the kite (Sykes and Chandler 1974) have proven successful in providing nesting sites secure from the effects of rapid deterioration and wind. Postupalsky and Stackpole (1974) reported that the Fletcher Pond colony, comprising approximately half of the osprey population of lower Michigan, has grown steadily since the introduction of artificial nest structures.

The purpose of this study was to design, erect, and test artificial nesting structures that would supplement the natural habitat of the double-crested cormorant. This report will present the results of the Mead study, along with guidelines for land managers in constructing and installing such structures on their properties.

STUDY AREA

The George W. Mead Wildlife Area is located in central Wisconsin, in Wood, Marathon, and Portage counties, 22.5 miles northwest of Stevens Point and 5.5 miles north of Milladore (Fig. 1). The Mead is 26,610 acres in size and characterized by 17 large impoundments created principally for waterfowl management. Townline Flowage, located in the central portion of the wildlife area, was created in 1964. The cormorant and

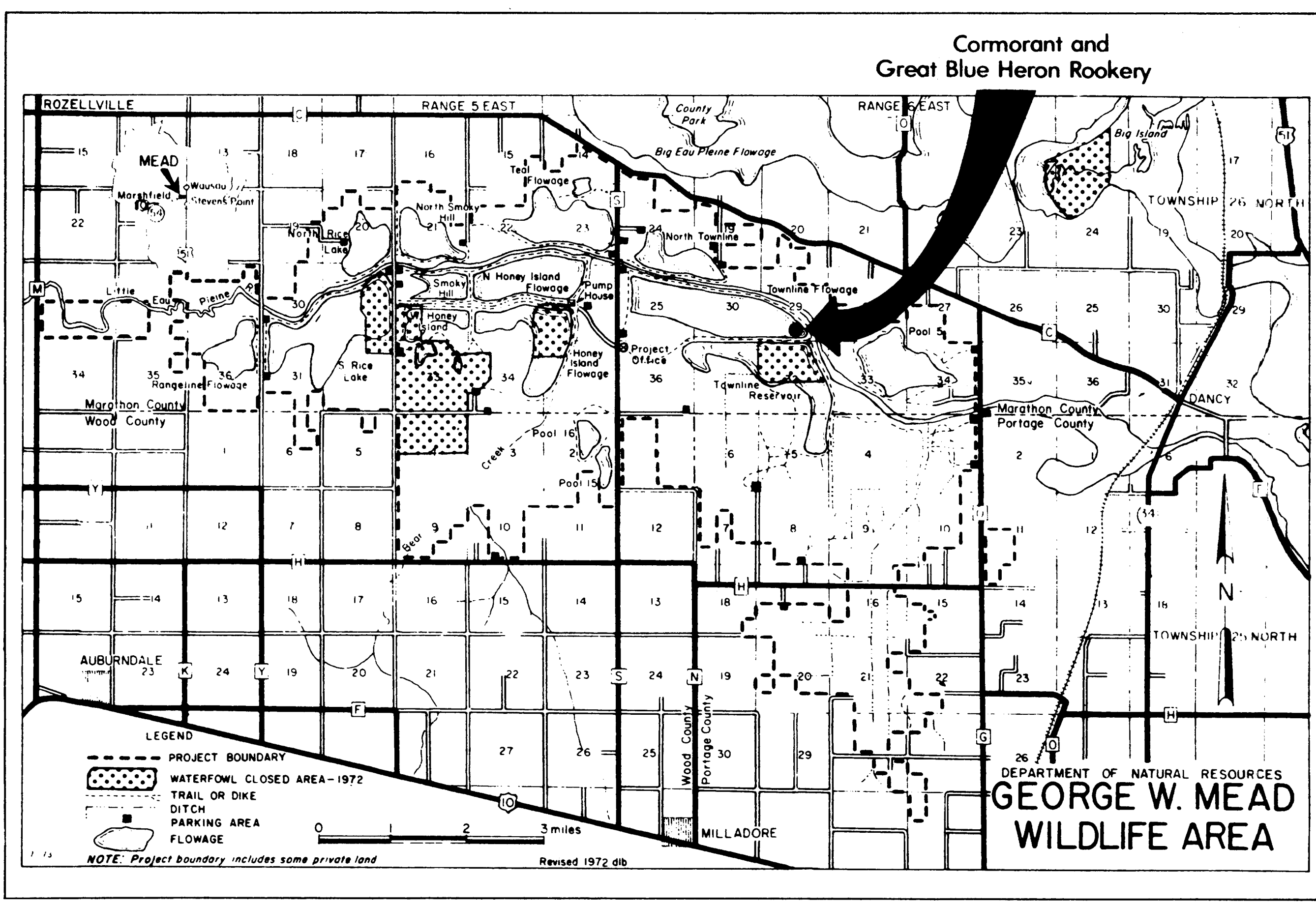


FIGURE 1. *Location of the George W. Mead Wildlife Area in central Wisconsin*

heron rookery researched in this study is located in the extreme southeast corner of this 1,100-acre impoundment and is approximately 13.7 acres in size (Fig. 2). Water depths within the rookery ranged from 6 inches to 8 ft. Soils consisted of clay overlain with fine silt. Flooded dead timber consisted principally of white ash *(Fraxinus americana)*, silver maple *(Acer saccharinum)* and elm (*Ulmus* sp.).

The study area was divided into four sections in which various platforms or combinations of them were tested. Sections A-C were inhabited primarily by cormorants, and Section D primarily by great blue herons (Fig. 2).

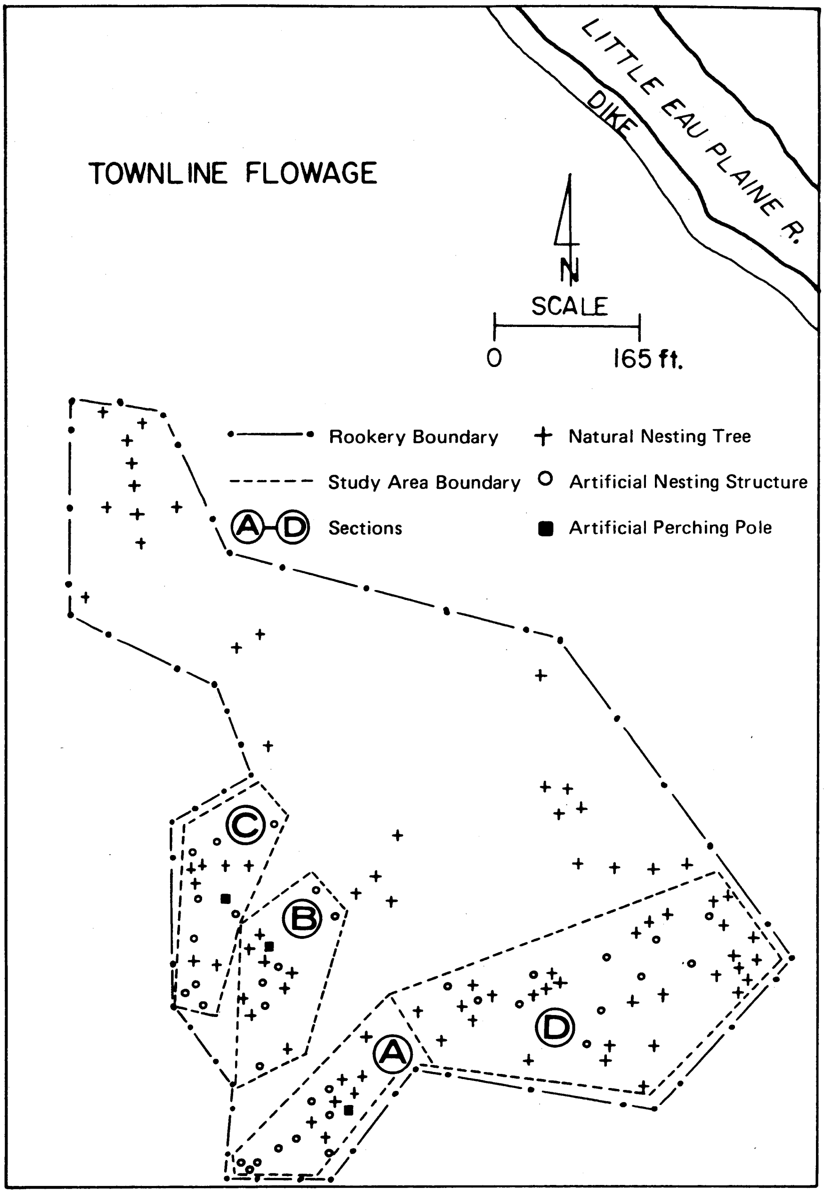


FIGURE 2. *Double-crested cormorant and great blue heron rookery on the George W. Mead Wildlife Area in central Wisconsin*

METHODS AND MATERIALS

Artificial structures consisted of wooden poles with attached platforms. Construction, installation, and testing of structures was undertaken in 1974, 1975, and 1976. Pole site selection and structure construction took place in February and March of each year, when the ice was thick enough to support vehicles and heavy equipment. Snow depths in 1974 prohibited good ice formation and it became necessary to remove snow with snowblowers on planned construction sites to permit the ice to freeze sufficiently to insure safe conditions for heavy equipment operations.

Major effort was directed toward nesting structures. However, in 1975 perching structures were placed in Sections A-C to provide resting and roosting sites.

PLATFORMS

Design

Three platform types were tested in the cormorant rookery during 1974 (Fig. 3): (1) a wire platform, consisting of a wooden frame with 1-inch-mesh chicken wire stapled to the top surface. A 60-inch perch, connecting each side arm and extending 18 inches beyond, was nailed to the front of the platform; (2) a lath platform, with pieces of lath spaced across the surface; and (3) a wooden box, measuring 19.5x12.5x8.0 inches. A 2x2-inch side brace was extended 55.5 inches and 45 inches out beyond the platform surface as a perch for the lath and box platforms, respectively. Wire, lath, and box platforms were tested in Sections A, B, and C, respectively.

The lath and box platforms were also used to test the feasibility of re-

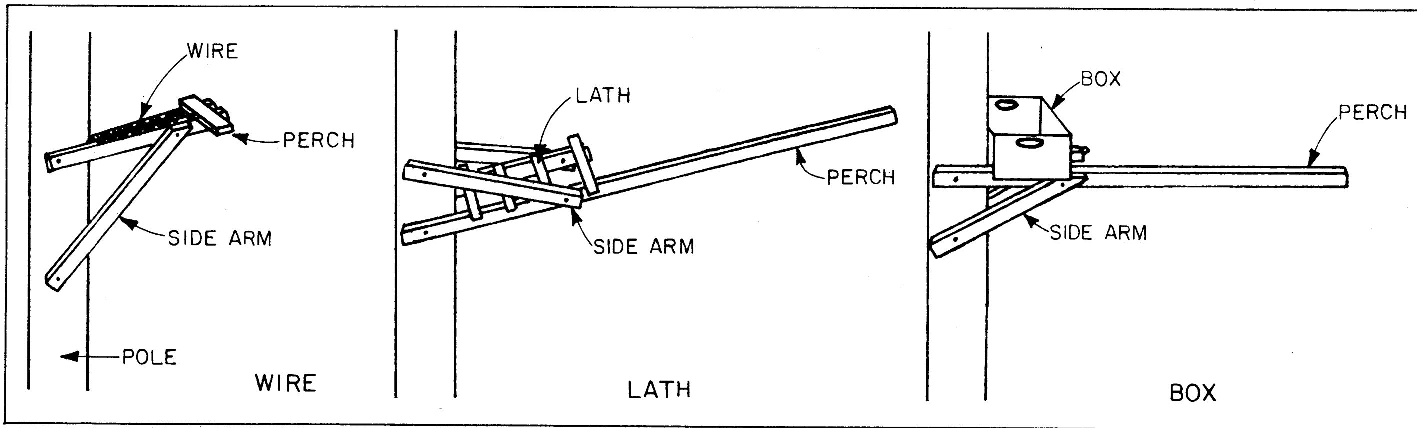


FIGURE 3. *Types of artificial nesting platforms tested in 1974*

placing fallen natural nests on artificial platforms in 1974 only.

In 1975 the lath platform, with two modifications, was used almost exclusively for new platform construction in each Section (Fig. 4). Modifications included rounding off the square edges on the top surface of the perch with a joiner, and extending the longest lath an additional 15.5 inches beyond the side of the platform to provide more perching space for a maximum family size of 2 adults and 4 young.

The modified lath platform was used in the heron portion of the rookery (Fig. 2, Section D) in 1976. Platforms were not constructed in the cormorant portion of the rookery during this last year of the study.

One 8x8-ft square platform, successful for cormorants at the Agassiz National Wildlife Refuge in northwestern Minnesota (Cline and Dornfield 1968), was also constructed in Section B in 1975.

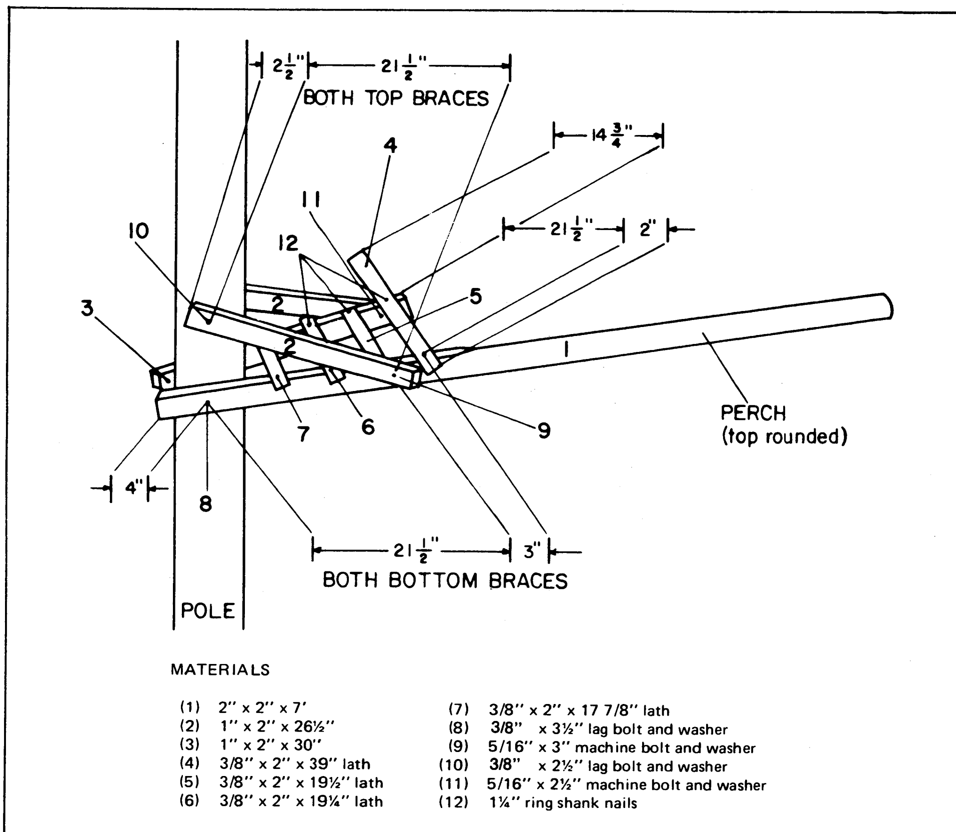


FIGURE 4. *Materials and measurements for construction of modified lath platform*

Construction

First-year platforms were constructed of old barn lumber and wooden boxes. Second- and third-year platforms and the Agassiz-type platform were constructed from new clear southern yellow pine (*Pinus* sp.) lumber treated with chromated copper arsenate under 0.40 retention. This process was chosen over other methods of treatment for its low toxicity and high estimated life expectancy (40-50 years). Platform designs for first-year platforms are shown in Figure 3, and materials and measurements for construction of the modified lath platform are shown in Figure 4.

Materials were precut, bolt holes predrilled, and platforms semiconstructed before going into the field. Semiconstruction involved the joining of top and bottom braces for each sidearm with machine bolts. The longest lath on Platform Type B was attached to the sidearms with a 21.5-inch distance between nailing points. This preset the width of the platform surface. The Agassiz-type platform was constructed totally in the field.

PERCHES

A perching structure consisted of 3 perches attached horizontally to a 30-ft pole. Perches were constructed of 14-ft 2x2-inch lumber rounded on the top surface, using new southern yellow pine treated in the same manner as that used for platforms. Construction details are shown in Figure 5. Perches were constructed in the field.

POLES

Design

In 1974, freshly cut 30-ft white ash and silver maple poles, with 6- to 8-inch diameters at the base, were used to accommodate the nesting platforms.

New and used treated poles, with 8-inch base and 5-inch top diameters, were used for additional construction in 1975. New poles were purchased lo-

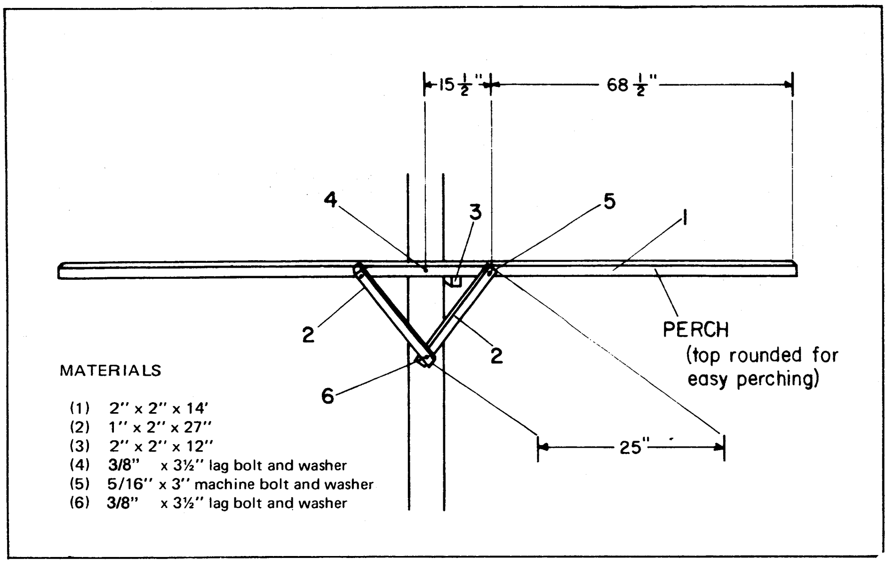


FIGURE 5. *Materials and measurements for construction of perch for perching structures*

cally while used poles were obtained from the Fire Control Bureau of the Wisconsin Department of Natural Resources. All poles had been treated under pressure with pentachlorophenol in a petroleum base. New and used poles had an estimated life expectancy of 45 and 20 years, respectively.

New treated 30-ft poles were used for structures in 1976 when 8 poles were placed in Section D.

Location

The poles were located in each section in 1974 as follows: 2 poles within 25 ft of natural nesting trees, 1 pole 25-50 ft from natural nesting trees, and another pole 50-100 ft from natural nesting trees. An additional pole was placed in both Sections B and C to accommodate the replacement of fallen natural nests onto artificial platforms.

In 1975, one new 35-ft pole and 2 used 30-ft poles were placed within 25 ft of natural nesting trees in each study area. The long pole and one short pole were used for platform structures and the remaining short pole was used for the perching structure. Four 17-ft poles were placed in Section B and served as legs for the Agassiz-type platform; one pole was placed at each corner of the square formation.

Site Selection

Soil and water depth determined the sites for pole placement. A clay layer of varying depth covers the main sand substrate within the rookery portion of the flowage. Pole placement sites were considered acceptable if the clay layer was at least 6.5 ft in depth and the water depth was no greater than 4.5 ft. Pole stability was essential and clay soils offered an excellent base for pole placement. In less stable soils it is recommended that rock riprap be placed around the base of each pole to provide added stability. Areas of extensive ice movement should be avoided.

Installation

A 1.5×1.5-ft hole was cut in the ice with a chain saw. A hole was then drilled into the flowage floor with a hydraulic, 8-inch auger mounted on the back of a truck. The auger was aligned with one corner of the opening in the ice. Holes were drilled to depths of 4.5, 6.0, and 6.5 ft into the soil for 17-, 30-, and 35-ft poles, respectively. Pole base and drill diameters were nearly equal. A point was cut on the butt of each pole prior to placement to facilitate the release of water pressure up the sides of the poles during placement.

A bulldozer, almost a pole length away from and with its back toward the placement site, was used to lift poles vertically into place. The butt end of the pole was placed against the corner of the hole and edge of the ice directly above the hole in the soil; the tip was placed on the top of the bulldozer cab. The pole was positioned by backing the bulldozer toward the pole site. The pole, when at approximately a 55° vertical angle with the ice, slid off the edge of the ice shelf and dropped to the flowage floor. The pointed butt of the pole slid along the bottom toward the hole in the soil as the bulldozer continued backing; the hole in the ice acted as a pivot point. The pole slipped into the augered hole in the soil when it reached a vertical position. The bulldozer was then turned around and a chain attached to the blade and wrapped around the pole. The pole was forced to the desired depth into the hole by hydraulically lowering the blade. The amount of pole length above the water level available for platform or perch construction was a function of water depth.

Placement of Platforms

Extension ladders were used to reach desired platform placement levels on the poles; construction began at the highest level and proceeded downward. Sidearms were attached to the pole with lag bolts; platform surfaces were nailed or stapled to them. Lag bolts were driven into poles with a hammer. Wire and lath platforms were placed at a 7° angle above the horizontal to provide a pocket for nest placement. This angle was not used with the box platform because the box itself provided this effect.

Platforms were positioned on poles in consecutive 90° staggered vertical placement, to preclude overlap. In 1974, platforms were spaced 3 ft apart vertically on 1 of the 2 poles placed within 25 ft of natural nesting trees in each study area. Platforms were spaced 6 ft apart vertically on all remaining poles. Placement began 18 ft above the water and proceeded downward to the respective spacing distance above the water. Natural nests were placed on 2 platforms at the 6- and 12-ft levels in Section B and on 1 platform at the 12 ft level in Section C.

In 1975, all platforms were spaced 3 ft apart vertically, beginning 9 ft above the water level. Platforms extended to the 18-ft level and 24-ft level on 30- and 35-ft poles, respectively.

The Agassiz-type platform was built 9 ft above the water level.

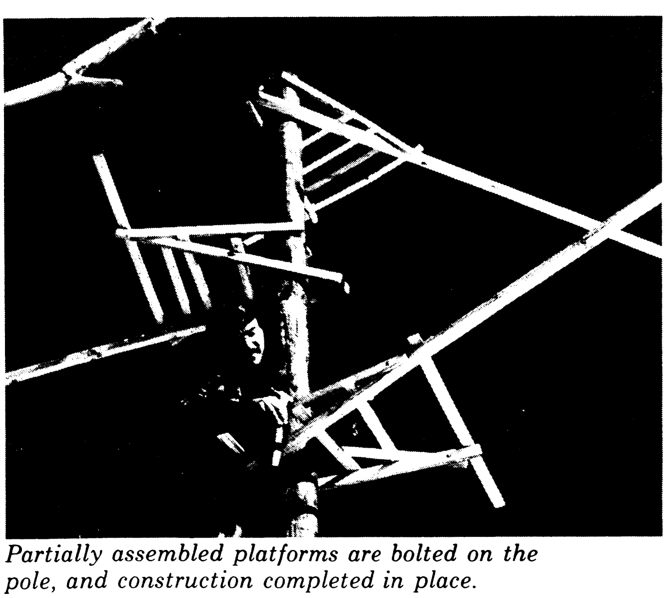
The placement pattern of platforms on poles in 1976 was modified to encourage great blue heron use. Platforms were spaced 4 ft apart beginning at the 8 ft level and proceeded to the 24-ft level in consecutive 180° staggered vertical placement.

Perches were attached at their horizontal midpoints to foundation poles with lag bolts. Diagonal braces were attached to the perch with machine bolts and to the pole with lag bolts. A horizontal brace was attached from the perch to the pole with nails to prevent rotational movement. Perches were

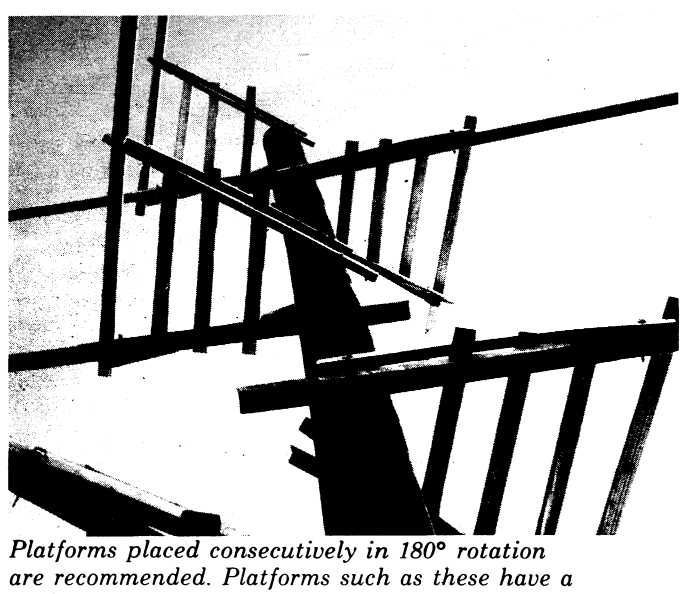
Structures are constructed through the ice in midwinter.

The first step is to insure that firm soil exists on the flowage or lake floor for pole placement (left). A hydraulic soil augur is then placed through the hole in the ice and drilling extends to a depth of 6 ft for a 30-ft pole (right).

The pointed butt of the pole is placed over the hole and the bulldozer is backed up slowly, raising the pole until the pole is vertical and slips into the drilled hole.



Partially assembled platforms are bolted on the pole, and construction completed in place.



Platforms placed consecutively in 180° rotation are recommended. Platforms such as these have a projected life expectancy if new of 45 years, and if used, 15 to 20 years.

placed at 12-, 15-, and 18-ft levels above the water and at right angles to each other.

DATA COLLECTION

An observation blind was placed atop a large stump 231 ft southwest of the rookery. Observations in 1974 and 1975 began in April and continued through August. Daily observation periods were scheduled to include either morning, daytime, evening, or nighttime platform use and behavior observations. Data collected included date, weather conditions, the number and species of birds using platforms, minutes of bird occupation time (both nesting and nonnesting birds), degree of nest construction, bird behavior, nest longevity in artificial and natural nest sites, and reproduction information. Cormorant production information was recorded for each active nest from the onset of incubation through the fledging stage. Heron production was recorded for nests on artificial platforms only. Poor visibility of most natural heron nests precluded accurate observations.

Information gathered in 1976 pertained to general platform use by species, nest longevity, and final production.

RESULTS AND DISCUSSION

USE OF PLATFORMS FOR NESTING

In 1974, 1975, and 1976, 8, 11, and 23 cormorant nests were constructed on artificial platforms respectively. This was 25.6, 26.8, and 57.5% of all nests constructed by cormorants on the study area in each year. The substantial increase in platform use for nesting purposes, observed in 1976, can be attributed to considerable deterioration of the natural nesting substrate during the winter of 1975-76. In spite of this deterioration, the cormorant spring resident population within the rookery increased from 107 adults and juveniles in 1974, to 124 in 1976.

Three, 2, and 10 heron nests were constructed on artificial platforms in 1974, 1975, and 1976, respectively. This was 3.8, 2.3, and 9.4% of all nests constructed by herons within the rookery in each year. The increase in platform use observed in 1976 was due to platforms being placed on structures in the heron portion of the rookery during that year. Deterioration of natural nesting sites was advanced and the platforms were a suitable substitute.

Type of Platform

In 1974 the wire, lath, and box platforms were tested in three different sections of the study area, and lath platforms had by far the greatest use by cormorants — twice as much as the box type and over 8 times as much as the wire platform (Table 1). The following year the modified lath platform was compared with each of the original platform types in each of the sections, and received greater use than any of the 3 original types, even far surpassing the regular lath platform. Cormorants will accept a variety of nesting substrates but prefer the modified lath platform. In fact, they did not nest on anything else except the box when modified lath platforms were available.

The modifications to the lath platform appear to be important to the birds and increase the desirability of this platform type. The lath design itself permits the birds to weave nesting material around the platform supports in a natural fashion and provides good aeration of the nest to prevent waterlogging and subsequent rotting of the platform surface. Mendall (1936) stated that the cormorant seldom uses weaving in the nest-building process. This is contrary to my observations at the Mead where cormorants frequently wove nesting material into their nests and around the platform supports.

Birds were reluctant to land or walk on the chicken wire surface of the wire platforms, resulting in low use for this platform type. A pair initiated nest building in 1974 on only 1 wire platform and abandoned it before construction was complete. When an alternative platform type was available (in 1975), no wire platforms were used.

Box platforms did have substantial use and proved to be a feasible platform. However, in the first year, no nests were constructed on the box platforms until all available lath platforms at or above the 9 ft level, and within 25 ft of natural nesting trees, were occupied by nesting pairs. Although the use of box platforms was similar to that of the modified lath platforms in 1975, this high use pattern is misleading. The box construction permitted nesting material to accumulate during the 1974 breeding season and remain within the nest box until the 1975 season. Cormorant nests are used from year to year unless they are destroyed (Mendall 1936). This was observed on 2 box platforms which became occupied early in the 1975 breeding season and biased the box platform data when they were compared to the modified lath type. These 2 platforms accounted for 71.8% of the use recorded for the box platform. The high level of use recorded for the lath platform over the box platform in 1974 is more representative of the comparison of these platform types, but further testing may be necessary to more precisely determine the desirability of one over the other.

The Agassiz-type platform was not used by the Mead cormorants in 1975. This type of platform was used at Agassiz when its existing rookery had deteriorated to a point where birds were nesting on floating mats of vegetation. The Mead rookery had not reached this stage of habitat deterioration by the time of this study.

The lath platforms, both original and modified, received 93% of all heron nesting activity on artificial platforms during the study. One successful nest was constructed on a wire platform while no nesting attempts occurred on the box type.

The modified lath platform is recommended for future restoration of deteriorating cormorant and heron rookeries.

Relationship to Distance from Natural Nesting Trees

Structures placed within 25 ft of natural nesting trees received an average of 98% of all recorded cormorant use during 1974 and 1975 (Table 2). An average of 99% of all recorded heron use also occurred on structures placed within 25 ft of natural nesting trees.

Structures should be placed within 25 ft of natural nesting trees, when present, to facilitate use by cormorants and herons. Clear aerial access to platforms is important and can be assured by placing structures 20 ft apart. Clumping of structures in groups adjacent to natural nesting trees will maximize the restoration potential of main nesting areas within the rookery. Expansion will then take place from these restored nesting nuclei.

Relationship to Height Above the Water

Cormorants used platforms at heights ranging from 3 to 24 ft above the water (Fig. 6). However, platform use increased with an increase in height. All nests built on artificial platforms occurred in the range of 9 to 24 ft. This corresponds to the vertical range for natural nest sites of 8 to 27 ft. The slightly lower use recorded for the 24-ft level in 1975 is a product of one platform becoming permanently occupied for nesting purposes late in the breeding season. Observations of platform use were terminated before young had fledged from this nest, underestimating use of this level. Lewis (1929) recorded nesting heights in tree nesting colonies ranging from 1 to more than 65 ft above the ground or water.

Herons used either of the top 2 platforms on any given structure throughout the study. These platforms ranged from 18 to 24 ft above the water and were within the height range occupied by nests in natural sites.

Providing artificial platforms within the vertical interval occupied by natural nests will maximize platform use. In rookeries where excessive deterioration precludes this determination, the 9- to 24-ft vertical interval is recommended.

TABLE 1. *Average platform use by type, 1974-75.*

Year	Section	Platform Type	No. Platforms*	Cormorant Use (minutes) **	Avg. Use/ Platform (minutes)
1974	A	Wire	8	2,114	264
	B	Lath	7	16,552	2,365
	C	Box	8	7,380	923
1975	A	Wire	9	0	0
		Mod-lath	10	3,620	362
	B	Lath	9	2,680	297
		Mod-lath	9	8,156	906
	C	Box	9	9,200	1,022
		Mod-lath	10	12,080	1,208

*Not all platforms of each type were available to cormorants due to occupation by great blue herons.

**Represents time cormorants occupied platforms out of totals of 5,345 and 3,900 observation minutes for 1974 and 1975 respectively. Each value represents more than one platform, each platform having the potential for 5,345 and 3,900 minutes of observed occupation time for 1974 and 1975 respectively.

TABLE 2. *Nesting structure use in relation to distance from natural nesting trees.*

Distance From Natural Nesting Trees (ft)	Year	No. Structures	No. Platforms	Cormorant Use (minutes) *	Percent of Total	Avg. Use/ Platform (minutes)
0-25	1974	6	23	26,046	98	1,132.4
	1975	12	54	35,736		661.7
25-50	1974	3	9	944	2	104.8
	1975	3	9	136		15.1
50-100	1974	2	6	1		.2
	1975	2	6	56		9.3

*Represents time cormorants occupied platforms out of totals of 5,345 and 3,900 observation minutes for 1974 and 1975 respectively. Each value represents more than one platform, each platform having the potential for 5,345 and 3,900 minutes of observed occupation time for 1974 and 1975 respectively.

Relationship to Vertical Distance Between Platforms

Vertical distance between platforms had little effect on platform use. Platforms spaced 3 ft apart had an average use of 1,086 observation minutes/platform in 1974 and 668 observation minutes/platform in 1975. Platforms spaced 6 ft apart averaged 1,220 observation minutes/platform in 1974 and 556 observation minutes/platform in 1975. The 3-ft spacing distance between platforms approximates the average 2.9-ft vertical spacing between nests in natural trees. This spacing distance has the added advantage of allowing more platforms/pole.

The 4-ft spacing distance used in platform construction in 1976 facilitated heron nesting on platforms below the top level on any given structure. Interference between cormorants and herons seldom occurred within the rookery. Interference did occur occasionally when a cormorant nesting directly beneath a heron would steal nesting material from the nest above. I recommend a 4-ft spacing distance between platforms in those areas of a rookery where both species nest.

Closer spacing between platforms has been tried in several locations in Wisconsin, but production and behavior patterns of the nesting birds have not been analyzed.

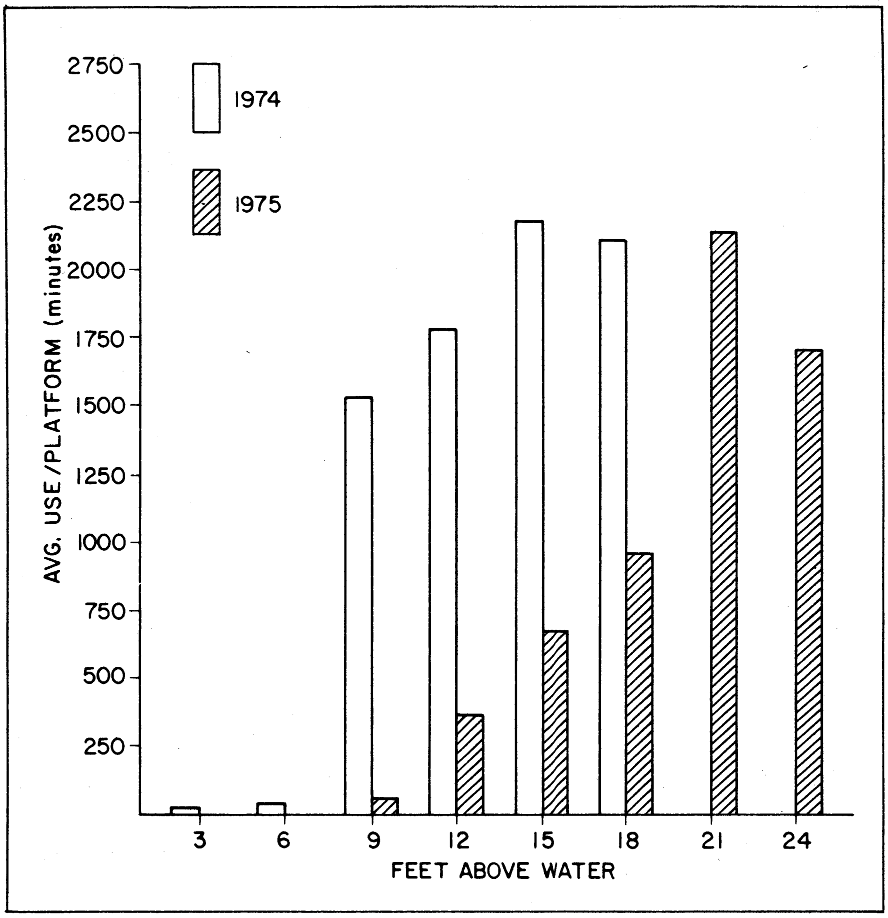


FIGURE 6. *Cormorant use of platforms in relation to height above water*

Effect of Vertical Rotation

Positioning of platforms in consecutive 90° staggered vertical placement was accepted by the cormorants. However, this pattern did allow defecations from upper nests to fall on the nests at lower levels. This was not uncommon in natural trees but it occurred more frequently in artificial structures. A consecutive 180° staggered vertical placement was used exclusively in the placement of platforms on all structures constructed in 1976. This resulted in platforms being back to back and oriented directly above each other. Since cormorants defecate sideways off the edge of the nest, this modification reduced defecation problems and facilitated use of lower platform levels. I recommend the 180° rotation pattern for future construction.

Heron use of structures for nesting was limited to the top platform on any given pole during 1974 and 1975. The 90° rotation pattern did not provide a desirable nesting site arrangement. The 180° vertical rotation also facilitated heron use of lower platform levels.

REPLACEMENT OF FALLEN NESTS ON PLATFORMS

Three fallen nests were placed on platforms during the first year of the study to determine if this technique was necessary to initiate platform occupation. All were readily accepted. However, two were blown out of the platforms by high winds early in the breeding season. The remaining nest was occupied by a pair of cormorants that subsequently nested successfully. One of the platforms continued to be occupied by a nesting pair after nest loss. This pair renested and produced 3 young. Renesting is not uncommon and has also been observed by McLeod and Bondar (1953).

Replacement of fallen nests may be desirable when attempting to develop new rookeries. Cormorants often feed in areas where nesting sites are not available, but where the establishment of artificial nesting structures is feasible. The presence of nests, obtained from active colonies, on selected platforms may encourage nesting. All replaced nests should be wired into their respective platforms to prevent loss from high winds.

USE OF PERCHING STRUCTURES

Perching structures received varying use depending upon the number of cormorants present in a particular section. In Section A, which had only 10% of the cormorant population, the perching structure received only 6 minutes of use, while in Section C, which had almost half of the population, the perching structure received 301 minutes of use. Perching structures will become increasingly important as natural roosting trees within a rookery deteriorate. They should be incorporated into rookery restoration plans when this particular aspect of the habitat is lacking.

Perching structures were not located in the heron portion of the Mead rookery. Structures placed in the cormorant portion of the rookery received 38 minutes of observed heron use during the 1975 breeding season from birds occasionally using the area for resting and roosting. Perching requirements of the heron are similar to the cormorants and I recommend that perching structures be incorporated into heron rookery restoration plans.

PRODUCTION

The average number of fledged young per nest, in this study, ranged from 1.30 to 2.34 for natural nests and 1.18 to 2.83 for nests on artificial platforms. This fluctuation can be attributed to yearly variations in weather patterns, predation, and human disturbance. Productivity in this study is based on the average clutch size of 3 eggs/nest recorded by Bent (1964) and approximates the average 2.4 young/nest recorded by Norton (1973). While nests normally possessed 2-4 young, 1 nest in 1976 contained 5 young; all fledged successfully.

Production of young was generally greater on the artificial platforms than in natural nest sites (Table 3). Although average production on the platforms in 1975 was lower than that in natural nest sites, the average number of fledged young on the modified lath platform was slightly higher.

Natural nesting trees were in advanced stages of deterioration and active nests were easily destroyed when limbs broke off during stormy weather. Artificial platforms were more secure because of their stability and resistance to deterioration. The deterio-

Production of young was generally greater on the artificial platforms than in natural nest sites.

rated condition of the natural trees was responsible for the loss of 13, 13, and 35% of the active nests in natural nest sites during stormy periods in 1974, 1975, and 1976, respectively. This contrasts with a loss of 0, 9, and 13% of the active nests on artificial platforms over the same period.

Some nests were lost because of human disturbance and predation. The part each of these factors played in nest abandonment was difficult to determine. Collectively they accounted for the loss of 3, 23, and 0% of the active nests in natural nest sites in 1974, 1975, and 1976, respectively. This corresponds with a loss of 0, 36, and 0% of the active nests on artificial platforms during the same period. The high loss of active nests in 1975, beyond those destroyed during stormy weather, was due to human disturbance within the rookery and suspected predation by great horned owls *(Bubo virginianus)*. Canoeists entered the rookery to investigate the nesting birds twice during the breeding season. On the first occasion the adult segment of the cormorant population flew off and did not return for over 30 minutes. At this time newly hatched young may have become overexposed to the burning rays of the sun. On the second occasion, the same canoeists observed young jumping from the nests and either drowning or dispersing. Human disturbance as a mortality factor has been reported by Houston (1962), and Erskine (1972). Human activity in a cormorant rookery should be restricted during the entire breeding season.

A pair of great horned owls nested in an old great blue heron nest on the south edge of the rookery in 1975 and raised 2 young. Throughout the cor-

TABLE 3. *Cormorant production on artificial platforms compared to natural nest sites, 1974-76.*

Year	Platform Type	Active Nests	Successful Nests	Young Fledged	Avg. Young Fledged/ Active Nest
1974	Wire	1	0	0	0
	Lath	4	4	12	3.00
	Box	3	3	8	2.67
	Total artificial	8	7	20	2.50
	Nat. nest sites	29	24	68	2.34
1975	Wire	0	0	0	0
	Lath	0	0	0	0
	Mod. lath	9	5	12	1.33
	Box	2	1	1	0.50
	Total artificial	11	6	13	1.18
	Nat. nest sites	30	19	39	1.30
1976	Wire	0	0	0	0
	Lath	0	0	0	0
	Mod. lath	19	18	60	3.16
	Box	4	2	5	1.25
	Total artificial	23	20	65	2.83
	Nat. nest sites	17	11	37	2.18

morant and heron breeding season it was not uncommon to hear the entire rookery reverberate with alarm calls from both species during the nighttime hours. Observations on days following this type of disturbance generally resulted in missing cormorant young or newly vacated nests. Norton (1973) observed an active great horned owl nest in the middle of the Woods Hole rookery in Oklahoma. Predation by other species has been reported in other colonies throughout North America. Kees (1970) reported predation on young and eggs by crows *(Corvus brachyrhynchos)* in British Columbia and on eggs by California gulls *(Larus californicus)* in California. Lewis (1929) reported predation on eggs and young by the great black-backed gull *(Larus marinus)*.

Eight known renesting attempts were observed over the 3-year period. It was difficult to determine the extent of renest attempts within the Mead population because the birds were not banded or marked.

Heron production on platforms in 1974 and 1976 was 1.6 and 2.8 young/nest, respectively. Production information was not obtained from the 2 nests on platforms in 1975.

STRUCTURE COSTS

I recommend treated poles and platforms for construction of artificial nesting structures and perching structures for the double-crested cormorant. The high life expectancy of treated wood materials outweighs initial cost. Material costs for nesting structures in 1980 were as follows: treated 30-ft poles - $50/pole; treated 35-ft poles - $90/pole; treated platforms - $3.75 each. The number of platforms that can be placed on a pole depends on water depth. A 30-ft pole at the Mead rookery held 4 platforms and a 35-ft pole held 6 platforms. Total cost/completed structure including labor and materials averaged $125 for 30-ft structures and $200 for 35-ft structures, respectively. Total cost/platform averaged $31.25 and $33.00 for 30- and 35-ft structures, respectively.

Material costs for perching structures in 1980 were as follows: treated 30-ft pole - $50; perches and bracing - $3.65 each. A 30-ft pole at the Mead held 3 perches. Total cost per completed structure including labor and materials averaged $97.75. Total cost per perch averaged $32.58.

Platforms and perches should be inspected and repaired annually prior to the breeding season. This can best be done in the winter when ice facilitates inspection and repair work. At the Mead, repairs were minimal and generally involved replacing and tightening bolts or replacing broken perches, sidearms, and lath.

SUMMARY AND CONCLUSIONS

1. Artificial platforms were a successful substitute for the cormorant's natural nesting substrate. Great blue heron use of platforms, in addition to cormorant use, increases the possibility of rehabilitating deteriorating rookeries containing one or both species.

2. Platform use by cormorants at the Mead rookery increased from 25.6% in 1974 to 57.5% in 1976 as deterioration of natural nest sites within the rookery accelerated.

3. Platforms constructed of wire, lath, and wooden boxes were tested at the Mead Wildlife Area. Lath platforms received the greatest use by cormorants and great blue herons, especially lath platforms later modified with additional perching space.

4. Use of perching structures by cormorants was proportional to the density of the birds present.

5. Production of young was generally greater on the artificial platforms than in natural nest sites.

6. Treated poles and platforms are recommended for the construction of artificial nesting structures and perches. Structures should be placed within 25 ft of natural nesting trees. Modified lath platforms should be placed on the poles 9-24 ft above the water, spaced 3 ft apart vertically for cormorants and 4 ft apart for herons, and staggered in a 180° rotation pattern. Perching structures should be incorporated when natural roosting trees are lacking. Human activity should be restricted during the entire breeding season.

7. Replacement of fallen nests on platforms may be desirable when attempting to develop new rookeries.

8. Material and labor costs were $125/4-platform structure and $200/6-platform structure. Total material and labor cost/perching structure was $97.75.

LITERATURE CITED

ANDERSON, D. W. AND J. W. ELLIS
1966. Cormorant nesting in northwestern Minnesota. Loon 38:5-8.

ANDERSON, D. W. AND F. HAMERSTROM
1967. The recent status of Wisconsin cormorants. Passenger Pigeon 29:3-15.

ANDERSON, D. W., J. J. HICKEY, R. W. RISEBROUGH, D. F. HUGES, AND R. E. CHRISTENSEN
1969. Significance of chlorinated hydrocarbon residues to breeding pelicans and cormorants. Can. Field-Nat. 83:91-112.

BENT, A. C.
1964. Life histories of North American petrels and pelicans and their allies. Dover Publ. Inc., N.Y. 335 pp.

CLINE, D. R. AND E. DORNFIELD
1968. The Agassiz Refuge cormorant colony. Loon 40:68-72.

ERSKINE, A. J.
1972. The great cormorants of eastern Canada. Can. Wildl. Serv. Occas. Pap. No. 14. 23 pp.

HENNY, C. J. AND J. E. KURTZ
1978. Great blue herons respond to habitat loss. Wildl. Soc. Bull. 6:35-37.

HOUSTON, C. S.
1962. Hazards faced by colonial birds. Blue Jay 20:74-77.

ILLINOIS DEPARTMENT OF CONSERVATION
1978. (Official list of endangered and threatened vertebrate species of Illinois.) Ill. End. Species Prot. Act Sec. 337 Art. CXXVIII.

KEES, V.
1970. Some aspects of the nesting of double-crested cormorants at Cypress Lake, Saskatchewan, in 1969; a plea for protection. Blue Jay 28:11-13.

KNUDSEN, G. J.
1951. An interesting Wisconsin rookery. Passenger Pigeon 13:119-24.

LEWIS, F. H.
1929. The natural history of the double-crested cormorant *(Phalacrocorax auritus auritus* (Lesson)). Ru-Mi-Lou Books, Ottawa. 94 pp.

MENDALL, H. L.
1936. The home-life and economic status of the double-crested cormorant *(Phalacrocorax auritus* (Lesson)). Univ. Maine Stud. No. 38. 159 pp.

McLEOD, J. A. AND G. F. BONDAR
1953. A brief study of the double-crested cormorant on Lake Winnipegosis. Can. Field-Nat. 67:1-11.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
1980. (Department of Natural Resources fisheries and wildlife divisions endangered and threatened species.) Mich. Adm. Code R.299.1026.

NORTON, P. W.
1973. A cormorant colony on Robert S. Kerr Reservoir. Okla. Ornithol. Soc. Bull. 6:17-20.

POSTUPALSKY, S. AND S. M. STACKPOLE
1974. Artificial nesting platforms for ospreys in Michigan. Raptor Res. Rep. 2:105-17.

SYKES, P. W., JR. AND R. CHANDLER
1974. Use of artificial nest structures by everglade kites. Wilson Bull. 86:282-84.

WERSCHKUL, D., E. MCMAHON, M. LEISCHUM, S. ENGLISH, C. SKIBINSKI, AND G. WILLIAMSON
1977. Observations on the reproductive ecology of the great blue heron *(Ardea heroidias)* in Oregon. Murrelet 58:7-12.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
1979. Endangered and threatened species. Wis. Adm. Code NR 27:201-202.20.

ACKNOWLEDGEMENTS

I thank the following individuals, who have contributed to my successful completion of this thesis: Dr. Ray Anderson, my graduate advisor, for his patience, advice, and continual encouragement; Dr. Neil Payne and Dr. Lyle Nauman, members of my graduate committee, for reviewing the thesis; John Berkhahn (DNR), Wildlife Manager - Mead Wildlife Area, for providing men and machinery; Greg Langrehr (DNR), Conservation Warden - Thorp, for his assistance in the construction of platforms and the gathering of data; Michael Brill, Stevens Point, for his assistance in the construction of platforms; Lullabye Furniture Company and Wisconsin Power and Light, Stevens Point, for providing miscellaneous building material; Southern District personnel (DNR), especially Jeanice Harrington, for typing the manuscript; my close friend, Karen Gardner, for typing many preliminary drafts of the thesis; my father, Dr. Stanley Meier, for his assistance in constructing platforms and providing continual encouragement; my mother, Marge Meier, for her moral support; my brother, William Meier, for his assistance in the construction of platforms; and my wife, Betsy, for her continuing love, encouragement, and assistance.

Supported by the University of Wisconsin - Steven's Point and the Department of Natural Resources (funds in part from the Federal Aid in Wildlife Restoration Act under Pittman-Robertson Project W-146-D.

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