1964

Studies of the germination and growth of cattail in relation to marsh management

John William Bedish

Iowa State University

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STUDIES OF THE GERMINATION AND GROWTH OF CATTAIL IN RELATION TO MARSH MANAGEMENT

by

John William Bedish

A Thesis Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: Wildlife Management

Iowa State University
Of Science and Technology
Ames, Iowa

1964
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INTRODUCTION

The total area of wetlands available to waterfowl has been greatly reduced during the past century due mainly to drainage for agricultural purposes. Moreover, the remaining marsh and pothole areas are subjected to fluctuating water levels which, at times, dramatically reduce waterfowl production. It has, therefore, become increasingly important to use effective management techniques to create and maintain optimum conditions for waterfowl in the remaining marshlands (Griffith, 1948).

The development of existing and potential wildlife-producing areas is more dependent on the selection of correct management techniques than on heavy investments of labor or materials (Leopold, 1933). Proper choice of these techniques is, in turn, dependent upon an understanding of the fundamental ecology of the plants and animals of the community.

An important, dominant plant member in most marsh areas is cattail (*Typha* spp.), an emergent that furnishes food and cover for many marsh animals. To provide favorable amounts of cattail, the marsh manager must know both the optimum environmental conditions for this plant and its range of tolerance. The over-all objective of this study was to
ascertain the optimum soil moisture or water depth conditions for germination, growth, and vegetative propagation of cattail, and to relate this information to marsh management procedures. Experiments were conducted under greenhouse and field conditions with a single, particularly robust and productive hybrid between *Typha latifolia* and *Typha angustifolia*. Although this study was restricted to one variety of cattail, it is believed that the results will contribute to a better understanding of the requirements of the genus and to the management of this important midwestern marsh plant.
Importance of Cattail to Marsh Animals

Cattail provides nesting sites and resting cover for many species of waterfowl and other marsh birds. Hochbaum (1959) stated that several of the diving ducks, especially the redhead (*Aythya americana)*⁠¹ and canvasback (*Aythya valisineria*), commonly nest in cattail. In addition, he indicated that the mallard (*Anas platyrhynchos*) occasionally nests in cattail stands. Williams and Marshall (1937) found that 21 per cent of the goose nests they located were in cattail although only 6 per cent of the vegetative cover in their study area was cattail. Beecher (1942) listed the following birds as important users of cattail cover: pied-billed grebe (*Podilymbus podiceps*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), sora rail (*Porzana carolina*), common gallinule (*Gallinula chloropus*), American coot (*Fulica americana*), and the black tern (*Chlidonias niger*).

Muskrats utilize cattail as food and as building

---

¹All scientific names of birds are from American Ornithologist's Union, Check-list of North American Birds, 5th edition, Baltimore, Maryland. 1957.
material for their lodges. Errington (1948) stated that a
good cattail marsh will support a higher population of muskrats than will an equivalent area of bulrushes (*Scirpus*
spp.). Bellrose and Brown (1941) found more muskrat houses
per unit-area in cattail areas than in other vegetation types
in the Illinois River Bottoms. Dozier (1945) noted that the
main roots and over-wintering shoots of cattail were a preferred winter food of muskrats on the Montezuma National
Wildlife Refuge.

Cattail is an important habitat component in many
marshes, if it is present in proper amounts. However,
periodic drought and flooding, "eat-outs" by muskrats, and
uncontrolled grazing by livestock, all reduce emergent
hydrophytes. The result is that these plants are not always
present in numbers conducive to optimum wildlife production.

Quantity is not the only consideration. It appears
that there is a direct relationship between the border area
of different types of vegetation and their utilization by
various wildlife species. Leopold (1933) defines this rela-
tionship as "edge effect". Beecher (1942) found fewer nests

---

1 All scientific names of plants are from Gleason, New
Britton and Brown Illustrated Flora, 1st edition, Lancaster,
of marsh birds in an area of large blocks of *Typha* or *Calamagrostis* than in equivalent acreages composed of numerous smaller blocks of the same plants. He stated that the population density of nesting birds increased with the increase in number of feet of edge present, or with the increasing floristic complexity of the environment in terms of communities per unit area. Steel, Dalke and Bizeau (1956) also showed that solid blocks of vegetation were less productive in terms of nesting waterfowl than were broken ones. Apparently, the resulting interspersion places plants suitable for nesting, brooding, and escape cover close to water and makes them attractive to ducks. If proper management techniques could be utilized to create and maintain this favorable interspersion of open water and vegetation, more breeding pairs of waterfowl might use the area.

**Relation of Water to Presence of Cattail**

Numerous authors have indicated that soil moisture and water depth strongly influence the ability of cattail to establish and maintain itself. However, there are few references in the literature which evaluate cattail growth and longevity under specific moisture conditions. Some of
those which do are quite contradictory in nature or provide only general observations.

Hotchkiss and Dozier (1947) list four major species of cattail in North America: *Typha latifolia*, *T. angustifolia*, *T. domingensis*, and *T. glauca*. Gleason (1958) stated that *Typha glauca* probably is a hybrid of *T. latifolia* and *T. angustifolia*. He also referred to *T. angustifolia elongata* as another hybrid, although Smith (1961) considers it to be the same plant as *T. glauca*. Hayden (1939) observed several hybrid forms in her studies in northwest Iowa. It is quite possible that the lack of agreement concerning moisture requirements of cattail may be due at least partially to inaccurate species identification.

Hayden (1939), in her work in northwest Iowa, found that the cattail phase of the emergent flora in shallow lakes advanced and receded with a rise or fall of the water level, which varied from a few inches to 3 feet. This would indicate a direct relationship between cattail occurrence and water depth. She also stated that *Typha angustifolia* generally occurred in deeper water than did *Typha latifolia*.

Penfound, Hall and Hess (1945) listed *Typha latifolia* as a species that grows readily in 1 foot or more of water.
They expressed the opinion that water level manipulation was not an effective means of controlling cattail. However, Uhler (1944) stated that permanent maintenance of a 1 1/2-foot water depth will eliminate *Typha latifolia*. In contrast, Bellrose and Brown (1941) said that the desirable water depth ranges between 6 and 24 inches, with the optimum being 12 to 18 inches.

Laing (1940a, 1940b, 1941) found that leaves and rhizomes of *Typha latifolia* could respire anaerobically and were able to endure anaerobic conditions in the dormant state. He stated, however, that in the active state the plant required appreciable amounts of oxygen to sustain growth and respiration. He further postulated that optimum growing conditions for cattails were found in shallow-water areas with well-aerated soils that were inundated only during part of the growing season. He felt that the plant's oxygen requirement prevented its successful invasion into deeper water. However, Dean (1933) stated that *Typha latifolia* displayed a high degree of adaptation to growth in stagnant soils by the development of finely branched "water roots". She rarely observed these structures in aerated cultures.

Dane (1956) cited water level as the single most
important factor controlling the existence of cattail stands in small marshes in New York. Giltz and Myser (1954) listed water level fluctuations in third place among the factors causing cattail die-offs in Lake Erie marshes. They cited high carp and muskrat populations as the major causes.

Seed Germination and Viability

The actual mechanics of cattail seed germination are described by Kerner (1895) as follows:

The germination of the Reed-mace (Typha) is quite peculiar. The small fruits which are blown off the spike, fall on to the surface of the water and remain floating for some days. Then the pericarp opens and the seed sinks slowly down into the water. The husk of the seed is pointed at one end, and at the other is closed by an extremely pretty trap-door. While sinking through the water the pointed end is turned downwards, and the covered end upwards. At the bottom the seed lies in the position indicated and germination commences. The cotyledon grows in length, pushes open the trap-door, and makes its appearance at the mouth of the seed-coat. It now describes an arch and the end in which are concealed the hypocotyl and the bud reaches the mud. Scarcely has it done so, however, when its epidermal cells elongate and form long tubular structures which penetrate into the slime, and the free end of the cotyledon is thus firmly fixed. Later on rootlets make their appearance, which, proceeding from the hypocotyl, break through the unresisting cotyledon. Meanwhile the reserve food has been sucked up by the apex of the cotyledon which remained in the seed; this apex is now drawn out of the seed-coat, the cotyledon straightens itself, turns green, and functions as a foliage-leaf.
Some work has been done on the effect of moisture on germination under controlled conditions. Morinaga (1926a, 1926b) found that light, reduced oxygen pressure, alternation of temperature, and nitrate compounds, all could be utilized to increase the germination of *Typha latifolia* seed. He found that mechanical rupturing of the seed coat increased the per cent of seeds germinating and removed the necessity for any other treatment of the seed. Sifton (1959) repeated much of Morinaga's work with the same species of seed and found the same results. He stated that the optimum temperature for germination was 30 degrees Centigrade. Bergman (1920) stated that seeds of *Typha*, *Sagittaria*, and *Alisma* germinate readily under water. In fact, all three of these workers experienced a high degree of success in bringing about cattail seed germination under water. Wilson (1955) induced seed of what he identified as *Typha latifolia*, *T. angustifolia*, *T. domingensis*, and *T. glauca* to germinate in simulated and actual marsh conditions in North Carolina. He found that seed germinated on exposed mud and under water depths of 1 to 2 inches. Seeds placed under 8 inches of water gave poorer results. He estimated that about twice as many seeds sprouted on simulated mud-flat conditions as under 2 inches of water. However, no mention was made of how
seeds were stored, and no data were presented on per cent of germination under the various moisture conditions.

Crocker (1938) found that *Typha latifolia* seeds stored air-dry at room temperature gave 78 per cent germination after 4 1/2 years, 96 per cent after 5 1/2 years, and no germination after 12 1/2 years. The seeds were placed in water that ranged in temperature from 15 to 30 degrees Centigrade. No mention was made of the temperature at which the seeds germinated. Crocker also stated that seeds of *Alisma, Typha*, and *Butomus* would stand several years of dry storage without injury, and added that, while it is claimed that seeds of water plants keep best in water, there are exceptions. In studies of salinity effects on marsh plants in Utah, Kaushik (1963) found that cattail seed which was stored dry or frozen prior to germination gave the highest percentage of germination. Seeds stored in mud or water gave poorer germination whether or not they were frozen. In addition, he noted more seeds germinating in moist conditions than under flooded conditions.

Other authors have published their findings from field observations on cattail establishment. Some of these observations indicate that flooded soil is more suitable for seed
germination, while others find a saturated soil best. Yeager (1949) listed *Typha latifolia* as a common invader of permanently flooded Illinois river bottoms. Mathiak and Linde (1956) noted an invasion of both *Typha latifolia* and *Typha angustifolia* in former blue-joint grass and sedge areas in Wisconsin, following a rise in water level. Kadlec (1960) indicated that cattail seedlings in Michigan established themselves only on very wet soil areas. He found that in areas where water depth remained under 1 foot, cattail, grasses, and sedges were among the most abundant plants. Brumsted and Hewitt (1952) surmised that pioneer communities of *Typha* and *Eleocharis* in New York germinated in areas flooded to a 10 to 14-inch depth. Bradley and Cook (1951), who also worked in New York, stated that cattails, once established, will tolerate much deeper water than the maximum depth in which they will germinate. Segadas (1951) observed the vegetative and physical factors present in 52 cattail stands in Oakland County, Michigan. He postulated that cattail stands in that area could be established in many kinds of soil, and that the only condition necessary for their establishment was the presence of large amounts of water, at least in the spring.

Lynch, O'Neil and Lay (1947) believed that prolonged
high water prevented seed germination and that cattail and other emergents invaded ponds when these areas went dry. They observed germination of cattail and other emergents on floating masses of plant debris and soil which had been lifted from the marsh bottom by decomposition gases. In addition, they stated that seeds of plants such as *Typha* and *Scirpus* which lie dormant under water must undergo this type of emersion before they can germinate. They did not indicate the requirements which this process met. Hayden (1946, 1948a, 1948b) observed the decline and re-establishment of emergent flora in the Ruthven area of northwest Iowa. She found that pond floors and lake beds from which the water had been evacuated were populated with seedlings within 2 to 3 weeks. July and August were especially favorable for germination of amply-seeded soil. Summerhayes and Turrill (1948) observed what they described as the establishment from seed of mature fruiting cattail plants on bare mud flats of Lake Binley in England. They did not indicate whether the seedheads developed in the first or the second season of growth, but they did state that the incident occurred in less than 12 months. They also stated that there was no *Typha* seedstock present in or around the area.
Another factor that apparently influences germination is the production of germination inhibitors by the leaves of cat-tail plants. Evenari (1949) lists *Typha* as one of the plants producing such inhibitors.
METHODS OF STUDY

The study was divided into two phases: greenhouse and field. Seeds and rhizomes were employed in both phases. Plant materials used were collected in both spring and fall from Round Lake, a state-owned marsh located in Clay County, northwest of Ruthven, Iowa (Section 3, R-35W, T-96N). Other collections were made at Laken's Slough, which also is state-owned and is located just east of Yale, Iowa, in Guthrie County (Section 34, R-30W, T-81N). Cattail seedheads were placed in separate polyethylene bags and stored at room temperature. Rootstocks, consisting of over-wintering rhizome shoots and attached rhizomes (Figure 1), were dug up and placed in galvanized tubs filled with mud from the same site. Vegetative material was then stored in a walk-in refrigerator at 35 degrees Fahrenheit. Water was added occasionally.

Greenhouse Studies

The greenhouse studies were divided into two sets of experiments, termed 1963 and 1964. The 1963 experiment was begun in December of 1962 and completed in early August of 1963. The 1964 experiment was started in December of 1963
Figure 1. Diagram of a cattail plant showing associated structures.
KEY
A - RHIZOME SHOOT
B - SEEDHEAD
C - PLANT BASE OR CULM
D - RHIZOME
E - ROOTS
and terminated in March of 1964.

The growth medium in both experiments was Webster Silt Loam, which was sterilized in a steam cabinet prior to use. Soil samples were taken in 4-ounce metal sampling cans and weighed, before and after oven-drying, to determine soil moisture percentages in each container.

Per cent germination of seeds, growth rate of plants established from rhizomes, and production of new rhizome shoots were noted according to various simulated moisture conditions.

1963 experiment

The 1963 greenhouse experiment consisted of two parts. The first was a comparison of seed germination in three different soil-moisture conditions. Soil was placed in galvanized pans measuring 22 inches by 14 inches by 3 inches (Figure 2). The following moisture conditions were then established: dry soil, maintained by adding a small amount of water every three days; saturated soil, maintained by placing these pans in shallow trays of water; and flooded soil, maintained by putting the pans in tubs so that there was 1 inch of water over the soil. Seeds of the cattail hybrid from Round Lake were planted in 10 rows of 30 seeds each. One such pan was placed in each moisture condition,
Figure 2. Photographs showing the moisture conditions used in the 1963 greenhouse experiments: dry soil (upper), saturated soil in pan of water (middle), and flooded with 1 inch of water (lower)
and per cent germination of seeds was recorded.

The second part of the experiment involved a comparison of growth rates of plants propagated from rhizome shoots in the same three moisture conditions. Two pans were placed in each moisture condition. Ten rhizome shoots and 10 pieces of rhizome were planted in each pan. Successful production of plants, weekly heights of 10 randomly-selected plants, and vegetative production of rhizome shoots were noted.

1964 experiment

This portion involved a type of investigation similar to the 1963 experiment, but the procedure was modified slightly. The same three moisture conditions used previously were repeated; in addition, a fourth condition of soil flooded with 6 inches of water was added to the setup. Instead of using pans, seeds were planted in 1-quart polyethylene containers that were placed in washtubs (Figure 3). This method permitted a more random arrangement of seed containers on the benches so that minor variability in light or temperature was less likely to be concentrated on one particular treatment.

The general setup for seed germination consisted of four treatments, two tubs per treatment, and ten pots per tub. One-year-old seed, from the same seedhead used in 1963, was
Figure 3. Photographs showing the setup for seed germination in the 1964 greenhouse experiments: general setup (upper), saturated soil in water (middle), and soil flooded with 6 inches of water (lower)
planted in half of the pots. New seed from the same area was planted in the other half. Twenty-five seeds were planted in each pot. Per cent germination was recorded in each pot. After germination occurred, all but five seedlings were removed.

Rhizome shoots were planted at the rate of ten per tub. The same soil-moisture conditions as used for the seed experiments were repeated. Ten plants in each treatment were randomly selected, and growth data were recorded at 10-day intervals.

Field Studies

Work began in May of 1963. Goose Lake, located 1 mile east of Jewell, Iowa, in Hamilton County (Section 27, R-24W, T-87N) was the site used for the field work. A small area of 60 feet by 80 feet on the south shore of the lake was selected for the actual observations. The effects of soil moisture and water depth were to be measured on introduced cattail and on natural vegetation present in the area. After close examination of the area to determine that no cattail was present, wood laths were placed at the four corners as markers.
In order to protect designated areas from disturbances such as grazing or trampling, two exclosures, 2 feet high, 3 feet wide, and 50 feet long, were constructed of hardware cloth and wood laths. The exclosures were placed so that they enclosed ecoclines, running from the drier soil of the bank out into the water (Figure 4).

Three rows of plant material were planted in one enclosure, and three rows were planted on the outside. One row consisted of over-wintering rhizome shoots, the second row was made up of 6-inch pieces of rhizomes, and the third row was of 3-inch pieces of rhizomes. Each row ran from dry soil down into the lake to a point under 16 inches of water. Plants were spaced 1 foot apart within the rows.

The second exclosure served as a control area. Nothing was planted in it, but observations were made to see if any cattail plants developed during the study.

Rhizomes were planted by cutting a slit in the soil with a spade, inserting the section of rhizome, and pressing the soil back together. Each site was marked with a numbered stake.

In another experiment, one hundred 6-inch pieces of rhizomes were cut and placed on an exposed mud flat. Each was marked with a numbered stake. Information was recorded as to
Figure 4. Photographs taken in early May, 1963, at the beginning of the study at Goose Lake, showing a completed exclosure (upper) and the study area (lower)
which were rhizome shoots and which were sections of underground rhizomes without shoots.

Seed was placed on three 40-square-foot areas from which the vegetation had been removed. Plantings of seed were made in May, June, and July.

In conjunction with all of the experiments, the entire previously-marked area was cover-mapped to show existing zones of vegetation and the locations of planted rhizomes. Cover maps were made, and four line-intercepts were taken to record major species of vegetation in May, July, and September. This provided a record of any changes in natural vegetation that occurred at the same time that the introduced cattail was growing.

A water guage was established, and readings were taken throughout the study period. At the same time, measurements were taken of the linear distance from the dry soil end of the exclosures to the edge of the water within the exclosures. The depth of the water at the submerged end of the exclosures also was measured. The data gave a record of depth of water at various points in the exclosures during the study period. This information then could be utilized as an aid in determining at what depth optimum plant growth
occurred.

Observations were made weekly. Water level data and height of successful plants were recorded each time. Soil samples were taken several times during the summer in 4-ounce sampling cans, from points 5 feet apart along a line running parallel to the exclosures and along the ecocline. These samples were weighed before and after oven-drying. Soil-moisture percentages were calculated on an oven-dry soil basis.
RESULTS

Greenhouse Studies

Plant growth was recorded in centimeters at regular intervals. Seed germination data consisted of counts of numbers of seeds germinating from the total planted in each repetition of a treatment. Average soil moisture percentages are listed in Table 1.

Table 1. Soil moisture conditions in experimental treatments

<table>
<thead>
<tr>
<th>Moisture condition</th>
<th>1963 Ave. %</th>
<th>1963 No. samples</th>
<th>1964 Ave. %</th>
<th>1964 No. samples</th>
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</thead>
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<tr>
<td>Rootstock tests:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dry soil</td>
<td>10</td>
<td>3</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Moist soil</td>
<td>54</td>
<td>3</td>
<td>33</td>
<td>2</td>
</tr>
<tr>
<td>Flooded - 1 inch</td>
<td>a</td>
<td></td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>Flooded - 6 inches</td>
<td>b</td>
<td></td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>Seed germination tests:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry soil</td>
<td>14</td>
<td>3</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>Moist soil</td>
<td>49</td>
<td>3</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>Flooded - 1 inch</td>
<td>a</td>
<td></td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>Flooded - 6 inches</td>
<td>b</td>
<td></td>
<td>a</td>
<td></td>
</tr>
</tbody>
</table>

*a Assumed to be saturated.

*b Not used in 1963.
Rootstock plantings

The 1963 experiment was exploratory in nature and was not highly suited for statistical analysis. The results of this study were similar to those obtained in 1964; however, the 6-inch flooded condition was not used the first year.

Rhizome shoots in the 1964 experiment, which were planted in dry soil, saturated soil, and soil flooded with 1 and 6 inches of water, all produced plants (Figure 5). However, plants in the dry soil condition did not survive through the study period, and 50 per cent of the rhizome shoots planted under 6 inches of water failed to grow. In addition, the initial growth of those which survived in 6 inches of water was slower (Figure 6). Plants in 1 inch of water had a faster rate of growth (Figure 7) and a greater amount of growth (Figure 8) than did plants in the other moisture conditions. Under all conditions, the major portion of growth occurred in the first one-third of the growing period.

An analysis of variance of the 1964 experiment, comparing total growth rate and total amount of growth in the different moisture treatments, shows a significant difference in growth response among treatments at the 99 per cent level.
Figure 5. Photograph showing the effect of different moisture levels on growth of cattail: 15 per cent soil moisture (A), 33 per cent soil moisture (B), one inch of water (C), and six inches of water (D).
Figure 6. A comparison of the time and amount of growth of cattail plants that were produced from rhizomes in four different soil moisture conditions.
Figure 7. A comparison of the total height attained by plants grown from rhizomes in two tests
KEY

FLOODED WITH 1" OF WATER

54 PERCENT SOIL MOISTURE

10 PERCENT SOIL MOISTURE

HEIGHT OF PLANTS IN CENTIMETERS

FLOODED WITH 6" OF WATER

FLOODED WITH 1" OF WATER

33 PERCENT SOIL MOISTURE

13 % SOIL MOISTURE

HEIGHT OF PLANTS IN CENTIMETERS
Figure 8. A comparison of cumulative growth of plants grown from rhizomes in four different soil moisture conditions.
of confidence (Tables 2 and 3). The variation within each treatment was not significant at this level.

Plants in the dry soil were the only ones that did not produce new rhizome shoots. Plants in the other three moisture conditions produced an average of one rhizome shoot per plant. In a few cases, these new shoots grew to about one-half the height of the parent plant, but usually they were dormant. However, if the dormant shoots were transferred to fresh soil which was saturated or flooded with water, they grew to heights comparable to those of the parent plants and produced new rhizome shoots. These new shoots were usually dormant also.

Table 2. Analysis of variance for mean growth rate of 1964-planted rhizomes for an 80-day growth period

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>M.S.</th>
<th>&quot;F&quot;</th>
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<tbody>
<tr>
<td>Plants (total)</td>
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<td>0.2962</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>3</td>
<td>3.2482</td>
<td>23.1419*</td>
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<tr>
<td>Tubs in treatments</td>
<td>4</td>
<td>0.1436</td>
<td>0.3749</td>
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<tr>
<td>Plants in tubs</td>
<td>32</td>
<td>0.0383</td>
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*Significant at 0.01 level of confidence

F test table value (3,4) (0.01) = 16.69
(Snedecor, 1961)
Table 3. Analysis of variance for mean total amount of growth of 1964-planted rhizomes during an 80-day growth period

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants (total)</td>
<td>39</td>
<td>1803.02</td>
<td></td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>20305.32</td>
<td>34.1759*</td>
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<tr>
<td>Tubs in treatments</td>
<td>4</td>
<td>594.14</td>
<td>2.6942</td>
</tr>
<tr>
<td>Plants in tubs</td>
<td>32</td>
<td>220.52</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 0.01 level of confidence.

\[ F \text{ test table value (3,4) (0.01) } = 16.69 \]
(Snedecor, 1961)

**Seed germination**

**1963 tests**

Seed germination occurred only when the soil was flooded to some degree. Saturated and dry soil treatments which had failed to produce seed germination did so only after their soil was covered with water. Otherwise, no germination occurred in these treatments.

The situation was further complicated by an apparent delay in germination. Some of the seed collected in the fall of 1962 was planted in January, 1963. When no germination had occurred after 30 days, the soil and seeds were destroyed.
A second series was established in early February, and a third in early March. Three days after the planting of the March series, germination was evident. A week prior to this, germination had begun in the February series as well. Seed plantings were also made in June and July. Germination occurred in each of these within three or four days. In all cases, germination occurred only in a flooded condition. The mean percentage of germination of the 1962 seed was 48.2 per cent.

1964 tests Samples of both 1962 seed and 1963 seed that were planted in December, 1963, germinated within one week under both 1 inch and 6 inches of water (Figure 9). The average germination of 1962 seed in 1 inch of water was 20.4 per cent, while 27.6 per cent of the 1963 seed germinated in the same depth. In 6 inches of water, the 1962 seed showed a mean germination of 14.4 per cent, while the mean for the 1963 seed was 32.8 per cent.

Separate t-tests (Snedecor, 1961) were made at the 99 level of confidence, comparing the effect of water depth on per cent germination of the 1962 seed and of the 1963 seed. Neither the 1962 nor the 1963 seed tests showed any significant effect of water depth on per cent germination. The calculated t-value for the effect of water depth on 1962
Figure 9. A comparison of per cent germination in 1964 of two ages of cattail seed in 6 inches of water and 1 inch of water
Figure 10. The effect of one year's dry storage on the viability of a sample of cattail seed germinated under 1 inch of water
seed was 0.811 while the t-table value (Snedecor, 1961) was 2.878. The t-table value (Snedecor, 1961) for the 1963 seed was again 2.878, compared to a calculated t-value of 0.187.

There did appear to be an effect of age on the per cent germination of seed. After one year, the per cent germination for seed that had been stored dry at room temperature was less than one-half its original value (Figure 10). A t-test showed this to be significant at the 99 level of confidence. The calculated t-value was 8.881, while the t-table value was 2.878 (Snedecor, 1961).

Field Studies

Factors influencing vegetation

The water level at Goose Lake declined steadily after exclosures were installed and planting was completed. Precipitation in June and July was below normal, and by early July there was no standing water in the exclosures (Table 4). However, in spite of the drop in water level, there was still a gradient of moisture present on the ecocline.

There was a shortage of natural food in the area, and resident muskrats decimated the exposed plantings during the
Table 4. Water level readings in planted exclosure, at Goose Lake study area, summer, 1963

<table>
<thead>
<tr>
<th>Date</th>
<th>Water gauge reading, ft.</th>
<th>Water depth at N. end of exclosure, in.</th>
<th>Distance from S. end of exclosure to water's edge, ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 10</td>
<td>1.00</td>
<td>15.0</td>
<td>20.0</td>
</tr>
<tr>
<td>May 19</td>
<td>0.89</td>
<td>13.5</td>
<td>22.5</td>
</tr>
<tr>
<td>May 24</td>
<td>0.81</td>
<td>12.5</td>
<td>24.5</td>
</tr>
<tr>
<td>June 1</td>
<td>0.86</td>
<td>13.0</td>
<td>23.5</td>
</tr>
<tr>
<td>June 8</td>
<td>0.76</td>
<td>12.0</td>
<td>25.5</td>
</tr>
<tr>
<td>June 15</td>
<td>0.64</td>
<td>10.5</td>
<td>27.5</td>
</tr>
<tr>
<td>June 22</td>
<td>0.40</td>
<td>8.0</td>
<td>33.0</td>
</tr>
<tr>
<td>July 6</td>
<td>a</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>July 13</td>
<td>0.48</td>
<td>8.5</td>
<td>31.5</td>
</tr>
<tr>
<td>July 20</td>
<td>0.60</td>
<td>10.0</td>
<td>28.0</td>
</tr>
<tr>
<td>July 28</td>
<td>a</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>July 30</td>
<td>a</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>August 3</td>
<td>a</td>
<td>b</td>
<td>b</td>
</tr>
</tbody>
</table>

---

*a* Water too low to read on depth gauge.

*b* No water in the exclosure.

*c* Exclosure length = 50 feet.
first two weeks. In some cases the rhizomes were dug up, and in others the plant was gnawed off close to the base. Some of these plants were cut off and regrew as many as four times, probably when the plant's growing center had not been damaged. Muskrats also utilized rhizome shoots growing outside the exclosure which were produced later in the summer by plants inside.

**Planted materials**

**Rhizomes**  The only vegetative material that produced plants was either the over-wintering rhizome shoot or a portion of a plant culm. These two types of plant material took root when placed on exposed mud and when planted in slits in the ground (Figure 11).

Only one-third of the rhizome shoots planted under water grew. Optimum plant growth and vegetative reproduction occurred in the area covered by 1 to 2 inches of water where at least part of the plant was always above water. Maximum rate and amount of growth occurred in the first 45 days (Figure 12). By the end of 80 days, the plants had reached their maximum height (Figure 13) and showed very little growth except for vegetative reproduction by rhizomes which had also decreased. At about this same time the plants in the driest
Figure 11. Photographs showing the exclosure in which rhizomes were planted. [Only the first row, which contained rhizome shoots, produced plants: Exclosure just after planting in mid-May, 1963 (upper), Exclosure in mid-July, 1963 (lower). Note water level.]
Figure 12. Growth rates of individual, planted rhizomes on the ecocline in relation to soil moisture. (Each bar represents one plant on the ecocline. The wide spaces represent areas where planted materials did not grow. These areas were under water at the time of planting.)
AVERAGE SOIL MOISTURE PERCENT GRADIENT CALCULATED ON AN OVEN-DRY BASIS.

KEY

- TOTAL HEIGHT OF BAR = AVERAGE GROWTH RATE FOR FIRST 45 OF 80 DAY PERIOD.
- BLACK PORTION OF BAR = AVERAGE GROWTH RATE FOR WHOLE 80 DAY PERIOD.
Figure 13. Total height reached by individual plants on the ecocline. (Each bar represents one plant on the ecocline. The wide spaces represent areas where planted materials did not grow. These areas were under water at the time of planting.)
AVERAGE SOIL-MOISTURE GRADIENT CALCULATED ON OVEN-DRY WEIGHT BASIS

PLANT HEIGHT IN CENTIMETERS
portion of the ecocline began to wilt.

**Seeds** Field plantings of cattail seed were unsuccessful (Figure 14). However, seed from the same head germinated when planted simultaneously in the greenhouse. In addition, soil samples that were taken from the naturally-occurring cattail stand and flooded under an inch of water in the greenhouse produced several seedlings (Table 5). No naturally-occurring cattail seedlings were observed at Goose Lake during the summer. There undoubtedly were cattail seeds present in the soil at Goose Lake, but for some reason they did not germinate.

Table 5. Types and number of plants occurring in a greenhouse-flooded soil sample taken from Goose Lake

<table>
<thead>
<tr>
<th>Plant</th>
<th>Scientific Name</th>
<th>Number of stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice-cut grass</td>
<td><em>Leersia oryzoides</em></td>
<td>189</td>
</tr>
<tr>
<td>Spike rush</td>
<td><em>Eleocharis palustris</em></td>
<td>24</td>
</tr>
<tr>
<td>Smartweed</td>
<td><em>Polygonum pennsylvanicum</em></td>
<td>11</td>
</tr>
<tr>
<td>Smartweed</td>
<td><em>Polygonum</em> spp.</td>
<td>7</td>
</tr>
<tr>
<td>Hardstem bulrush</td>
<td><em>Scirpus acutus</em></td>
<td>17</td>
</tr>
<tr>
<td>River bulrush</td>
<td><em>Scirpus fluviatilis</em></td>
<td>2</td>
</tr>
<tr>
<td>Burreed</td>
<td><em>Sparganium</em> spp.</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 5 (Continued)

<table>
<thead>
<tr>
<th>Plant</th>
<th>Scientific Name</th>
<th>Number of stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattail</td>
<td><em>Typha</em> <em>spp.</em></td>
<td>7</td>
</tr>
<tr>
<td>Beggar's tick</td>
<td><em>Bidens laevis</em></td>
<td>9</td>
</tr>
<tr>
<td>Boneset</td>
<td><em>Eupatorium perfoliatum</em></td>
<td>4</td>
</tr>
<tr>
<td>Vervane</td>
<td><em>Verbena</em> <em>spp.</em></td>
<td>2</td>
</tr>
<tr>
<td>Arrowhead</td>
<td><em>Sagittaria</em> <em>spp.</em></td>
<td>1</td>
</tr>
<tr>
<td>Water plantain</td>
<td><em>Alisma</em> <em>spp.</em></td>
<td>4</td>
</tr>
<tr>
<td>Unidentified forbs</td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

**Control area**

The effect of the decline in water level on the natural vegetation in the control area was rather pronounced. The exposure of formerly-flooded areas produced noticeable changes in the size of vegetation zones in the area (Figures 15 and 16). In addition, plant composition in these zones changed quite radically. Table 6 lists the more abundant plants occurring in each zone before and after the decline in water level. Each zone is designated by the generic name of the dominant emergent plant occurring in it in early June.
Figure 14. Photographs showing a seed bed prepared for cattail seed germination trials (upper), and the same plot 30 days later (lower). (Plants that grew in the plot consist mostly of *Scirpus*, *Leersia* and *Bidens*. There were no cattail seedlings.)
Figure 15. Distribution of vegetation at the beginning of the study. (Each dot represents a planted section of cattail vegetative material.)
Figure 16. Status of the vegetation at the end of the study. (This illustration shows the surviving cattail plants as well as sites of vegetative reproduction. Comparison with Figure 15 shows the changes in natural vegetation that occurred with the decline in water level.)
Table 6. Naturally-occurring plants in each vegetation zone before and after the decrease in water level in the summer of 1963

<table>
<thead>
<tr>
<th>Zone</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Poa-Solidago zone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>Poa pratensis</td>
<td>X</td>
</tr>
<tr>
<td>golden rod</td>
<td>Solidago missouriensis</td>
<td>X</td>
</tr>
<tr>
<td>aster</td>
<td>Aster spp.</td>
<td>X</td>
</tr>
<tr>
<td>New Jersey tea</td>
<td>Ceanothus americanus</td>
<td>X</td>
</tr>
<tr>
<td>broad-leafed milkweed</td>
<td>Asclepias syriaca</td>
<td>X</td>
</tr>
<tr>
<td>vervane</td>
<td>Verbena hastata</td>
<td>X</td>
</tr>
<tr>
<td><strong>Carex zone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sedge</td>
<td>Carex spp.</td>
<td>X</td>
</tr>
<tr>
<td>manna grass</td>
<td>Glyceria spp.</td>
<td>X</td>
</tr>
<tr>
<td>jewelweed</td>
<td>Impatiens pallida</td>
<td>X</td>
</tr>
<tr>
<td>mint</td>
<td>Lycoptus americana</td>
<td>X</td>
</tr>
<tr>
<td>boneset</td>
<td>Eupatorium perfoliatum</td>
<td>X</td>
</tr>
<tr>
<td>vervane</td>
<td>Verbena hastata</td>
<td>X</td>
</tr>
<tr>
<td><strong>Leersia zone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rice-cut grass</td>
<td>Leersia ozyzoides</td>
<td>X</td>
</tr>
<tr>
<td>spikerush</td>
<td>Eleocharis palustris</td>
<td>X</td>
</tr>
<tr>
<td>jewelweed</td>
<td>Impatiens pallida</td>
<td>X</td>
</tr>
<tr>
<td>beggar's tick</td>
<td>Bidens laevis</td>
<td>X</td>
</tr>
<tr>
<td>smartweed</td>
<td>Polygonum lapathifolium</td>
<td>X</td>
</tr>
<tr>
<td>river bulrush</td>
<td>Scirpus fluvatilis</td>
<td>X</td>
</tr>
<tr>
<td><strong>Bidens zone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>beggar's tick</td>
<td>Bidens laevis</td>
<td>X</td>
</tr>
<tr>
<td>rice-cut grass</td>
<td>Leersia ozyzoides</td>
<td>X</td>
</tr>
<tr>
<td>arrowhead</td>
<td>Sagittaria engelmanniana</td>
<td>X</td>
</tr>
<tr>
<td>water plantain</td>
<td>Alisma plantago aquatica</td>
<td>X</td>
</tr>
<tr>
<td>river bulrush</td>
<td>Scirpus fluvatilis</td>
<td>X</td>
</tr>
<tr>
<td>hard-stem bulrush</td>
<td>Scirpus acutus</td>
<td>X</td>
</tr>
<tr>
<td>smartweed</td>
<td>Polygonum pennsylvanicum</td>
<td>X</td>
</tr>
</tbody>
</table>
Table 6 (Continued)

<table>
<thead>
<tr>
<th>Sagittaria zone (formerly open water)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
</tr>
<tr>
<td>duckweed</td>
</tr>
<tr>
<td>great duckweed</td>
</tr>
<tr>
<td>pondweed</td>
</tr>
<tr>
<td>smartweed</td>
</tr>
<tr>
<td>arrowhead</td>
</tr>
<tr>
<td>water plantain</td>
</tr>
<tr>
<td>beggar's tick</td>
</tr>
<tr>
<td>rice-cut grass</td>
</tr>
<tr>
<td>hard-stem bulrush</td>
</tr>
</tbody>
</table>
Effects of Moisture on Cattail

Seed germination

The results of this study indicate that the optimum moisture condition for seed germination, growth, and vegetative reproduction of cattail is a flooded condition with water approximately 1 inch deep.

Cattail seeds germinate in conditions of reduced oxygen tension which are provided by flooding. It should be realized, however, that there are other factors that play important roles. Morinaga (1926a, 1926b) found that the germination of seeds of Typha latifolia was also influenced by light, alternation of temperature, and nitrates. Sifton (1959) listed temperature as an important controlling factor as well as light and oxygen tension.

Typha seeds probably will germinate under any depth of water into which light can penetrate, as long as other influential factors are favorable (Meyer and Mayber, 1963). The fact that they do not germinate in water too deep for light penetration prevents germination in sites where seedlings will not survive.
Although several authors [for example Wilson (1955); Lynch, O'Neil and Lay (1947); and Hayden (1948a, 1948b)] have indicated that cattail seeds germinate without water cover, the results of this study indicate that the actual germination occurs in shallow water. These references to germination of seeds of cattail and other aquatic plants may well have been the result of field observations of seedlings left growing on mud exposed by natural lowering of water levels. Or seeds of other varieties of cattail may germinate under different conditions than did the variety used in this study.

An additional factor in seed germination may be the production by cattail leaves of inhibitors which prevent germination of *Typha* seed in an established cattail stand (Evenari, 1949). The presence of such inhibitors might explain the failure of cattail seed plantings at Goose Lake. While there is no positive evidence on this point, observations in the small cattail area at Goose Lake showed only vegetative reproduction and no cattail seedlings. The amount of emergent vegetation at Goose Lake has been very limited since the summer of 1960 when a combination of high water and excessive exploitation by muskrats caused its deterioration (Errington, Siglin and Clark, 1963). The
recovery of the emergent vegetation, including \textit{Typha}, has been quite slow. However, soil samples which were removed from the cattail stand and flooded with 1 inch of water in the greenhouse produced several cattail seedlings from seed already present in the soil. Soil from the cattail stands at Round Lake also produced seedlings when flooded in the greenhouse. The effects, if any, of inhibitors must remain a question for further study since they cannot be properly evaluated from the limited observations available.

Another factor that must be considered is the longevity of cattail seed in the soil of a marsh. The work of Crocker (1938) and Kuashik (1963) indicates that a period of wet storage is detrimental to \textit{Typha} seeds. However, Lynch, O'Neil and Lay (1947) and Hayden (1948a, 1948b) observed germination of cattail seed that had obviously been under water for some period of time. How long these seeds had been submerged before they germinated was not known, or at least not stated, in either study.

The realization that many factors affect seed germination makes one aware that water level control is not a "cure-all" that will provide luxuriant stands of \textit{Typha} seedlings. However, if seed stock is present and the other
factors affecting seed germination potential are favorable, the manipulation of water level to a shallow depth would provide an optimum environment for the germination of cattail seed.

**Growth and propagation of plants**

One inch of water also appears to provide optimum growing conditions for cattail plants. In addition, this study indicates that moisture conditions ranging from saturated soil to 6 inches of water will provide almost equally favorable growing conditions.

Dane (1959) compared the effect of different water levels on *Typha* in two marsh areas in New York. One area, Klossner Marsh, was drawn down in 1952 while the other area, Weaver Marsh, was not. With no drawdown, Weaver Marsh had a stagnated water level with a greater average depth and range of depth than did Klossner. *Typha* in Klossner Marsh showed a steady increase over a 4-year period, while it declined in Weaver Marsh. Dane stated that water level during the growing season was the single most important factor in the growth and spreading of emergent plants. He found an overcrowding of emergents during years of low water level.

It appears that water level management can be an impor-
tant aid in the propagation of cattail as well as marsh vegetation in general. However, from a marsh management point of view, a heavy growth of emergents with no pothole-like openings is not conducive to optimum production of waterfowl. In a marsh area, "edge" may be of two types: 1) the interspersion of two or more cover types, or 2) the interspersion of cover and water. In the case of an area covered by Typha, the latter is more important. The muskrat often creates this type of "edge" in solid stands of emergent vegetation through its feeding and lodge building activities. The presence of such openings provides additional sites for waterfowl breeding and nesting. However, while muskrats are quite useful in this function, their populations are difficult to control and the result may be an "eat-out." Muskrats must be regarded as powerful ecological agents with potentialities for affecting their own habitat, either adversely or beneficially (Errington, 1948).

Management Recommendations

Typha in proper amounts is a valuable source of cover for several species of waterfowl. The following management recommendations should be helpful in encouraging and maintain-
ing favorable numbers of cattail in marsh areas.

**Water level management**

The drawdown has been indicated as a technique which can contribute to an increase in emergent and submerged marsh plants (Kadlec, 1960). However, the desired result must influence the use of this technique, and the timing of the drawdown is an important factor to be considered. The reduction in water level should be made at a time that would provide maximum results, not only in growth of emergent vegetation for cover, but also in maximum production of duck food plants.

If a drawdown is made during the reproductive season, the direct effect on waterfowl production must be considered, for it is well known that hens will abandon their nests (Wolf, 1955). During the brooding period, a drawdown would seriously hinder the rearing of ducklings since broods would have to travel a greater distance to water. However, if the amount of cover or interspersion of cover is not acceptable to mating duck pairs, they will not utilize the area. Under such conditions every means should be used to increase the amount of emergent vegetation, since lack of adequate cover is often the most limiting factor to nesting in waterfowl.
breeding areas (Griffith, 1948).

It appears that cattail produced in Iowa from overwintering rhizome shoots usually starts growing in early May when soil and water reach a suitable temperature. The observations made in this study also indicated that by late July growth of plants in *Typha* stands had essentially ceased. A water drawdown in June would, therefore, contribute to optimum growth of cattail and, at the same time, would expose seeds of other emergents that were formerly under deeper water, thus increasing species such as *Scirpus*, *Sparganium*, and *Sagittaria*. However, it should be realized that a drawdown also provides favorable conditions for the introduction and growth of woody plants such as willows (*Salix* spp.) and buttonbush (*Cephalanthus occidentalis*) which are of little or no value to waterfowl (Bellrose, 1941).

The observations made at Goose Lake in July and September of 1963, during and after the drop in water level, showed an increase of certain emergents in the formerly inundated areas. The areas of exposed mud near the water's edge, as well as the shallow water areas, were covered with seedlings of *Sagittaria* and *Alisma*. There was also a spreading of *Leersia* and *Bidens* in the direction of the receding water, with the
understory of the \textit{Bidens} zone made up largely of \textit{Sagittaria} and \textit{Alisma}. The success of these species indicates that the very wet soil and shallow water areas provided by a drawdown will support the propagation of emergents as stated by Kadlec (1960).

An early drawdown that resulted in exposed mud flats and shallow water areas might contribute to the establishment and increase of moist-soil duck food plants such as nutgrass (\textit{Cyperus strigosus} and \textit{Cyperus esculentus}), pigweed (\textit{Acmidis tuberculata}), rice-cut grass (\textit{Leersia oryzoides}), and wild millet (\textit{Echinochloa crusgalli}) (Bellrose, 1941). However, an early drawdown of this type would not cause an increase of submerged pondweeds such as sago (\textit{Potamogeton pectinatus}) or longleaf (\textit{Potamogeton nodosus}). Since these plants predominate in water depths of 2 to 3 feet (Bellrose, 1941), maintenance of such a depth should be more beneficial in the spreading these submergents. However, if an early drawdown were made in June in marshes with sloping bottoms, it might contribute to the germination of the potamogetons in areas of about 1 foot in depth. Sharp (1939) found that \textit{Potamogeton} seeds that were planted in June germinated best at this depth. Nevertheless, Bellrose (1941) advised 2 to 3 feet of water
with low turbidity for optimum growth and seed production. Brumsted and Hewitt (1952) also found that raising the water level after growth of plants had begun produced a more luxuriant growth of pondweeds. This would indicate that if maximum production of potamogetons were desired, it would be necessary to raise the water level after germination had occurred. However, the degree of water turbidity also must be considered in any such action.

If the water were raised in late July, it probably would not affect the amount of growth of plants such as Typha which are propagated from the rhizomes of parent plants, since plants of this origin have usually reached full growth by this time. However, seedlings of such emergents could not be expected to survive such a flooding. In addition, any chance of late summer germination of cattail seeds would be lessened by raising the water level. Hayden (1948a, 1948b) believed that late July and August were favorable for the germination of such seeds when the water level was low.

Artificial propagation

It has been shown in the results of this study that either a rhizome shoot or a portion of the plant base is required for the vegetative production of a new cattail
A large number of these culms (plant bases) were observed floating in the water at Goose Lake in late April and early May of 1963. It would appear that some of these culms function in the establishment of new cattail stands. The rhizomes that were placed on an exposed mud flat at Goose Lake are evidence of this. All of the root stock material that contained a rhizome shoot or had been taken from a basal portion of a plant gave rise to new plants. It seems logical to assume that if floating culms reach an area where they are in contact with soil containing sufficient moisture to delay dessication, they will take root and grow.

The work at Goose Lake demonstrated that a high muskrat population can rapidly eliminate any attempted planting of rhizome shoots. Fencing of plantings and regulation of muskrats would be necessary in such a situation. However, the labor involved in obtaining planting materials and building fences, as well as the expense of the fencing materials, would make such an undertaking economically unsound.

Planting seeds in an area is probably the most economical method of artificial propagation. However, a complex combination of factors influences germination so that the degree of success would be uncertain. The correct amount
and timing of water level manipulation can be effective in stimulating germination of seeds of cattail and other emergents when seedstock is available and other germination-influencing factors are favorable.
SUMMARY

1. This investigation attempted to determine what soil-moisture condition or water depth is optimum for the germination, growth, and vegetative reproduction of cattail (Typha spp.) and to relate this information to marsh management procedures.

2. Greenhouse and field experiments were made with the seeds and rhizomes of a hybrid between Typha latifolia and Typha angustifolia, which were obtained from Round Lake near Ruthven, Iowa.

3. Greenhouse experiments were made in 1963 to observe the effect of three soil-moisture conditions (dry soil, saturated soil, and soil flooded with 1 inch of water) on seed germination and on the growth and vegetative reproduction of plants produced from rhizomes. Additional experiments of the same type were made in 1964; however, a flooded condition of 6 inches of water was added to the original three moisture conditions.

4. The field studies were made in the summer of 1963, at Goose Lake near Jewell, Iowa. One phase consisted of measuring the growth of planted rhizomes on an enclosed and an exposed moisture ecocline, 50 feet in length.
Other field experiments included the placing of cut pieces of rhizomes on an exposed mud flat, seed germination trials on bare soil, and the observation of changes in natural vegetation following a decline in water level.

5. A depth of 1 inch of water was found to be the optimum moisture condition for seed germination, growth of plants produced from rhizome shoots, and vegetative reproduction of cattail. Flooding was found to be necessary for germination of the seed of the hybrid.

6. There was no apparent difference in per cent germination of seeds in 1 inch of water and 6 inches of water in greenhouse experiments. Field germination experiments were unsuccessful.

7. Greenhouse experiments showed a reduction in per cent germination of a seed sample after one year of dry storage at room temperature.

8. Either the over-wintering rhizome shoot or a portion of a plant base (culm) was needed to produce a new cattail plant.

9. Exposed plantings of rhizomes at Goose Lake were decimated by muskrats within two weeks.
10. A decline in water level at Goose Lake produced quite noticeable changes in vegetation in the study area. An increase was noted in emergents such as *Leersia*, *Bidens*, *Sagittaria*, and *Alisma* in areas that were exposed by the receding water.

11. Water level manipulation was recognized to be an effective tool in the production of food and cover plants for waterfowl. However, other factors such as timing of the change in water level, temperature, water turbidity, and available seed stock must be considered.

12. Artificial propagation of cattail by planting rhizomes was found to be economically unsound because of the need for muskrat control and fencing, as well as the labor involved in obtaining and planting rhizomes.

13. Planting seeds would be the most economical means of introducing or propagating cattail in a marsh area. However, results would be uncertain because of the many factors that affect seed germination.
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