WETLAND MANAGEMENT FOR WATERFOWL

HANDBOOK

WETLAND MANAGEMENT FOR WATERFOWL HANDBOOK

Natural Resources Conservation Service
Mississippi Fish and Wildlife Foundation
United States Fish and Wildlife Service
Ducks Unlimited
Delta Wildlife

2001

Edited and Compiled by
Kevin D. Nelms, Natural Resources Conservation Service, Mississippi

Acknowledgements
The following biologists made contributions to one or more parts of this publication:
Leigh Fredrickson, Gaylord Laboratory, University of Missouri
Brett Hunter, U.S. Fish and Wildlife Service, Louisiana
Jody Pagan, Natural Resources Conservation Service, Arkansas
Pat Stinson, U.S. Fish and Wildlife Service, Mississippi
Bob Strader, U.S. Fish and Wildlife Service, Mississippi
Mark Tidwell, Natural Resources Conservation Service, Arkansas

Photography
Photographs courtesy of Russell Stevens and Chuck Coffey, Samuel Roberts Noble Foundation, Ardmore, Oklahoma; Jody Pagan, NRCS, Arkansas; Victor Ramey and Anne Murray, Center for Aquatic and Invasive Plants, University of Florida; James Manhart, Department of Biology, Texas A&M University; Robert Kowal, Kenneth Sytsma, and Michael Clayton, Department of Botany, University of Wisconsin-Madison; Dennis Woodland, Biology Department, Andrews University; USDA, NRCS PLANTS database. Some of the photographs can be found on the internet at:
www.noble.org/imagegallery
www.csdl.tamu.edu/FLORA/gallery.htm
www.wisc.edu/botany/virtual.html
http://plants.usda.gov/plants

Cover photograph provided by Ducks Unlimited.

WETLAND MANAGEMENT FOR WATERFOWL HANDBOOK

TABLE OF CONTENTS

Wetland types common to the Lower Mississippi Alluvial Valley 1
Waterbird migration season overview 3

Wetland Management Strategies for Food and Habitat
Moist-soil management for wildlife 5
Management of seasonally flooded impoundments for wildlife 7
Strategies for water level manipulations in moist-soil systems 18
Preliminary considerations for manipulating vegetation 26

Other Waterfowl Foods
Flooded food plots for wildlife 33
Managing agricultural foods for waterfowl 35
Aquatic invertebrates important for waterfowl production 39
Invertebrate response to wetland management 46

Life History and Wetland Management for Wood Ducks
Life history and habitat needs of the wood duck 53
Managing beaver to benefit waterfowl 61

Wetland Plant Identification Guide
Vegetation control strategies 69
Common wetland plants (in alphabetical order) 70-116

Appendix
Moist-soil data sheet 117

Wetland Types Common to the Lower Mississippi Alluvial Valley

Seasonally Flooded Bottomland Hardwoods
Bottomland hardwood wetlands are forested wetlands comprised of trees, shrubs, broadleaf herbaceous plants, and grasses that withstand flooding of various depths, duration, and times. This is the predominant wetland type in the LMAV. When selecting tree species for planting, susceptibility of flooding and flood tolerance of species should be considered. Species that are tolerant of flooding will do well on elevated sites, but species intolerant to prolonged flooding will not do well on flood prone sites.

If water control is possible on bottomland hardwood sites then it is called a greentree reservoir. Greentree reservoirs should only be flooded during dormancy, usually December 1 to March 15 in Mississippi. Early fall flooding can be more detrimental than late spring flooding. When managing greentrees, flooding and draining at the same time annually should be avoided. Water depth, duration of flooding, and flood timing should be changed each year. The reservoir should be left dry 1 in 4 years. Improper flooding will result in tree stress and over time will kill desirable oaks and favor flood tolerant trees such as tupelo and cypress. Swollen and cracked trunks at water level, acorn crop failure, dead branches, and yellowish leaves are signs of tree stress and improper flooding.

Moist-Soil Wetlands
Moist-soil wetlands historically occurred where openings existed in bottomland hardwoods. Forest openings were often caused by high winds, catastrophic floods, beavers, fires, etc. Man-made impoundments are commonly managed as moist-soil wetlands. Moist-soil areas are typified by seed producing annuals such as smartweeds, wild millets, panicums, and sprangletop. Planting moist-soil areas is not necessary because native plant seeds are abundant in frequently flooded soils. Over 2,500 pounds per acre of seed can be produced in a properly managed moist-soil area. Over time, plant succession will favor perennials and moist-soil areas will need to be disturbed.

If more than one moist-soil area is being managed, it is best to stagger draining and flooding between units. This will increase plant diversity, prolong habitat availability, and increase wildlife benefits. Of 156 species of birds that use moist-soil, 131 prefer water depths 10 inches or less. Once again, varying depth, duration, and timing will provide the best results.

Emergent Marshes
Emergent marshes are generally 6" to 3' deep and contain vegetation rooted in soil that emerges above the water surface. Emergent plants include cattail, bulrush, spikerush, and sedges. These marshes are valuable as nesting and brood rearing habitat for resident wading birds. They also provide feeding, resting, and roosting habitat for migratory shorebirds and waterfowl. Emergent marshes are often managed in rotation with moist-soil areas.

Maximum use of emergent marshes takes place when plant cover reaches 50% leaving 50% open water; this is called a *hemimarsh*. As marsh succession occurs, a marsh will move from open marsh to hemimarsh to predominately emergent cover. Emergent marsh

succession should be manipulated when invading woody plant stems are 2-3 inches in diameter. Disturbance is best accomplished by bushhogging and heavy disking. This will set succession back to the grass stage. This area can then be managed for moist-soil while another area is allowed to become emergent marsh. Water levels of emergent marshes can be drawdown in late summer and early fall to provide mudflats and shallow water for migrating shorebirds and teal.

Shrub/Scrub Swamps

Shrub/scrub swamps usually contain 6" to 24" of water during the growing season. They are typified by willows, buttonbush, other woody species, and perennial herbaceous vegetation. In the LMAV, shrub/scrub swamps are often transitional between emergent wetlands and forested wetlands. Decaying leaves provide substrate for invertebrates which in turn provides food for waterbirds, fish, amphibians, and other wetland wildlife. Studies have found over 25 pounds of invertebrates in an acre of flooded willows. Buttonbush seeds are often fed on by wood ducks and mallards. However, the primary value of shrub/scrub is not food, it is thermal roosting cover for waterfowl. On cold nights the low, thick vegetation helps retain heat.

Microtopography/Depressions

Historically, flooding in the LMAV resulted in shallow ridge/swale topography and isolated depressional areas. This is often referred to as microtopography. Microtopography is important because it can provide valuable habitat for amphibians and feeding waterbirds. When creating microtopography, the goal is to create as much variation in depth, duration, and timing of flooding as possible. This can be accomplished by digging isolated depressions, digging depressions within other wetland types, creative borrowing when constructing dikes, and by diking small suitable areas. Depressional wetlands found at high enough elevations to escape seasonal flooding are often called fishless ponds. These areas are valuable for amphibians since no fish or bullfrog tadpoles are present to feed on eggs or young. Water budgets for the Mississippi Delta have shown 3' depressions will maintain some water 9 out of 10 years.

Deep Open Water

Deep, open water is generally 3' or more deep and is usually a river, slough, brake, bayou, or oxbow lake. These wetlands are valuable as fisheries and also provide resting and roosting cover for waterbirds. Deep, open water is generally not limiting but can provide valuable habitat in dry years.

Wetland Complexes

A variety of wetland types located in close proximity will ensure that each wetland species can meet its physiological requirements at each stage of its life. Most managed tracts are not large enough to provide all the previously mentioned wetland types. However, different wetland types should be provided and steps should be taken to provide wetland types that are not available within adjacent areas. Studies indicate that a mallard must have all the resources needed for survival within a 12-mile radius. A good goal when planning is to provide bottomland forest, moist-soil wetlands, emergent marsh, shrub/scrub swamps, microtopography, and flooded cropland all within a 12-mile radius. The most benefit occurs when each wetland type is in several stages of succession.

This was adapted from a publication written by Phil Covington, Ducks Unlimited Private Lands Biologist, Arkansas.

Waterbird Migration Season Overview

Waterfowl and other migratory bird species associated with each season are shown in the following table. Dates were calculated based on information concerning growing season and bird migration. Calculated dates represent long-term averages for the beginning and end of migration and may differ in any given year due to climatic conditions. Knowledge of species arrival and departure can help make wetland management decisions.

Season	Bird Species	Date
Fall migration - Early flood	Blue-winged teal, pintail, rails, shorebirds	8/01 – 11/9
Fall migration - Normal flood	Widgeon, gadwall, green-winged teal, snipe, white geese, small Canada geese	11/10 – 11/24
Fall migration - Reserve flood	Mallards, large Canada geese	11/24 – 1/05
Spring migration - Early drawdown	Mallards, pintail, geese	3/01 – 3/31
Spring migration - Mid drawdown	Teal, shoveler, shorebirds, rails, arriving herons, early waterfowl broods	4/01 – 5/25
Spring migration - Late drawdown	Waterfowl broods, resident and young herons, rail broods, breeding shorebirds	5/25 – 7/8

Wetland Management Strategies For Food and Habitat

Photo courtesy of Ducks Unlimited.

USDA NRCS
Natural Resources Conservation Service
MISSISSIPPI

MOIST-SOIL MANAGEMENT FOR WILDLIFE

MS-ECS-646-01 (JS)
May 2000

Definition: Moist-soil management is the drawdown of water to promote germination of native plants on exposed mudflats and the subsequent reflooding of same areas.

Purpose: Native plants favored by moist-soil management provide valuable food and cover for wetland wildlife species. Seasonally flooded moist-soil areas also provide an abundance of aquatic invertebrates used by wildlife. This practice provides food and habitat for waterfowl, wading and shorebirds, reptiles, amphibians, and other wetland species.

Management: The most important factor when managing moist-soil areas is the timing of the annual drawdown. Early season drawdowns occur within the first 45 days of the growing season, generally between March 15 and May 1 in Mississippi. Mid season drawdowns occur during the second 45 days of growing season, May 1 to July 15 in Mississippi. Late season drawdowns occur after July 15 in Mississippi. Early season drawdowns generally result in the most seed production. Mid to late season drawdowns tend to favor desirable grasses.

Length of drawdown can also affect vegetation response. Slow (2-6 weeks) drawdowns will produce a greater diversity of plants and can be achieved by removing one board from the water control structure every 4 to 10 days. Fast drawdowns typically produce stands of similar vegetation and are achieved by pulling all boards at once.

Moist-soil areas do not have to be completely drained. A partial drawdown (1/4 to 1/2 of boards) of the area will provide moist-soil benefits while retaining late spring and summer habitat for wildlife. The remaining water may evaporate and provide conditions favorable for the continued germination of preferred moist-soil plants. A remnant pool may provide water for early migrants, such as teal, in late summer and early fall.

On properties with multiple moist-soil areas being managed, different drawdown rates and dates can provide maximum wildlife benefits. Because every site is different, it is important to keep records of drawdown dates and plant responses so that conditions produced one year can be reproduced or improved in subsequent years.

Timing of reflooding is important to assure habitat use. To provide habitat for teal and other early migrants, a few boards should be replaced between August 15 and September 15 in an effort to shallowly flood up to 25% of a moist-soil area. Between October 15 and December 15 the remainder of the boards should be replaced, one board every 7-10 days. This will allow new food and habitat to become available slowly. When multiple moist-soil units are available, some units should be flooded early and some should be flooded between October 15 and December 15 to provide continued food and habitat. When enough units are available, a unit can be reserved and flooded one board at a time between December 1 and January 1.

Maintenance: Moist-soil areas should be inspected weekly during the growing season for weed competition. Undesirables such as cocklebur and sesbania can quickly invade the area. When undesirable broadleafs cover 50% or more of the area they should be controlled by approved herbicide, disking, shredding, prescribed burning, and/or flooding. Contact the local NRCS or County Extension office for weed control recommendations.

Desirable seed producing plants tend to decrease each year an area is managed for moist-soil plants and the soil is undisturbed. Therefore, moist-soil areas should be disturbed by disking or prescribed burning every 2-3 years. This will also help to control the encroachment of undesired woody plants.

Considerations:

- A water control structure is needed for manipulation of water levels.
- Low permeability soils will inhibit subsurface water loss and assure proper water control.
- All federal and state laws shall be followed when managing moist-soil areas. When constructing a moist-soil area, NRCS and local Army Corps of Engineers District should be contacted for permit information.
- Rainfall is generally adequate, but a reliable water supply for flooding is desirable.

Some Characteristics of Selected Moist-Soil Plants

	Germination			Best Seed Production Drawdown				Moisture			Wildlife Value
lant	Early	Mid	Late	Early	Mid	Late	Dry	Moist	Wet	Food	Habitat
ɔrangletop			X			X		X		X	X
rabgrass		X			X	X	X			X	X
ɜnicum grasses	X	X	X		X	X	X			X	X
ɜrnyardgrass	X		X		X	X		X		X	X
ɔikerush	X	X	X	X	X	X	X			X	
ɜakrush			X			X		X	X	X	X
ɔmmon rush			X	X				X	X		X
ɜdroot sedge			X			X			X	X	X
ɔmmon burhead		X						X	X	X	X
ɜnn. Smartweed	X		X	X				X		X	X
urltop ladysthumb	X		X	X				X		X	X
ɔck	X		X	X			X			X	
arshpurslane	X				X	X		X	X	X	
ɜggarticks		X	X		X	X	X	X		X	
vamp milkweed			X			X		X			X
orningglory		X	X		X	X	X	X		X	
ıttonbush						X			X	X	X
ack willow	X			X				X			
reen ash	X							X		X	
ɔmmon ragweed		X	X		X		X			X	
ɔcklebur		X	X		X	X		X			X
ɜezeweed		X	X		X	X	X	X			
ɜsbania		X	X		X	X		X			

ote: MS-ECS-646-01(SS) "Moist-Soil Management Specification Sheet" should be used when planning moist-soil areas.

The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at 202-720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice or TDD). USDA is an equal opportunity provider and employer.

MANAGEMENT OF SEASONALLY FLOODED IMPOUNDMENTS FOR WILDLIFE

By

Leigh H. Fredrickson and T. Scott Taylor

Waterfowl, particularly dabbling ducks, often concentrate on wetlands where natural foods are abundant. Foods that attract waterfowl are produced regularly on exposed mudflats after a controlled drawdown or when surface water disappears from natural wetlands in spring or summer. Naturally occurring seeds from plants associated with wetlands regularly survive flooding for several months or even years, whereas grains such as corn, Japanese millet, domestic rice and soybeans deteriorate rapidly when flooded continuously for 90 days or more. Viable seeds of wetland plants readily germinate in moist habitats when favorable conditions occur-usually when moisture is at or slightly below field capacity.

Work with seasonally flooded impoundments in the 1950's indicated that the production of different types of vegetation was related to the timing of water removal in spring. However, plant species composition varied considerably from year to year, even though drawdown dates were similar. Reasons included yearly changes in seed availability, plant succession and weather.

Plant response to wet, cool conditions differ from the response to dry, warm conditions. In one year impoundments may drain within in a few days, but in another year the drawdown may extend over several weeks. The resulting vegetation differs accordingly. Vegetation response is affected by the degree of soil drying that follows a drawdown.

In his early work in the Illinois River Valley, Frank Bellrose used the term "moist soil" plants to refer to species that grew on exposed mudflats. This handbook has resulted from our efforts as well as those of Bellrose and others who developed an understanding of the plant communities associated with mudflats or similar habitats. Although the title of this handbook reflects our research on seasonally flooded impoundments, "moist soil" is used in the text because the term is widely recognized by wetland managers throughout the Midwest and is less cumbersome than, for example, "man-made seasonally flooded impoundments."

Our goal is to discuss techniques that can be used by managers to develop and maintain wildlife food production in both man-made and natural wetlands. We encourage the use of management schemes based on the migration or breeding phenology of wildlife species and their food requirements to maximize use of habitat and available funds.

Advantages and Disadvantages of Moist Soil Management

Many species of plants satisfy nutritional requirements and provide suitable habitats for waterfowl and other wildlife throughout the year. Until recently, the seeds of only a few moist soil plants were recognized as valuable food sources for wildlife, but evidence now suggest that many plants provide essential nutrients and energy. Before 1970, waterfowl food studies relied heavily on bird gizzard samples obtained from hunters in the fall. Such studies, though valuable in determining foods eaten, often overlooked the importance of different plants in the diet. Local availability of plants may have been an important factor in these earlier studies. That is, many of the important wild plant species may not have been abundant or even present at the locations where waterfowl were collected for food analyses.

Esophageal samples obtained form ducks that fed on moist soil impoundments in Missouri have shown that soft seeds such as those of crabgrass, panic grass and beggarticks are eaten readily when available. Often these naturally occurring seeds, which are not generally recognized as important foods for ducks by the public, have higher overall nutritive qualities than many of the cereal grains.

At mid and southern latitudes, row-cropping is an integral part of wildlife and waterfowl management. Row crops are particularly important in providing high-energy foods for large concentrations of waterfowl during winter, but the grains are suitable only for a select group of the larger species- primarily geese, mallards and a few others. Row crops fail to provide adequate shelter for many species of waterfowl and other wildlife. In addition, grains alone do not satisfy nutritive requirements because many essentials amino acids are lacking.

When weather is favorable and management is intensive, more food per unit area is consistently provided by row crops than by naturally occurring vegetation. Where sharecroppers on public lands produce row crops, typically much of the grain is removed as the tenant's share. In many situations, the grains left for wildlife by sharecroppers are available to only a few species because habitat requirements for many species are lacking. Even though the potential agricultural production is great, adverse weather conditions that result in floods or droughts often reduce production. Adverse weather has a lesser effect on production of naturally occurring plants because a diverse natural flora includes species that produce well under a variety of conditions. Different species or groups of plants are adapted to different conditions and site characteristics, such as specific water depths or degree of soil saturation. For example, water-tolerant or wetland-adapted plants such as smartweeds, barnyardgrasses, and spikerushes are productive during wet years; beggarticks are productive on drier sites; and crabgrasses and panic grasses do well under more intermediate moisture conditions. Because naturally occurring plants often are productive despite weather conditions that restrict production of row crops, crop failures are less likely to occur in moist soil management.

The total energy in moist soil foods often is as high as or higher than that in corn, milo or soybeans (Table 1). Total energy values in the table do not reflect the difference in metabolizable energy precisely because the caloric value of indigestible crude fiber is unavailable to most birds. Unfortunately, little information is available on the true metabolizable energy in naturally occurring foods. However, many naturally occurring foods are known to contain essential nutrients that are not present in domestic grains.

Table 1. Gross energy, fat, fiber, ash and protein content of plant seeds commonly encountered in moist soil impoundments.

	Component				
Species	Energy calories/kg	Crude Fat (%)	Crude Fiber (%)	Ash (%)	Protein (%)
Crabgrass	3,717	3.1	10	20.8	9.94
Barnyard grass	3,635	2.5	22.7	13.9	7.56
Rice cutgrass	3,738	2	10.7	10.2	11
Milo	4,400	3.1	2.2	2.7	11.94
Rice	3,560	1.7	0.6	1.1	7.5
Sedge		5.4	20.2	7.9	9.63
Smartweed	4,514				
Curly Dock	4,024	1.2	20.4	6.9	10.38
Devils Beggarticks	5,177	18	20.8	5.6	23.5

In addition to plant foods, diverse populations of invertebrates, reptiles and amphibians regularly occur in moist soil impoundments. These animals are desirable components of wildlife areas and serve as important prey species for waterfowl, raptors, herons and other wildlife. In contrast, aquatic invertebrates and cold-blooded vertebrates are virtually nonexistent in agricultural areas. The presence of aquatic invertebrates may partly explain why diverse populations of waterfowl are more attracted to moist soil impoundments than to flooded row crops.

Managers of public lands can no longer consider management for one or two waterfowl species as adequate. Public interest and pressure are gradually shifting toward enhancement of more natural habitats and multi-species management. Habitat quality and vegetative diversity largely determine the number of wildlife species that can occupy an area. Well-managed row crops often attract some species in great numbers, but relatively few different species are attracted to these monocultures. In contrast, moist soil sites provide diverse habitats that continuously support a multitude of wildlife species, including waterfowl. In some moist soil units, over 80% more species are accommodated than on adjacent row crops. Herons, rails, prairie and marsh passerines and upland game birds and mammals that are rare or lacking on agricultural fields concentrate on moist soil sites.

Management of Seasonally Flooded Impoundments

Good management decisions require regular inspections of management units to monitor subtle changes in habitat conditions that influence the potential for attracting wildlife. When impoundments are flooded, they should be inspected weekly to ensure that correct water levels are maintained. They should be checked more often during and after a drawdown to monitor germination and plant growth. (Our use of "drawdown" refers to total de-watering, whether rapid or incremental, to promote growth of plants adapted to germinate in saturated soils, and not to a reduction of water levels like that often used to stimulate true aquatics in more permanently flooded marshes and lakes.) Depending on weather and other factors, soils may or may not be completely dry after a drawdown. Regular inspections allow a manager to stimulate growth of food-producing plants or to control problem species by prompt irrigation and shallow re-flooding.

Ideally, several moist soil impoundments should be available on each management area. Each impoundment can then be managed individually for different types of wildlife. A master plan involving a group of impoundments can provide a maximum diversity of wildlife continuously by rotating management options among the different units.

In the following sections we describe management options for maximizing vegetative growth and attracting different kinds of wildlife. For convenience, we discuss plants first and then describe how to attract wildlife to these sites.

Vegetation Management

Plants regularly encountered on moist soil areas are categorized by their desirability as food and habitat. Plants that provide habitat, energy, or nutritive requirements for wildlife are considered desirable, and plants that interfere with such production are classed as undesirable. Undesirable species are usually those that tend to become dominant in later successional stages after repeated annual drainage of impoundments. Species such as cattails, trees, shrubs and vines create management problems on some sites when flooding

is regular. Even though plants have been placed in these categories, we emphasize that some plants classed as undesirable for seed production might provide excellent cover.

An important factor that determines the species composition of moist soil plants that pioneer on exposed mudflats is the composition of seeds in the soil at a site. Most soils contain ample seeds to produce dense stands of desirable moist soil plants native to a locality. This is true whether the site was previously in row crops or in moist soil management. The actual species composition of the seeds available in the soil is related to the previous plant composition and seed production. That is, if environmental conditions are similar, an impoundment with a good stand of desirable species in a given year will probably produce seeds that result in a similar vegetative composition the next year. However, the same probability applies to undesirable species; consequently, management to control their germination, growth, and seed production is essential.

Herbicides have a residual effect on some desirable moist soil plants. The extent of the detrimental effects depends on the chemical, the application rate, and time elapsed since the chemical was last used. Managers should not expect maximum production on such sites until the herbicides have decomposed or been flushed from the soil.

Two important factors that determine plant responses to moist soil manipulations are (1) the timing of annual drawdowns and (2) the stage of succession (number of years since the area was disturbed by disking or plowing or the number of years since the impoundment was flooded continuously). For example, early drawdowns tend to stimulate germination of smartweeds on early successional sites. However, smartweeds are less likely to respond to early drawdowns by the third year after a soil disturbance such as disking or continuous flooding. Mid-season drawdowns result in millets, and late-season drawdowns result in sprangletop, beggarticks, panic grass and crabgrass.

Once areas have been under moist soil management for 4 or more years, there is a gradual increase in perennial species, including some excellent seed producers. Perennials like rice cutgrass and marsh smartweed not only produce seeds, but (like most other fine- or multi-leafed plants) also provide excellent habitats for invertebrates. These invertebrates are consumed directly by waterfowl, rails, herons, and other birds and indirectly by raptors, herons, mammals, etc., that eats such other direct consumers as fish, reptiles or amphibians. Invertebrate populations are important to many wildlife species, either directly or indirectly, throughout the year.

Two general types of drawdowns that we describe as slow or fast usually produce different results. In slow drawdowns, impoundments are gradually drained during a period of two weeks or more. Fast drawdowns occur within a few days and produce similar conditions over the entire impoundment simultaneously.

Early in the season a slow drawdown usually produces a more diverse vegetative cover than a fast drawdown; fast drawdowns normally produce excellent and extensive stands of similar vegetation, but the rapid de-watering forces wetland wildlife from the area almost immediately. Slow drawdowns may produce vegetation of greater density and diversity than fast drawdowns late in the season when soils dry quickly because soils near the receding water remain saturated long enough for germination to occur. Fast drawdowns late in the season may produce less desirable vegetation than those early in the season. This is especially true when temperatures exceed about 32 degrees C and where rainfall is required for flooding because little germination occurs when saturated soils become dry within a few days. Regardless of whether a drawdown is slow or fast, total seed production usually is higher on impoundments after early drawdowns, but late drawdowns result in higher stem densities and greater species diversity.

Encouraging Desirable Vegetation

Many annual grasses and sedges consistently have the highest seed production during early successional stages. Many herbaceous plants, and especially cockleburs, are also high-volume seed producers, but they

should be controlled. Each species must be regarded on its own merits. At the Mingo Refuge, some areas with undesirable forms such as cockleburs had unusually heavy use by filter-feeding ducks such as shovelers. Experimental evidence is lacking, but possibly the leaf litter from herbaceous plants provides an ideal substrate for invertebrates. Some herbs e.g., beggarticks have a high nutritive quality and are considered desirable seed producers.

After germination and early growth, plants should attain a height of 4-6 inches before impoundments are re-flooded. Barnyardgrass, sedges, and smartweeds respond well to shallow flooding (1-2 inches), but panic grasses, crabgrasses and beggarticks are less tolerant. Identification of seedlings is essential if desirable species are to be encouraged or undesirable plants controlled. Water depths should be 1-2 inches over as much of the area as possible so that the newly established plants will not be completely submerged for extended periods. Complete submergence for longer than 2-3 days can retard the growth of millets, other grasses, and smartweeds. Water levels must be lowered if the majority of the desirable plants that are submerged do not reach the surface within the 2 to 3 day limit. With experience a manager can estimate the water tolerance of plants on an area and manipulate the water level accordingly.

Water levels can be increased gradually to a maximum of 6-8 inches as the desired plants grow, but water levels should generally equal only about one-third of the total height of newly established moist soil plants. If the plants develop a light-green cast, the water is probably too deep and should be lowered immediately.

Controlling Undesirable Vegetation-
Herbaceous Growth

Using some of the same techniques that are used to encourage desirable vegetation can control undesirable vegetation. Timing of re-flooding is particularly important if undesirable herbaceous plants such as cockleburs or asters germinate before desirable species. Re-flooding to shallow depths should then begin as soon as desirable species are established and begin to grow. Initially, water levels should be kept low (1 inch or less) so that growth of the desired vegetation is not inhibited by flooding.

Cockleburs are controlled easily by shallow flooding. When the root systems and bases are submerged, cockleburs either die or are stunted and produce few seeds. As the desirable species grow in response to the flooding, water levels can be increased so those higher contours are inundated before cockleburs become dominant and shade out the desirable plants. Some perennials can also be controlled by well-designed flooding schedules. Broomsedge bluestem is readily controlled by shallow flooding (4 inches) until midsummer and joe-pye-weed can be eliminated by flooding in late summer and early fall, when the plants are in bloom. If extensive stands of cockleburs, asters and other undesirable plants develop within an impoundment where few desirable plants are established, we suggest that the area be disked and then re-flooded to set back succession to an earlier and more productive stage of seed production.

The extended period required to flood an area without damaging desirable plants, or to control undesirable species, emphasize the importance of frequent inspections. Only by inspecting units regularly can a manager make the timely decisions necessary for effective control and enhancement of seed production. Contour intervals of 6-8 inches are optimal for immediate control of undesirable plants because large areas can be flooded to shallow depths with little water.

In areas where late spring rains are common, a little patience may save the cost the cost pumping water. Rainfall may flood the areas naturally, but total dependence on rain to re-flood the areas naturally, but total dependence on rain to re-flood moist soil areas is a risky substitute for pumping water. In situations where impoundments cannot be flooded by pumping, managers can replace stop logs after plant germination and early growth to hold runoff water within the impoundment until midsummer grasses become dominant and cockleburs are stunted. The shade of dense stands of desirable species restricts late-germinating

cockleburs. Because flooding stimulates the growth of many woody species adapted to wetlands, we caution southern managers to examine each unit closely for seedlings before they begin summer flooding.

If the accumulation of plant litter in an impoundment becomes excessive, germination and growth of desirable plants may be reduced because of shading. This litter can be burned and the soil exposed a practice used extensively in the southern coastal regions to set back succession. When possible, a burn should be conducted in early spring, after the vegetation dries and before new germination occurs.

Mowing, mechanical chopping, and shredding or crushing followed by burning or flooding or both, have been used to eliminate various types of low value vegetation. Grazing has also been used in special situations with moderate success.

Controlling Undesirable Vegetation-
Woody Growth

The control of undesirable woody vegetation is difficult and techniques vary considerably with latitude. At northern latitudes, shallow flooding can control woody growth. In southeastern Missouri, impoundments must be dried and disked to remove unwanted woody species because shallow flooding merely stimulates growth of wetland adapted forms and worsens the problem. Additional diskings may be required to completely destroy heavy herbaceous and woody growths of willows, ashes, and cottonwoods.

Impoundments on areas where moist soil management has been initiated within the last 5 to 7 years should be disked once every 3 years to control woody growth and to stimulate seed production of annuals. Once an area has been managed for moist soil plants for 5 to 7 years, there appears to be less need for soil disturbance every 3 years. Apparently the soil condition and seed availability gradually change, so that management for maintaining high seed production is easier and more effective. One obvious difference in units that have been managed for moist soil plants for several years is the increase in seed-producing perennials. Seed production from these forms usually occurs early in the season. Perennial seeds are resistant to flooding and appear to be readily available in the following spring.

Early drawdowns restrict the germination of woody species adapted to wet sites at southern latitudes; however, irrigation may then be required to stimulate germination of seed-producing plants during dry seasons.

Manipulations of Water Levels
For Wildlife

Management practices often revolve around a set calendar date, though exact timing varies with latitude, local climatic conditions, or hunting seasons. Even though adherence to the same drawdown date does not necessarily produce the same kinds and quantities of foods annually, the diversity of natural vegetation probably attracts and provides food and cover for a diversity of waterfowl and other wildlife. Because environmental variations are an inherent part of habit management, we recommend a flexible framework for manipulating moist soil sites that is based on climatic and ecological variations in life histories of plants and animals rather than on a set calendar date, and makes use of plants or wildlife as indicators for specific habitat manipulations. For example, the arrival of a shorebird species might be used as a cue that a series of habitat manipulations should be started, to provide a set of new habitat conditions for the next migrants.

Our experience suggests that waterfowl initially respond best to units with some open water, such as borrow ditches, flooded roads, or areas with short sparse vegetation. These open water areas often result from uneven topography or from discontinuous plant distribution. After several days of use, ducks drop directly into or swim into rank or dense vegetation.

Fall Flooding and Winter Impoundment

Although waterfowl may be the primary species on impoundments during fall and winter, management for dabbling ducks also provides conditions attractive to many wildlife species. The deeper water used by most diving ducks excludes most non-waterfowl species and requires substantial, costly levees.

The fall flooding of moist soil areas can be timed on the basis of the arrival of waterfowl. Blue-winged teals and pintails usually arrive first. If no impoundments are flooded, or if the impoundments already flooded for summer wetland wildlife are deemed too small to provide feeding areas for the expected teal and pintail populations, other impoundments should be flooded to provide feeding areas for the expected teal and pintail populations, other impoundments should be flooded to provide the maximum amount of area with water 4-10 inches deep. These water depths are ideal for most dabbling ducks as well as for Canada geese. As waterfowl number increase, more impoundments can be flooded.

An irregular topography within an impoundment results in ideal water depths for a variety of species. On Mingo NWR, some sites are not flooded whereas others may be flooded to depths of 12-20 inches. This irregularity is important because these diverse depths create different conditions that are compatible with the preferred feeding modes of many bird species.

American coots often dive for food and are most abundant where water is about 12 inches deep. Deeper areas also attract muskrats. Northern shovelers use a variety of water depths, but usually strain invertebrate foods from near the surface in water that can be deeper than that used by most dabbling ducks. Both mallards and pintails feed extensively on the bottom, but mallards generally dabble from the surface in shallow water 4-6 inches deep, whereas pintails tip-up in deeper water. Teals prefer intermediate depths of 5-8 inches. Blue-winged teals frequent areas with submerged vegetation.

American bitterns and other wading birds often use depths of 3-5 inches, preferably where emergent vegetation is present. Dense emergent vegetation is apparently attractive to rails, common snipes, and passerines such as swamp, white-crowned, white-throated and song sparrows. Rails prefer water depths of 2-4 inches but snipes use areas that are flooded to depths of only 1-2inches. White-tailed deer, turkeys and ring-necked pheasants heavily use areas of abundant, dense, rank cover when sites are dry. Passerines often use sites whether or not they are flooded.

Raptors are attracted to the abundant prey present on moist soil impoundments. Golden and bald eagles are attracted by waterfowl, marsh hawks by frogs and small ducks, and red-tailed and red-shouldered hawks by ducks and small mammals. Short-eared owls are regularly seen on some areas.

Manipulations to Attract Wildlife in Spring

The major management options for the desired group of birds in the spring involve manipulations to provide their preferred water depths when they arrive. Shorebirds require mudflats or shallow water of 2 inches or less. Wading birds are attracted to water 3-5 inches deep, whereas migratory and breeding waterfowl prefer water 4-10 inches deep.

Early Spring Drawdown

Early spring drawdowns should be timed to shorebird migration. For example, in southeastern Missouri, lesser yellowlegs and pectoral sandpipers arrive from early to mid April. The timing of the drawdown at

other locations will vary with latitude and with the phenology of species that migrate through or nest on an area. After an early spring drawdown, most areas within an impoundment are nearly devoid of old vegetation. This situation is ideal for shorebirds because they respond well to shallow water zones that are interspersed with mudflats. The most attractive water depths are between 1 and 2 inches. However, on some sites within each impoundments, especially on sites that are flooded to shallow depths, new growth of spikerushes and old clumps of soft rushes, bulrushes, and stems and blades of grasses and sedges provide concealment for rails and late-wintering passerines. Like waterfowl, shorebirds appear to have preferred feeding depth; the larger, longer-legged birds. Because most of the emergent vegetation has often been flattened by wind and wave action or waterfowl activity, or eaten by waterfowl, shorebirds often find an ideal habitat when they arrive.

Table 2. Response of common moist soil plants to drawdown date.

	Drawdown Date		
Plant	Early	Midseason	Late
Swamp timothy	+	+++	+
Rice cutgrass	+++	+	
Sprangletop		+	+++
Crabgrass		+++	+++
Panic grass		+++	++
Wild millet (crusgalli)	+++	+	+
Wild millet (walteri)	+	+++	++
Wild millet (muricata)	+	+++	+
Red-rooted sedge		+++	
Chufa	+++	+	
Spikerush	+++	+	+
Penn. Smartweed	+++		
Curltop ladysthumb	+++		
Dock		+++	+
Sesbania	+	++	
Cockleburr	++	+++	++
Beggarticks	+	+++	+++
Aster	+++	++	+
Toothcup	+	++	++
Morning Glory	++	++	

Early drawdown completed within first 45 days of the growing season.
Midseason drawdown completed after first 45 days of growing season and before July 10th.
Late season drawdown completed after July 10th.
+ = fair response; ++ = moderate response; +++ = excellent response.

Gradually fluctuating water levels provide maximum potential for maintaining shorebirds use. For example, a slow drawdown concentrates shorebirds in the zone of shallow water near mudflats. Changing water levels daily or continuously can provide the largest effective area of this zone. As water levels drop and habitat conditions deteriorate, water levels in other impoundments can be gradually lowered to maintain shorebird concentrations for longer periods. Observation towers positioned near the lowest point of the impoundments-so they face up the slope or gradient-will provide excellent viewing for the entire period of the drawdown.

When the topography of a moist soil impoundment varies, sites that were flooded shallowly during winter still provide enough emergent cover for rails. The deeper waters of impoundments-especially those in which the drawdowns were late –contain submerged, decaying, and regenerating vegetation with scattered

emergents that are ideal for wading birds, rails, and late-migration or resident waterfowl. Invertebrates, amphibians, and fish are usually concentrated in or near submerged vegetation such as marshpurslane, water-starwort, or regenerating swamp smartweed. Grasses, rushes, sedges, arrowheads and water plantains provide emergent cover. These flooded sites with diverse vegetative cover are ideal for insect production. Swallows, chimney swifts, and eastern kingbirds feed over these areas and rest on the emergent vegetation. Exposed mudflats are used by foraging passerines such as American goldfinches.

Spring drawdowns that expose mudflats make impoundments unavailable for nesting coots or ducks and these impoundments are not available as brood habitat later in the season. However, spring drawdowns make lower vertebrates and invertebrates, especially crustaceans, available to variety of wildlife, including blackbirds, crows, raptors, egrets, herons, and raccoons. Mudflats exposed by spring drawdowns are excellent feeding sites for young killdeers and spotted sandpipers as well.

Late Spring Drawdown

A late or delayed spring drawdown is most effective if it is divided into two phases. Initially water levels should be lowered to 2-6 inches and maintained at this level until plant germination and growth occur on the mudflats in impoundments managed for shorebirds. Once germination begins, the drawdown can continue until completed.

The initial phase of a late-spring drawdown should be timed with the arrival of herons or other bird groups such as rails or swallows to derive maximum wildlife benefits from all moist soil sites. In our study area in southeastern Missouri, we begin our drawdown with the arrival of little blue and yellow-crowned night herons. Herons prefer open water with an abundance of submerged and floating vegetation but only sparse emergent vegetation. Rails prefer emergent vegetation and use both shallow and deep water. Some late spring migrating and resident waterfowl feed on insects and other invertebrates. Swallows are attracted to the areas to feed on emerging insects.

Coordinated Timing of Early and Late Drawdowns

Both early and late spring drawdowns are needed in an optimal moist soil management plan. The most effective management requires that sites intended to attract herons or rails be kept flooded until impoundments that were drawn down early are revegetated and the new vegetation can tolerate re-flooding. The impoundments managed for herons can then be drained without permanently displacing wetland wildlife. Herons are attracted to the newly revegetated and re-flooded impoundments.

Because environmental conditions vary from year to year, manipulations should be coordinated with the arrival and departure of wildlife species or with habitat conditions, not with a calendar date. We emphasize the importance of keeping good records on each moist soil situation so that continuity of management is possible as personnel changes occur.

Manipulations to Attract Summer Wildlife

In the summer, as in the spring, the major options are to attract either upland or wetland wildlife. At this point, the decision to attract certain wildlife depends on the types and growth of the vegetation present after the drawdown. Management for upland wildlife is possible only when that vegetation will meet the management goals for wetland wildlife in the upcoming fall and winter. The growth of woody species or

extensive germination of cocklebur or other noxious forms sometimes makes control of this vegetation more important than considerations for upland wildlife.

Management for Upland Wildlife

Areas intended for upland wildlife are not re-flooded until fall as long as rainfall is adequate to stimulate optimum vegetative growth. These areas typically are vegetated with plants like aster, ragweed, beggarticks, crabgrass and panic grass. During dry summers, the vegetation will require irrigation by shallow re-flooding. Adequate irrigation requires that soils become saturated at the highest sites within the impoundments. Water can be removed within 1 to 2 hours after complete soil saturation is achieved. If the area with the highest elevation is watered first, overflow water can be reused to irrigate areas at lower elevations.

Cottontails and other small mammals are able to find food and cover on sites managed for upland wildlife, but their breeding is tenuous because flooding may eliminate nests and young if irrigation is required. However, new vegetative growth on impoundments that are not flooded will attract many different passerines, the species varying with location. Common yellowthroats, indigo buntings and sedge wrens are especially abundant at mid-continent locations. Dewatered moist soil areas also provide brood and foraging habitats for game birds such as bobwhites, turkeys and pheasants. Deer use the sites as nurseries and for feeding.

Management for Wetland Wildlife

Wetland wildlife species that depend on shallow water respond well to moist soil areas. Impoundments that are selected to attract wetland wildlife should be re-flooded as soon as the desirable vegetation can tolerate flooding. Plants on sites that are flooded in summer are less likely to be barnyardgrasses, smartweeds or beggarticks and more likely to be sedges, rushes, rice cutgrass or even lotus. Once the plants are tall enough, we recommend continuous flooding to depths of 2-6 inches.

Herons, rails, resident waterfowl, and some passerines such as red-winged blackbirds and marsh wrens feed and often breed on these wetter sites. Yellowthroats, indigo buntings and dickcissels tend to breed on the drier sites. Marsh hawks and other raptors hunt for prey; turkeys, pheasants and deer typically considered more upland wander out in the impoundments to feed and obtain water. Raccoons, minks, muskrats and other furbearers also benefit from these flooded areas.

Migrant shorebirds begin returning by mid to late summer. Moist soil sites that have been disked and then flooded with surface water provide ideal habitat. At the latitude of Missouri, units are revegetated extensively if they are disked in July and plants like spikerush respond well if disking is in August. Geese concentrate on units that are disked in late summer and have some surface water; they loaf on the mudflats and graze on the newly sprouted spikerush.

Developing Integrated Management Plans

Ideally, management areas should have several impoundments that can be manipulated to promote the production of different foods or to attract different groups of wildlife. Each manipulation adjusts the attractiveness of wetland conditions for different groups of wildlife. Grebes, coots and diving ducks use fairly deep water; dabbling ducks, medium depths and shallow pools; herons, shallow water; shorebirds,

shallow water and mudflats; rails, shallow water with upright emergent cover; and upland wildlife, dry ground. Much of the response by wildlife is related to the structural components of vegetation as well as to water depth: Rails require robust emergents that remain upright, whereas most shorebirds avoid dense vegetation and center their activities on mudflats; herons concentrate where some vegetation is present but visibility is not restricted; and waterfowl are more adaptable to a variety of habits.

The attractiveness of the habitat for these different groups is adjusted by raising or lowering the water level and (when necessary) controlling undesirable vegetation in summer. For example, a series of manipulations of waterfowl habitat to make it attractive to shorebirds would include a gradual de-watering (to a depth of 2 inches) in early spring; complete de-watering, disking to get rid of undesirable vegetation and re-flooding to a depth of 2 inches in summer; and increasing the water level in late fall and winter, after shorebirds have migrated to their winter ranges. The manager has a number of options (one of which is to take no action), depending on the perceived needs, for seasonal adjustments of habitats to attract the various bird groups. Different strategies are appropriate in different years.

The four water conditions depicted in the above example (1) deep (more than 6 inches), (2) medium (6 inches), (3) shallow water mudflat and (4) dry-should be viewed as a continuum and are not necessarily desirable conditions to maintain for extended periods. We emphasize this point because wetland plants and wildlife are well adapted to the dynamic nature of water fluctuations in natural wetlands. Because the topography within the impoundment basins is usually uneven, water depths are variable and provide desirable depths for more than one group of species when the impoundments are flooded. The drawdown process provides constantly changing water conditions that (1) concentrate prey, (2) create habitat conditions that can be exploited by a variety of wildlife, and (3) provide soil and water conditions that promote the germination and growth of a wide variety of plants. For example, a gradual drawdown of deeply flooded impoundment in spring provides suitable conditions for grebes, coots, diving ducks, dabbling ducks, herons, and shorebirds as water recedes from full pool to mudflat.

Moist soil manipulations over a series of years tend to result in the predominance of annuals if disturbance has been frequent, or of perennials if disturbance has been lacking. Annuals are desirable where high seed production is the management goal. Impoundments must be disturbed regularly by practices such as disking or carefully timed flooding to promote maximum seed production. Perennials become increasingly common wherever moist soil management has been practice for several years. Some perennials are excellent seed producers and those that develop early in the season provide robust cover for spring migrants. On sites that are difficult to drain, however, the establishment or perennials with large underwater rhizomes may be undesirable because they often form dense stands and shade out food-producing species.

Our techniques for controlling undesirable vegetation require much refinement. Not all plants can be controlled effectively by disking and re-flooding. Plants such as American lotus and yellow water lily, which are found in impoundments with low areas and more or less permanent water, cannot be satisfactory controlled by disking. Not only do these species occur on sites that are difficult to drain, but when disks cut rhizomes into smaller sections, new shoots may develop from sections of rhizomes having internal energy reserves and stem-forming tissue.

The most difficult decisions in moist soil management are related to situations in which undesirable species are abundant, but the potential for food production is excellent because desirable seed-producing plants also are present in abundance. For example, the control of small woody seedlings such as willows or oaks in an impoundment with an excellent stand of a good food-producing plant like millet may be a difficult decision. Disking the impoundment would result in the immediate loss of the potential for seed production but is also the most effective control of the undesirable woody growth. Although food production would probably be reduced in the year of disking, the disturbance would enhance the production of annual seeds in the next growing season. If this situation were to occur on Mingo Refuge, our decision would be to control willow immediately but delay the control of oaks until the following season. The decision is based on our experience with plant responses in relation to soils and temperature, as well as other factors in southeastern Missouri. The experience we have gained over the years has facilitated our decision making and refined what might best be called the art of moist soil management on Mingo Refuge. Development of these refinements in management is necessary for each management area and provides opportunities for managers to optimize use of resources on areas they oversee.

13.4.6. Strategies for Water Level Manipulations in Moist-soil Systems

Leigh H. Fredrickson
Gaylord Memorial Laboratory
The School of Natural Resources
University of Missouri–Columbia
Puxico, MO 63960

Water level manipulations are one of the most effective tools in wetland management, provided fluctuations are well-timed and controlled. Manipulations are most effective on sites with (1) a dependable water supply, (2) an elevation gradient that permits complete water coverage at desired depths over a majority of the site, and (3) the proper type of water control structures that enable water to be supplied, distributed, and discharged effectively at desired rates. The size and location of structures are important, but timing, speed, and duration of drawdowns and flooding also have important effects on plant composition, plant production, and avian use. When optimum conditions are not present, effective moist-soil management is still possible, but limitations must be recognized. Such situations present special problems and require particularly astute and timely water level manipulations. For example, sometimes complete drainage is not possible, yet water is usually available for fall flooding. In such situations, management can capitalize on evapotranspiration during most growing seasons to promote the germination of valuable moist-soil plants.

Timing of Drawdowns

Drawdowns often are described in general terms such as early, midseason, or late. Obviously, calendar dates for a drawdown classed as early differ with both latitude and altitude. Thus the terms early, midseason, and late should be considered within the context of the length of the local growing season. Information on frost-free days or the average length of the growing season usually is available from agricultural extension specialists. Horticulturists often use maps depicting different zones of growing conditions (Fig. 1). Although not specifically developed for wetland management, these maps provide general guidelines for estimating an average growing season at a particular site.

In portions of the United States that have a growing season longer than 160 days, drawdowns normally are described as early, midseason, or late. In contrast, when the growing season is shorter than 140 days, drawdown dates are better described as either early or late. Early drawdowns are those that occur during the first 45 days of the growing season, whereas late drawdowns occur in the latter 90 days of the growing season. For example, the growing season extends from mid-April to late October (200 days) in southeastern Missouri. In this area, early drawdowns occur until 15 May, midseason drawdowns occur between 15 May and 1 July, and late drawdowns occur after 1 July (Table 1). The

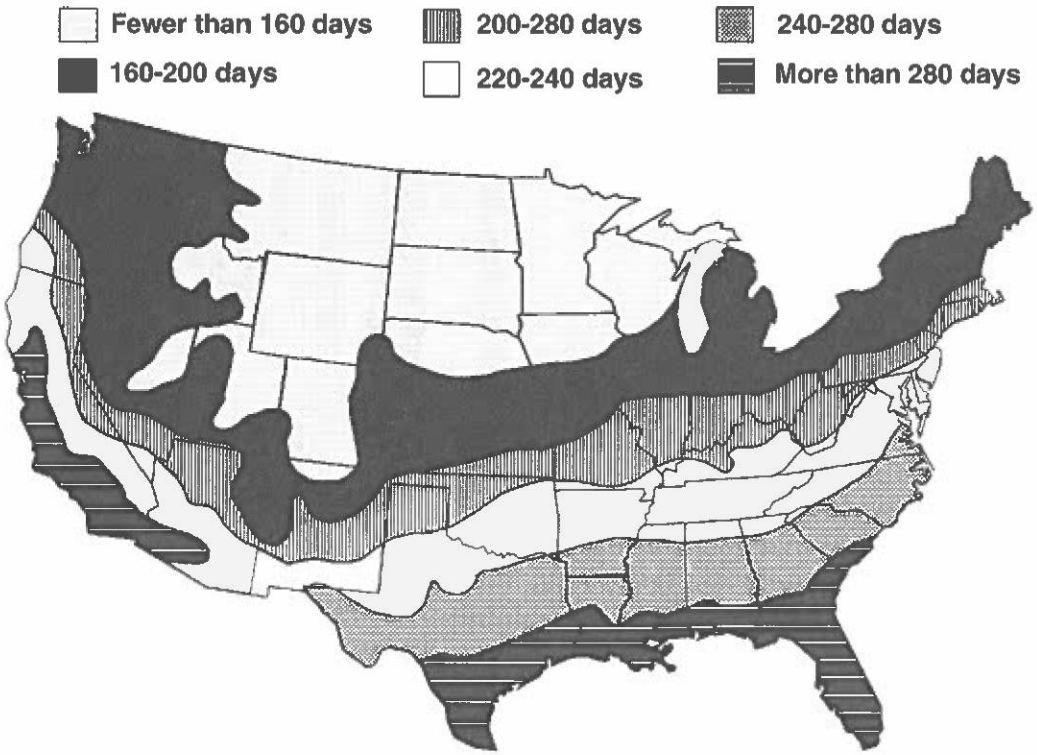


Fig. 1. Zones depicting general differences in the length of the growing season.

correct terminology for drawdown date can be determined for each area using these rules of thumb.

Moist-soil Vegetation

The timing of a drawdown has an important influence on the composition and production of moist-soil plants. Although the importance of specific factors resulting in these differences has not been well studied for moist-soil vegetation, factors such as seed banks, soil types, soil temperatures, soil moisture levels, soil–water salinities, day length, and residual herbicides undoubtedly influence the composition of developing vegetation.

Water manipulations will be effective and economical only if the site has been properly designed and developed (Table 2). Levees, type and dependability of water source (e.g., ground water, river, reservoir), type and placement of water control structures, water supply and drainage systems, and landform are among the most important elements that must be considered. Independent control and timing of water supply, distribution, depth, and discharge within and among units are essential (Table 2).

An independent water supply for each unit is required to optimize food production, maintain the potential to control problem vegetation, and make food resources available for wildlife (Table 2). Optimum management also requires that each unit have the capability of independent discharge. Stoplog water control structures that permit water level manipulations as small as 2 inches provide a level of fine tuning that facilitates control of problem vegetation or enhancement of desirable vegetation.

Table 1. *Environmental conditions associated with time of drawdown in southeastern Missouri.*

	Date	Temperature	Rainfall	Evapotranspiration
Early	1 April- 15 May	Moderate	High	Low
Mid	15 May- 1 July	Moderate - High	Moderate	Moderate
Late	1 July or later	High	Low	High

Table 2. *Important considerations in evaluating wetland management potential.*

Factors	Optimum condition
Water supply	Independent supply into each unit Water supply enters at highest elevation
Water discharge	Independent discharge from each unit Discharge at lowest elevation for complete drainage Floor of control structure set at correct elevation for complete drainage
Water control	Stoplog structure allowing 2-inch changes in water levels Adequate capacity to handle storm events
Optimum unit size	5 to 100 acres
Optimum number of units	At least 5 within a 10-mile radius of units

Wetland systems with high salinities can easily accumulate soil salts that affect plant vigor and species composition. Wetland unit configurations that allow flushing of salts by flowing sheet water across the gradient of a unit are essential in such areas. A fully functional discharge system is a necessity in arid environments to move water with high levels of dissolved salts away from intensively managed basins. Thus, successful management in arid environments requires units with an independent water supply and independent discharge as well as precise water-level control.

Scheduling Drawdowns

During most years, early and midseason drawdowns result in the greatest quantity of seeds produced (Table 3). However, there are exceptions, and in some cases, late drawdowns are very successful in stimulating seed production.

Table 3. *Response of common moist-soil plants to drawdown date.*

Family	Species: Common name	Species: Scientific name	Drawdown date: Early[a]	Drawdown date: Midseason[b]	Drawdown date: Late[c]
Grass	Swamp timothy	*Heleochloa schoenoides*	+[d]	+++	+
	Rice cutgrass	*Leersia oryzoides*	+++	+	
	Sprangletop	*Leptochloa* sp.		+	+++
	Crabgrass	*Digitaria* sp.		+++	+++
	Panic grass	*Panicum* sp.		+++	++
	Wild millet	*Echinochloa crusgalli* var. *frumentacea*	+++	+	+
	Wild millet	*Echinochloa walteri*	+	+++	++
	Wild millet	*Echinochloa muricata*	+	+++	+
Sedge	Red-rooted sedge	*Cyperus erythrorhizos*		++	
	Chufa	*Cyperus esculentus*	+++	+	
	Spikerush	*Eleocharis* spp.	+++	+	+
Buckwheat	Pennsylvania smartweed	*Polygonum pensylvanicum*	+++		
	Curltop ladysthumb	*Polygonum lapathifolium*	+++		
	Dock	*Rumex* spp.		+++	+
Pea	Sweetclover	*Melilotus* sp.	+++		
	Sesbania	*Sesbania exalta*	+	++	
Composite	Cocklebur	*Xanthium strumarium*	++	+++	++
	Beggarticks	*Bidens* spp.	+	+++	+++
	Aster	*Aster* spp.	+++	++	+
Loosestrife	Purple loosestrife	*Lythrum salicaria*	++	++	+
	Toothcup	*Ammania coccinea*	+	++	++
Morning glory	Morning glory	*Ipomoea* spp.	++	++	
Goosefoot	Fat hen	*Atriplex* spp.	+++	++	

[a] Drawdown completed within the first 45 days of the growing season.
[b] Drawdown after first 45 days of growing season and before 1 July.
[c] Drawdown after 1 July.
[d] + = fair response; ++ = moderate response; +++ = excellent response.

In areas characterized by summer droughts, early drawdowns often result in good germination and newly established plants have time to establish adequate root systems before dry summer weather predominates. As a result, early drawdowns minimize plant mortality during the dry period. Growth is often slowed or halted during summer, but when typical late growing-season rains occur, plants often respond with renewed growth and good seed production. In contrast, midseason drawdowns conducted under similar environmental conditions often result in good germination, but poor root establishment. The ultimate result is high plant mortality or permanent stunting. If the capability for irrigation exists, the potential for good seed production following midseason or late drawdowns is enhanced.

Germination of each species or group of species is dependent on certain environmental conditions including soil temperature and moisture. These conditions change constantly and determine the timing and density of germination (Table 3). Smartweeds tend to respond best to early drawdowns, whereas sprangletop response is best following late drawdowns. Some species are capable of germination under a rather wide range of environmental conditions; thus, control of their establishment can be difficult. Classification of an entire genera into a certain germination response category often is misleading and inappropriate. For example, variation exists among members of the millet group (*Echinochloa* spp.). *Echinochloa frumentacea* germinates early, whereas *E. muricata* germinates late because of differences in soil temperature requirements. Such variation among members of the same genus indicates the need to identify plants to the species level.

Natural systems have flooding regimes that differ among seasons and years. Repetitive manipulations scheduled for specific calendar dates year after year often are associated with declining productivity. Management assuring good production over many years requires variability in drawdown and flooding dates among years. See *Fish and Wildlife Leaflet* 13.2.1 for an example of how drawdown dates might be varied among years.

Wildlife Use

Drawdowns serve as an important tool to attract a diversity of foraging birds to sites with abundant food resources. Drawdowns increase food availability by concentrating foods in smaller areas and at water depths within the foraging range of target wildlife. A general pattern commonly associated with drawdowns is an initial use by species adapted to exploiting resources in deeper water. As dewatering continues, these "deep water" species are gradually replaced by those that are adapted to exploit foods in

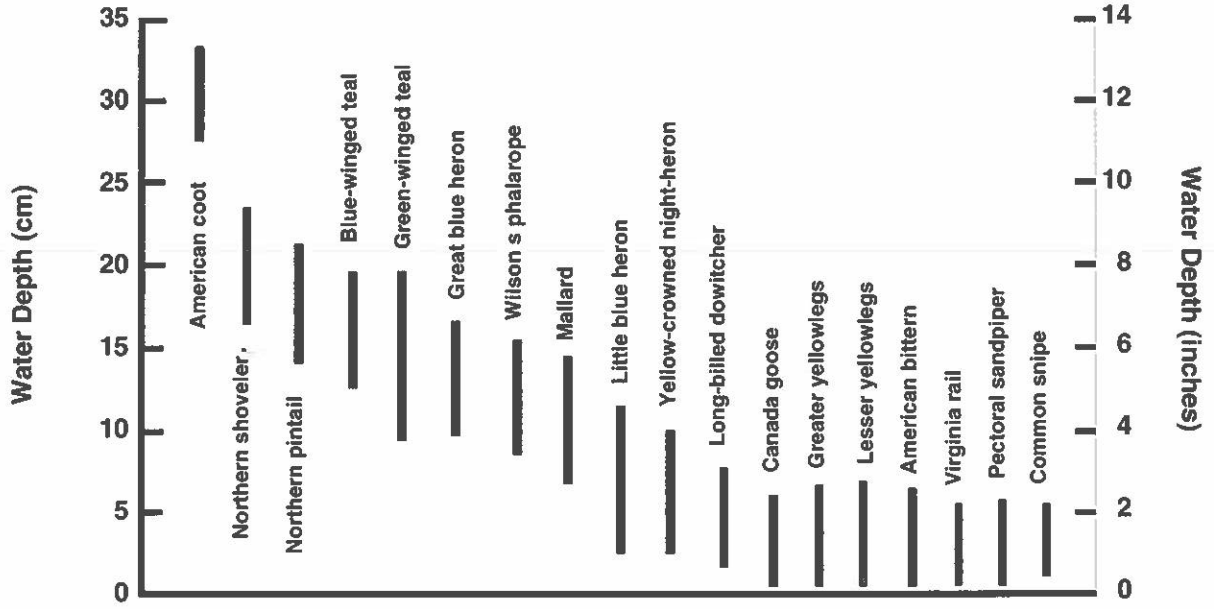


Fig. 2. Preferred water depths for wetland birds commonly associated with moist-soil habitats.

shallower water (Fig. 2). The most effective use of invertebrate foods by wetland birds occurs when drawdowns to promote plant growth are scheduled to match key periods of migratory movement in spring. By varying drawdown dates among units, the productivity of each unit can be maintained and resources can be provided for longer periods. Slow drawdowns also prolong use by a greater number and diversity of wetland wildlife.

Effects of Drawdown Rate

Moist-soil Plant Production

Fast Drawdowns

Sometimes fast drawdowns (1-3 days) are warranted, especially in systems with brackish or saline waters where the slow removal of water may increase the level of soil salts. However, in most locations fast drawdowns should only be scheduled early in the season or when flood irrigation is possible. Rapid drawdowns that coincide with conditions of high temperature and little rainfall during the growing season create soil moisture conditions that often result in poor moist-soil responses (Table 4). Some germination may occur, but generally development of root systems is inadequate to assure that these newly established plants survive during summer drought. Thus, at latitudes south of St. Louis, fast drawdowns are never recommended after 15 June if irrigation is not possible.

Slow Drawdowns

Slow drawdowns (2-3 weeks) usually are more desirable for plant establishment and wildlife use. The prolonged period of soil saturation associated with slow drawdowns creates conditions favorable for moist-soil plant germination and establishment (Table 4). For example, slow drawdowns late in the growing season can result in seed yields of 700 pounds per acre. Rapid drawdowns on adjacent units subject to identical weather conditions have resulted in 50 pounds per acre. Furthermore, slow drawdowns provide shallow water over a longer period, ensuring optimum foraging conditions for wildlife. If salinities tend to be high, slow drawdowns should only be scheduled during winter or early in the season when ambient temperatures and evapotranspiration are low.

Table 4. *Comparison of plant, invertebrate, bird, and abiotic responses to rate and date of drawdown among wet and dry years.*

	Drawdown rate	
	Fast[a]	Slow[b]
Plants		
Germination		
Period of ideal conditions	short	long
Root development		
Wet year	good	excellent
Dry year	poor	excellent
Seed production		
Early season	good	excellent
Midñlate season	not recommended	excellent
Wet year	good	good
Drought year	poor	good
Cocklebur production	great potential	reduced potential
Invertebrates		
Availability		
Early season	good	excellent
Mid-late season	poor	good
Period of availability	short	long
Bird use		
Early season	good	excellent
Mid-late season	poor	good
Nutrient export	high	low
Reducing soil salinities	good	poor

[a] Less than 4 days.
[b] Greater than 2 weeks.

Invertebrate Availability in Relation to Drawdowns

When water is discharged slowly from a unit, invertebrates are trapped and become readily available to foraging birds along the soil-water interface or in shallow water zones (Table 4). These invertebrates provide the critical protein-rich food resources required by pre-breeding and breeding female ducks, newly hatched waterfowl, molting ducks, and shorebirds. Shallow water for foraging is required by the vast majority of species; e.g., only 5 of 54 species that commonly use moist-soil impoundments in Missouri can forage effectively in water greater than 10 inches. Slow drawdowns lengthen the period for optimum foraging and put a large portion of the invertebrates within the foraging ranges of many species. See *Fish and Wildlife Leaflet* 13.3.3 for a description of common invertebrates in wetlands.

Spring Habitat Use by Birds

Slow drawdowns are always recommended to enhance the duration and diversity of bird use (Table 4). Creating a situation in which the optimum foraging depths are available for the longest period provides for the efficient use of food resources, particularly invertebrate resources supplying proteinaceous foods. Partial drawdowns well in advance of the growing season (late winter) tend to benefit early migrating waterfowl, especially mallards and pintails. Early-spring to mid-spring drawdowns provide resources for late migrants such as shovelers, teals, rails, and bitterns. Mid- and late-season drawdowns provide food for breeding waders and waterfowl broods. These later drawdowns should be timed to coincide with the peak hatch of water birds and should continue during the early growth of nestlings or early brood development.

Fall Flooding Strategies

Scheduling fall flooding should coincide with the arrival times and population size of fall migrants (Table 5). Sites with a severe disease history should not be flooded until temperatures

Table 5. *Water level scenario for target species on three moist-soil impoundments and associated waterbird response.*

	Unit A		Unit B		Unit C	
	Water level		Water level		Water level	
Period	Scenario	Response	Scenario	Response	Scenario	Response
Early fall	Dry	None	Dry	None	Gradual flooding starting 15 days before the peak of early fall migrants; water depth never over 4 inches	Good use immediately; high use by teal, pintails, and rails within 2 weeks
Mid fall	Dry	None	Flood in weekly 1-2-inch increments over a 4-week period	Excellent use by pintails, gadwalls, and wigeons	Continued flooding through September	Excellent use by rails and waterfowl
Late fall	Flood in weekly 2-4-inch increments over a 4-6-week period	Excellent use immediately by mallards and Canada geese	Continued flooding, but not to full functional capacity	Excellent use by mallards and Canada geese	Continued flooding to full functional capacity	Good use by mallards and Canada geese
Winter	Maintain flooding below full functional capacity	Good use by mallards and Canada geese when water is ice free	Maintain flooding below full functional capacity	Good use by mallards and Canada geese when water is ice free	Continued flooding to full pool	Good use by mallards and Canada geese when water is ice free
Late winter	Schedule slow drawdown to match northward movement of migrant waterfowl	Excellent use by mallards, pintails, wigeons, and Canada geese	Schedule slow drawdown to match northward movement of early migrating waterfowl	Excellent use by mallards, pintails, wigeons, and Canada geese	Schedule slow drawdown to match northward movement of waterfowl	Good use by mallards and Canada geese when water is ice free
Early spring	Continued slow drawdown to be completed by 1 May	Excellent use by teals, shovelers, shorebirds, and herons	Drawdown completed by 15 April	Excellent shorebird use	Drawdown completed by 15 April	Excellent shorebird use

moderate. When flooding is possible from sources other than rainfall, fall flooding should commence with shallow inundation on impoundments suited for blue-winged teals and pintails. Impoundments with mature but smaller seeds, such as panic grass and crabgrasses, that can be flooded inexpensively are ideal for these early migrating species. Flooding always should be gradual and should maximize the area with water depths no greater than 4 inches (Fig. 3). As fall progresses, additional units should be flooded to accommodate increasing waterfowl populations or other bird groups such as rails. A reasonable rule of thumb is to have 85% of the surface area of a management complex flooded to an optimum foraging depth at the peak of fall waterfowl migration.

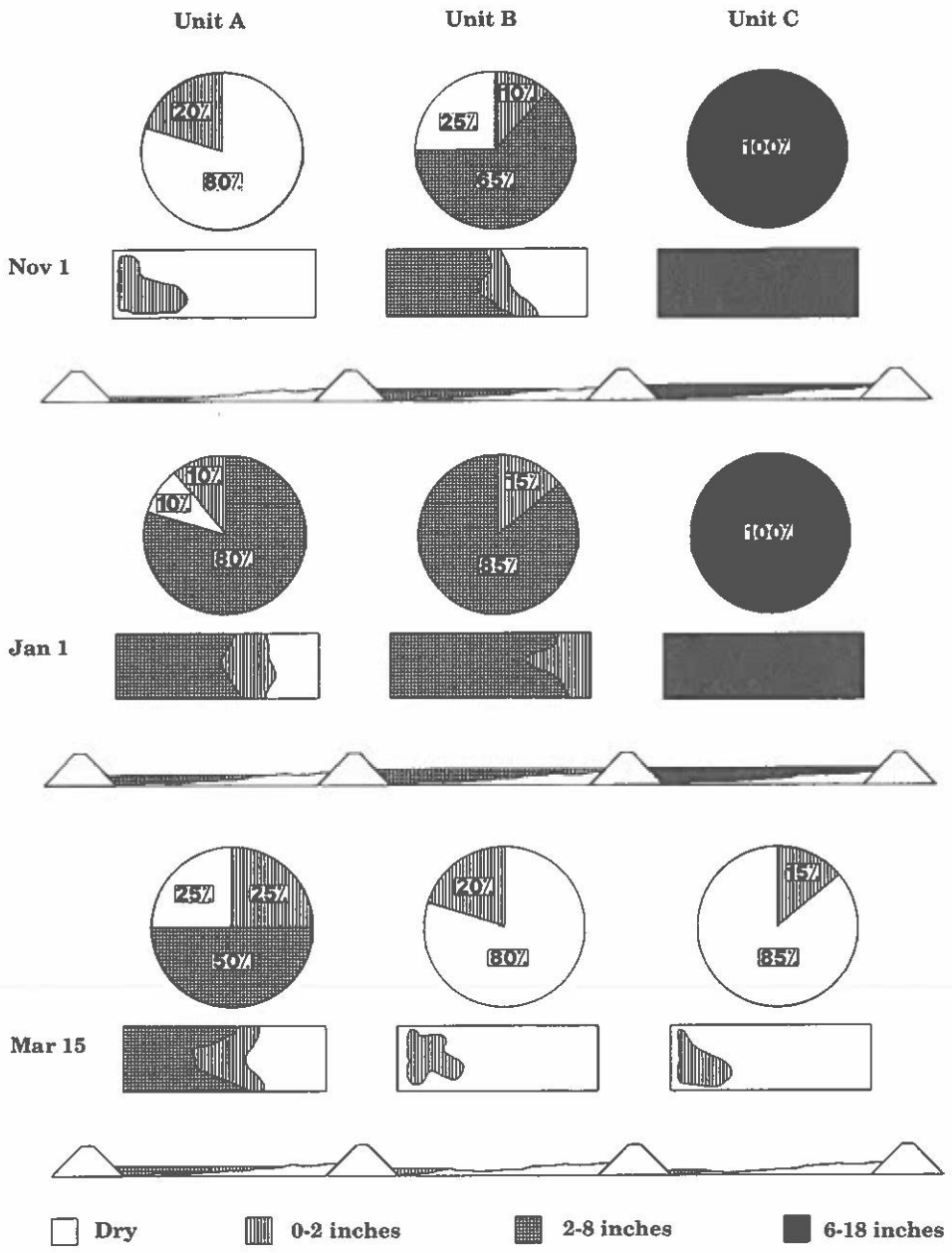


Fig. 3. Planned flooding strategies for three moist-soil units during one winter season. The initiation, depth, and duration of flooding are different for each unit. Note that two of the three units were never intentionally flooded to capacity. This does not mean that natural events would not flood the unit to capacity. Flooding strategies should be varied among years to enhance productivity.

Suggested Reading

Eldridge, J. 1990. Aquatic invertebrates important for waterfowl production. U.S. Fish Wildl. Leafl. 13.3.3. 7 pp.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish Wildl. Serv., Resour. Publ. 148. 29 pp.

Fredrickson, L. H., and F. A. Reid. 1986. Wetland and riparian habitats: a nongame management overview. Pages 59-96 *in* J. B. Hale, L. B. Best, and R. L. Clawson, eds. Management of nongame wildlife in the Midwest: a developing art. Northcentral Section, The Wildlife Society, Madison, Wis.

Fredrickson, L. H. and F. A. Reid 1988. Waterfowl use of wetland complexes. U.S. Fish Wildl. Leafl. 13.2.1. 6 pp.

Reid, F. R., J. R. Kelley, Jr., T. S. Taylor, and L. H. Fredrickson. 1989. Upper Mississippi Valley wetlands—refuges and moist-soil impoundments. Pages 181-202 *in* L. Smith, R. Pederson, and R. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Appendix. Common and Scientific Names of Birds Named in Text.

Pied-billed grebe	*Podilymbus podiceps*
American bittern	*Botaurus lentiginosus*
Great blue heron	*Ardea herodias*
Little blue heron	*Egretta caerulea*
Yellow-crowned night-heron	*Nycticorax violaceus*
Tundra swan	*Cygnus columbianus*
Snow goose	*Chen caerulescens*
Canada goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Blue-winged teal	*Anas discors*
Canvasback	*Aythya valisineria*
Virginia rail	*Rallus limicola*
American coot	*Fulica americana*
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Pectoral sandpiper	*Calidris melanotos*
Long-billed dowitcher	*Limnodromus scolopaceus*
Wilson's phalarope	*Phalaropus tricolor*
Common snipe	*Capella gallinago*

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
***Fish and Wildlife Leaflet* 13**
Washington, D.C. • 1991

13.4.9. Preliminary Considerations for Manipulating Vegetation

Leigh H. Fredrickson and Frederic A. Reid
Gaylord Memorial Laboratory
School of Forestry, Fisheries and Wildlife
University of Missouri—Columbia
Puxico, MO 63960

A wide diversity of plants has adapted to the dynamic nature of wetlands. The continually changing floral landscape is shaped by physical or abiotic components that include climate, fire, soil, and water. Water quantity, quality, and chemistry have a dominating influence on wetlands as do factors such as hydroperiod (period when soils are saturated) and hydrological regime. Other factors that may affect the abundance, structure, and species composition of macrophytes or robust emergents are natural grazing, disease, and interspecific plant competition.

Vegetation is important to waterfowl for producing seeds, tubers, and browse; providing nest sites; and serving as substrates for animal foods. For example, the emergent marsh stage with the greatest number and diversity of birds has been called the "hemimarsh." A maximum diversity and number of birds occur when vegetation cover and water interspersion in Type IV (semipermanent marsh) wetlands is at a 50:50 ratio. This wetland condition provides ideal nesting cover for waterbirds, as well as substrates and litter for invertebrate populations.

Emergent wetlands other than glacial marshes also require good interspersion of cover and water to attract waterfowl. Likewise, a diversity of wetland vegetation is much more desirable than a monoculture. As man expanded his activities in North America, the natural events producing mosaics of wetland vegetation were eliminated or altered. As an example, drainage or water diversion to enhance row crop production not only affects the immediate site, but often affects soil moisture conditions on adjacent areas as well.

This change in water availability influences plant species composition. Intensive cultivation for grains and forage, together with other human-related activities (water diversion projects, livestock grazing, and the elimination of natural fires) have modified the physical processes that influence the productivity of wetland systems. Managed areas throughout North America now must provide predictably good wetland habitat, despite modifications to water supplies, flooding regimes, and other physical factors.

Manipulation of wetland vegetation is a commonly employed tool. Although water-level manipulation is the traditional technique for modifing plant communities under intensively managed systems, other options include fire, grazing, and other physical and chemical disturbances. Values of vegetation structure and composition along with general concepts relating to manipulations are discussed.

Desirable or Undesirable?

Traditionally, plants in waterfowl wintering or migration corridors were considered desirable if they produced large amounts of seed for food, whereas on waterfowl breeding grounds cover for nesting, broods, and molting birds was the desired characteristic. The value of plants as food (in the form of tubers and browse) and cover has long been acknowledged. However, recent information indicates plants are vitally important to invertebrates as nutrient sources and substrates. Likewise, structural characteristics of vegetation may provide

important habitat components when waterfowl court, molt, or require escape cover. Robust marsh vegetation serves as a nutrient pump within wetlands and can influence water chemistry and primary productivity. All of these functions are integral values of wetlands that are important considerations beyond the provision of seeds for waterfowl.

"Undesirable" plants are not simply "a group of plants whose seeds rarely occur in waterfowl gizzard samples." Rather, plants that quickly shift diverse floral systems toward monocultures, are difficult to reduce in abundance, have minimal values for wetland wildlife, or outcompete plants with greater value should be considered less desirable. When manipulation of undesirable plants is required, it should be timed so that the resultant decomposing vegetation can be used effectively by wetland invertebrates. If reflooding is shallow, these organisms with high protein content are readily available for consumption by waterfowl or shorebirds.

The Need For Disturbance

Vegetation within semipermanent and permanent wetlands can shift rapidly to a monoculture of robust plants. If water regimes remain constant or if muskrat populations are low, these monocultures may rapidly reduce associated waterfowl use. Manipulation of these monocultures by flooding or drying, fire, or chemical means can modify the structure and potentially increase plant and animal diversity. Disturbance tends to destroy monocultures and sets back succession. For instance, moist-soil wetlands that once were dominated by seed-producing annuals (Fig. 1), but have shifted to less desirable perennials after several years, may require mechanical mowing or discing.

"Undesired," especially exotic, plants may also plague managers. Problem plants often differ among regions. For example, purple loosestrife is a hardy perennial that causes management problems in the Northeast and Midwest, whereas American lotus with its elaborate tuber systems is a serious problem for managers in the Southeast and Midwest, where static water regimes occur. Invasions of young woody trees must be controlled in intensively managed marsh sites, because these same small sprouts can only be removed by very expensive bulldozer operations once sapling stages are reached. Problem woody and herbaceous growth forms are compared by region in Table 1.

Vegetation structure can also be modified with machinery to provide good interspersion. Mowing and rototilling have successfully produced the ìhemimarshî conditions under controlled experiments in Canadian prairies. Tracked vehicles are used to open dense stands of plants in Hawaii to improve habitat for endangered waterbirds, and duck-hunting clubs in California mow to create good interspersion for hunting. In summary, manipulation of vegetation may be desired to set back succession and reduce monocultures of robust plants, to diversify monotypic plant communities with undesirable characteristics, to reduce woody invasion in moist-soil areas, and to modify vegetation structure.

Initial Considerations in Development of Managed Wetlands

Careful considerations of potential vegetation problems and identification of anticipated, re-

	Year 1		Year 5		Year 6
Dominant vegetation	water smartweed		black willow		water smartweed
	common barnyardgrass	* →	aster	** →	straw-colored flatsedge
	sprangletop		swamp smartweed		common barnyardgrass

* Similar annual water regime/no physical disturbance.
** Physical disturbance (disc).

Figure 1. Successional shift of moist-soil plants.

Table 1. *Comparison of problem woody and herbaceous vegetation by region.*

Vegetation	West	Midwest/Southeast	Northeast
Woody	Salt cedar	Eastern cottonwood	Mountain alder
	Willow	Willow	
	Fremont cottonwood	Silver maple	
Herbaceous	Alkali bulrush	American lotus	Purple loosestrife
	Cattail	Cattail	
		Sesbania	
		Common cocklebur	
		Alligatorweed chafflower	

quired manipulations before construction can reduce management costs on intensively managed sites. Input by knowledgeable managers is essential as engineering plans are developed. Disturbance of unmodified or critical sites by development can negate any benefits of construction. Undoubtedly, any obstruction (such as a levee) will modify the previous hydrological regime. Typically, lands within levee systems become wetter because water is retained longer. Severe damage may be avoided by simply knowing where parking lots, drainage ditches, and roads can be placed. Initial considerations should include climatic, edaphic, and hydrologic information, as well as life history information for dominant flora (Table 2). An understanding of natural flooding regimes on a local scale should be developed in order to emulate natural conditions. Drainage patterns within a watershed indicate proper locations of levees and water-control structures. Improperly placed drainage structures preclude complete dewatering and reduce management options. Soil characteristics and potential to hold water affect seed germination and effectiveness of subsequent flooding. Placement of borrow ditches requires considerations such as costs of pumping water into or away from ditches and whether access to the site with equipment is required regularly. On areas where hunting is allowed, access across deep ditches is essential.

Costs associated with flooding, as well as providing as much area as possible with optimum water depths, make contour levees highly desirable. Optimum water control to enhance manipulation of plants and to promote proper flooding depths for most waterfowl requires levees on con-

Table 2. *A checklist of variables important in the development of management scenarios for wetland habitats critical to vegetation management.*

Management considerations
Climate
Precipitation cycle
Temperature ranges
Length of growing season
Soils
Structure/texture
Fertility
Topography
Residual herbicides
Water control potential
Water supply/source
Levees
Control structures
Pumps
Impoundments in complex
Number
Size
Juxtaposition
Plants
Species composition
Species life history
Structure and maturity
Seedbank
Exotic and problem species
Equipment for manipulations
Access
Repair capabilities
Other land uses
Grazing
Mineral development

tours at intervals of no more than 18 inches. Larger, more permanent levees that can withstand the weight of machinery and have a slope of 4:1 are desirable. On undeveloped areas, smaller levees built with road graders or specially designed equipment such as rice-levee plows offer management potential. These smaller levees, however, are less permanent and are difficult to repair if damage occurs during flooding.

Improvements in previously developed areas should stress fine tuning of water control or relocation of water-control structures. Major renovations may include establishment of contour levees, decreased intervals between levees, or reconfiguration of the area. Individual water control on each management parcel enhances management potential. For example, the addition of a header ditch with appropriate control structures may provide independent control on each management unit. Although initial development costs may be great, the area of high-quality habitat may increase dramatically. Installation of stoplogs that give finer control of water levels may be a minor but important improvement. Because plants readily respond to water level changes of as little as 1 in., the full potential of manipulations can only be met when the structure allows control at this level of precision. A mix of stoplogs of different dimensions, rather than only 4 in. or more in thickness, assures this potential. In dry regions, design of levees, ditches, and other control structures should be developed to make maximum use of available waters and reduce evapotranspiration.

Requirements of Vegetation Management

Manipulation of managed wetland areas often is better described as a learned craft or art, rather than strictly as applied science. Many differences exist among wetlands in different regions, areas, and sites. By recognizing the unique characteristics of their particular management area and of sites within each area, managers may enhance the ecological processes to emulate a more natural dynamic system. Preliminary assessments should include the following considerations:

Location: The site is of prime importance. Saline or alkaline areas have different problems from freshwater systems. Latitude is also important because of length of growing season and types of resources normally required by migrants or residents at that location.

Topography: An understanding of the subtle elevational differences within specific wetland sites is essential for predicting vegetation response. Further, the topography may influence management options such as rate of drawdown or appropriateness of management options (e.g., wet and dry sites for common snipe).

Water levels: A systematic record of water level changes is critical when assessing vegetation response to dewatering and when determining availability of optimum foraging depths (less than 10 inches)for dabbling ducks. A monitoring program should be designed with respect to the flooding source (i.e., rainfall or pumping), or important fluctuations may be overlooked.

Water quality: In some locations water sources should be monitored for the presence of toxic substances to alert managers to potential problems.

Site inspections and monitoring: Vegetation and wildlife responses should be monitored to evaluate site use and to identify manipulations needed to enhance or prevent certain vegetative conditions. Time of day, weather conditions, visibility, disturbance, and time in season are important considerations when observing wildlife use in a specific vegetation zone. Some species (e.g., migrants) may use specific wetland sites for only short periods of time, but these sites may be critical at those times. Monitoring schedules may vary depending on management objectives, but weekly or biweekly inspections or surveys during periods of peak use are more desirable than surveys at longer intervals. Records should be maintained for each unit rather than pooling all information for the area.

Plant identification: Plants must be identified at all stages, including the young seedling stage, to ensure proper timing and type of manipulation. For undesirable plants, effective control requires action at the young seedling stage and before seed maturation. Unfortunately, most taxonomic texts do not include adequate information for identification of seeds or seedlings.

Burrowing animals: Fur bearers (such as muskrat and beaver) and other mammals (such as groundhogs) are important components of a dense wetland system, but control of these mammals is essential to maintain levee integrity in some situations.

Rough fish: Carp and some other fish create high turbidity that influences the establishment

and growth of submergents. Tilapia cause problems by competing with waterbirds for food and by forming nest bowls that are difficult to drain. Control of such fish is an integral part of effective vegetation management.

Equipment: Equipment availability is essential for well-timed manipulations. Expensive dewatering activities may be wasted if equipment is unavailable or unreliable. Quick repair of equipment is often necessary when suitable conditions for manipulations may be restricted to a few weeks annually. Likewise, ineffective manipulations may occur with the most knowledgeable managers if inexperienced or overly enthusiastic equipment operators manipulate more than is necessary or modify the wrong vegetation.

Timing: Manipulations are most effective if implemented at critical times. Management strategies that are designed for convenience or are conducted routinely may be ineffective because they do not match floral phenology or chronology of wildlife activities. Proper timing of manipulations enhances the potential for maximum production of foods and may increase the use of foods produced. Manipulations to modify vegetation require careful considerations because of costs, structural changes, diverse wildlife requirements, and long-term implications.

Suggested Reading

Fredrickson, L.H., and T.S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish Wildl. Serv., Resour. Publ. 148. 29 pp.

Kaminski, R.M., H.R. Murkin, and C.E. Smith. 1985. Control of cattail and bulrush by cutting and flooding. Pages 253–262 in Coastal Wetlands. Lewis Publishers, Inc., Chelsea, Mich. 286 pp.

Kantrud, H.A. 1986. Effects of vegetation manipulation on breeding waterfowl in prairie wetlandsóA literature review. U.S. Fish Wildl. Serv., Spec. Sci. Rep. -Wildl. 3, 15 pp.

Linde, A.F. 1985. Vegetation management in water impoundments: Alternatives and supplements to water-level control. Pages 51–60 *in* M.D. Kighton, ed. Water Impoundments for Wildlife: A Habitat Management Workshop. U.S. Dep. Agri. For Serv. St. Paul, Minn. 136 pp.

Murkin, H.R., R.M. Kaminski and R.D. Titman. 1982. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Can. J. Zool. 60: 2324–2332.

Rundle, W.D. 1981. Habitat selection by fall migrant snipe in southeastern Missouri. Proc. Annu. Conf. Southeast Assoc. Fish Wildl. Agencies 35:20–26.

Smith, L.M., and J.A. Kadlec. 1985. Fire and herbivory in a Great Salt Lake marsh. Ecology 66:259–265.

Weller, M.W., and L.H. Fredrickson. 1973. Avian ecology of a managed glacial marsh. Living Bird 12:269–691.

Appendix. Common and Scientific Names of Plants and Animals Named in Text.

Plants	
Silver maple	*Acer saccharinum*
Mountain alder or speckled alder	*Alnus incana*
Alligatorweed chafflower	*Alternathera philoxeroides*
Straw-colored flatsedge	*Cyperus strigosus*
Common barnyardgrass	*Echinochloa crusgalli*
Sprangletop	*Leptochloa* spp.
Purple loosestrife	*Lythrum salicaria*
American lotus	*Nelumbo lutea*
Common reed	*Phragmites australis*
Marsh knotwood or water smartweed	*Polygonum coccineum*
Swamp smartweed	*Polygonum hydropiperoides*
Eastern cottonwood	*Populus deltoides*
Fremont cottonwood	*Populus fremontii*
Willow	*Salix* spp.
Black willow	*Salix nigra*
Saltmarsh bulrush or alkali bulrush	*Scirpus robustus*
Sesbania	*Sesbania* spp.
Saltcedar tamarisk or salt cedar	*Tamarix pentandra*
Cattail	*Typha* spp.
Common cocklebur	*Xanthium strumarium*
Birds, mammals, and fish	
Common snipe	*Gallinago gallinago*
Beaver	*Castor canadensis*
Groundhog or woodchuck	*Marmota monax*
Nutria	*Myocastor coypus*
Muskrat	*Ondatra zibethicus*
Common carp	*Cyprinus carpio*
Tilapia	*Tilapia* spp.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
***Fish and Wildlife Leaflet* 13**
Washington, D.C. • 1988

Other Waterfowl Foods

Photo courtesy of Ducks Unlimited.

USDA NRCS
Natural Resources Conservation Service
MISSISSIPPI

FLOODED FOOD PLOTS FOR WILDLIFE

MS-ECS-646-02 (JS)
May 2000

Purpose:
Agricultural plantings are often established for wildlife use. These plantings are commonly referred to as food plots. Food plots can be established in seasonally floodable impoundments for waterfowl and other wetland wildlife. Because these food plots are normally established for waterfowl, this jobsheet addresses waterfowl. However, other wetland wildlife species will benefit.

Management:
Water should be held in impoundments until 2 weeks prior to planting date of planned crop. This will help provide weed control and also prolong wildlife use of habitat. After drainage, seedbed preparation can begin when area has dried enough for equipment use, generally 14 days or longer.

Common agricultural plantings used by waterfowl are corn, milo, Japanese millet, browntop millet, and rice. Soybeans should not be planted because they deteriorate rapidly when flooded (Table 1) and contain an enzyme that inhibits protein digestion. Suggested broadcast planting rates and times are:

Japanese millet	20 lbs/ac.	May-July	Browntop millet	20 lbs/ac.	May-July
Milo	15 lbs/ac.	April-June	Corn	20 lbs/ac.	March-April
Proso millet	20 lbs/ac.	May-July	Wheat	90 lbs/ac.	September
Rice*	120 lbs/ac.	April-June	*Rice should only be planted where irrigation is possible.		

Fertilizer and lime should be applied according to soil test recommendations.

Do not use herbicides or cultivation unless there is excessive weed competition. Native weeds and grasses often benefit wildlife by producing more seed and providing higher protein levels (see "Moist-soil Management for Wildlife", MS-ECS-646-01 (JS)). If species such as sesbania, cocklebur or other undesirable broadleafs become a serious competition problem, spot treat with approved herbicide, mowing, or disking. Contact local Extension office for herbicide recommendations. When irrigation is possible, rice should be flooded 3-4 inches deep after plants reach 6 inches (3-4 weeks). Also, Japanese millet can be shallowly flooded, not inundated, after establishment. Shallow flooding of these plants will provide good weed control.

Impoundments should be gradually flooded to provide waterfowl access. If grain is mature, shallowly flood 10-25 percent of the area between August 15 and September 15. Rice and Japanese millet can be flooded. Slowly flood remainder of impoundment between October 15 and December 15. If multiple impoundments are being managed for waterfowl, an impoundment can be reserved and flooded between December 1 and January 1 to provide continued food.

Requirements:
- Impoundments must have a water control structure to facilitate draining for planting and subsequent reflooding.
- Current migratory game bird hunting regulations allow hunting of waterfowl over standing crops, flooded standing crops, and harvested croplands. These crops may not be manipulated except by normal agricultural practices used to produce and harvest the crop. Grain inadvertently scattered by entering and leaving the field, placing decoys, or retrieving birds is not considered baiting. Japanese millet can readily reseed in subsequent years and can be manipulated when naturally reseeded, but not during the establishment year. **Check with the U.S. Fish and Wildlife Service and Mississippi Department of Wildlife, Fisheries, and Parks for current hunting and baiting regulations.**
- Currently food plots established on Conservation Reserve Program and Wetland Reserve Program lands cannot exceed 5% of the total contract acreage and cannot be harvested. Individual food plots on Conservation Reserve Program lands cannot exceed 5 acres. Future changes in USDA program policies and procedures may restrict or supercede information in this job sheet. Therefore, check with the appropriate USDA agency for guidelines pertaining to lands under USDA programs.

onsiderations:

When managing impoundments for waterfowl, agricultural food plots should not be the only food provided. Research suggests agricultural crops do not contain enough protein or amino acids to provide a complete diet for waterfowl. Food plots should be mixed with moist-soil management in order to provide maximum wildlife benefits (see "Moist-soil Management for Wildlife", MS-ECS-646-01 (JS)).

In order to provide optimal benefits, linear food plots can be established around moist-soil impoundment fringes where drying occurs first. Japanese millet and rice can be hand seeded into wet areas.

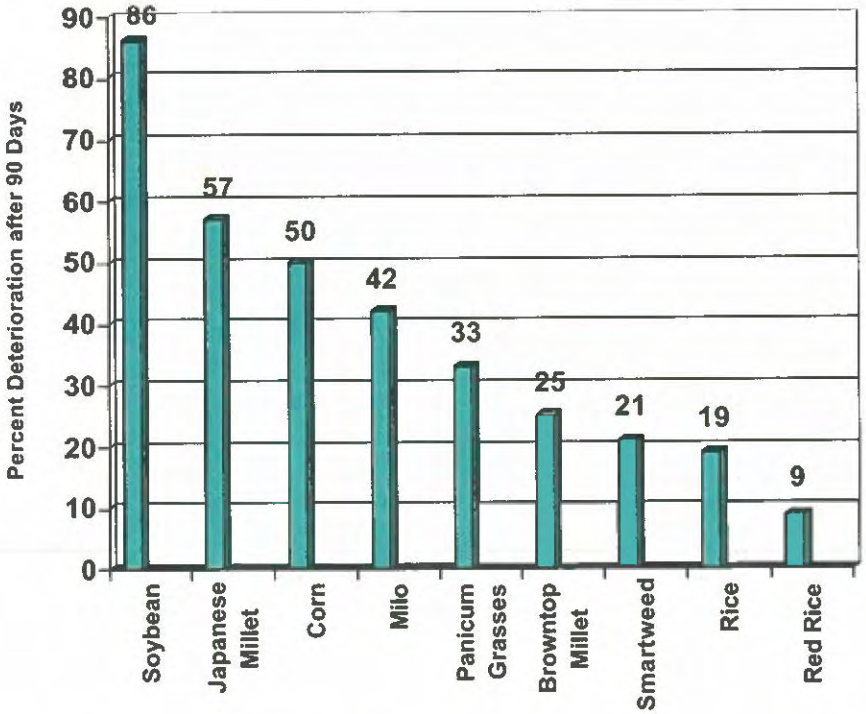
Moist-soil plants commonly last longer when flooded than do agricultural crops (Table 1). Longevity of seed when flooded should be considered when planting agricultural crops.

Maturation time of crop should be considered when determining crop and planting time. Maturity for Japanese millet = 90 days, browntop millet = 60 days, milo = 100 days, corn = 120 days, proso millet = 70 days, rice = 115-140 days depending on variety.

Wheat can be planted in September and flooded when plants are about 6 inches tall. This provides excellent food for white-fronted and Canada geese and widgeon.

Millets, especially Japanese, will commonly reestablish in subsequent years. If plants do reseed, they are considered naturalized and can be manipulated for wildlife.

Table 1



Percent deterioration of selected agricultural crop and native plant seeds submerged for 90 days;
from Neely 1956, Nelms and Twedt 1996.

'he United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, gender, religion, age, isability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who equire alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at 202-720-600 (voice and TDD).

'o file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326W, Whitten Building, 14th and Independence Avenue, SW, Vashington, DC 20250-9410 or call (202) 720-5964 (voice or TDD). USDA is an equal opportunity provider and employer.

13.4.3. Managing Agricultural Foods for Waterfowl

James K. Ringelman
Colorado Division of Wildlife
317 West Prospect Road
Fort Collins, CO 80526

Agriculture, more than any other human activity, has had a profound influence on North American waterfowl. Most agricultural effects have been detrimental, such as the conversion of grassland nesting cover to cropland, the widespread drainage of wetlands, and the use of pesticides that may poison waterfowl or their food. However, some by-products of agriculture have been beneficial, particularly grain or other foods left as residue after harvest. Many waterfowl are opportunistic feeders, and some species such as Canada geese (*Branta canadensis*), snow geese (*Chen caerulescens*), mallard (*Anas platyrhynchos*), northern pintails (*A. acuta*), and green-winged teal (*A. crecca*) have learned to capitalize on the abundant foods produced by agriculture. During the last century, migration routes and wintering areas have changed in response to these foods. Some species have developed such strong traditions to northern wintering areas that many populations are now dependent on agricultural foods for their winter survival.

Their relatively large body size enables waterfowl to store fat, protein, and minerals for later use. These reserves can then be mobilized for egg formation, migration, molt, or in times of food shortage. Although strategies for depositing and using nutrient reserves differ among species, and are necessarily dependent upon seasonal availability of foods, waste grains are among the most extensively exploited food resources. Arctic-nesting snow geese, for example, feed extensively in agricultural fields during their northward migration. Their ability to exploit croplands has been largely responsible for dramatic population increases in this species. Clutch size and perhaps nesting dates of mallards and other early-nesting ducks are thought to be directly related to the amount of reserves obtained on their wintering grounds.

During breeding and molting periods, waterfowl require a balanced diet with a high protein content. Agricultural foods, most of which are neither nutritionally balanced nor high in protein, are seldom used during these periods. However, during fall, winter, and early spring, when vegetative foods make up a large part of the diet, agricultural foods are preferred forage except in arctic and subarctic environments. Waterfowl management during these periods is often directed at small grain and row crops. Corn, wheat, rice, barley, oats, peas, sorghum, rye, millet, soybeans, and buckwheat are commonly planted as waterfowl foods. The species and varieties suitable for a particular area, as well as the seeding and cultivation techniques necessary for a good yield, are dependent on soil conditions, growing season, moisture regimes, irrigation, the availability of farm implements, and other considerations. My purpose is therefore not to recommend crops or describe planting techniques, because these are site-specific considerations. Instead, I present guidelines that discuss the quality and quantity of agricultural foods needed by waterfowl, and techniques to enhance the availability of these foods.

Food Quality of Grains

Waste grain is a locally abundant, high-energy food that can be quickly consumed by waterfowl. The best indication of the nutritional quality of foods is given by an analysis of their chemical composition. The amount of gross energy, crude protein, fat, ash, fiber, and digestible carbohydrates (NFE) are indices to food value. However, since waterfowl use grains primarily as a high-energy food and supplement their diet with natural foods to compensate for nutritional deficiencies, the energy content of grains is the most commonly used basis for comparison. Unfortunately, energy content varies among varieties of the same grain, as well as by soil and environmental conditions. Moreover, waterfowl cannot digest different grains with similar efficiencies. In recognition of this digestive efficiency, metabolizable energy, which is indicative of the energy actually derived from a food, is a better comparative measure than gross energy content.

Agricultural foods (with the exception of soybeans) provide high levels of metabolizable energy (Table 1). Energy values, while indicative of fresh seeds, are not representative of grains underwater or exposed outdoors for an extended period. Under these conditions, energy value may decline rapidly. For example, rice will lose only 19% of its energy value after 90 days of flooding, but milo and corn will lose 42 and 50%, respectively, and soybeans will lose 86% of their energy content. Such losses underscore the need for well-timed harvests and manipulations to maintain food quality. Harvesting fields at intervals will help ensure a constant supply of fresh feed. When fields are flooded, water should be applied gradually so that a "flooding front" is created that progressively inundates new grain. Soybeans should be avoided as a waterfowl food crop. They not only decompose rapidly in water, but may also cause food impaction in the esophagus, which can be fatal. Additionally, legumes such as soybeans are undesirable because they often contain digestive inhibitors that reduce the availability of protein and other nutrients.

How Much to Plant?

Even though modern implements harvest about 95% of a ripened grain crop, most harvested fields still contain 50–310 pounds/acre of residual grain (Table 2). Waterfowl are efficient feeders, and will continue to use agricultural foods long after residual food density has been reduced. Waste corn, at typical postharvest densities of 100–500 pounds/acre, has to be reduced to a density of 90 pounds/acre before mallard feeding rates begin to decrease. Generally, waterfowl feeding on land will reduce densities to 13 pounds/acre before switching to alternate food sites, whereas waterfowl using foods underwater may abandon fields after densities decline to 45 pounds/acre. Daily food consumption varies among species, individuals within species, and with energetic demands related to behavior and thermoregulation. As a rule of thumb, average-sized geese will consume about 150–200 g/day, whereas large ducks need about half this amount. Although waterfowl will fly 20 miles or more to obtain grain, it is best to provide food no farther than a 10-mile radius from waterfowl concentrations.

Cost is always a consideration when planting food crops. Species that can be grown without irrigation will always be less expensive than water-demanding grains. Some crops, such as millets, are closely related to wild plants used by waterfowl. Millets are advantageous because they can be either

Table 1. *Energy content and chemical composition of common agriculture foods planted for waterfowl.*

	Metabolizable energy[a]		Percent (dry weight)				
Crop	Mallard	Canada goose	Protein	Fiber	NFE[c]	Fat	Ash
Barley	2.98[b]	3.32	14	5	—	2	2
Milo	—	3.85	12	3	80	3	2
Rice	3.34	—	9	1	—	2	1
Rye	3.14	2.74	14	4	68	2	2
Soybeans	2.65	3.20	42	6	28	19	5
Wheat	3.32[b]	3.35	26	19	34	4	17
Yellow corn	3.60	4.01	10	5	80	5	2

[a] Apparent metabolizable energy in kcal/g.
[b] Estimated as 6% less than the true metabolizable energy value.
[c] Nitrogen-free extract.

Table 2. *Average preharvest and postharvest densities of common agricultural crops planted for waterfowl.*

Crop	Density (pounds/acre) Preharvest	Postharvest	Location
Barley	2,613	105	Colorado
Corn (for grain)	5,580	320	Iowa, Illinois, Nebraska, Texas
Grain sorghum	3,678	258	Texas
Japanese millet	2,227	89	Colorado
Rice	5,205	160	Mississippi Valley
Soybeans	1,093	53	Mississippi Valley
Wheat	1,768	106	Colorado

drilled or broadcast, are inexpensive, grow quickly, and are less susceptible to wildlife depredations than other crops. Japanese millet tolerates shallow flooding and saturated soils, and produces high yields of seed. Other species, such as white proso millet, achieve a low growth form with no loss in seed production if grown under low moisture conditions. Carefully planned crop rotations may eliminate the need for inorganic nitrogen or insecticide applications, thereby reducing costs. One common rotation used in midwestern States is a mixture of sweet clover and oats the first year, followed by corn in the second year and soybeans in the third year. Winter wheat is planted in the fall of the third year, with clover and oats repeated in the summer of the fourth year.

Enhancing Food Availability

Before grain crops are selected, managers should consider not only the energy value of grains but also the physical characteristics of the seed head. Large seeds, such as corn kernels, are more quickly located and consumed by waterfowl than smaller seeds. Seed head structure is also important. For example, even though barley has a lower metabolizable energy, it is preferred over hard spring wheat because ducks are able to remove seeds more quickly from the heads.

Abundant grain crops are worthless if they are not presented in a manner that makes them available to birds. The amount of residual food remaining after harvest is affected by harvester efficiency and operation, slope of the field, insects, disease, cultivar, and moisture content of the grain. Reductions in surface grain density result from all postharvest, cultivation treatments (Table 3). In some instances, postharvest treatments may be beneficial, even if aboveground residues are decreased, because reduced ground litter increases the foraging efficiency of waterfowl. However, such benefits are often difficult to quantify; therefore, the best strategy is to present unharvested or freshly harvested crops in ways that have proven attractive to waterfowl (Table 4). Such practices regulate secondary availability, or the accessibility of grain residues after harvest.

In mild winter climates, precipitation or flooding from runoff usually enhances grain availability by making food more available to waterfowl. In cold

Table 3. *Estimated waste corn residues resulting from different tillage systems. See text for other variables affecting harvest residues.*

Tillage system	Grain density (pounds/acre) Middle range	Lower range
Untilled	320	76
Disk (tandem)	233	56
Chisel (straight shank)	148	35
Chisel (twisted shank)	27	5
Chisel (straight shank—disk (tandem)	22	4
Chisel (straight shank)—disk (offset)	8	1
Chisel (twisted shank)—disk (tandem)	5	<1
Chisel (twisted shank)—disk (offset)	3	0
Moldboard plow	2	0

Table 4. *Recommended treatments to enhance food availability for waterfowl.*

Crop	Treatment
Barley, wheat	Leave low-growing varieties standing, since their seed heads are easily fed upon by ducks and geese.
Corn, milo	Harvest when grain moisture is <21%. Burn corn stubble, then leave field dry—do not flood. Graze cattle if snow cover is persistent.
Soybeans	Do not flood fields. Beware of potential impaction problems if dry beans are consumed by birds.
Millets	Best if unharvested. Flood gradually to a depth of 8 inches.
Rice	Disk harvested fields to loosen and mix soil with grain and straw, or roll with a water-filled drum to create openings in stubble. Flood to a depth of 8 inches.

climates, however, food usually becomes less available after precipitation. In these regions, snowfall and cattle grazing are the most important components of secondary availability. After heavy snowfall, mallard and other ducks often use standing grain crops, since these are the only foods above snow. Cattle, turned loose to graze in harvested cornfields, create openings in the snow and break up corn ears, thereby increasing kernel availability.

The physical layout of fields may also affect food availability. In severe winter climates, wide swaths of harvested crops should be separated by several rows of unharvested plants, thereby providing a "snow fence" to enhance the availability of grain on the ground as well as provide a reserve of food that will remain above even the deepest snow. It may be advantageous to plant crops in blocks of rows running perpendicular to one another. This helps ensure that the tops of some rows will be exposed by the prevailing winds during heavy snow.

Suggested Reading

Alisauskas, R. T., C. D. Ankney, and E. E. Klaas. 1988. Winter diets and nutrition of midcontinental lesser snow geese. J. Wildl. Manage. 52:403–414.

Baldassarre, G. A., R. J. Whyte, E. E. Quinlin, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildl. Soc. Bull. 11:25–31.

Clark, R. G., H. Greenwood, and L. G. Sugden. 1986. Influence of grain characteristics on optimal diet of field–feeding mallards. J. Appl. Ecol. 23:763–771.

McFarland, L. Z., and H. George. 1966. Preference of selected grains by geese. J. Wildl. Manage. 30:9–13.

Reinecke, K. J., R. M. Kaminski, D. J. Moorhead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi alluvial valley. Pages 203–247 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Ringelman, J. K., W. R. Eddleman, and H. W. Miller. 1989. High plains reservoirs and sloughs. Pages 311–340 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Sugden, L. G. 1971. Metabolizable energy of small grains for mallards. J. Wildl. Manage. 35:781–785.

Warner, R. E., and S. P. Havera. 1985. Effects of autumn tillage systems on corn and soybean harvest residues in Illinois. J. Wildl. Manage. 49:185–190.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Fish and Wildlife Leaflet 13
Washington, D.C. ¥ 1990

13.3.3. Aquatic Invertebrates Important for Waterfowl Production

Jan Eldridge
Bell Museum of Natural History
University of Minnesota
Minneapolis, MN 55455

Aquatic invertebrates play a critical role in the diet of female ducks during the breeding season. Most waterfowl hens shift from a winter diet of seeds and plant material to a spring diet of mainly invertebrates. The purpose of this chapter is to give managers a quick reference to the important invertebrate groups that prairie-nesting ducks consume.

Waterfowl species depend differentially on the various groups of invertebrates present in prairie wetlands, but a few generalizations are possible. Snails, crustaceans, and insects are important invertebrate groups for reproducing ducks (Table). Most species of laying hens rely on calcium from snail shells for egg production. The northern shoveler and gadwall are dependent on crustaceans that swim in the water and forage on algae and fine organic matter. The northern shoveler has an enlarged bill and finely developed lamellae for sieving crustacea from the water. Early-nesting species such as northern pintails and mallards consume early-emerging midge larvae in addition to earthworms, which are often the most available food in ephemeral wetlands shortly after the snowmelt. The diving ducks consume free swimming amphipods or larger insects such as caddis fly and dragonfly larvae that tend to occur in deeper water.

The community of invertebrates present in a wetland can indicate the history of water changes in that wetland. For example, invertebrates such as leeches, earthworms, zooplankton, amphipods, isopods, and gastropods are dependent on passive dispersal (they can't leave the wetland under their own power). As a result, they have elaborate mechanisms to deal with drought and freezing. A second group that includes some beetles and most midges can withstand drought and freezing but requires water to lay eggs in spring. A third group that includes dragonflies, mosquitoes, and phantom midges lays eggs in the moist mud of drying wetlands during summer. A fourth group that includes most aquatic bugs and some beetles cannot cope with drying and freezing, so,they leave shallow wetlands to overwinter in larger bodies of water. Managers can use the presence of these invertebrates to determine the effectiveness of water management regimes designed for waterfowl production.

The following descriptions of invertebrate natural history are based on Pennak (1978).

Invertebrate Natural History

OLIGOCHAETA (Aquatic and Terrestrial Earthworms)

Natural History: Earthworms mix the substrate soils and consume algae and detritus. Their distribution is usually not limited by temperature and many truly aquatic forms survive in low oxygen concentrations. Some earthworms form cysts or cocoons that are transported by birds or the wind.

Table. *Invertebrate classification. The following is a list of the taxonomy of aquatic organisms that will serve most management purposes.*

Phylum	Class	Order
Annelida	Oligochaeta (terrestrial and aquatic earthworms)	
	Hirudinea (leeches)	
Arthropoda	Crustacea	Anostraca (fairy shrimp)
		Conchostraca (clam shrimp)
		Cladocera (water fleas)
		Copepoda(copepods)
		Ostracoda (seed shrimp)
		Amphipoda (scuds and side-swimmers)
	Insecta	Ephemeroptera (mayflies)
		Odonata (dragonflies)
		Hemiptera (true bugs)
		Trichoptera (caddis flies)
		Coleoptera (beetles)
		Diptera (flies and midges)
		Lepidoptera (butterflies and moths)
Mollusca	Gastropoda (Snails)	

Importance to Waterfowl: Terrestrial earthworms in temporarily flooded, ephemeral ponds early in spring are particularly important to early-nesting mallard and northern pintail hens.

HIRUDINEA (Leeches)

Natural History: Some leeches are blood sucking and forage on birds, mammals, fish, snails, insects, and earthworms. Leeches prefer warm water, and are common in protected shallows. They are primarily nocturnal and require a substrate of rocks or vegetation, so they are uncommon in wetlands that have pure mud or clay bottoms. Leeches survive winter and droughts by burrowing into the mud and becoming dormant.
Importance to Waterfowl: Leeches are not particularly important to waterfowl as food, although they are eaten by mallards in small amounts.

Crustacea

ANOSTRACA (Fairy Shrimp)

General Description: Fairy shrimp generally swim on their backs. They have 2 stalked, compound eyes, 11 pairs of swimming legs that resemble paddles, and no hard external covering.
Natural History: Fairy shrimp are common in small ephemeral and temporary ponds early in spring. They glide upside down, beating their legs in a wave-like pattern from tail to head. Their leg action draws food into the ventral groove toward the mouth. They feed on algae, bacteria, protozoa, and bits of detritus.

Fairy shrimp lay two kinds of eggs: summer eggs that hatch soon after laying, and resting eggs that sink to the bottom, where they withstand drying or freezing and hatch the next spring. Larvae develop through a series of "nauplius" instars and mature rapidly; some become adults in as few as 15 days.
Importance to Waterfowl: Because fairy shrimp are among the first invertebrates in spring, they are consumed by early laying northern pintail and mallard hens. They also occur in the diets of northern shoveler and blue-winged teal.

CONCHOSTRACA (Clam Shrimp)

General Description: This organism is enclosed in a shell-like outer carapace, and resembles a tiny swimming clam. Clam shrimp have 10–32 pairs of legs and 2 pairs of antennae.
Natural History: Clam shrimp seem to prefer brackish water and swim by moving their large biramous antennae in a rowing motion. Their natural history is similar to that of the fairy shrimp.
Importance to Waterfowl: Clam shrimp form an important part of the diet of laying gadwall hens, and also occur in the diet of mallards and northern shovelers.

CLADOCERA (Water Fleas)

General Description: Water fleas range in size from 0.2 to 3.0 mm long. Superficially, the body appears bivalve with the abdomen and thoracic regions covered by a carapace. The head is compact with two large, compound eyes. Water fleas have large antennae with two segmented rami extending from a large base. They have five to six pairs of biramous legs that are hidden in the carapace.

Natural History: Water fleas use their antennae to swim and appear to hop uncertainly in the water. Their legs produce a current between the valves of their carapace where food collects in the median groove and streams toward the mouth. Algae, detritus, and protozoans are the major items consumed. Water fleas migrate vertically, moving upward in the evening and downward at dawn. They can exist in a variety of temperature and oxygen concentrations.

Water fleas hatch from resting eggs at first thaw. As the water warms they reproduce rapidly, often reaching a large population of 200–500 fleas per liter of water. The population wanes and by summer, few are present in the ponds. Usually they reproduce parthenogenetically; however, as conditions deteriorate later in the season, they produce eggs.
Importance to Waterfowl: Water fleas form a major part of the diet of the laying northern shoveler. Cladocera are also consumed by gadwall and mallard hens.

COPEPODA (Copepods)

General Description: Most copepods are less than 2.0 mm long. Usually they are drab in color; however, in spring, some species are bright orange, purple, and red. The head and part of the thorax are fused in a cephalothorax. The remainder of the thorax and abdomen are segmented. Copepods have large antennae and five thoracic segments that have legs that are used for swimming. They have no abdominal appendages.
Natural History: Most copepods forage on algae, plankton, and detritus. Some forage by scraping food from the pond bottom and some by filtering plankton from the water. Many swim in a smooth, slow motion that is produced by the feeding movements of the mouthparts and antennae, punctuated by jerky leg movements. The front antennae are held stiff and act as a parachute to keep the copepod from sinking.

Copepods breed throughout summer, and are tolerant of oxygen depleted water and adverse conditions such as drying and freezing. Some survive winter as resting eggs, some go into diapause on the wetland bottom and others form cysts or cocoons. Development is through a series of stages before maturity. The time to maturity varies, depending on the environment and the species.
Importance to Waterfowl: Waterfowl do not depend on this group but copepods account for a small portion of the diet of laying northern shoveler and gadwall hens.

OSTRACODA (Seed Shrimp)

General Description: Superficially, ostracods resemble tiny seeds. They are usually less than 1 mm long with an opaque, bivalve shell that varies in color.
Natural History: Seed shrimp tolerate a wide range of environments, temperature, and water chemistry. Most species occur in water less than 1 m deep on varying substrates. Omnivorous scavengers, they forage on bacteria, molds, algae, and fine detritus. Eggs can suspend development in dry and freezing conditions and some live as long as 20 years in the dried condition.
Importance to Waterfowl: Seed shrimp, like copepods, do not dominate the diet of laying females; however, they are consumed in small amounts by gadwall, northern shoveler, and blue-winged teal.

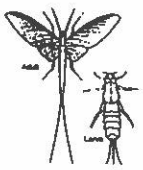
AMPHIPODA (Scuds, Side-swimmers, or Freshwater Shrimp)

General Description: Most amphipods are 5–20 mm long with segmented thorax and abdomen. Their eyes are usually well developed.
Natural History: Amphipods are primarily nocturnal. They swim rapidly just above the substrate, rolling from side to back. Omnivorous scavengers, they consume various plant and animal material. They often browse on the film covering vegetation that is composed of microscopic plants, animals, and detritus.

Amphipods are restricted to cold, shallow water, and an abundance of oxygen is essential. They are generally found in permanent wetlands where they can become abundant, and are not generally adaptable to withstanding droughts.
Importance to Waterfowl: Amphipods are very important to scaup, especially in fall, but they are not particularly important for dabbling ducks. Blue-winged teal, gadwalls, and mallards consume small amounts.

Insecta

EPHEMEROPTERA (Mayflies)



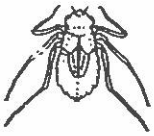
General Description: The aquatic juvenile stage of a mayfly, known as a nymph, is characterized by a long body with a large head, large eyes, and long antennae. The tracheal gills on the abdominal segments are the important

feature for distinguishing the mayfly nymph from other insects.

Natural History: Mayflies occur in fresh water with a high oxygen concentration. Most are herbivores or detritivores, however, some are carnivorous and feed on midge larvae. Mayflies are nymphs most of their lives, which can extend for 1–3 years. Adults live 24 h to a few days, mate, lay eggs, and then die.

Importance to Waterfowl: Although mayfly nymphs are not an important item in the diets of waterfowl, they are commonly found in wetlands.

ODONATA (Dragonflies, Damselflies)



General Description: Nymph—Dragonfly nymphs according to Pennack are "...grotesque creatures, robust or elongated and gray, greenish or somber-colored." The body may be smooth or rough, bearing small spines; it is often covered with growths of filamentous algae and debris. The most striking feature of the larva is the modified mouthparts that are large and folded under the head and thorax.

Natural History: Many dragonflies and damselflies live for 1 year but the large aeschnids live for about 4 years. Odonate nymphs are carnivorous. Nymphs emerge from the water in the morning.

Importance to Waterfowl: Dragonfly nymphs are more important to diving ducks than to dabbling ducks.

HEMIPTERA (True Bugs)

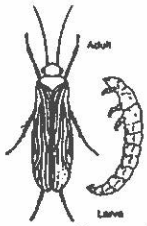
General Description: True bugs have mouthparts that form a piercing beak. Their wings are leathery at the base and membranous at the tip. Their size and shape varies.

Natural History: Aquatic bugs are predaceous, primarily foraging on other insects. They grasp their prey with specialized front legs and suck body fluids with their beak. They winter as adults hidden in the mud and vegetation.

Importance to Waterfowl: Hemiptera occur in small amounts in the diets of gadwall, blue-winged teal, and northern shoveler hens.

TRICHOPTERA (Caddis Flies)

General Description: Adult—Adults are small and inconspicuous. They resemble moths with folded wings and a dodging flight pattern. Caddis

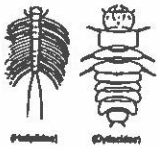


fly larvae are aquatic and most build portable cases of debris.

Natural History: Caddis flies occur in a variety of wetland types that have sufficient oxygen concentrations. They may have one or two generations per year and many larvae overwinter in the wetland. Most are omnivorous but there are grazers, scrapers, suspension feeders, filter feeders, and carnivores.

Importance to Waterfowl: Caddis flies are particularly important to laying canvasbacks and they also occur in the diets of mallard, gadwall, blue-winged teal, and redhead hens.

COLEOPTERA (Beetles)

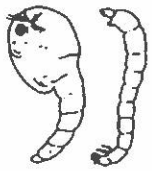


General Description: Beetles are easily distinguished as adults—their forewings are modified into horny shields that cover the abdomen. Larvae are long and thin with six legs; three on a side—characteristic of insects.

Natural History: Most adult aquatic beetles are dependent on air. Adults and larvae occur in shallow water near shore, particularly where there are quantities of debris and aquatic vegetation. Beetles are generally absent from wave-swept shores and deep water. Adults overwinter by burrowing into debris or mud on the bottom of the wetland. The aquatic larvae are highly variable; for example, Dytiscidae (predatory diving beetles) are adapted for a carnivorous life style, whereas Haliplidae (crawling water beetles) larvae are vegetarian, sluggish and sticklike in appearance. Aquatic beetles often have terrestrial pupae.

Importance to Waterfowl: Aquatic beetles occur in small amounts in the diets of gadwall, mallard, northern pintail, blue-winged teal, northern shoveler, redhead, and canvasback hens.

DIPTERA (Flies and Midges)



General Description: This order ineludes all two-winged flies such as horseflies, mosquitoes, crane flies, midges, houseflies, hover flies, and bot flies. Aquatic diptera larvae are highly variable; most are wormlike and lack eyes or jointed thoracic legs. Their bodies are usually soft and flexible. Some larvae such as midges (Chironomidae) have short, stumpy forelegs.

Natural History: Midges are especially important to waterfowl. They occur throughout aquatic vegetation and on the bottom of all types of wetlands. Many hide in fragile tubes they construct of algae and silt. The most abundant type, known as "bloodworms," are bright red in color. Midge larvae are chiefly herbivorous and feed on algae, higher plants, and detritus.
Importance to Waterfowl: Aquatic Diptera are of major importance to blue-winged teal, northern pintail, mallard, gadwall, and redhead hens.

LEPIDOPTERA (Butterflies and Moths)

General Description: Only one family of Lepidoptera have larvae that are truly aquatic. These larvae resemble terrestrial caterpillars; adults are small and inconspicuous.
Natural History: The aquatic moth larvae are found in ponds that are densely overgrown with aquatic vegetation. Larvae often construct cases with two leaves and crawl around with the case. Species winter as immature larvae.
Importance to Waterfowl: Moth larvae are only of minor importance to mallard hens.

GASTROPODA (Snails)

General Description: Most snails are readily identified because of their coiled shell.
Natural History: Most snails are vegetarian. They consume the film of algae that coats submerged surfaces. Many are hermaphroditic and may be self-fertilized or cross-fertilized. Eggs are often deposited in a gelatinous mass in spring, and early development takes place before hatch. When a snail leaves the egg mass, it has taken on the morphological characteristics of the adult. Most snails live 9 to 15 months. In warmer climates, snails may have two to three generations per year. They overwinter by burrowing into the mud and hibernating.

Snails are most common in shallow water, less than 3 m deep. Most species occur in greatest abundance in slightly alkaline conditions. They need calcium carbonate for shell production. They also need water that is clean and has high levels of dissolved oxygen.
Importance to Waterfowl: Snails are very important as a source of calcium for most laying ducks.

Suggested Reading

Drobney, R. D., and L. H. Fredrickson. 1979. Food selection by ducks in relation to breeding status. J. Wildl. Manage. 43:109–120.

Merritt, R. W., and K. W. Cummins. 1984. An introduction to the aquatic insects of North America. Kendall- Hunt Publishing Company, Dubuque, Iowa. 722 pp.

Pennak, R. W. 1978. Freshwater invertebrates of the United States. John Wiley & Sons, New York. 803 pp.

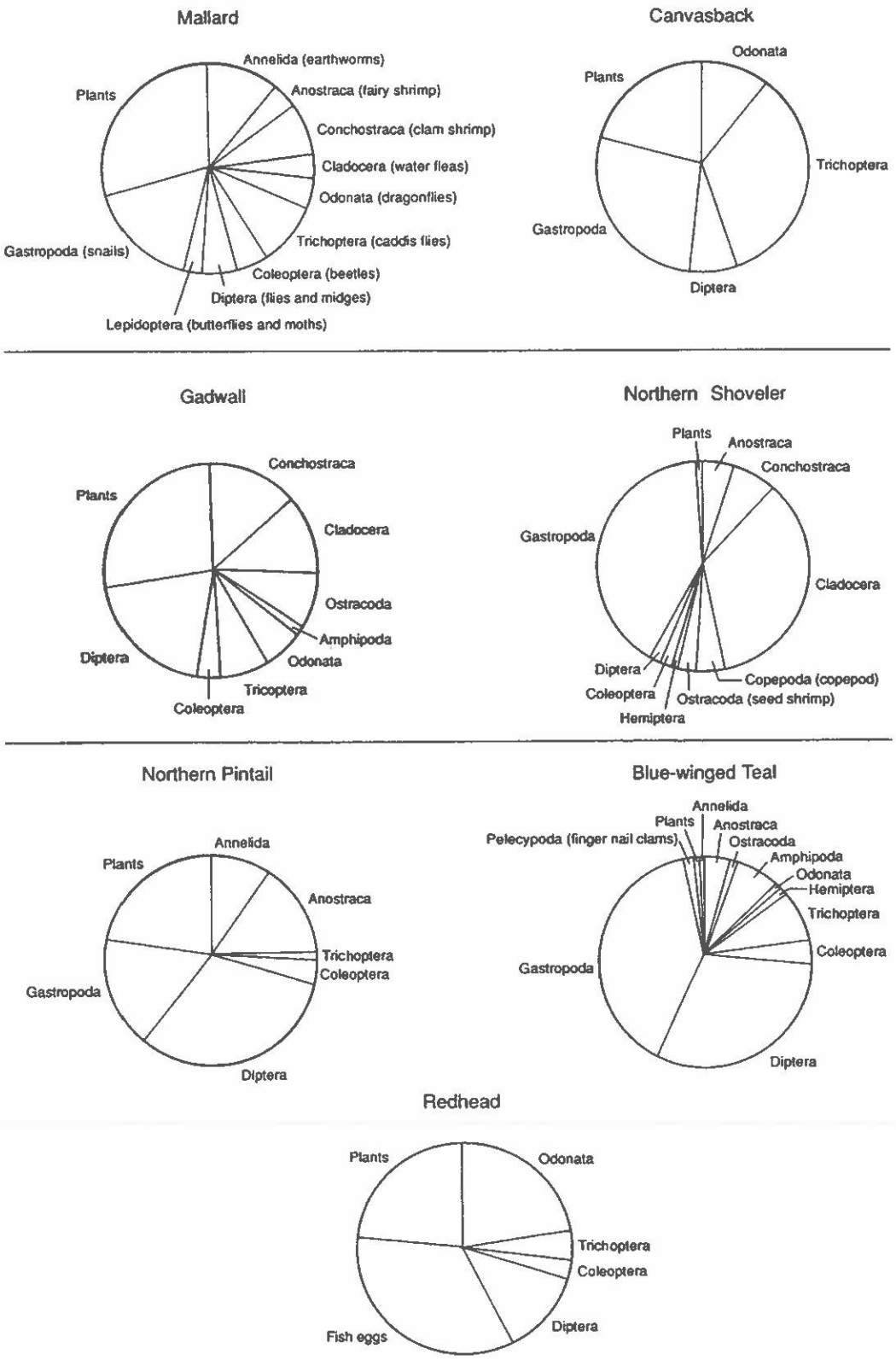
Swanson, G. A., G. L. Krapu, and J. R. Serie. 1979. Foods of laying female dabbling ducks on the breeding grounds. Pages 47–57 in T. A. Bookhout, ed. Waterfowl and wetlands—an integrated review. North-central Section, The Wildlife Society, Madison, Wis.

Swanson, G. A., M. I. Meyer, and V. A. Adomaitus. 1985. Foods consumed by breeding mallards on wetlands of south-central North Dakota. J. Wildl. Manage. 49:197–203.

van der Valk, A. 1989. Northern prairie wetlands. Iowa State University Press, Ames. 400 pp.

Weller, M. W. 1987. Freshwater marshes: ecology and wildlife management. Second ed. University of Minnesota Press, Minneapolis. 150 pp.

Wiggins, G. B., R. J. MacKay, and I. M. Smith. 1980. Evolutionary and ecological strategies of animals in annual temporary pools. Arch. Hydrobiol. Suppl. 58:97–206.



Dietary preferences by laying females of 7 duck species.

Appendix. Common and Scientific Names of Animals Mentioned in the Text.

Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Lesser scaup	*Aythya affinis*
Redhead	*Aythya americana*
Greater scaup	*Aythya marila*
Canvasback	*Aythya valisineria*

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
***Fish and Wildlife Leaflet* 13**
Washington, D.C. • 1990

13.3.1. Invertebrate Response to Wetland Management

Leigh H. Fredrickson and Fredric A. Reed
Gaylord Memorial Laboratory
School of Forestry, Fisheries and Wildlife
University of Missouri–Columbia
Puxico, MO 63960

By gaining greater understanding and appreciation of wetland environments, managers have developed creative insights for waterfowl conservation. Among the most exciting new developments in the understanding of functional wetlands has been the recognition of the important roles of invertebrates in aquatic ecosystems. These roles include trophic linkage from primary production to secondary consumers such as waterfowl, packaging of specific nutritional components such as amino acids and micronutrients for vertebrate predators, and detrital processing of wetland organic material. Although specific invertebrate responses to various management techniques are not always predictable and may differ among invertebrate species, patterns related to water regimes, water chemistry, and vegetative structure have emerged. Managers should consider the following invertebrate responses to natural and manipulated wetland complexes when managing for waterfowl.

Importance to Waterbirds

Although wetland systems are some of the most productive ecosystems in the world in terms of vegetation biomass, few duck species acquire substantial energetic or nutritional resources directly from consumption of plant material other than seeds. Much of the energy from plants is initially transferred to the primary consumers which include a diverse group of invertebrate species. A variety of invertebrates are consumed by waterfowl. Ducks rely heavily on invertebrates as a major food source throughout the annual cycle. Dabbling and diving ducks use invertebrates extensively during protein-demanding periods, such as egg laying or molt (Table 1). Duck species are adapted to consumption of invertebrate prey by selection of microhabitats, structure of the bill and lamellae and foraging strategies.

Relation to Water Regimes

Long-term hydrologic cycles have shaped the life history strategies of wetland invertebrates. These organisms have developed many adaptations that include:

- egg or pupal stages which can tolerate drought periods,
- initiation of egg development only after specific water/oxygen levels have been reached,
- marked seasonality in life cycle,
- rapid development,
- large number of offspring (high reproductive potential)
- obligate diapause (period of nondevelopment) tied to seasonal flooding, and
- parthenogenic reproduction (as in cladocera).

Invertebrates often move into deeper pools, wetland sediments within the water table, and other nearby wetlands when water levels drop or change within a specific wetland. Many species (e.g.,

Table 1. *Invertebrates consumed by laying female waterfowl collected from 1967 to 1980 in North Dakota. Data expressed as aggregate percent by volume. Modified from Swanson 1984.*

Food item	Blue-winged teal (20)	Northern shoveler (15)	Gadwall (saline) (20)	Gadwall (fresh) (35)	Mallard (37)	Northern pintail (31)
Snails	**38**	**40**	**0**	**4**	**16**	**15**
Insects	**44**	**5**	**52**	**36**	**27**	**37**
Caddis flies	7	tr	1	8	9	1
Beetles	3	2	16	4	5	3
True flies	32	2	26	18	6	3
Midges	20	1	26	17	4	20
Miscellaneous	2	1	9	6	7	0
Crustaceans	**14**	**54**	**20**	**32**	**13**	**14**
Fairy shrimps	5	6	tr	0	4	14
Clam shrimps	tr	7	0	14	6	tr
Water fleas	0	33	10	10	3	tr
Scuds	8	0	0	7	tr	tr
Miscellaneous	1	8	10	7	tr	tr
Annelids	**1**	**0**	**0**	**tr**	**13**	**11**
Miscellaneous	2	0	0	0	3	0
Total	**99**	**99**	**72**	**72**	**72**	**77**

leeches, crayfish) will burrow in sediments to avoid desiccation. Adults of several insect groups may fly to other wetlands if conditions become unsuitable. Flight distances may be less than a few yards to another basin within a wetland complex or more than 50 miles to a distant wetland.

Long-term hydrologic changes shape invertebrate life history strategies. Short-term hydrologic regimes may determine the actual occurrence and abundance of invertebrates. Flooding affects wetland invertebrate occurrence, growth, survival, and reproduction. Entirely different invertebrate communities (Fig. 1) are present in wetland basins with differing hydrological regimes (timing, depth, and duration of flooding). As litter is flooded, nutrients and detrital material (as coarse particulate organic matter) are released for a host of aquatic invertebrates (Fig. 2). As material is broken down into finer particles (fine particulate organic matter), organisms that gather detritus or filter feed will take advantage of the newly available foods. Grazing organisms (Fig. 3) feed on free-floating algae or periphyton, which grows on aquatic plant surfaces. When litter material is consumed, invertebrate populations decrease rapidly. Thus, prolonged flooding (longer than 1 year) of uniform depth leads to reduced wetland invertebrate numbers and diversity. Freezing may also lower spring invertebrate populations in northern locations.

Association with Vegetation Structure

Water regimes not only directly affect invertebrate populations, but indirectly affect other fauna through modification of aquatic plant communities. Hydrological regimes influence germination, seed or tuber production and maturation, and plant structure of aquatic macrophytes. Invertebrate associations are influenced by the leaf shape, structure, and surface area of aquatic vegetation. Macrophytes with highly dissected leaves, such as smartweeds, tend to support greater invertebrate assemblages than do plants with more simple leaf structure, such as American lotus (Fig. 4). The composition of invertebrate populations is associated with plant succession.

Discing and other physical treatments are regularly used to modify less desired plant communities. Initial invertebrate response is great following shallow discing in late summer when the shredded plant material is flooded immediately. The shredding of coarse litter material by discing results in quick decomposition in fall, but invertebrate numbers are reduced the following spring. Cutting robust, emergent vegetation above the ice in winter can also result in a rapid invertebrate response, after spring thaw.

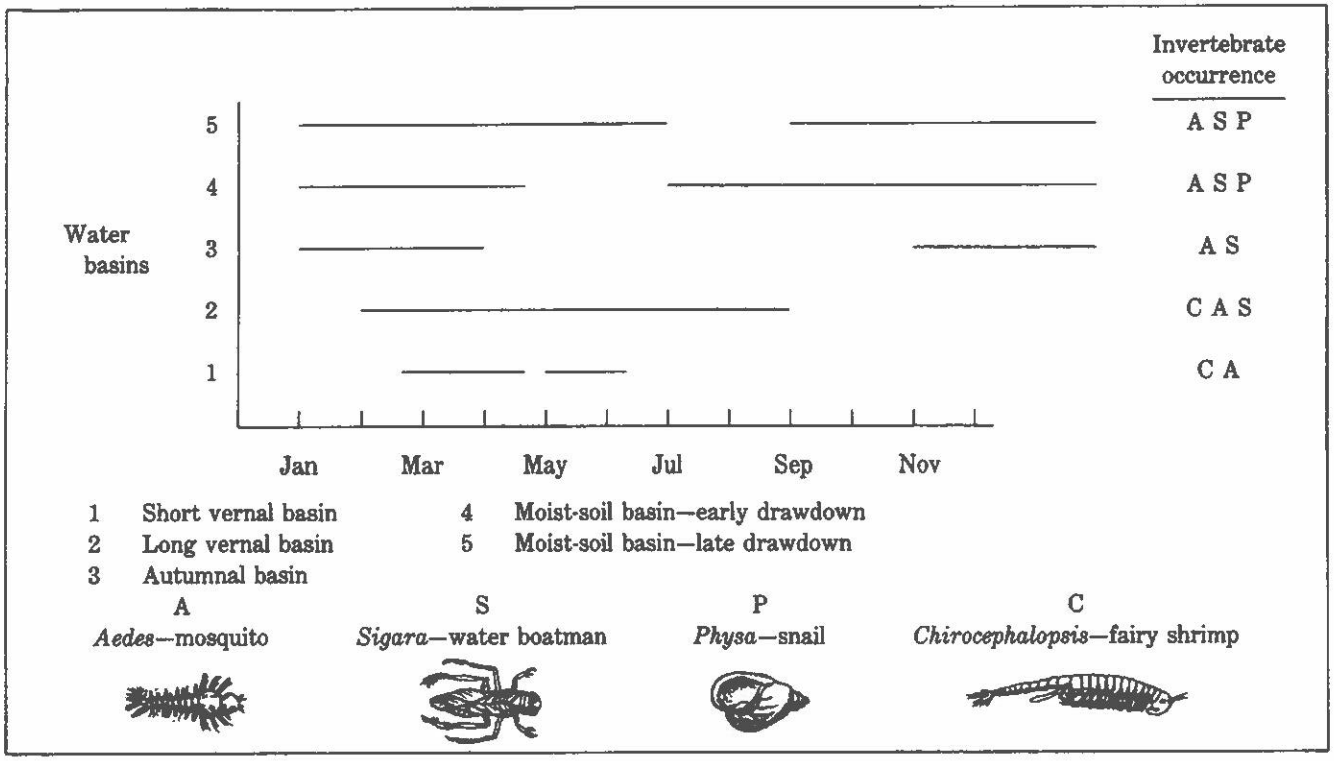


Figure 1. Occurrence of four common invertebrate genera relative to water regimes of five different seasonally flooded basins. Horizontal lines represent presence of water.

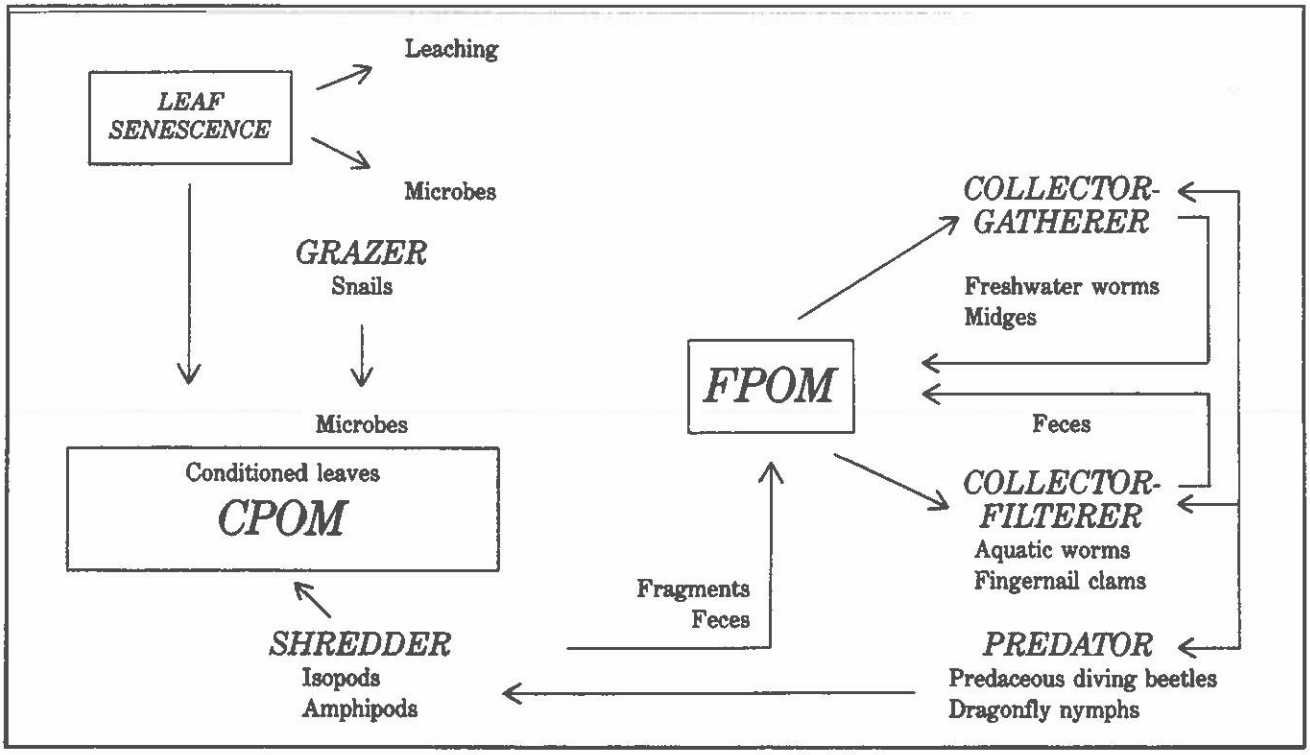


Figure 2. Invertebrate detritivore community. CPOM = Coarse particulate organic matter; FPOM = Fine particulate organic matter.

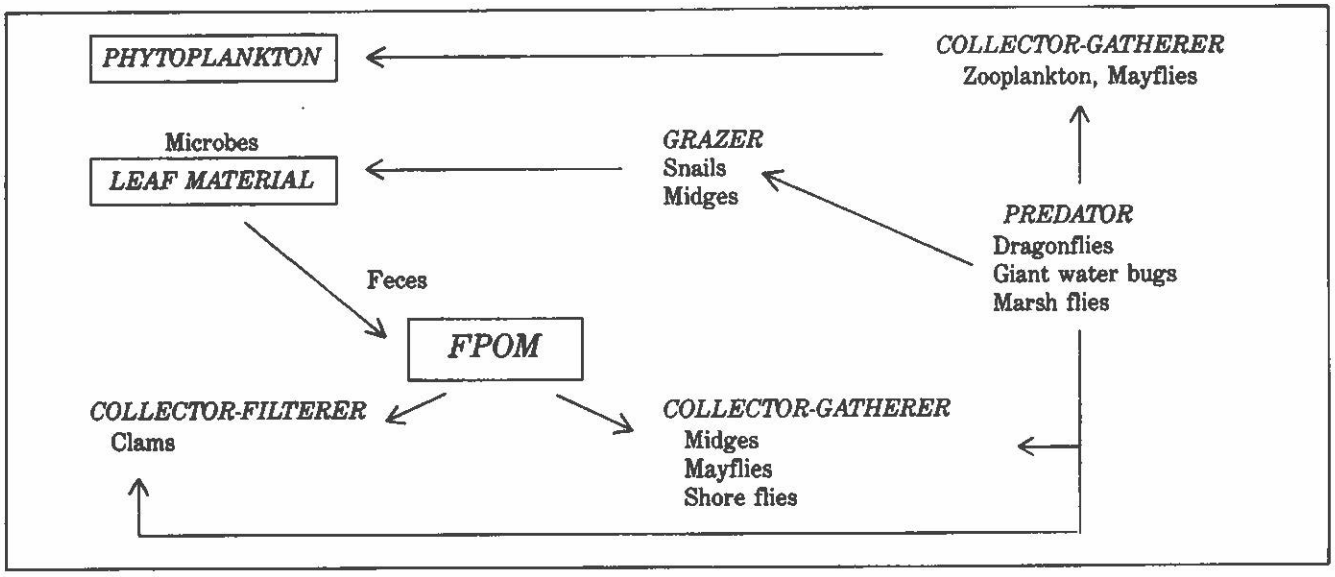


Figure 3. Invertebrate grazer community. FPOM = Fine particulate organic matter.

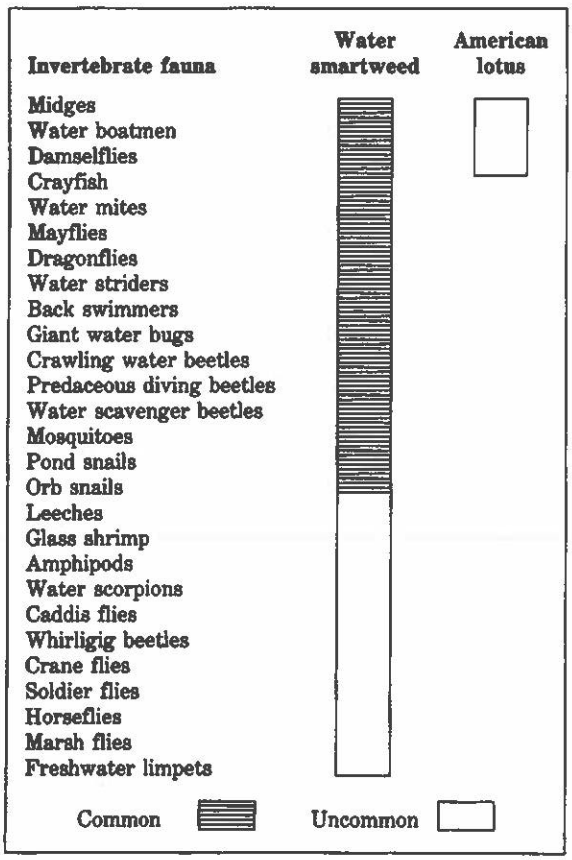


Figure 4. Macroinvertebrates associated with water smartweed and American lotus in seasonally flooded wetlands.

Management Implications

Acquisition of wetlands or protection of previously acquired wetland complexes will continue to be the best means to support diverse invertebrate fauna. The restoration of disturbed wetlands has its greatest potential in areas of marginal agricultural lands. Pesticide use should be eliminated on all refuge areas, regardless of proximity to urban sites where mosquito control is a concern, or the quality of such wildlife areas will be reduced. Inflow waters must be monitored for pollutants and pesticides. The timing of water movements should coincide with the exploitation of leaf litter by invertebrates. Waters should not be drained when nutrient export may be high, such as in early stages of leaf litter decomposition. Present knowledge of water manipulations suggests that management for specific aquatic or semi-aquatic plant communities may be the most practical means of increasing invertebrate production. Managers can enhance the potential for invertebrate consumption by waterfowl if peak periods of waterfowl use of wetlands coincide with reduced water levels. Exploitation of invertebrates by waterbirds can be optimized through shallow water levels, partial drawdowns that concentrate prey, and extended (3–5 week) drawdowns with "feather-edge" flooding to increase the available time and area for foraging.

Suggested Reading

Batema, D.L., G.S. Henderson, and L.H. Fredrickson. 1985. Wetland invertebrate distribution in bottomland hardwoods as influenced by forest type and flooding regime. Pages 196–202 *in* Proc. Fifth Annu. Hardwood Conf., Univ. Ill., Urbana.

Cummins, K.W. 1973. Trophic relations of aquatic insects. Annu. Rev. Entomol. 18:183–206.

Euliss, N.H. Jr., and G. Grodhaus. 1987. Management of midges and other invertebrates for waterfowl wintering in California. Calif. Fish and Game. 73:242–247.

Murkin, H.R., and J.A. Kadlec. 1986. Responses by benthic macroinvertebrates to prolonged flooding of marsh habitat. Can. J. Zool. 64:65–72.

Murkin H.R., R.M. Kaminski, and R.D. Titman. 1982. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Can. J. Zool. 60:2324–2332.

Nelson, J.W., and J.A. Kadlec. 1984. A conceptual approach to relating habitat structure and macroinvertebrate production in freshwater wetlands. Trans. N. Am. Wildl. Nat. Resour. Conf. 49:262–270.

Reid, F.A. 1985. Wetland invertebrates in relation to hydrology and water chemistry. Pages 72–79 *in* M.D. Knighton, ed. Water Impoundments for Wildlife: A Habitat Management Workshop. U.S. Dep. Agric. For. Serv., St. Paul, Minn. 136 pp.

Swanson, G.A. 1984. Invertebrates consumed by dabbling ducks (Anatinae) on the breeding grounds. J. Minn. Acad. Sci. 50:37–40

Swanson, G.A. and M.I. Meyer. 1977. Impact of fluctuating water levels on feeding ecology of breeding blue-winged teal. J. Wildl. Manage. 41:426–433.

Wrubleski, D.A. 1987. Chironomidae (Diptera) of peatlands and marshes in Canada. Mem. Ent. Soc. Can. 140:141–161.

Appendix. Common and Scientific Names of Plants and Animals Named in Text.

Plants

American lotus	*Nelumbo lutea*
Smartweed	*Polygonum* spp.
Water smartweed *or* marsh knotweed	*Polygonum coccineum*

Birds

Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*

Invertebrates (Families)

Crayfish	Astacidae
Giant water bugs	Belostomatidae
Midges	Chronomidae
Water boatmen	Corixidae
Mosquitoes	Culicidae
Predaceous diving beetles	Dytiscidae
Water striders	Gerridae
Whirligig beetles	Gyrinidae
Crawling water beetles	Haliplidae
Water scavenger beetles	Hydrophilidae
Pond snails	Lymnaeidae
Water scorpions	Nepidae
Back swimmers	Notonectidae
Orb snails	Planorbidae
Marsh flies	Sciomyzidae
Soldier flies	Stratiomyidae
Horseflies	Tabanidae
Crane flies	Tipulidae

Invertebrates (Orders)

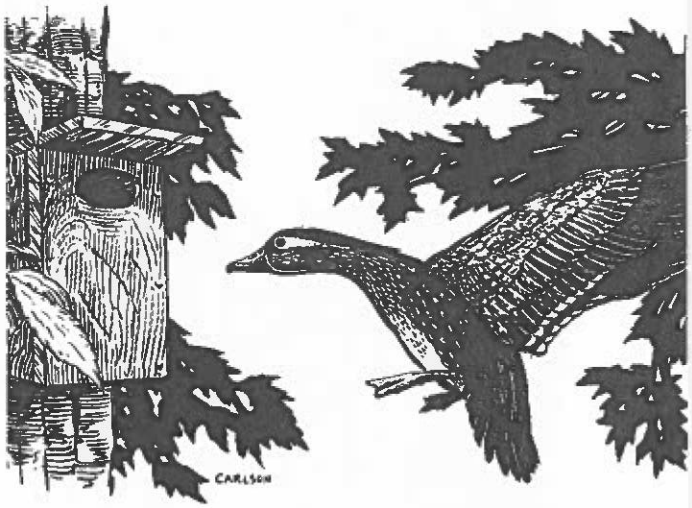
Scuds *or* sideswimmers	Amphipoda
Leeches	Annelida
Fairy shrimp	Anostraca
Water fleas	Cladocera
Beetles	Coleoptera
Clam shrimp	Conchostraca
True flies	Diptera
Mayflies	Ephemeroptera
Water mites	Hydracarina
Isopods	Isopoda
Damselflies, dragonflies	Odonata
Caddis flies	Trichoptera

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
***Fish and Wildlife Leaflet* 13**
Washington, D.C. • 1988

Life History and Wetland Management For Wood Ducks

Photo courtesy of Ducks Unlimited.

13.1.6. Life History and Habitat Needs of the Wood Duck



Katie M. Dugger
Gaylord Memorial Laboratory
The School of Natural Resources
University of Missouri—Columbia
Puxico, Missouri 63960

and

Leigh H. Fredrickson
Gaylord Memorial Laboratory
The School of Natural Resources
University of Missouri—Columbia
Puxico, Missouri 63960

The wood duck is North America's most widely distributed endemic species, and most of its wintering and breeding range falls within the 48 contiguous states (Fig. 1). The wood duck inhabits forested wetlands and, because of its need for nest cavities, is closely tied to North America's remaining forest resources. Habitat destruction, market hunting, and liberal hunting seasons contributed to drastic declines and, in some cases, regional eradication of local wood duck populations. Subsequent implementation of hunting restrictions and the high reproductive rate of the species are responsible for the recovery of wood duck populations to current stable levels.

As prairie duck populations continue to decline, hunting pressure on the wood duck continues to increase. The wood duck is popular with hunters and consistently ranks high among species in Atlantic and Mississippi flyway duck harvests.

Species Profile—Wood Duck

Scientific name: *Aix sponsa*
Weight in pounds (grams):
Adults—male 1.5 (682), female 1.5 (673)
Immatures—male 1.5 (668), female 1.4 (614)
Age at first breeding: 1 year
Clutch size: 12, normal range 7–15
Incubation period: 30 days, range 26–37
Age at fledging: 56–70 days
Nest sites: Tree cavities or artificial nest boxes within about 0.6 mi (1 km) of water.
Food habits: Omnivorous. Plant foods include primarily acorns, maple samaras, elm seeds, and moist-soil plant seeds. Animal foods consist mainly of aquatic-associated and nonaquatic insects, but also some aquatic invertebrates.

Harvest pressure and continued degradation of riparian and lowland hardwood forests increases the need for a thorough understanding of wood duck population dynamics. Equally important to sustaining current wood duck population levels is an understanding of annual life cycle events and requirements.

Distribution

Three distinct wood duck populations occur in North America: the Atlantic, Interior, and Pacific. The Atlantic population includes states of the

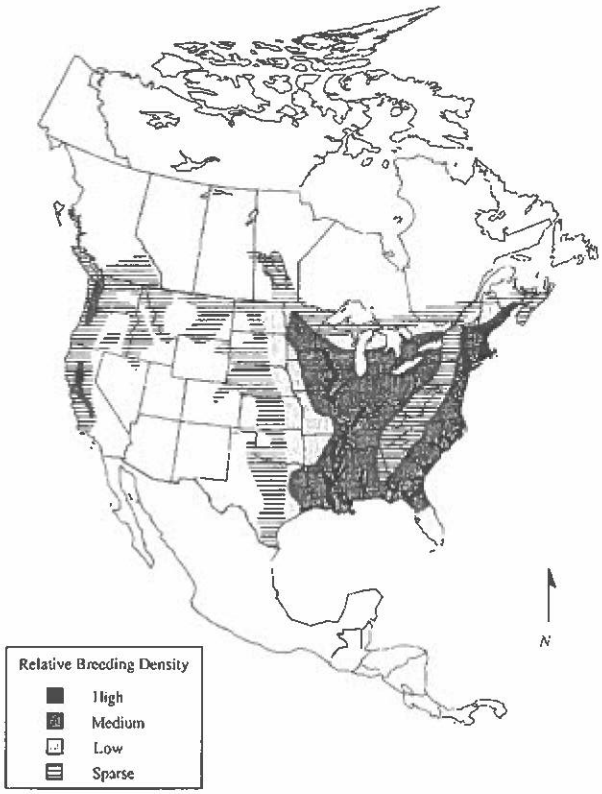


Fig. 1. Current wood duck breeding distribution (after Fredrickson et al. 1990).

Atlantic Flyway and southeastern Canada, the extreme northern range of the wood duck. The Interior population includes wood ducks throughout the Mississippi Flyway, part of Ontario, and the eastern tier of states in the Central Flyway. Historically, the Rocky Mountains and treeless portions of the Great Plains created a discontinuity between the Interior and Pacific populations. As woody riparian corridors developed in the plains, a westward expansion by breeding wood ducks occurred throughout the Great Plains states after the 1960's (Fig. 1). Currently, northern portions of the Pacific and Interior populations are contiguous. The Pacific population ranges principally from British Columbia southward into Washington, Oregon, California, northwestern Idaho, and western Montana, but small numbers of breeding wood ducks are also present in Nevada, Utah, New Mexico, and Arizona. Wood ducks breed throughout most of their range but are at particularly high breeding densities in the Mississippi alluvial valley (Fig. 1). Wintering wood ducks use the more southern habitats throughout their range; habitats of greatest importance include California's Central Valley and the southern states of the Mississippi and Atlantic flyways (Fig. 2).

Population Status and Harvest

Traditional aerial census techniques are ineffective in forested habitats; thus, the current status of wood duck populations can only be approximated.

The average annual wood duck harvest before 1963 was <165,000 birds, but during 1980–1989, an annual average of 1,067,000 wood ducks was harvested in the United States (Frank Bellrose, personal communication). While the dramatic increase in wood duck harvest levels since the 1960's can be attributed to an overall increase in the continental wood duck population, the interactions between wood duck population

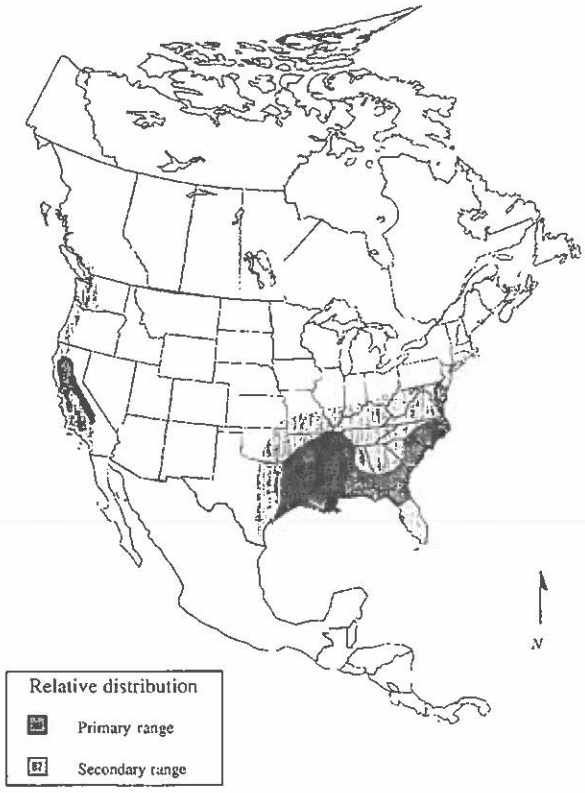


Fig. 2. Wood duck winter distribution (after Bellrose 1980).

dynamics and harvest levels is poorly understood. Current research and historic events suggest harvest regulations can have an effect on wood duck populations in some situations. For example, female wood ducks breeding in northern areas are extremely susceptible to hunting during early seasons that open before the onset of migration. In addition, northern birds are subjected to continued harvest pressure as they migrate southward to winter because waterfowl hunting seasons open in succession from north to south.

Spring Migration and Breeding

In southern regions, wood ducks breed and winter in essentially the same areas. Birds that nest farther north begin northward movements in late winter. Wood duck nests are initiated as early as late January in the South, early March in the Midwest, and mid March to early April in the North. Migrating female wood ducks lack the fat and protein reserves necessary for egg production when they arrive on the breeding grounds. Therefore, upon arrival, wood duck pairs disperse into forested and riparian habitats where females forage intensively in preparation for egg laying.

During this time, nesting pairs also begin searching for suitable cavities, primarily in tracts of forest adjacent to important waterways. Although natural cavities within 0.3 mile (0.5 km) of water and near forest canopy openings are preferred, wood ducks will nest ≥0.6 mile (1 km) from water when necessary. The availability of suitable cavities varies within the wood duck's range (Table 1) because some tree species develop cavities more readily than others. Large trees, ≥12 inches (30 cm) dbh (diameter breast height), produce the most important cavities for wood ducks. Cavities with an entrance size of ≥3.5 inches (8.9 cm), an interior basal area of ≥40 square inches (258 cm^2), and height ≥6 feet (2 m) above the ground are preferred for nesting.

Average clutch size is 12 eggs, but more than one female may contribute to a clutch (dump nest), which can result in clutches of more than 60 eggs. These huge clutches are rarely incubated, but successful dump nests of less than 30 eggs are common in nest boxes. A wood duck clutch is incubated for an average of 30 days at middle latitudes and a few days less in the South.

Female wood ducks and their broods are highly mobile. Initial movements by broods after leaving a nest can be up to 2.4 miles (4 km) but average 0.8 mile (1.3 km), mostly along waterways. Shallowly flooded habitat with good understory cover, such as shrub–scrub or emergent vegetation, is the most important habitat for wood duck broods. Duckling survival ranges from 36 to 65% with most mortality (86–91%) occurring the first week after hatching. Common duckling predators include mink, raccoon, snapping turtle, bullfrog, largemouth bass, and other large predatory fishes.

The bond between the female and her brood begins to weaken after about 4 weeks; ducklings fledge between 6 and 8 weeks. Some early-nesting

Table 1. *Nest cavity density in some North American tree species.*

Location	Species	Cavity density	
		Number/acre	Number/hectare
Southeastern Missouri	Blackgum, green ash, pumpkin ash, red maple	0.13	0.33
Illinois	Black oak, bitternut hickory, mockernut hickory, blackjack oak, red oak, American elm, hackberry	0.21	0.51
Massachusetts	Apple, ash, maple	—	—
New Brunswick	Silver maple, American elm	2.23	5.50
Indiana	American beech, American sycamore, red maple	0.50	1.23
Minnesota	Quaking aspen, American elm, sugar maple, basswood	1.70	4.20
Wisconsin	Silver maple, sugar maple, basswood, quaking aspen	0.26	0.65
Mississippi	American sycamore, American beech, blackgum, shagbark hickory, water oak, cherrybark oak	0.08	0.19
	Overcup oak, slippery elm, sugarberry	0.09	0.23

females in southern latitudes renest, successfully producing two broods before finishing the Prebasic molt (Table 2). Females begin the Prebasic molt in early spring, but it is interrupted during nesting and is not completed until late summer (Fig. 3), when the females regain their flight feathers. Conversely, males may acquire their eclipse plumage as early as mid-May. After the female begins incubation, the male wood duck begins the Prebasic molt and becomes flightless about 3 weeks later. After regaining flight (in about 22 days), the male begins the Prealternate molt and returns to Alternate plumage by late summer.

Table 2. *Length of breeding season and frequency of double brooding in wood ducks.*

Location	Mean length of breeding season (days)	Captured females (*n*)	Double-brooding females (%)	Mean interval between clutches (days)
Alabama	159	231	9.2	37
South Carolina	157	275	7.6	47
California	134	1,540	3.6	26 ± 1.7
Missouri	132	924	2.2	33 ± 1.8
Massachusetts	95	—	—	—

Post-breeding Dispersal and Fall Migration

After completing the Prebasic molt and before southward migration begins, adult and immature males, as well as some immature females, disperse radially from their breeding and natal areas into new habitats. At southern latitudes, this dispersal tends to be lateral, but in central and northern regions, northward dispersal is most common. In late September, wood ducks begin migrating south. During peak migration in October and November, wood duck numbers fluctuate erratically at migration stopovers where they form large roosting flocks (>100 birds). On the wintering grounds, smaller groups (<30 birds) are more common.

Behavior and Pairing

Wood ducks begin courting before fall migration. Courting activity drops off during harsh weather in winter and resumes in spring. Courtship activity is more intense in fall than in spring; courting parties are larger and displays are longer and more frequent. Wood ducks breed as yearlings, but evidence suggests that only about 40% of the surviving yearling females nest each season. Yearling females produce smaller clutches and fledge fewer young than experienced nesters. The productivity of young male wood ducks may also be low. When compared with adult drakes, yearling males do not perform courtship displays with the proper orientation and timing. Thus, early pairing by inexperienced males is unlikely.

Foraging Ecology

Food habits of adult wood ducks are sex related and seasonally driven (Fig. 4). During winter, nearly 100% of the diet of wood ducks consists of plant foods, of which 75% may be acorns. An increase in animal foods in the diet (to about 35%) occurs in both sexes in early spring. This percentage remains constant for the male wood duck through summer and fall while undergoing the Prebasic and Prealternate molts, but increases to about 80% for the female during egg laying. Female wood ducks increase the amount of invertebrates in the diet to meet daily protein needs during egg laying. After egg-laying, animal foods compose less of the female's diet, while consumption of high-energy seeds increases to meet the daily dietary requirements of incubation (Fig. 4).

Wood ducks consume a variety of plant and animal foods (see Appendix), typically by pecking or dabbling at foods on the surface. Subsurface and bottom feeding are rare. Therefore, shallow depths are important to make food available to foraging wood ducks. Because wood ducks feed mainly on the surface or at the edge of wetlands, nonaquatic and aquatic-associated invertebrates make up a large percentage of the invertebrates consumed. Live-forest and emergent vegetation are common wood duck foraging habitats. Wood ducks do not forage readily in agricultural fields unless shallowly flooded, live-forest habitats are not available.

Habitat Management

The wood duck carries out its entire annual cycle within a forested wetland complex, including a mixture of habitats such as live forest, greentree

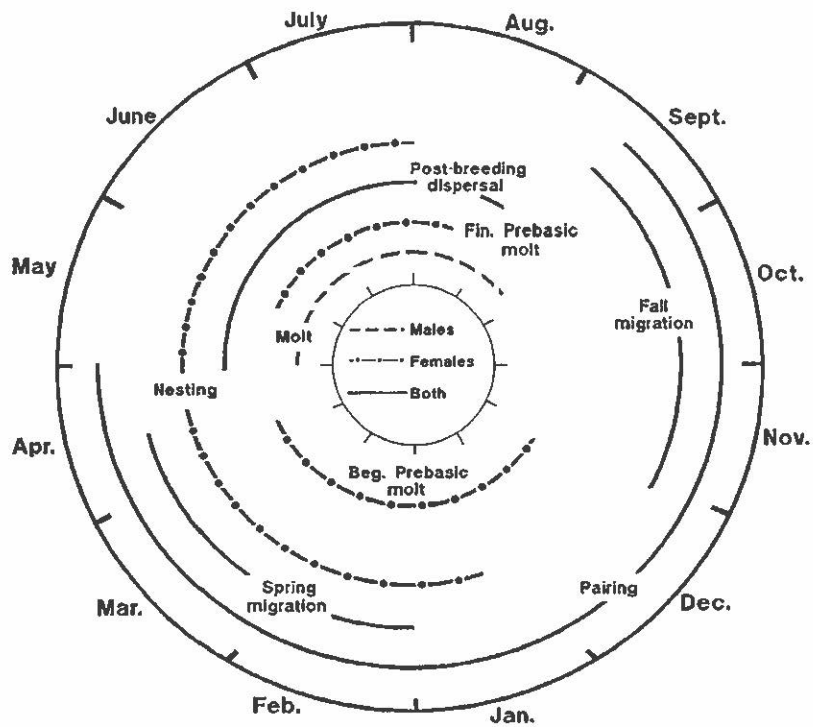


Fig. 3. The chronology of important life history events in the annual cycle of the wood duck.

reservoirs, rivers, oxbows, riparian corridors, beaver ponds, shrub–scrub, and robust emergent vegetation. Such habitats have been destroyed or modified across the continent. For example, only 17% of the original forest acreage remains in the Mississippi alluvial valley today. In addition, certain management practices have detrimental effects on tree vigor and mast production. Flooding before fall senescence or beyond dormancy into the growing season reduces mast production, causes tree damage, and may eventually kill trees. Improper flooding regimes change tree species composition in a stand from desirable oak species that produce small acorns, easily eaten by waterfowl, to the more water-tolerant overcup oak, which produces very large acorns that are unsuitable for waterfowl food. Water depths ≤8 inches (20 cm) are ideal for foraging wood ducks, while loafing and roosting sites can be maintained where water levels are higher.

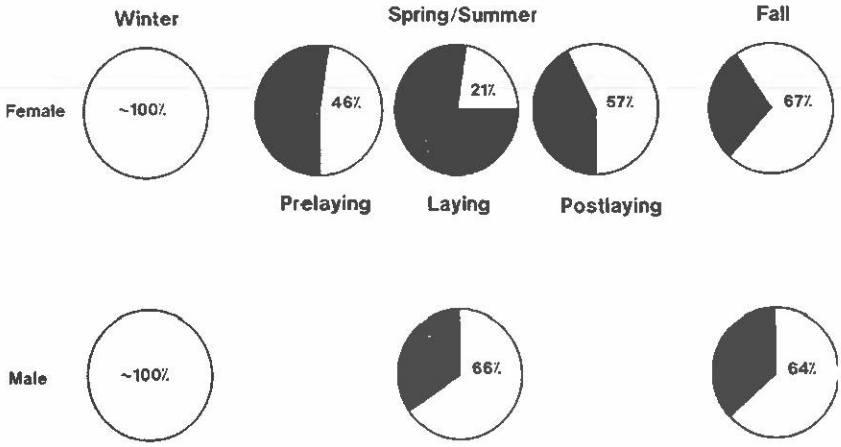


Fig. 4. Proportion of plant (open) and animal (dark) foods consumed by wood ducks throughout their annual cycle.

Timber management within greentree reservoirs and naturally flooded forests is an important component of habitat management for wood ducks. Most timber harvest practices remove large, overmature trees, the primary source of wood duck nest cavities. Although selective thinning within a stand promotes regeneration of desirable shade-intolerant red oak species, some large and overmature trees should be preserved as potential wood duck nest sites. In addition, a mix of species within a stand should be encouraged because desirable mast species may not form cavities. Elm and maple are important components of most wood duck habitat because they provide protein-rich samaras in spring and suitable nest cavities (Table 1).

Nest boxes are a useful management tool where natural cavities are scarce but good brood habitat is available. Currently, nest box management may contribute approximately 150,000 juvenile wood ducks to fall flights in the Mississippi and Atlantic flyways. Although this constitutes only a small portion of the juvenile component in the eastern fall flight, nest boxes, when properly erected and maintained, can substantially increase local populations.

Wood ducks will readily nest in boxes constructed of wood, metal, or plastic. Rough-cut cypress boxes are durable, economical, and blend well with the environment within a few years. Although plastic and metal boxes are durable, internal temperatures of boxes placed in the direct sun in the South are high enough to kill developing embryos.

Whatever the construction material, boxes must be predator-proof. Inverted conical shields or smooth, wide pieces of metal wrapped around the pole or tree beneath a box can keep raccoons and some snakes from entering boxes. Predation can also be discouraged by placing boxes on poles over water or by mounting boxes on bent metal brackets that suspend them 2 feet (0.6 m) from a tree or post.

Annual maintenance and repair of boxes is necessary for continued use by wood ducks. Boxes with unsuccessful nests are unavailable for use until debris from the nest is removed. The frequency of box checks necessary for maintenance depends on climatic conditions and the types of use boxes receive during winter (e.g., screech-owl roosts, squirrel or raccoon dens).

Number and placement patterns of nest boxes within habitats influence box use, nest success, and dump-nesting rates. When box management began 50 years ago, some local wood duck populations were small, and box use was higher when boxes were placed in highly visible, clumped arrangements rather than as widely spaced single units. As wood duck populations grew, high dump-nesting rates, nesting interference, and overall decreases in production occurred. In some situations, single, well-spaced boxes may decrease dump-nesting and nesting interference; however, in prime wood duck breeding habitats hidden boxes simply require more effort to maintain. Boxes acceptable to nesting wood ducks must also be accessible to managers for maintenance and data collection. Although wood duck boxes can increase local production, the preservation of bottomland hardwoods and proper water and timber management in these habitats are paramount to the continued success of continental wood duck populations.

Summary

Although current wood duck populations are stable, continued preservation and proper management of bottomland hardwood and riparian forest resources are imperative. Wood duck population estimates are inaccurate; hence, managers have little knowledge about population cycles or the effect of increased hunting pressure on the continental population. Moreover, protecting North America's remaining forest resources in the face of increasing agricultural and commercial development remains difficult. In particular, forest resources in the lower Mississippi alluvial valley must be carefully preserved and managed to continue providing wintering habitat for a large percentage of the continental wood duck and mallard populations.

At the local level, wood duck populations can be boosted by production from nest boxes, but more information is needed on the density-dependent effects of box placement on nesting interference. Nest box maintenance can be expensive and time consuming. Thus, management for natural cavities should be encouraged. Flooding of greentree reservoirs should simulate natural hydrology and reflect wood duck water depth needs. Remaining forested habitats should be protected and maintained in the best possible condition to sustain larger numbers of birds throughout their annual cycle as high quality habitat continues to disappear.

Suggested Reading

Bellrose, F. C. 1980. Ducks, geese and swans of North America. Third ed. Stackpole Books, Harrisburg, Penn. 540 pp.

Delnicke, D., and K. J. Reinecke. 1986. Mid-winter food use and body weights of mallards and wood ducks in Mississippi. Journal of Wildlife Management 50:43–51.

Fredrickson, L. H., G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, editors. 1990. Proceedings of the 1988 North American Wood Duck Symposium, St. Louis, Mo. 390 pp.

Grice, D., and J. P. Rogers. 1965. The wood duck in Massachusetts. Massachusetts Division of Fish and Game, Final Report Federal Aid in Wildlife Restoration Project W-19-R. 96 pp.

Trefethen, J. B., editor. 1966. Wood duck management and research: a symposium. Wildlife Management Institute, Washington, D.C. 212 pp.

Appendix. Common and Scientific Names of Plants and Animals Named in Text.

Plants

Red maple	*Acer rubrum*
Silver maple	*Acer saccharinum*
Sugar maple	*Acer saccharum*
*Maple	*Acer* spp.
*Asiatic dayflower	*Aneilema keisak*
*Beggarticks	*Bidens* spp.
*Watershield	*Brassenia schreberi*
Bitternut hickory	*Carya cordiformis*
Shagbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
Sugarberry	*Celtis laevigata*
Hackberry	*Celtis occidentalis*
*Buttonbush	*Cephalanthus occidentalis*
*Barnyard grass	*Echinochloa crusgalli*
*Barnyard grass	*Echinochloa muricata*
American beech	*Fagus grandifolia*
Green ash	*Fraxinus pennsylvanica*
*Ash	*Fraxinus* spp.
Pumpkin ash	*Fraxinus tomentosa*
*Soybeans	*Glycine max*
*St. John's-wort	*Hypericum walteri*
*Rice cutgrass	*Leersia oryzoides*
*Sweetgum	*Liquidambar stryraciflua*
*Primrose willow	*Ludwigia leptocarpa*
*Water milfoil	*Myriophyllum pinnatum*
*White waterlily	*Nymphaea odorata*
Blackgum	*Nyssa sylvatica*
*Panic grasses	*Panicum* spp.
*Floating paspalum	*Paspalum fruitans*
American sycamore	*Platanus occidentalis*
*Smartweeds	*Polygonum* spp.
Quaking aspen	*Populus tremuloides*
*Pondweeds	*Potamogeton* spp.
Apple	*Pyrus malus*
Cherrybark oak	*Quercus falcata*
Overcup oak	*Quercus lyrata*
Blackjack oak	*Quercus marilandica*
*Water oak	*Quercus nigra*
*Nuttall oak	*Quercus nuttallii*
*Pin oak	*Quercus palustris*
*Willow oak	*Quercus phellos*
Red oak	*Quercus rubra*
*Post oak	*Quercus stellata*
Oak	*Quercus* spp.

Black oak	*Quercus velutina*
*Blackberry	*Rubus cuneifolius*
*Sassafras	*Sassafras albidum*
*Slough grass	*Sclera reticularis*
*Big duckweed	*Spirodela polyrrhiza*
*Baldcypress	*Taxodium distichum*
Basswood	*Tilia americana*
American elm	*Ulmus americana*
Slippery elm	*Ulmus rubra*
Elm	*Ulmus* spp.
Black haw	*Viburnum prunifolium*
Grapes	*Vitus* spp.
Vertebrates	
Wood duck	*Aix sponsa*
Mallard	*Anas platyrhynchos*
Snapping turtle	*Chelydra serpentina*
Largemouth bass	*Micropterus salmoides*
Mink	*Mustela vison*
Screech-owl	*Otus* spp.
Raccoon	*Procyon lotor*
Bullfrog	*Rana catesbeiana*
Invertebrate taxa	
*Spiders	Araneida
*Crayfish	Astacidae
*Midges	Chironomidae
*Water boatmen	Corixidae
*Scuds	*Gammarus* sp.
*Whirligig beetles	Gyrinidae
*Sowbugs	Isopoda
*Back swimmers	Notonectidae
*Damselflies	Odonata
*Dragonflies	Odonata
*Orb snails	*Planorbis* sp.
*Caddis flies	Trichoptera

*Common wood duck foods.

Note: Use of trade names does not imply U.S. Government endorsement of commercial products.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
***Fish and Wildlife Leaflet* 13**
Washington, D.C. • 1992

13.4.7. Managing Beaver to Benefit Waterfowl

James K. Ringelman
Colorado Division of Wildlife
317 West Prospect Road
Fort Collins, CO 80526

Aside from humans, no other organism has the capacity to modify its environment as much as the beaver. In doing so, beaver create wetlands that provide valuable waterfowl habitats. Because beavers are widely distributed in North America (Fig. 1), beaver ponds can benefit waterfowl during breeding, migrating, and wintering periods. Mismanaged beaver populations, however, can severely degrade riparian habitats and become a costly problem. The key to successfully managing beaver for waterfowl benefits is understanding the values of beaver ponds in meeting the seasonal needs of waterfowl. Beaver populations must then be managed to provide these benefits in a self-sustaining manner compatible with the carrying capacity of the habitat.

Before the arrival of Europeans, 60-400 million beavers occupied 5.8 million square miles of North America. But by 1900, beavers had been so severely over-exploited by trappers and hunters that they were almost extinct. Today, beaver populations are on the upswing: 6 million to 12 million animals occupy diverse habitats ranging from the boreal forests of Canada south to the Texas gulf coast, and from California's Central Valley east to the Atlantic seaboard. This recent population increase is a testament to the resiliency of beaver populations and their responsiveness to management techniques. I review some techniques useful for managing beaver populations and enhancing beaver habitats to benefit waterfowl, and explain the ecological relations and characteristics that make beaver ponds attractive waterfowl habitats.

Beaver Ponds as Breeding Habitats for Waterfowl

Ecological Relations

Most of the important habitats created by beaver and used by breeding waterfowl are north of 40° latitude in the mixed hardwoods-coniferous forests of the Northeast, in the montane habitats of the West, in parklands and the Precambrian Shield regions of southern Canada, and in the boreal and subarctic forests of northern Canada. Beaver ponds in these regions are attractive to most dabbling duck species, particularly American black ducks, mallards, and green-winged teal. Hooded mergansers, ring-necked ducks, common goldeneyes, and buffleheads are common diving duck species found on beaver ponds. Beaver ponds also provide important breeding habitat for wood ducks throughout their breeding range.

A beaver colony is defined as a group of beavers occupying a pond or stretch of stream, using a common food supply, and maintaining a common dam or dams. An average of one or two beaver colonies per mile occur along suitable streams and

Fig. 1. Range of the beaver in North America. Modified from Novak 1987.

rivers. Each colony usually contains four to eight beavers. Their activities, most notably the creation of ponds by flooding of riparian habitats and removal of woody vegetation, may influence 20 to 40% of the total length of second- to fourth-order streams and may remain as part of the landscape for centuries. Unexploited beaver populations can create as many as 26 ponds per mile of stream length in suitable habitats, but typically the number of ponds ranges from three to six per mile. Most stream sections used by beaver have valley slopes of 1 to 6%, and of the remaining use, one-quarter occurs along sections with 7 to 12% slope. Beavers generally do not occupy streams where valley slopes exceed 15%. Suitability of a site also increases with valley width. First-order streams usually are narrow with high gradients and an undependable water supply, and therefore receive little use. Conversely, many streams greater than fourth-order often flood in spring, destroying on-channel beaver dams. On these streams and rivers, beaver activities are mostly confined to banks, backwater wetlands, and floodplains. Beavers commonly occupy natural lakes and glacial depressions, such as kettle ponds, throughout their range.

Availability of food is the most important biotic constraint to beaver distribution. In northern regions, beavers annually cut at least a ton of forage. Usually, they take food resources closest to their lodge or bank dens first. Most food is gathered within 100 yards of their pond. Although they will

consume a wide range of woody and herbaceous plants, beaver prefer quaking aspen, cottonwood, willow, alder, maple, birch, and cherry, supplemented by herbaceous emergents such as sedges and floating-leaved vegetation, including pondweeds and waterlilies. In agricultural areas, they consume a wide variety of crops such as corn and soybeans. Riparian zones dominated by deciduous tree species preferred by beaver may be virtually clear-cut. An important effect of removing this tree canopy is an increase in the density and height of the grass-forb-shrub layer, which enhances waterfowl nesting cover adjacent to ponds. Additionally, the deep channels created by beaver to help transport food within the pond provide travel lanes for breeding pairs and broods of waterfowl.

Beaver pond complexes create a wetland community with characteristics similar to waterfowl breeding habitats on the northern Great Plains. Most important among these characteristics is a wetland complex that is usually composed of several wetlands of varying sizes, shapes, depths, and successional stages. These diverse wetlands provide space for territorial birds to isolate themselves from individuals of the same species. Also, as in prairie habitats, such complexes enable breeding waterfowl to optimize their use of aquatic resources. For example, beaver colonies in highly desirable locations may persist for several decades, and wetlands may advance to late successional stages with vegetation and aquatic invertebrate communities functionally similar to semipermanent and permanent wetlands in the prairies. Other beaver ponds located on less suitable sites, or new ponds created by beavers dispersing from an established colony, may possess vegetative structure and invertebrate communities more similar to temporary or seasonal prairie wetlands. Wetland fertility, water permanency, and water temperature regimes also vary within a beaver pond complex.

In addition to increasing the quantity of wetlands available to waterfowl, beaver enhance wetland quality. Wetland fertility is increased because much of the sediment and organic matter that is normally carried downstream is retained behind beaver dams. Beavers also add new sources of organic matter in the form of fecal matter and the plant material they haul or fell into the pond and later use as food or building material. The net effect is an increase in the nutrient base for aquatic plants and invertebrates. Total invertebrate biomass and density in beaver ponds may be two to five times greater than in stream riffle sites, ranging from 1,000 to 6,800 organisms per square foot and from 0.1 to 1 gram per square foot, depending on the season. Moreover, the structure of invertebrate communities is changed as running-water taxa are replaced by pond taxa, which are more readily exploited by waterfowl. These aquatic invertebrates make up the protein food base so important to laying females and to growing ducklings.

The structural characteristics of beaver ponds also are attractive to breeding waterfowl. Habitat diversity increases as beaver flood lands and open forest canopies. The flooded area under the tree canopy and underlying shrub layer provides lateral and overhead cover sought by many dabbling duck pairs and broods. Later, northern flickers and other primary excavators may create waterfowl nesting cavities in the dead trees that remain standing in ponds. The "feathered edge," typical of many beaver ponds, creates shallow-water foraging areas that warm quickly in early spring, and often provides sites where seeds and invertebrates can be obtained. Beaver lodges and dams afford loafing areas and nesting sites for geese, ducks, and sandhill cranes, depending on the degree of vegetative concealment on the structure.

Management Strategies

Beaver ponds provide a mosaic of environmental conditions, dependent on pond size and age, successional status, substrate, and hydrologic characteristics. Hydrologic characteristics are especially important to waterfowl managers. Controlling water levels in beaver ponds is an important but sometimes difficult proposition. As in any nesting habitat, water in early spring must be sufficient to attract and hold breeding pairs, and stable enough to sustain water through the brood-rearing period. Beaver ponds located in relatively small watersheds, off the main channel, or with dams in disrepair, may have inadequate water in early spring. Such wetlands do not provide optimal habitat for waterfowl. Conversely, beaver ponds located in montane habitats far below snowline may fill with water from snowmelt about the time early-nesting waterfowl species complete their clutches, flooding nests located around the pond margin.

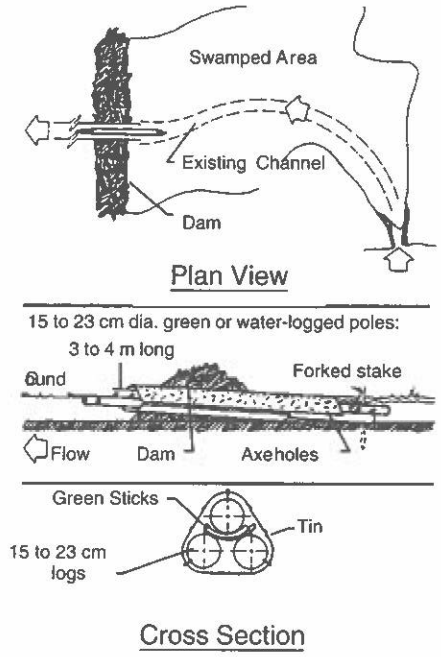
Consider transplanting beaver to a site if water and food are adequate, but dams are in disrepair because beavers have abandoned the area. If water

flow is inadequate, examine the feasibility of channeling water from a reliable source into the pond complex. One objective of managing beaver ponds as waterfowl breeding habitat should be to manage ponds for seasonally stable water levels.

Despite the benefits of stable water within the breeding season, this type of water regime reduces the productivity of beaver ponds when maintained over several years. The decline is primarily caused by anaerobic conditions, which bind nutrients to soil and organic matter, thereby making them unavailable to plants and animals. These anaerobic processes are exacerbated by the tranquil flow regimes and high organic loads typical of beaver ponds. Artificially increasing flow rates may help increase aerobic decay, but the best approach is to periodically drain or reduce the water levels in ponds to promote aerobic decay of organic matter and to reverse wetland succession. The interval between drawdowns is difficult to prescribe because the need for such action depends on the length of the warm season, water temperature, pond size and organic load, and water flow rates. In low latitudes, beaver pond productivity may decline in a few years, whereas ponds at high latitudes may take much longer to reach detrimental anaerobic conditions.

Drawing down a beaver pond is often easier said than done, because of the natural tendency of beavers to quickly plug any breach in their dam. Explosives or backhoes can be used to remove dams, but this often becomes an ongoing process because dams are quickly reconstructed. Better results are often achieved with beaver-resistant water control structures (Fig. 2), which are installed in the dam and are resistant to blockage by beaver. Only a fraction of the wetlands in a beaver pond complex should be dewatered during a given year to ensure adequate habitat for waterfowl and beaver in the remaining ponds. Ponds should not be drawn down during the brood-rearing period because young birds may become stranded or have to move, and become more exposed to predators.

Managing distribution of beaver can be a challenge equal to that of controlling water levels. Beaver that occupy sites adjacent to private lands, roads, or other human structures may impound water that causes timber or crop damage or creates a nuisance. Often, the only solution is to trap the offending beaver. If live-trapped, such individuals can often be successfully transplanted to suitable but unoccupied habitats. Supplemental feeding has



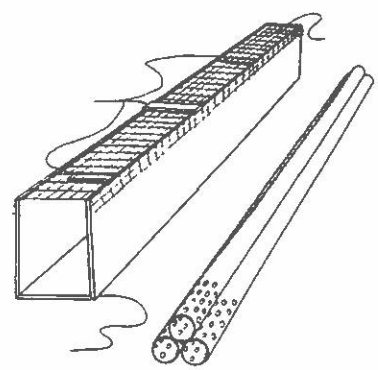


Fig. 2. Three designs for beaver-proof water control structures: three-log drain (*top*), box drain (*lower left*), and perforated plastic drainpipe (*lower right*). From Arner and Hepp 1989.

been used to "hold" transplanted beavers in new areas until they become established, but supporting a beaver population by artificial feeding is an intensive and costly approach that is not recommended. A woven-wire fence, stretched across a stream channel between steel posts may be installed (where legal) to encourage beavers to build dams at selected sites.

Unexploited beaver populations can create numerous wetlands. With the extirpation of the gray wolf, which was a primary predator of beaver,

other factors such as trapping, food depletion, space, and disease have become the agents of population control. Before these agents intercede, however, beavers may severely degrade riparian and upland habitats. If unchecked, beaver populations and associated wetlands may oscillate from locally abundant to scarce. Populations exploited by trapping often remain at more constant levels commensurate with their food supply, their principal limitation. Field surveys are the most reliable means to determine the adequacy of remaining food resources. In good stands, 4 acres of quaking aspen, 12 acres of willow, or intermediate acreages of the two in combination are adequate to support an average colony of six animals. Such indices of adequate food supply are available for most regions of the United States. If managers control beaver by trapping, a general rule for maintaining stable populations at mid-latitudes (40-50°) is to remove about 25% of the fall population in willow habitat, 40% in quaking aspen habitat, and 70% in cottonwood habitat. This prescription reflects the progressive increase in reproductive rates of beaver with decreasing altitude and climatic severity, and increasing food quality and quantity.

In forested habitats, managing upland nesting cover around beaver ponds is usually impractical. Fortunately, the grass-forb-shrub cover that is common near beaver ponds often provides high quality, albeit limited, waterfowl nesting habitat. Nest success is often relatively high because many forested habitats have high habitat diversity, an abundance of buffer prey species, and predator populations that are more in balance with the habitat than are those on the northern Great Plains. Nevertheless, nests located along travel lanes such as dams and shorelines are more exposed to predators. Nests located on beaver lodges are often successful because such sites are secure from most mammalian predators. Trampling by livestock and flooding also cause nest failure, but flooding can be controlled by water-level management techniques, and fences often minimize damage by livestock.

Beaver Ponds as Migratory and Wintering Habitats

Ecological Relations

During spring and fall, beaver ponds are used by migrating waterfowl throughout North America. Open (ice-free) water, in which migrants can obtain aquatic invertebrates and plant seeds, tubers, winter buds and rhizomes, is the most important characteristic of these habitats. Beaver ponds, however, usually are not managed for migratory waterfowl except in the southeastern United States, where intensive management is sometimes used to attract fall migrants and wintering waterfowl for hunting. These areas are often associated with hardwood bottomlands or floodplain forests, where mallards and wood ducks are especially common.

Ecological relations described for beaver pond breeding habitats in northern regions are similar or identical to those in beaver ponds at southern latitudes. Successional patterns in beaver ponds in the South are similar to those in northern habitats, but occur more quickly. After beaver have created permanently flooded wetlands, trees die and the canopy opens, making conditions more suitable for growth of herbaceous plants or semi-aquatic vegetation. Sediments and organic matter are retained over time, thereby decreasing pond depth. Aquatic invertebrate communities develop and invertebrate biomass increases as the pond vegetation becomes established. Physical features of habitat created by beaver, such as dead, standing timber with a well-developed shrub layer, provide excellent habitats for wood ducks and other waterfowl to roost at night. Seed-producing annual plants associated with beaver ponds provide vegetative foods important to many dabbling ducks, particularly in years when mast crops such as acorns are unavailable. The wetland complex created by beaver provides diverse habitats that are readily exploited by waterfowl.

Management Strategies

Management strategies for migrating and wintering waterfowl must first consider important characteristics of beaver ponds: (1) those with few emergent plant species and shallow water areas, but with the potential for manipulating water level; (2) those with emergents and shallow water, where water levels can be manipulated; and (3) those with no possibilities for drainage. Ponds of the first type, which are common in the Southeast, are best managed by lowering the water level to allow germination of seed-producing, annual plants that are beneficial to waterfowl (Table). This technique, known as moist-soil management, relies on the timing and duration of drawdown to promote the germination and growth of seeds

Table. *List of desirable plants that occur in beaver ponds of the southeastern United States.*

Common name	Scientific name
Redroot flatsedge	*Cyperus erythrorhizos*
Millets	*Echinochloa* spp.
Pennywort	*Hydrocotyle ranunculoides*
Duckweed	*Lemna* spp.
Frogbit	*Limnobium spongia*
Water primrose	*Ludwigia leptocarpa*
Parrotfeather	*Myriophyllum brasilense*
Stout smartweed	*Polygonum densiflorum*
Nodding smartweed	*Polygonum lapathifolium*
Pondweeds	*Potamogeton* spp.
Beakrush	*Rhynchospora corniculata*
Burreed	*Sparganium chlorocarpum*
Watermeal	*Wolffia* spp.

already in the soil. In rare instances, when desirable aquatic vegetation is absent and the seed bank is inadequate, commercially available seed can be used. In Alabama, beaver ponds which were dewatered as described earlier, and then planted with Japanese millet, have yielded 1,400-2,400 pounds of seed per acre. Although moist-soil plants typically do not attain such high seed production, they do support high densities of aquatic invertebrates and provide seeds of a better nutritional balance than many commercially available plants.

Beaver ponds with an abundance of desirable emergent plants are best left undisturbed. If undesirable emergents are present, however, managers can alter the vegetative composition by water-level manipulations, mechanical disturbance, burning, or herbicide application. Water-level control is most easily achieved with beaver-proof control structures (Fig. 2). Mechanical disturbances and burning share the common objective of retarding vegetation succession and opening dense stands of vegetation. These management activities are usually conducted in late winter or early spring after water is drawn down. To effectively change plant composition, burning or mechanical treatments must damage roots of plants. Usually, this requires dry soil conditions, so that heavy mechanical equipment can be operated in the pond. If fire is used, heat must be sufficient to penetrate to root level. Herbicides such as Dalapon, Banvel, and Rodeo also can be used to control plants where such use is permitted. Managers should make certain that their herbicide of choice is approved for aquatic use and is applied at proper rates by a licensed applicator.

Impounded areas without drainage most commonly occur in cypress-tupelo wetlands where there is insufficient elevation change to use hidden drains. In these situations, managers may attempt to enhance the vegetative composition by introducing beneficial aquatic plants to the pond (Table). Floating-leaved plants such as duckweed and watermeal are beneficial species that are easy to introduce. If the overstory of trees provides too much shade to allow aquatic plants to establish, it may be beneficial to clear-cut small openings to help vegetation become established. By manipulating vegetative composition and interspersion, beaver ponds can provide attractive winter habitats for waterfowl.

Suggested Reading

Arner, D. H., and G. R. Hepp. 1989. Beaver pond wetlands: a southern perspective. Pages 117- 128 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Beard, E. B. 1953. The importance of beaver in waterfowl management at the Seney National Wildlife Refuge. J. Wildl. Manage. 17:398- 436.

Johnson, R. C., J. W. Preacher, J. R. Gwaltney, and J. E. Kennamer. 1975. Evaluation of habitat manipulation for ducks in an Alabama beaver pond complex. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 29:512-51 8.

Longley, W. H., and J. B. Moyle. 1963. The beaver in Minnesota. Minn. Dep. Conserv., Tech. Bull. 6. 87 pp.

Naiman, R. J., C. A. Johnston, and J. C. Kelley. 1988. Alteration of North American streams by beaver. Bioscience 38:753-76 2.

Novak, M. 1987. Beaver. Pages 282-313 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario, Canada.

Renouf, R. N. 1972. Waterfowl utilization of beaver ponds in New Brunswick. J. Wildl. Manage. 36:740-744.

Yeager, L. E., and W. H. Rutherford. 1957. An ecological basis for beaver management in the Rocky Mountain region. Trans. North Am. Wildl. Conf. 22:269-300 .

Appendix. List of Common and Scientific Names of Plants and Animals Named in Text.

Animals

Wood duck	*Aix sponsa*
Green-winged teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
American black duck	*Anas rubripes*
Ring-necked duck	*Aythya collaris*
Common goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Gray wolf	*Canis lupus*
Beaver	*Castor canadensis*
Northern flicker	*Colaptes auratus*
Sandhill crane	*Grus canadensis*
Hooded merganser	*Lophodytes cucullatus*

Plants

Maple	*Acer* spp.
Alder	*Alnus* spp.
Birch	*Betula* spp.
Sedges	*Carex* spp.
Japanese millet	*Echinochloa crusgalli*
Rushes	*Juncus* spp.
Duckweed	*Lemna* spp.
Waterlily	*Nymphaea* spp.
Tupelo	*Nyssa aquatica*
Cottonwood	*Populus* spp.
Quaking aspen	*Populus tremuloides*
Pondweeds	*Potamogeton* spp.
Cherry	*Prunus* spp.
Willow	*Salix* spp.
Baldcypress	*Taxodium distichum*
Watermeal	*Wolffia* spp.

Note: Use of trade names does not imply U.S. Government endorsement of commercial products.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
***Fish and Wildlife Leaflet* 13**
Washington, D.C. • 1991

Wetland Plant Identification Guide

Photo courtesy of Ducks Unlimited.

Vegetation Control Strategies

Agriculture - Farm the unit to control undesirable vegetation; crops will be left standing in the fall.

Bulldoze - Bulldoze or root rake; primarily used to control large (>2" dbh) woody vegetation.

Burn - Prescribed burn.

Deep disk - Disk >4" deep.

Deep disk then dry - Deep disk then keep unit dry until after senescence of undesirable plants.

Delay drawdown - Delay drawdown until late spring or summer to discourage germination of certain undesirable plants.

Early drawdown - Drawdown unit in late winter or early spring to discourage germination of certain undesirable plants.

Early flood - Flood unit in early fall to control certain undesirable plants and provide resources to early migrant birds.

Herbicide - Treatment of problem plants with herbicides; used only as a last resort because it is expensive and highly dependent on the skill of the applicator.

Ignore - Ignore a vegetation problem if control actions are not possible or feasible this year.

Keep dry - Keep unit dry.

Late disk then flood - Shallow disk (<4") in late summer or early fall and immediately shallow flood; this controls certain undesirable plants and provides mudflats for shorebirds.

Mow - Mow to remove an overstory of undesirable plants and leave an understory of desirable plants.

Mow then burn – Mow to remove undesirable plants and then prescribe burn during growing season, often used to control undesirable perennial grasses.

Mow then semi-permanent - Mow and then flood deeply to overtop undesirable plants, deep flooding is maintained for the rest of the year.

Plow - Plow undesirable plants; may be required if undesirable plants are too dense to disk.

Semi-permanent – Keep unit flooded throughout the growing season.

Shallow disk - Disk <4" deep; if done late winter or early spring, some moist-soil seed production will occur by fall.

Slow drawdown – Drawdown unit slowly to maintain a zone of elevated soil moisture in order to decrease germination of undesirable plants adapted to drier sites.

Stress flood - Well-timed and precise flooding during the growing season to stress certain undesirable plants.

ALLIGATORWEED (*Alternanthera philoxeroides*)

Alligatorweed is an emersed perennial aquatic that often forms dense mats of vegetation. It primarily occurs in fresh water but will tolerate brackish water. Growth occurs under a wide range of soil and water conditions from dry fields to free floating in ditches. Reproduction is by vegetative methods.

Plant Value:

Alligatorweed has limited value for waterbirds. Although reportedly used as brood habitat, other plant species are of greater value for this purpose.

Control:

The best control prevents germination. The species is difficult to control once established because it is adapted to a wide range of soil moisture conditions and salinity.

Frequency of occurrence:

Problem: If present

Severe Problem: If present

Control Strategies:

Agriculture, deep disk, deep disk then dry, plow, herbicide, ignore.

Control depends on keeping the site dry for sufficient time to permit repeated mechanical disturbances to disrupt underground nutrient and energy reserves. Herbicide applications may be necessary in dense stands, but should be applied with caution because chemicals may destroy invertebrate base.

AMERICAN LOTUS (*Nelumbo lutea*)

American lotus is a floating leaf, aquatic plant with spongy rhizomes. Adapted to sites characterized by shallow (1.5 feet) to moderate (14 feet) water depths through most of the year. Once established, this plant can withstand short periods of drought. In moist-soil impoundments, most common in ditches or low lying areas that cannot be completely dewatered. Reproduction occurs from seeds (seeds may remain viable for greater than 100 years) or vegetatively from rhizomes.

Plant Value:

During summer, leaves often become elevated above the water surface and serve as brood cover. Prior to plant senescence, lotus also provides good wood duck roosting habitat. Seeds are of little value to waterfowl. Although small stands of lotus are of value in marsh systems, this plant is not considered desirable in moist-soil impoundments.

Control:

Frequency of occurrence:

Problem: >5 percent cover

Severe Problem: >15 percent cover

Control Strategies:

Agriculture, deep disk, deep disk then dry, keep dry, mow, shallow disk, herbicide, ignore.

Preventative water management scheduling is the best method of controlling lotus. Complete dewatering reduces the germination potential of lotus and promotes germination of desirable plants adapted to drier sites. If lotus becomes well established, mechanical treatment normal must accompany dewatering. In some cases, combinations of treatments (i.e., deep disk/keep dry) may need to be performed for 2 consecutive years to provide adequate control.

ASTER (*Aster spp.*)

Aster includes a large group of similar plants that belong to the Compositae family. They are predominantly perennials and indicators of later stages of succession. Most are common on drier moist-soil sites or are most abundant during drier years. Germination primarily occurs from late spring through summer.

Plant Value:

The greatest value of aster is for cover. The stiff erect stems provide a robust vertical cover that tends to remain upright despite flooding. Seed production is prolific but the seeds are small and have no value as food for waterbirds.

Control:

Frequency of occurrence:

Problem: >20 percent cover

Severe Problem: >50 percent cover

Control Strategies:

Agriculture, deep disk, plow, early fall flood, burn, shallow disk, semi-permanent, late disk then flood, ignore.

Strategies that set back succession by soil disturbance are most commonly used. Good control of perennial asters can be achieved by early fall flooding over root crowns when the plants are blooming.

BIDENS, BEGGARTICKS, STICKTIGHTS, BUR MARIGOLD, TICKSEED SUNFLOWER, SPANISH NEEDLE, BOOT JACKS *(Bidens spp.)*

Bidens are a common group of plants in moist-soil impoundments. Characteristic of early stages, bidens are dicots and members of the Compositae family. Germination is usually associated with dry to moist-soil conditions. Best germination and seed production occurs following late spring or summer drawdowns. Some species germinate early but the bright yellow flowers do not appear in most species until late summer or early fall. They are prolific seed producers.

Plant Value:

Bidens are excellent seed producers and seeds are readily consumed by mallards. The seeds are particularly high in protein.

Common species: *B. polylepis* - A robust plant with the earliest flowering cycle. Some blossoms by mid summer. Seeds tend to drop readily from the plants. *B. aristosa* -A robust plant with peak flowering in September. *B. frondosa* - A robust plant with peak flowering in September. *B. cernua* - Generally a smaller form and more tolerant of wetter conditions than others listed here. Ducks clip entire heads while foraging if seeds are still attached.

Control:

Frequency of occurrence:

Problem: never considered a problem.

Severe problem: never considered a problem.

BONESET (*Eupatorium serotinum*)

Boneset is a robust herb sometimes reaching heights of 3-5 feet. This species is an indicator of later successional stages and is most common on drier sites of moist-soil impoundments. Best germination occurs following late spring or summer drawdowns. Because of its robust nature, boneset often out competes higher seed producing plants.

Plant Value:

Boneset has no food value for waterbirds, but provides robust cover for rails.

Control:

Frequency of occurrence:

Problem: >20 percent cover

Severe Problem: >50 percent cover

Control Strategies:

Agriculture, deep disk, plow, mow, early flood, mow then semi-permanent, semi-permanent, shallow disk, ignore.

Mechanical treatments resulting in soil disturbance that sets back succession are the most commonly used control strategies. If a desirable understory is established (e.g., crabgrass, panic grass), mowing at a height that removes the apical meristem of boneset but does not harm desirable plants will reduce the amount of boneset seed added to the seed bank and will enable seed production by beneficial plants.

BROOMSEDGE (*Andropogon virginicus*)

A perennial grass found at the higher and drier elevations of impoundments in the southeastern U.S. Broomsedge is not tolerant of flooding during the growing season.

Plant Value:

Provides cover for passeriformes and roosting habitat for common snipe. Broomsedge is not valuable for seeds or as invertebrate substrate.

Control:

Because this plant is not tolerant of continuously saturated soils, flooding during the growing season when the plant is actively growing is a good control strategy. Flooding the root crowns for a week just after green shoots appear will kill broomsedge and stimulate species such as millet at the same time. Flooding in late summer or early fall as seeds are being formed also controls broomsedge. Deep soil disturbance will also reduce the abundance of broomsedge. Although burning will not completely eradicate broomsedge, this technique will enhance the growth of more desirable vegetation by reducing competition for nutrients and sunlight.

Frequency of occurrence:

Problem: > 30%

Severe Problem: never considered a serious problem

Control Strategies:

Agriculture, deep disk, late disk then flood, plow, delay drawdown, semi-permanent, stress flood, early flood, burn, ignore.

THREESQUARE BULRUSH (*Scirpus americanus*)

Associated with more permanent or semi-permanent conditions, threesquare bulrush readily establishes from seed, particularly following late spring drawdowns. However, this species is capable of initiating growth from rhizomes as well.

Plant Value:

Rhizomes are of greatest food value, but seeds can be important. New growth or newly established plants have some browse value. It provides good cover for nesting or foraging when plants have a clumped distribution.

Control:

Frequency of occurrence:

Problem: > 40%

Severe Problem: > 80%

Control Strategies:

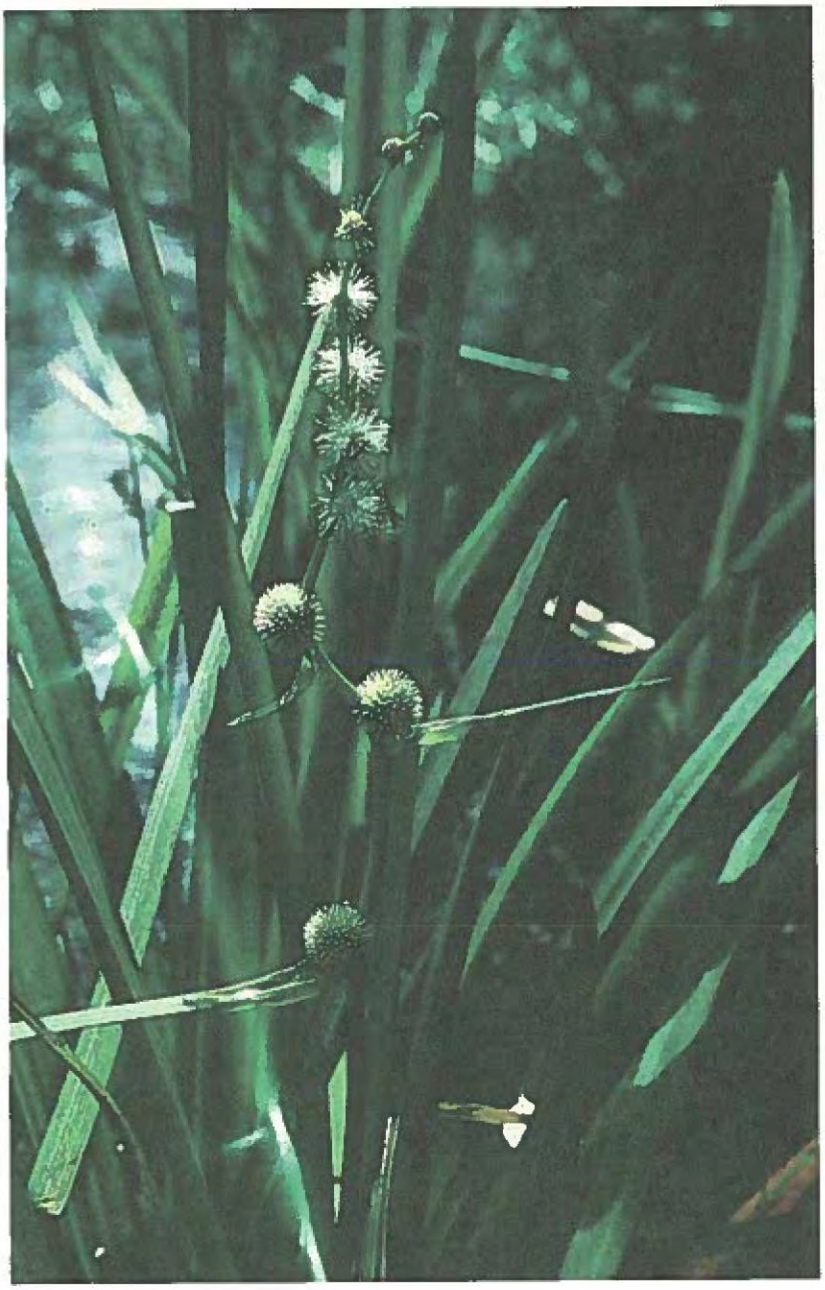
Agriculture, keep dry, deep disk, deep disk then dry, plow, shallow disk, early drawdown, mow, burn, mow then burn, ignore.

BURREED (*Sparganium americanum, S. androcladum, S. eurycarpum*)

Burreeds are robust perennial herbs with creeping rhizomes that reproduce primarily by seeds. These species are capable of growth on damp soil or in water up to 1 foot in depth. Commonly found around perimeters of moist-soil units at more northern latitudes or low areas within impoundments that remain saturated.

Plant Value:

Seeds are consumed by waterfowl and marsh birds. Vegetative parts provide good overwater nesting cover for marsh birds.



Control:

Frequency of occurrence:

Problem: >50 percent cover

Severe Problem: >70 percent cover

Control Strategies:

Agriculture, deep disk, deep disk then dry, keep dry, herbicide, plow, mow, shallow disk, burn, ignore. Burreed should only be considered a problem if it prevents germination of more beneficial seed producing plants over an extensive area. Burreeds are moderate producers of seeds that are consumed by waterfowl and are adapted to sites that many other plants are not capable of inhabiting. Therefore, they often provide value resources in sites that cannot be managed for more traditional moist-soil plants. Control is more likely to be needed in water transfer ditches because dense growth can hinder water removal.

BUTTERCUP (*Ranunculus spp.*)

Buttercups are small plants that germinate early in the growing season. They are adapted to sites with high soil moisture. Most species require exposed soil for germination, but *Ranunculus longirostris* is a submergent aquatic capable of growth in shallow standing water. Germination is enhanced by early drawdowns.

Plant Value:

Seed production of buttercups is nominal, but waterfowl do consume the seeds. The foilage of some submergent aquatic buttercups are eaten.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Control Strategies:

Buttercups are not considered a problem because germination and seed production occurs early in the growing season. In addition, the growth form of buttercups does not impede germination and growth of other early germinating plants. As a result, competition among buttercups and other seed producing species is negligible. Rather, buttercups supplement seed production in an impoundment.

BUTTONBUSH (*Cephalanthus occidentalis*)

A woody, robust shrub with a wide distribution on sites with continuously saturated soils or semi-permanent flooding. Under ideal conditions, dense stands develop rapidly. A prolific seed producer. Vigor of plants is reduced under dry conditions or when water levels are deep (more than 2 feet) and stable for long periods.

Plant Value:

Seeds are one of the more common foods appearing in mallard diets throughout the Mississippi Flyway. In semi-permanent wetlands, stands of buttonbush provide excellent cover for mallards, wood ducks and other waterbirds. Often cited as good brood cover for wood ducks.

Control:

Not a desirable plant in moist-soil environments. Control measures are related to size of the plant and the distribution in moist-soil impoundments. The best strategy is to solve the problem during the year of establishment when plants are short and have not developed an extensive root system. Best control is to keep the site in a dry condition for one or more consecutive growing seasons.

Frequency of occurrence:

Problem: >20 percent of area with stems either in a clump or scattered.

Severe problem: >40 percent of area with stems in a clump or scattered.

Control Strategies:

Agriculture, deep disk, deep disk then dry, mow, herbicide, plow, keep dry, ignore.

CATTAIL (*Typha spp.*)

Cattails are robust perennials that are tolerant of saturated soils or shallow flooding. Some species can tolerate deep flooding. They propagate from small wind dispersed seeds, but following establishment their annual growth is from rhizomes. Usually respond best when drawdowns occur during midsummer. Requires mudflats and/or shallow water for germination and soils must remain saturated for best establishment. Under ideal conditions, they can expand rapidly and "choke" wetland systems with dense monocultures.

Plant Value:

Their greatest value is for cover, especially as nesting sites for diving ducks, brood habitat, and for seclusion or predator protection during molt, fall staging, and wintering. The litter from cattail is an important source of detritus for many marsh invertebrates that serve as food for waterbirds.

Control:

Not a desirable plant in moist-soil systems. Indicative of more semi-permanent flooding.

Frequency of occurrence:

Problem: >20 percent cover

Severe Problem: >40 percent cover

Control Strategies:

Agriculture, deep disk, deep disk then dry, mow, burn, plow, herbicide, keep dry, ignore.
The best long-term strategy is to keep moist-soil units in a drought cycle during the growing season for two consecutive years. When mudflats and/or shallow water are present in midsummer, units should be inspected regularly to determine if cattails are germinating. Once a colony is established and has developed an extensive mass of rhizomes, control is costly and difficult.

CHUFA, YELLOW NUTSEDGE, YELLOW NUTGRASS
(*Cyperus esculentus*)

Chufa or yellow nutsedge is a perennial that rarely produces seed but consistently produces underground nutlets of great value as a waterfowl food. The plant is widespread across the U.S. Generally the plant develops early in the growing season and senesces in July. Little evidence of the above ground structure remains by the time of fall flooding.

Plant Value:

The underground nutlet is the most important food produced by this plant. The small seeds are never produced in abundance.

Invertebrates:

Chufa has limited value as litter for invertebrates in most situations because the above ground biomass is largely decomposed before fall flooding. In cases where chufa is a late season plant, the structure of the plant provides moderately good cover for invertebrates.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Enhancement:

Shallow disking early in the growing season often results in greater stem densities of this plant. Quite often the parent plant is not killed and begins to grow.

COCKLEBUR (*Xanthium spp.*)

Cocklebur is a broadleaf annual that is a common nuisance in moist-soil impoundments. Dense stands shade out more desirable vegetation or compete so effectively with moist-soil plants that production of moist soil-seeds is reduced. Germination requires higher soil temperatures and moist soils, thus rapid drawdowns after mid-May often result in dense stands of cocklebur. Each seedpod usually has two viable seeds that may sprout at different times in the same or different growing seasons.

Plant Value:

Seeds are not of value to waterfowl. The litter from cocklebur appears to provide either nutrients or substrates valuable for invertebrate production.

Control:

The most effective control is to prevent conditions conducive to the germination of cocklebur. Thus, units with a history of cocklebur should always have slow drawdowns. Furthermore, drawdowns during periods of high ambient air temperatures should be avoided or monitored closely. Recognition of cocklebur seedlings at the 2-cotyledon stage is essential for effective control. Once cocklebur is established, the four commonly used control techniques are stress flooding, disking, mowing, and herbicides.

Stress flooding: This technique is recommended only for plants less than 6 inches in height. Cocklebur less than 3 inches in height are controlled much easier because plants must be flooded only 2/3 the plant height for 3 days or until plants begin to turn yellow. For 4-6 inch plants, flooding must be equal or greater than the height of the plant and must be maintained for 57 days or until plants turn yellow. If timed correctly, stress flooding not only eliminates cocklebur, but also enhances the growth of more desirable moist-soil plants. **Disking:** Disking destroys the plant, but more cocklebur may germinate if soil moisture conditions become favorable following disking. **Disking followed by irrigation:** If disking can be followed by irrigation, germination of cocklebur will be eliminated or at least greatly reduced. If this technique is used, care must be taken to keep the soil in a moist to saturated condition for at least 7 days to ensure germination of desirable moist-soil plants. If irrigated for shorter time periods, soil moisture and temperature conditions may become more favorable for germination of cocklebur. **Mowing:** The timing of mowing is critical for effective control. The technique works best if performed just prior to seed set, when plants are more than 8 inches tall. Clipping the tops to within 6 inches of the ground will eliminate most seed production. If performed earlier in the growing season, mowing immediately before a rain will enhance the growth of seed producing moist-soil plants

located below the cocklebur canopy. **Herbicide:** Only recommended as a last resort. There are many side effects from the use of herbicides that are poorly understood. Furthermore, certain herbicides have an adverse effect on desirable moist-soil vegetation.

Frequency of occurrence:

Problem: >10 percent as a solid block, >25 percent as scattered patches

Severe Problem: >25 percent cover

Control Strategies:

Agriculture, shallow disk, deep disk, late disk then flood, plow, semi-permanent, stress flood, mow, herbicide, ignore.

Semi-permanent flooding of moist-soil units for 1 or more years will result in good control of cocklebur if water can be held through late summer.

CRABGRASS (*Digitaria spp.*)

Crabgrasses are low growing annuals and are most common on drier moist-soil sites. Best germination and seed production occurs following late spring or summer drawdowns when ambient air temperatures are moderate to high and the soil dries at a sufficient rate to permit crabgrass to become established prior to the germination and early growth of more robust plants adapted to wetter sites. Normally, other seed producing species are found in association with crabgrass and contribute to the overall seed production in an impoundment.

Plant Value:

Seeds of crabgrass are consumed by rails and many waterfowl species, particularly teal and pintail. Seed production may reach 200 lbs./ac.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Enhancement:

Crabgrass is never considered a problem and often represents a second source of seed produced in an impoundment. Other species stimulated by late spring or summer drawdowns, such as millet, often occur in conjunction with crabgrass if soil moisture levels are favorable. Mowing taller, undesirable vegetation prior to crabgrass seed formation may enhance crabgrass seed production. This increases sunlight penetration and reduces competition for moisture and nutrients. Care must be exercised to ensure the apical meristem of favorable plants (e.g., millet) that have already initiated seed set are not destroyed by mowing.

DOCK, SORREL, RUMEX (*Rumex spp.*)

Members of this plant group are adapted to a wide range of soil types and water conditions ranging from wet woods and swamps (e.g., swamp dock [*R. verticillatus*]) to sandstone and chert dominated soils (e.g., common sorrel [*R. acetosella*]). Several species, including bitter dock (*R. obtusifolius*), curly dock (*R. crispus*), and water dock (*R. orbiculatus*) commonly occur on intermediate sites characterized by wet or damp soils. Germination and survival to the seed producing stage appears to be dependent on the water regime. Many of these species may germinate in moist-soil impoundments if the unit is completely dewatered and soils dry sufficiently. Normally, however, those species adapted to wetter sites predominate. Germination occurs in early spring on dry to moist sites. Reproduction of annuals is accomplished through seed dispersal, whereas perennials (most species) typically initiate growth from established rootstocks. Often associated with other early germinating plant species adapted to drier soils such as pigweed and foxtail.

Plant Value:

Seeds are consumed by a variety of waterfowl including mallards and pintails. Although this species normally is sparsely distributed within impoundment, each plant produces a large amount of seed. Seed production as high as 1,500 lbs./ac. may occur in small areas.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Control Strategies:

Because of its sparse distribution, senescence early in the growing season, and high seed production capabilities, dock, is never considered a problem plant. Impoundments with dock typically contain a diversity of other beneficial seed producing plants adapted to similar germination and growing conditions.

DUCK POTATO, DELTA DUCK POTATO
(*Sagittaria latifolia, S. platyphylla*)

Duck potato is an aquatic perennial commonly found along the borders of ditches or in low areas within impoundments that are inundated by shallow water well into the growing season. Germination is during early spring. This species reproduces by seeds or tubers attached to slender rhizomes.

Plant Value:

Seeds and tubers of duck potato are consumed by many species of waterfowl including ducks and geese.

Control:

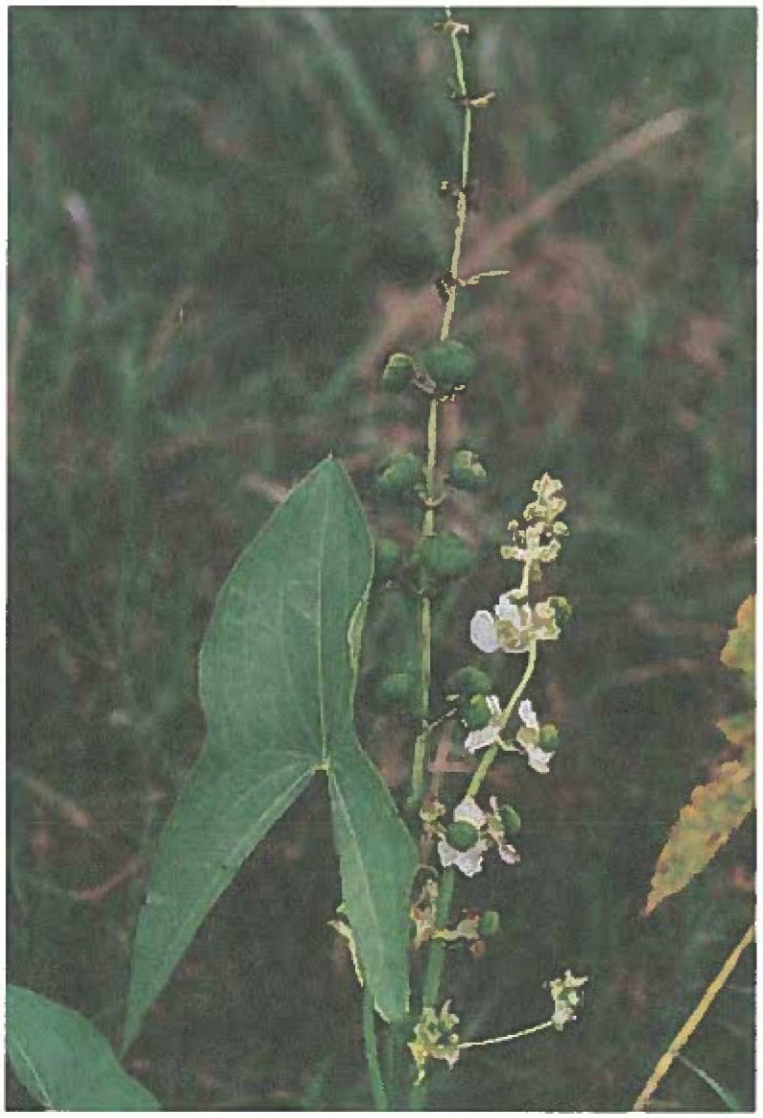
Frequency of occurrence:

Problem: never a problem

Severe Problem: never a problem

Control Strategies:

In moist-soil impoundments, this species is never considered a problem because it represents a good food source and is adapted for growth on sites where other seed producing plants can not be established.



FLATSEDGE, UMBRELLA SEDGE, NUTSEDGE (*Cyperus spp.*)

Flatsedges can be subdivided into two main groups: perennials and annuals. Perennial flat sedges are herbs with creeping rhizomes that may produce tubers, an important waterfowl food. For information on perennial umbrella sedges, see chufa (*C. esculentus*). Annual umbrella sedges, which include redrooted flatsedge (*C. erythrorhizos*) and rice flatsedge (*C. iria*), reproduce by seeds and do not have rhizomes and tubers. In general, early to late spring drawdowns tend to result in the best seed production of rice flatsedge, whereas late spring to summer drawdowns result in the best seed production of redrooted flatsedge. Slow drawdowns lasting longer than two weeks tend to increase the germination density of both species because they are adapted to wetter soil conditions. Redrooted flatsedge will germinate in fresh to slightly brackish water. The salt tolerance of rice flatsedge has not been documented. In areas with saline water conditions, the potential for increasing salt loads in the impoundments should be an important consideration in determining the drawdown date and rate used to promote annual flatsedge.

Plant Value:

Rails and a wide variety of waterfowl readily consume seeds of annual flatsedge. Although seeds are small, high densities often accumulate in small areas as they are windrowed against standing vegetation, making them readily available to species ranging from teals to mallards. Seed production of redrooted flatsedge and rice flatsedge may reach 2,000 lbs./ac. and 160 lbs./ac., respectively, during early successional stages.

Control:

Frequency of occurrence:

Problem: never considered a problem

Severe Problem: never considered a problem

Enhancement techniques:

Disking that creates a fine seedbed enables a higher density of the small annual flatsedge seeds to germinate. In some cases, cross disking or use of a cultipacker after disking enhances germination. In dry years, irrigation often helps promote higher seed production.

FOXTAIL (*Setaria spp.*)

Foxtails are early successional or perennial grasses that commonly occur on drier sites within moist-soil impoundments. During wet years, germination is best following late spring or summer drawdowns. In dry years, germination and seed production often is better following early spring drawdowns.

Plant Value:

Seeds of foxtails are consumed by many waterfowl species. Seed production may exceed 400 lbs./ac in dense stands. Foxtails do not withstand flooding; stems often form mats above the soil soon after flooding. Therefore, foxtail provides little cover, but may represent an important invertebrate substrate.

Control:

Foxtails are among the best seed producers adapted to dry sites within moist-soil impoundments. Thus, they are not considered a problem. Enhancement is difficult because the height of the foxtail normally precludes the use of mowing to reduce competition and irrigation is not necessary in most years.

Frequency of occurrence:

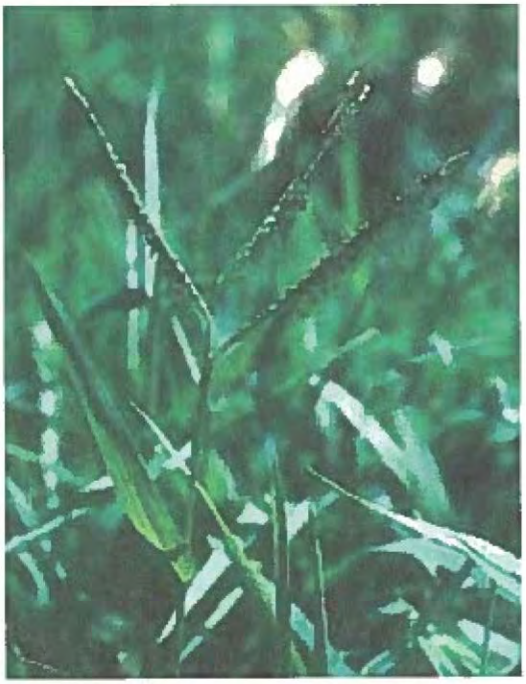
Problem: never a problem

Severe problem: never a severe problem

KNOTGRASS (*Paspalum distichum*)

Knotgrass is a perennial paspalum grass that occurs along streams and in marshes, ponds, and irrigation ditches from California to North Carolina. Associated with sites that are shallowly flooded with fresh, clear water. Knotgrass monocultures often develop because the creeping stolons rapidly invade areas surrounding the site of establishment and outcompete other plant species. The plant is a problem in irrigation ditches and semi-permanent moist-soil impoundments.

Plant Value:



Prolific seed producer but seed value has not been evaluated. Provides good breeding habitat for rails and coots. Also serves as a good substrate for invertebrates. May provide some good brood habitat.

Control:

Frequency of occurrence:

Problem: > 5% cover

Severe Problem: > 10% cover

Control Strategies:

Early drawdown, keep unit dry, disc and keep unit dry, burn.

Best control is to vary flood conditions among units with a history of knotgrass problems. Shallow fresh water should not be present for extended periods during the growing season for more than one year at a time. Soil disturbance may represent an appropriate technique for controlling dense stands of knotgrass, but the impoundment must be kept dry for at least 2 years following mechanical treatment. In addition, the implement should be cleaned prior to use in areas that are not infested to prevent spreading viable rhizomes into non-problem areas. Burning may be a useful tool but the technique has not been thoroughly tested.

MILLET, BARNYARDGRASS, WATERGRASS (*Echinochloa sp.*)

Millets are a group of annual grasses that have high food value for waterfowl across the continent. Seeds require moist to saturated soils for germination. In general, drawdowns conducted during late spring result in the best seed production, but some species respond better following early spring drawdowns whereas other species respond better following summer drawdown. Millets grow on a wide variety of soils, are readily digestible, and the seeds decompose very slowly when subjected to prolonged flooding.

Characteristics of different species:

Echinochloa frumentacea

Best response for seed production occurs with an early drawdown. Sometimes this species also responds to late drawdowns, but stems are usually widely scattered.

Echinochloa crusgalli

Best seed production occurs with a midseason drawdown. Under some conditions, however, seed production following a late season drawdown is as good as production following a midseason drawdown. Poor response with an early drawdown. Seeds will germinate in brackish water but seedlings will not survive salinities exceeding 5-ppt total dissolved solids.

Echinochloa muricata

Best response for seed production occurs with a late season drawdown. Midseason drawdowns also produce good results.

Echinochloa walteri

This species seems to do best where soils are a silt loam. Response is good following mid and late season drawdowns.

Plant Value:

Excellent seed producer: Seeds are readily used by waterfowl. During the first growing season after soil disturbance, seed production may reach 1,500 to 3,000 lbs./ac. Seed production gradually decreases in subsequent years as follows: year 2 - 1,200 to 2,000 lbs./ac., year 3 - 800 to 1,200 lbs./acre.

Invertebrate substrate: Millets provide a moderately valuable substrate for invertebrates.

Control:

Control is never considered necessary for millets.

Enhancement:

Slow drawdowns, particularly during midseason, usually produce excellent results. Soil should be disturbed after 3 or 4 growing seasons. Best production usually occurs when the soil is disturbed late in the previous growing season. A good technique to increase millet in the next growing season consists of disking in late summer or early fall followed by shallow flooding to provide shorebird habitat.

MORNING GLORY (*Ipomoea spp.*)

Morning glories are trailing or twining vines that occur in dry to moist sites. This group of plants, which includes both annuals and perennials, exhibits a wide distribution and is an indicator of late successional stages. Best germination and seed production occurs when drawdowns are conducted in late spring or summer.

Plant Value:

Seeds are consumed by waterfowl, but the amount of seed produced is small. In dense occurrences, morning glory can retard development of other moist-soil plant species.

Control:

Frequency of occurrence:

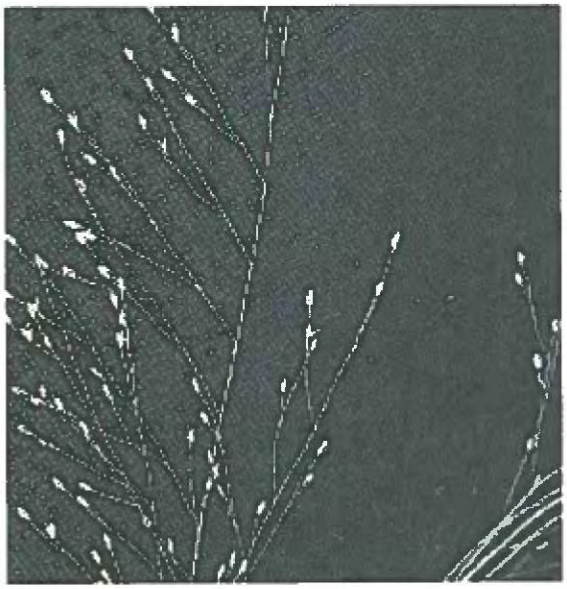
Problem: >15 percent cover

Severe Problem: >30 percent cover

Control Strategies:

Agriculture, deep disk, late disk then flood, plow, shallow disk, stress flood, semi-permanent, ignore.
Control of morning glory can be achieved by disturbing the soil. In dry years, or if soil disturbance is conducted later in the growing season, irrigation may be necessary to stimulate germination of other plant species and retard morning glory germination. Stress flooding is a viable option, but should be conducted early in the growing season.

PANIC GRASSES (*Panicum spp.*)



Panic grasses are characteristic of early successional stages. Common on drier moist-soil sites, germination and seed production of these low growing annuals is best following late spring or summer drawdowns. Normally, other seed producing species are found in association with panic grass and contribute to the overall seed production in an impoundment.

Plant Value:

Seeds of panic grasses are consumed by rails and many waterfowl species, particularly teal and pintail. Seed production may be as high as 400 lbs./ac. in years immediately following soil disturbance. In subsequent years, seed production gradually decreases.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Enhancement:

Panic grass is never considered a problem and often represents a second source of seed produced in an impoundment. Other species stimulated by late spring or summer drawdowns, such as millet and crabgrass, often occur in conjunction with panic grass if soil moisture levels are favorable at the correct time. Mowing taller, undesirable vegetation prior to panic grass seed formation may enhance panic grass seed production. Mowing should occur at a height that removes the apical meristem of undesirable plants but does not harm desirable plants.

PIGWEED (*Amaranthus sp.*)

Pigweed is an annual herb with stiff erect stems that normally are branched. Commonly found in drier sites within moist-soil impoundments and often associated with crabgrass and panicgrass. Best germination occurs following late spring and summer drawdowns. The occurrence of pigweed most often is highest following floods.

Plant Value:

The small seeds are consumed by waterfowl, particularly teal and pintail.

Control:

Frequency of occurrence:

Problem: >40 percent cover

Severe Problem: >70 percent cover

Control Strategies:

Shallow disk, ignore. A common pest in agricultural fields, soil disturbance that sets back succession is the most effective technique for control of pigweed. Early drawdowns that enhance germination of species adapted to wetter sites also helps reduce the occurrence of pigweed.

COMMON RAGWEED (*Ambrosia artemisiifolia*)

Common ragweed is an early successional species occurring predominantly on drier sites in moist-soil impoundments. Germination occurs from late spring to summer. Best seed production normally occurs following late spring drawdowns. Ragweed is commonly associated with pigweed, panic grasses, and crabgrass.

Plant Value:

Waterfowl consume seeds and leaves serve as an invertebrate substrate.

Control:

Frequency of occurrence:

Problem: >25 percent cover

Severe Problem: >50 percent cover

Control Strategies:

Agriculture, burn, deep disk, herbicide, late disk then flood, mow, mow then semi-permanent, semi-permanent, shallow disk, slow drawdown, stress flood, ignore.

The best control strategy for ragweed is to maintain soil moisture at elevated levels. This reduces the germination of ragweed and promotes moist-soil plants adapted to wetter sites. This can be accomplished either by initiating early drawdowns when evapotranspiration rates and ambient temperatures are low or stress flooding to kill ragweed and increase soil moisture to levels required for germination of other plants. Mowing also can be used to decrease ragweed cover and reduce competition with moist-soil seed producing plants. Although creating a semi-permanent condition is a control strategy, areas that contain ragweed often cannot be maintained in a semi-permanent condition.

REDVINE, LADIES' EARDROPS, BUCKWHEAT VINE
(*Brunnichia cirrhosa*)

Redvine, a member of the smartweed family, is a climbing woody vine. The species is an indicator of later successional stages. Growth occurs from exposed rootstocks, thus growth often occurs before germination of more desirable herbaceous plants. As a result, redvine, also known as ladies' eardrops or buckwheat vine, often outcompetes more desirable plants and may form dense monocultures that reduce seed production by other plants.

Plant Value:

Redvine has no food value for waterbirds.

Control:

The best strategy is to prevent the plant from becoming established or to restrict the plant to a small portion of the unit.

Frequency of occurrence:

Problem: 10% occurrence over entire unit, 5% of unit if clumped

Severe Problem: 20% occurrence over entire unit, 10% of unit if clumped

Control Strategies:

Control consists of using mechanical treatments to set back growth. If allowed to remain in an impoundment for over 3 years, repeated disturbance in the same growing season often is necessary to deplete energy reserves stored in an extensive underground root system. In some cases, good control can be achieved by mechanical disturbances followed by early fall flooding. If other herbaceous vegetation is present to serve as an invertebrate substrate, this strategy also provides good fall shorebird habitat. Applied at normal rates, herbicides appear to destroy existing vegetation, but do not solve the problem. Control measures include agriculture, shallow disk for early developing stands, deep disk, plow, semi-permanent, late disk then flood, herbicide, and ignore.

COMMON REED, PHRAGMITES (*Phragmites australis*)

Common reed is a robust perennial grass that may attain a height of 13 feet under ideal conditions. Establishment of common reed occurs predominantly from rhizomes, which are viable if they have at least two or three nodes and are eight inches long. Although uncommon, germination may occur from seed. More common in areas characterized by wet to shallowly flooded (<12 inches) soils through much of the growing season. Common reed is capable of establishment and growth in fresh or brackish water, but growth often is stunted in highly saline water. In moist-soil impoundments, common reed often is first detected around the perimeter of impoundments with stabilized water regimes. If conditions are suitable, however, common reed can expand into the interior of impoundments and reduce food production by more desirable plants.

Plant Value:

When interspersed with other vegetation or open water, common reed provide cover for rails, bitterns and waterfowl. However, use of dense, monotypic stands is negligible, except along edges. Vegetative parts provide substrate for invertebrates, but seeds have no food value for waterfowl.

Control:

Common reed can provide an important cover component for a diversity of wetland wildlife. Therefore, this plant should not be considered undesirable. However, in moist-soil impoundments the presence of common reed normally is associated with other plant species adapted to static water conditions that produce only marginal amounts of food. In addition, the potential for rapid invasion and cost of controlling common reed normally dictate that control must be implemented at low occurrences in moist-soil impoundments. The most effective control is to prevent conditions conducive to common reed establishment. This can be best accomplished by varying water regimes in an impoundment.

Frequency of occurrence:

Problem: >5 percent cover

Severe Problem: >10 percent cover

Control Strategies:

Agriculture, mow, burn, mow then burn, deep disk, deep disk then dry, keep dry, plow, herbicide, ignore.
Deep soil disturbances that cut rhizomes are the most common strategy. Disking often is more effective than plowing because disking normally severs rhizomes into smaller, nonviable, sections with greater

frequency. Timing of disturbance is important. Disking late in the growing season (midsummer to early fall) reduces stem density and rhizomes moved to the soil surface are susceptible to killing frosts and may supplement the diet of some wildlife species (e.g., cranes). In contrast, disking from late winter through mid summer stimulates bud production and often leads to stands of higher density. Mowing is most effective if performed late in the growing season. Repeated mowing for several years may be needed to achieve control. Dewatering often must be accomplished for at least 2 consecutive years to reduce common reed density and coverage. In many cases, a combination of treatments may be needed to achieve control. Techniques proven effective on some areas include burn/disk and mow/burn.

RICE CUTGRASS (*Leersia oryzoides*)

Rice cutgrass is a perennial grass with creeping rhizomes. A late successional adapted to moist or wet sites, best germination and seed production occur following late spring and summer drawdowns. Reproduction primarily is by seeds.

Plant Value:

Rice cutgrass is a valuable source of seeds for numerous waterfowl species. Rootlets appear in the late winter/early spring diets of mallards. In addition, vegetative parts also serve as an invertebrate substrate. On recently disturbed sites, rice cutgrass is not common and seed production may approach only 45 lbs./acre. However, seed production can exceed 325 lbs./ac. on sites that have not been recently disturbed and are dewatered late in the growing season.

Control:

Frequency of occurrence:

Problem: never a problem

Severe problem: never a severe problem

Enhancement:

Implementing a slow drawdown late in the growing season can increase germination of rice cutgrass. The objective is to maintain high soil saturation for as long as possible.

ROSE MALLOW (*Hibiscus moscheutos* and *H. laevis*)

Rose mallows are robust perennial herbs that may obtain heights of 8 feet. These species are found in sites where soil moisture levels remain high well into the growing season such as ditches and low depressions. They also are capable of growth in shallow standing water. Germination is greatest following late spring to summer drawdowns.

Plant Value:

Although seeds are consumed by waterfowl, rose mallows are considered undesirable because their robust structure excludes growth of other plants that produce more seed.

Control:

Frequency of occurrence:

Problem: >10 percent cover

Severe Problem: >20 percent cover

Control Strategies:

Agriculture, deep disk, deep disk then dry, keep dry, plow, ignore.
Control of rose mallows is best achieved by performing manipulations that increase the extent of soil drying. Deep soil disturbances also are beneficial because they destroy established root systems.

RUSHES (*Juncus spp.*)

Rushes are predominantly perennials that have hollow or solid round stems and range in size from small to large (>5 feet). The linear leaves are either round or flat. Flower heads are terminal and seeds are small. They commonly occur on sites characterized by saturated soils or shallow standing water and typically develop in clumps and form dense mats. In general, rushes germinate best following early spring drawdowns.

Plant Value:

Seeds not common in the diets of ducks or other waterbirds. Vegetative parts provide foraging or nesting cover for some species.

Control:

Usually not a problem in moist-soil impoundments.

Frequency of occurrence:

Problem: > 40 percent cover

Severe Problem: >60 percent cover

Control Strategies:

Agriculture, shallow disk, deep disk, deep disk then dry, plow, ignore.

SEDGES (*Carex spp.*)

The sedges exhibit a cosmopolitan distribution and represent the largest genus of plants in North America. They are characteristic of later successional stages. Some sedges are robust perennials with rhizomes, whereas others are annuals with fibrous root systems. Germination requirements are variable among the over 500 species present in the United States. Some species are capable of growth on dry ground, but most species occur in areas with moist to wet soils.

Plant Value:

Sedges are valuable as rail habitat, providing both robust vertical cover that withstands flooding and seeds that are heavily consumed. Waterfowl consume sedge seeds in moderate amounts. Production of fox sedge (*C. vulpinoidea*) may approach 180 lbs./ac. in some years.

Control:

Frequency of occurrence:

Problem: >65 percent cover

Severe Problem: never a severe problem

Control Strategies:

Agriculture, burn, deep disk, late disk then flood, mow, mow then semi-permanent, semi-permanent, plow, shallow disk, herbicide, ignore.

Because sedges provide important rail habitat, control should be initiated only if the density of sedges hinders seed production of more desirable plants or a mix of undesirable species (e.g., broomsedge) are found in association with sedges. To maximize the value of this species, control actions should be timed to permit use of these habitats by rails prior to rehabilitation.

SESBANIA, HEMP SESBANIA, COFFEEWEED
(*Sesbania macrocarpa*)

Sesbania is a legume that typically grows to a height of 10 feet. It prefers wet, highly disturbed habitats and sandy sites. Optimum germination occurs later in the growing season when mudflats are exposed during periods of elevated temperatures. Although germination is late (best following late spring or summer drawdown), sesbania sometimes forms dense stands that preclude germination and growth of desirable moist-soil species. Longevity of seeds is great and sporadic occurrences are common, particularly following disturbance.

Plant Value:

Produces large amounts of seed but value for waterfowl is poorly documented. Use of sesbania stands by green-winged teal has been recorded in the southeast, but it is undetermined whether use is related to seeds or invertebrates. Dense, robust stands tend to be avoided by waterfowl.

Control:

Frequency of occurrence:

Problem: 5 percent cover

Severe Problem: 10 percent cover

Control Strategies:

Agriculture, deep disk, deep disk then dry, early drawdown, late disk then flood, mow, plow, herbicide, ignore.

Control of sesbania is best accomplished by creating conditions favorable for the germination of beneficial plants early in the growing season. Once established, beneficial plants can outcompete newly germinated sesbania. Therefore, control strategies should be performed early in the growing season. If early control is not possible, late disk flood often prevents re-establishment of sesbania and creates conditions favorable for fall migrating shorebirds. This can be followed by an early drawdown during the subsequent growing season.

ANNUAL SMARTWEEDS (*Polygonum spp.*)

Smartweeds are widely recognized as a valuable food for waterfowl. Seeds have a hard coat that is not easily broken down in the digestive tract; thus True Metabolizable Energy is low for smartweeds. Seeds require moist to saturated soil conditions in freshwater systems for germination.

The annual smartweeds, which include ladysthumb or nodding smartweed (*P. lapathifolium*) and pinkweed or Pennsylvania smartweed (*P. pennsylvanicum*), are good seed producers, have a wide distribution, and are considered to be of great importance as waterfowl food. These species respond best to drawdowns conducted early in the growing season and normally occur on wetter sites within a unit. Highest seed production typically occurs the year after a soil disturbance or in areas that are drawn down after a period of prolonged flooding.

Plant Value:

Excellent seed producer: Seed production is best the first year after disturbance and may approach 2,000 lbs./acre. Seed production decreases rapidly in each succeeding year and may be only a few hundred lbs./acre by the third year after soil disturbance.

Invertebrate substrate: Excellent substrate for invertebrates but leaves must remain attached to the stem. Drought and insect infestations reduce leaf abundance and thus invertebrate populations.

Control:

Control is never necessary.

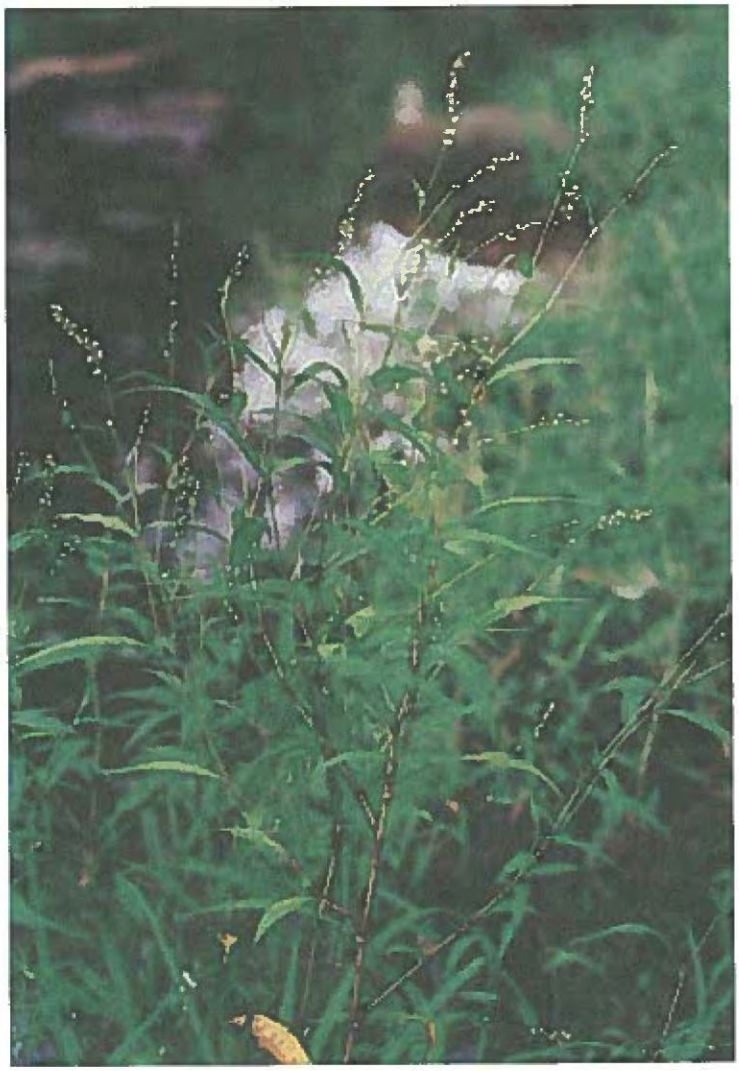
Enhancement:

Early drawdowns are essential. Soil disturbance (e.g., disking) can be used as a technique to provide shorebird habitat in the same year as the disturbance and increase smartweed production the following growing season. Early dewatering of areas that have been deeply flooded for one or more continuous years also result in high seed production.

PERENNIAL SMARTWEEDS (*Polygonum spp.*)

Two of the most common perennial smartweeds are water smartweed (*P. coccineum*) and water pepper (*P. hydropepperoides*). Both species occur in the wetter sites within units. *P. hydropepperoides* usually is associated with sites that have some surface water until July or sometimes even later.

Plant Value:



Poor seed producer: Seeds are small and hard with poor digestibility. Seed production is variable among years but is never as high as production by annual smartweeds.

Invertebrate substrate: Excellent substrate for invertebrates provided that the leaves remain on the stem.

Control:

Short-term control strategies involve deep soil disturbance such as deep disking, plowing. Long-term control strategies should involve keeping the impoundment in a drier condition for at least 2 years.

Frequency of occurrence:

Problem: >30 percent cover

Severe Problem: >30 percent in a block or >60 percent as scattered clumps.

Control Strategies:

Agriculture, bulldoze, deep disk, plow, ignore.

SPATTERDOCK, YELLOW COWLILY (*Nuphar luteum*)

An aquatic plant with woody rhizomes, spatterdock is adapted to sites characterized by standing water through most of the year. In moist-soil impoundments, most common in ditches or low lying areas that cannot be completely dewatered. Reproduction occurs from seeds or vegetatively from rhizomes.

Plant Value:

Although seeds have been reported as an occasional secondary food source of some waterfowl species, this plant is not considered beneficial. Other plants (e.g., burreed) adapted to growth in similar sites are more desirable. Extensive growth of spatterdock in ditches can impede dewatering of impoundments.

Control:

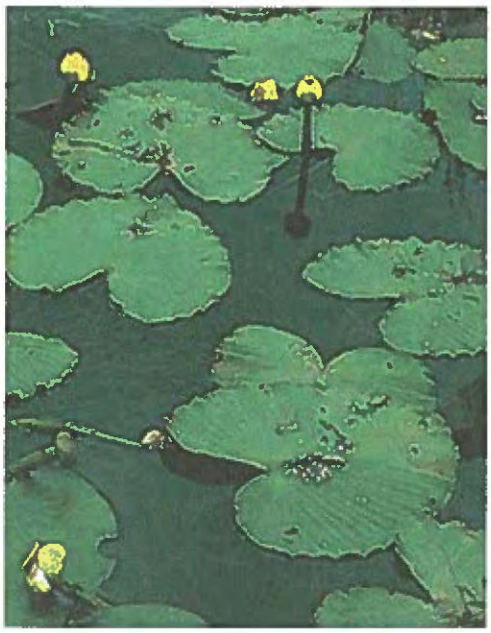
Frequency of occurrence:

Problem: >5 percent cover

Severe Problem: > 15 percent cover

Control Strategies:

Deep disk, keep dry, deep disk then dry, plow, herbicide, ignore. Control of spatterdock or yellow cowlily is best achieved by implementing appropriate water management strategies. Complete dewatering that facilitates soil drying reduces germination of spatterdock and promotes germination and growth of more desirable plants adapted to drier sites. Some type of mechanical treatment normally must accompany complete dewatering to control well developed stands. In some cases, treatment may need to be performed for 2 consecutive years to accomplish adequate control. If distribution is restricted to ditches within impoundments, control should be implemented if water removal is obstructed.



BLUNT SPIKERUSH *(Eleocharis obtusa)*

Blunt spikerush is a small annual rush that provides a high quality green browse. The plant is widespread and often occurs as a carpet under more robust moist- soil vegetation. Although germination is most prolific following late winter drawdowns, blunt spikerush is capable of germinating throughout the growing season.

Plant Value:

Greatest value as a green browse. The plant does produce an abundance of very small seeds, but the seeds are rarely detected during food habitat studies.

Control:

Blunt spikerush is never considered a problem; thus control is not necessary.

Enhancement:

Disking followed by irrigation to bring soil to saturation will enhance browse production of blunt spikerush. This technique works particularly well in late summer or early fall to provide browse for geese.

LARGE SPIKERUSH (*Eleocharis spp.*)

Large spikerush, which includes *Eleocharis palustris*, *E. quadrangulata*, and *E. interstincta*, are round-stemmed perennial plants with terminal flowers that are common on saturated soils or on sites with shallow flooding early in the growing season. Species composing this group of plants are capable of germination early (15 March to 15 May) in the growing season and often become increasingly common on sites after moist-soil management is practiced for a series of years.

Plant Value:

The seeds of large spikerushes are small and not important as food. These species do provide protective cover for waterbirds when present in scattered clumps, but the lack of plant structure reduces their value as invertebrate substrates.

Control:

Frequency of occurrence:

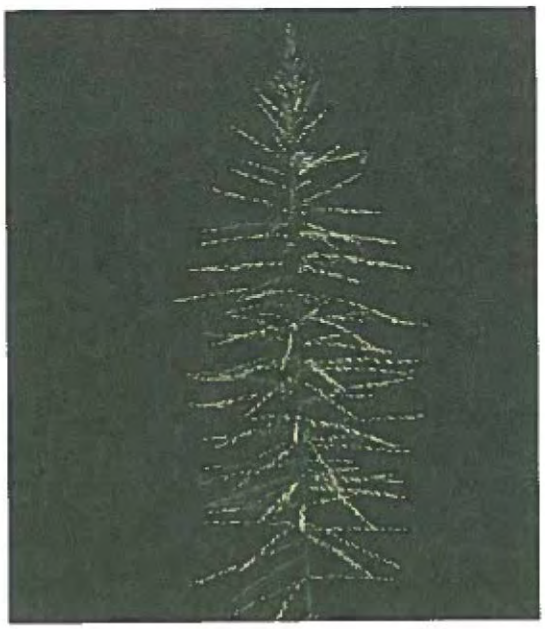
Problem: >10 percent cover in dense clumps or >25 percent cover scattered

Severe Problem: >20 percent cover in dense clumps or >40 percent cover scattered

Control Strategies:

Agriculture, deep disk, deep disk then dry, burn, plow, keep dry, ignore.
The best long-term strategy is to keep large clumps from developing. This can be accomplished by varying the hydrological regime among years or continuously setting back succession using soil disturbance techniques.

SPRANGLETOP (*Leptochloa filiformis and L. fascicularis*)



Sprangletops are annual grasses associated with moist to wet sites in moist-soil impoundments. They are early successional species that germinate late in the growing season. Best seed production occurs following summer drawdowns.

Plant Value:

Sprangletop is a valuable source of seeds and provides cover for waterfowl. In addition, vegetative parts also serve as an invertebrate substrate. Seed production can exceed 1,500 lbs./acre in recently disturbed sites that are dewatered late in the growing season. Seed production is lower (300 lbs./ac.) in areas that are dewatered early in the season. Regardless of drawdown date, production gradually decreases in subsequent years following disturbance.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Enhancement:

Maintaining vegetation in early successional stages and lengthening the period soils are in a moist condition increases germination of sprangletop. High seed production always is associated with a summer drawdown or on drier sites in wet years or wet sites in dry years. Therefore, periodic mechanical disturbances (i.e., shallow disking) and irrigation treatments often can be used to enhance sprangletop occurrence and seed production.

SWAMP MILKWEED (*Asclepias incarnata*)

Swamp milkweed is a perennial with a fibrous root system common in areas with moist soils. A late successional species, germination and seed production is best following late spring to summer drawdowns.

Plant Value:

Milkweed has no food value for waterfowl, but the erect stems can withstand flooding and provide cover.

Control:

Frequency of occurrence:

Problem: >20 percent cover

Severe Problem: >40 percent cover

Control Strategies:

Agriculture, deep disk, late disk then flood, mow, plow, shallow disk, ignore.
Soil disturbance that reverts vegetation to early successional species is the most common control strategy. Mowing often is beneficial if desirable understory vegetation is present.

WHITE SWEETCLOVER (*Melilotus alba*)

White sweetclover germinates very early, often before the normal growing season (i.e., late winter drawdown). To prevent germination, units should remain flooded until early spring.

Plant Value:

White sweetclover has very limited seed value for waterbirds. Tall rank structure is not good for invertebrate habitat unless structure is modified by mowing. White sweetclover has the potential to add nitrogen to units.

Control:

Frequency of occurrence:

Problem: > 70%

Severe Problem: never considered a severe problem

Control Strategies:

Agriculture, shallow disk, delay drawdown, deep disk, deep disk then keep dry, mow then semi-permanent, semi-permanent, deep disk, plow, mow, stress flood, ignore.

TOOTHCUP (*Ammania coccinea*)

Toothcup is an annual herb associated with moist to wet sites in moist-soil impoundments. Toothcup grows up to 2 feet high and has square stems and slender, linear, opposite leaves. It is an early successional species that germinates late in the growing season. Best seed production occurs following late spring or summer drawdowns. Normally found with sprangletop.

Plant Value:

Toothcup is a valuable source of seeds for gadwall and pintails. Seed production may be as high as 500 pounds per acre.

Control:

Frequency of occurrence:

Problem: never a problem

Severe Problem: never a severe problem

Enhancement:

Maintaining vegetation in early successional stages and lengthening the period soils are in a moist condition increases germination of toothcup. High seed production always is associated with a summer drawdown or on drier sites in wet years or wet sites in dry years. Therefore, periodic mechanical disturbances (i.e., shallow disking) and irrigation treatments often can be used to enhance toothcup occurrence and seed production.

TRUMPET CREEPER (*Campsis radicans*)

Trumpet creeper is a woody vine distributed across the eastern portion of the continent. This species is aggressive, having the potential to rapidly expand across moist-soil areas. Trumpet creeper requires dry to moist soils for germination, which tends to be greatest following early spring drawdowns. Growth also is initiated as areas are dewatered and over-wintering rootstocks become exposed.

Plant Value:

Trumpet creeper has no value for waterfowl.

Control:

Frequency of occurrence:

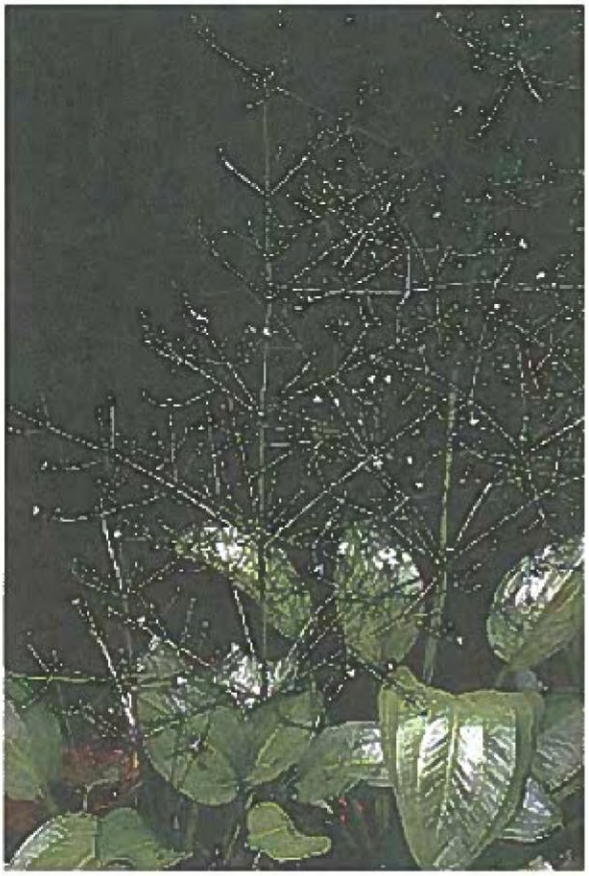
Problem: >5 percent cover

Severe Problem: >10 percent cover

Control Strategies:

Agriculture, deep disk, shallow disk, late disk then flood, semi-permanent, herbicide, ignore.
This species develops an extensive underground root system. Therefore, the best strategy is spot treatment of problem areas to prevent extensive root system development. If detected early, control often can be accomplished by shallow or deep disking. Treatments performed early in the growing season will allow the area to become revegetated by more beneficial plants. If the problem is not detected until after the root system has become established, repeated disking, late disk/flood, or herbicides may be needed to achieve complete control.

WATER PLANTAIN (*Alisma subcordatum*)



A perennial herb with thickened roots, water plantain commonly is found in areas that retain shallow water early in the growing season. Therefore, germination tends to be best following early spring drawdowns. In moist-soil impoundments, typically found in ditches, borrow areas, or units managed as semi-permanent wetlands.

Plant Value:

Achenes are consumed by waterfowl.

Control:

Frequency of occurrence:

Problem: never considered a problem

Severe Problem: never considered a severe problem

Control Strategies:

Water plantain normally is not considered a problem because it develops and completes seed production early in the growing season. Thus, competition with other seed producers is not a problem.

WATER PRIMROSES, PRIMROSE WILLOWS, SEEDBOXES (*Ludwigia spp.*)

Water primroses are commonly found in shallow water areas such as borrow or water transfer ditches. This group can be divided into two categories: species with erect stems and alternate leaves (e.g., *L. alternfolia* and *L. polycarpa*) and species with opposite leaves that creep or form mats (*L. palustris* and *L. repens*).

Plant Value:

The seeds of primroses (i.e., *L. repens*) are consumed in small amounts by some species (e.g., teals) and the leaves serve as an invertebrate substrate. Generally, few seeds are consumed compared to the quantity of seeds available. In some areas, use of primrose as wood duck brood habitat has been reported.

Control:

Frequency of occurrence:

Problem: >20 percent cover

Severe Problem: >40 percent cover

Control Strategies:

Deep disk, deep disk then keep dry, keep dry, early drawdown, shallow disk, plow, ignore.

Control of primroses is best accomplished by altering water management schedules. Complete dewatering that allows soils to dry reduces germination of primroses while stimulating germination of species adapted to moist soil conditions. If distribution is restricted to ditches within impoundments, control should be initiated only if density hinders water removal.

WILLOWS *(Salix spp.)*

Willows are rapid invaders of riparian zones and sites characterized by wet or saturated soils. Willows produce large amounts of light seeds that are distributed by the wind. Viability of these wind-born seeds usually is restricted to a few weeks following dispersal in late spring or early summer. The best germination occurs in late spring on bare, saturated soils. Early growth is very rapid and first year plants can reach heights greater than 6 feet. Extensive stands often develop immediately following spring floods when large areas of mud flats are available.

Plant Value:

Limited in moist-soil units but can provide important habitats for migrants, wading birds, and waterfowl if restricted to narrow zones. Leaf litter from willow serves as an important nutrient base for invertebrates. Willows can provide an excellent visual screen to reduce disturbance.

Control:

The best long-term strategy is to monitor units closely to prevent the establishment of extensive stands of willow. Newly established seedlings should be controlled immediately.

Frequency of occurrence:

Problem: >10 percent cover either in clumps or scattered

Severe problem: >20 percent cover either in clumps or scattered

Control Strategies:

Agriculture, shallow disk, mow, deep disk, deep disk then dry, plow, late drawdown, ignore.

Moist-Soil Data Sheet

Unit:_____ Year:_____

Acres:_____ Water Source (well, rain, etc):_____

Number of Water Control Structures:_____ Structure Maintenance Required: Y N

Management Objectives:_____

_____

Last Years Plant Composition (5 dominant species, including undesirables): _____

_____

Tasks Planned (drawdown, disking, mowing, etc.): _____

_____

_____

_____

Management and Weather Log

Date	Management Action/Weather Event	Water Level (% full or gauge)	Response (plants, birds, etc.)

Comments: _____

_____

_____

Attach map and delineate management actions: (areas disked, areas with undesirable plants, etc.)

NOTES

NOTES