Chapter 16

Managing Small Impoundments for Wildlife

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16.1 INTRODUCTION

In addition to providing habitat for fish, small impoundments that are constructed and managed properly can attract and support various wildlife species. Managed impoundments are important water sources for wildlife and can provide food and cover necessary for survival and reproduction. This chapter introduces impoundment characteristics and management techniques that provide wildlife habitat. We also address management of major groups of wetland dependent wildlife that use impoundments.

Most wildlife need water for daily survival. Some species have adapted to and require water for their entire life cycle (Marks 2006). These species are called wetland dependent wildlife. At least 150 bird species in the USA are classified as wetland dependent (Marks 2006). Additionally, another 900 terrestrial wildlife species use wetlands for breeding, foraging, or other life cycle activities (Marks 2006). Impoundments that are managed properly can play an important role in providing habitat for wetland dependent species.

Most small impoundments provide deepwater habitat (>2 m in depth), but also create shallow flooded areas known as wetlands. Wetlands are areas where water covers the soil or is present near the surface of the soil for at least part of the year (Lewis 1995; Mitsch and Gosselink 2000; Marks 2005; Baldassarre and Bolen 2006). The presence of water and the subsequent lack of oxygen create particular types of soils called hydric soils (Lewis 1995; Mitsch and Gosselink 2000; Baldassarre and Bolen 2006; Marks 2006). Saturated soil conditions and impounded water in wetlands favor the growth of water-loving plants, called hydrophytes (Lewis 1995; Mitsch and Gosselink 2000; Marks 2005; Baldassarre and Bolen 2006).

Wetlands are responsible for producing and supporting many wildlife species, such as waterfowl, songbirds, shorebirds, reptiles, amphibians and some mammals. Wetlands provide habitat for one-third of the federally listed endangered and threatened plant and animal species (Marks 2006). Many wildlife species require a complex of wetlands to meet life cycle needs (Baldassarre and Bolen 2006; Marks 2006). For example, migratory waterfowl and shorebirds need wetlands at their breeding grounds located in the northern USA and Canada, but also need wetlands during migration, which can extend to Central and South America. Other species such as amphibians frequently disperse among wetlands, and their populations depend on this exchange of individuals to maintain genetic diversity. Thus, impoundments can provide important habitat for various wildlife across a landscape, and contribute to maintaining populations.

Creation and management of impoundments for wildlife is important because the lower 48 states of the USA have lost approximately 53% of historic wetlands (Dahl 1990, 2000). Impoundments can function as important surrogates for natural wetlands (Knutson et al. 2004). However, management of impoundments for fish may not be complementary with wildlife management objectives. Our goal is to outline the essentials to managing small impoundments for wildlife. Where appropriate, we discuss how fisheries management can be incorporated.

16.2 IMPOUNDMENT CHARACTERISTICS AND WILDLIFE IMPACTS

16.2.1 Physical Characteristics

Different wildlife species have varying habitat needs and consequently respond differently to impoundment size. Loafing, roosting, and brood-rearing waterfowl prefer larger impoundments (Lokemoen 1973; Evans and Kerbs 1977; Rumble and Flake 1983). Lokemoen (1973) recommended impoundments should be 3.7 ha or larger to attract large numbers of waterfowl, although smaller impoundments also will be used. Smaller impoundments may be preferred for shorebird management, because management of this group depends on providing very shallow habitat or exposed mudflats (Evans and Kerbs 1977). Smaller impoundments tend to encompass fewer topographic contours, which can facilitate management for species that are dependent on shallow water conditions. Knutson et al. (2004) suggested impoundments smaller than 0.4 ha provide habitat for the greatest diversity of amphibian species, because larger impoundments tend to be deeper and provide more habitat for various amphibian predators. White (2003) reported abundance of all wetland dependent bird species increases as impoundment size increases, and suggested that impoundments be larger than 1 ha for waterbird use. Thus, impoundments should be at least 1 ha to have the greatest likelihood of attracting the greatest number of wildlife species.

Wildlife species also show preferences for different water depths. Shorebirds use water that is less than 15 cm deep, while most waterfowl prefer to feed in water depths less than 25 cm (Fredrickson 1991). Waterfowl commonly use deeper water areas for roosting and loafing. Wolinsky (2006) recommended the following criteria for optimum puddle duck habitat in impoundments: 50% with water less than 45 cm deep, 30% between 45 cm and 91 cm deep, and 20% with water between 91 cm and 122 cm deep. Rumble and Flake (1983) suggested maximizing amount of shallow water in impoundments to increase waterfowl use. Wading bird species forage in water that is less than 40 cm deep (USDA 2005) and prefer depths of less than 13 cm (Fredrickson 1991). Amphibians need shallow water (<30 cm deep) for breeding, but some frog species (e.g., bullfrogs) will use deeper water areas of impoundments for hibernation (Wolinsky 2006). A diversity of water depths, especially shallow areas, provides suitable habitat for various wildlife species.

Impoundment bottom substrate can also affect wildlife use. Some amphibians and turtles prefer muddy bottoms for hibernation (Marks 2006). Rock or gravel bottoms can provide amphibians some protection from predators (Wolinsky 2006). Shorebirds and wading birds need mud or sand bottoms and detritus for foraging. Detritus on impoundment bottoms provides food and habitat for many invertebrates (Wolinsky 2006), which in turn provide food resources for many birds (Fredrickson and Reed 1988; USDA 2005), amphibians, and reptiles

(Marks 2006). Impoundment substrate is a consequence of site selection, which is driven usually by local topography and soil permeability characteristics. In general, impoundments should be constructed in soils with high clay and silt content to minimize permeability or seepage. These soils also facilitate hydrophyte establishment, which benefit most wetland wildlife by providing cover or food resources.

Water quality impacts wildlife use of impoundments. Elevated concentrations of nitrogen, phosphorus, and suspended sediments reduce amphibian reproductive success (Knutson et al. 2002). Low nitrogen concentrations are associated with increased amphibian abundances, species richness, and reproductive success (Knutson et al. 2004). Elevated turbidity tends to decrease waterfowl and other bird use (Lokemoen 1973; Wolinsky 2006). Thus, it is important to establish vegetated buffers between human land uses and wildlife impoundments.

Irregularly shaped shorelines improve habitat for many wildlife species (Barclay 1985; Wolinsky 2006). Typically, as the length of irregular shorelines increases, wildlife habitat quality, diversity and structure increases (Barclay 1985). Additionally, a gradual shoreline slope increases wildlife diversity. When shallowly sloped, shorelines provide habitat for amphibians and mudflat feeding areas for shorebirds following a drawdown (Fredrickson and Taylor 1982; Semlitsch 2000). To provide good waterfowl habitat, Evans and Kerbs (1977) suggested a minimum average shoreline slope of 1 vertical meter per 5 horizontal meters. Varying slope from 1 vertical meter per 8–16 horizontal meters provides the greatest suitability and use for various bird species (Wolinsky 2006). Further, when water recedes on shorelines, it exposes embankments often devoid of vegetation that can provide nesting sites for turtles (Wolinsky 2006). When exposed embankments are steeply sloped, such as steeper than 1 vertical meter per 3 horizontal meters, they can provide burrowing sites for aquatic mammals such as beaver and muskrat. Thus, wildlife impoundments should have shallow slopes (>1 vertical meter per 10 horizontal meters) and irregular shorelines. Contour modifications can be made to improve slope and shoreline shape.

Physical features within impoundments provide important habitat components for wetland-dependent wildlife. Islands provide feeding, nesting, loafing, and escape cover for waterfowl, wading birds, and shorebirds (Wolinsky 2006). However, islands also serve as habitat for predatory species such as snakes and raccoon. Small islands measuring 0.04 ha or less with low profiles of 1 m or less above water are less attractive to predators (Johnson et al. 1978). Islands in impoundments managed for most birds and amphibians should have herbaceous vegetation for nest cover and should have little or preferably no woody plants. Structures such as rock piles or logs can provide basking and sunning sites for reptiles and amphibians, perches for birds, and egg-laying substrate for frogs and salamanders (Marks 2006; Wolinsky 2006). Basking logs can be added to impoundments to improve reptile and amphibian habitat. Logs should be dried for 6–12 months to create buoyancy, should be 1.5–2.4 m long and 15–25 cm in diameter, and should be anchored at least 1.5 m from shore to restrict predator access (Wolinsky 2006).

16.2.2 Biological Characteristics

Small impoundments provide water, food, and other essential habitat components for many mammals, birds, reptiles, amphibians, and fishes. Vertebrate organisms typically associated with water are attracted to small impoundments because small impoundments satisfy many, sometimes all, of their habitat requirements. A few examples of such organisms include beaver, river otter, belted kingfisher, bald eagle, waterfowl, great blue heron, water snakes, sliders, and frogs. Many waterbird species are attracted to impoundments with shallow water and abundant food resources (Huner et al. 2009). About 900 terrestrial wildlife species (May 2001) also are attracted to small impoundments because impoundments provide water for drinking or bathing, animals for food, mesic plants, lush foliage, and moist soil. Examples of terrestrial vertebrates commonly attracted to small impoundments include raccoon, black bear, white-tailed deer, and moose.

Most species of fish in small impoundments are primarily predacious and typically feed on zooplankton, invertebrates, amphibians, other fish, and in some cases on snakes, birds, and small mammals. Predatory fish, such as largemouth bass, green sunfish, cutthroat trout, rainbow trout or brook trout, can limit the abundance of some vertebrate species, especially amphibians (Knapp et al. 2001; Larson and Hoffman 2002; Knutson et al. 2004; Knapp et al. 2005; Julian et al. 2006). Fish can reduce the abundance of many aquatic invertebrates, such as insects (Knapp et al. 2001; Knapp et al. 2005), which serve as important foods for several wildlife species. Fish also serve as food for various wildlife species (Table 16.1).

Herbivorous fish such as grass carp can impact wildlife use of impoundments by decreasing submersed aquatic plants and increasing turbidity (Rottmann and Anderson 1976; Leslie et al. 1983). Common carp are destructive and can uproot hydrophytes and decrease water quality, which can negatively affect wildlife use (Parkos et al. 2003; Haas et al. 2007; Przemyslaw et al. 2009). In general, carp species should not be added to an impoundment that is managed for wildlife.

Hydrophytes provide food and cover for several wildlife and fish species, stabilize shorelines and bottom sediments, and maintain water quality (Mitsch and Gosselink 2000). Many hydrophyte species are the primary food of several wetland dependent animals (Table 16.2). Hydrophytes also serve as substrate and food for various aquatic invertebrates, which are food for higher trophic levels. Numbers of insect species in impoundments are greatest amid rooted aquatic plants (McCafferty 1981). Aquatic invertebrates are the primary foods of female breeding ducks (Krapu 1974; Ankney and Afton 1988), ducklings (Baldassarre and Bolen 2006), juvenile aquatic turtles (Clark and Gibbons 1969; Hart 1983), several juvenile fish species, and some amphibian larvae.

Hydrophyte composition is critical when managing for wildlife (Traut and Hostetler 2004). Dense, tall vegetation, such as cattails *Typha* spp., common reed *Phragmites australis* or common river grass *Scolochloa festucacea* that dominate more than 50% of an impoundment can decrease duck use (Kaminski and Prince 1981; Traut and Hostetler 2004). However, an abundance of these same plants increases red-winged blackbird and yellow-headed blackbird use (May et al. 2002). Thus, composition and horizontal coverage of hydrophytes must be considered when managing for wildlife.

Managers or landowners should provide a vegetated watershed around wildlife impoundments to maintain water quality and provide upland habitat for wildlife (Declerck et al. 2006). Vegetation buffers act as a biofilter that removes pollutants and traps soil in runoff. The appropriate width of buffers is dependent on the volume of water flowing through the buffer into an impoundment and the type of vegetation. For example, a 0.5-ha pond created by damming a small drainage ideally should have 50–100 m of undisturbed vegetation in and along the drainage that enters the impoundment and a band about 15-m wide along the remainder of the shoreline if water enters primarily via one drainage (Deal et al. 2000). Large impoundments should have larger buffers. Upland buffers also provide habitat for various wildlife. For ex-

Table 16.1. Examples of vertebrates that typically consume at least 50% fish in their adult diets and are commonly associated with small impoundments.

Class	Common name	References
Reptilia	Diamond-backed water snake	Bowers 1966
Aves	Double-crested cormorant	Fenech et al. 2004
	Great blue heron	Hoffman 1978; Verbeek and Butler 1989
	Great egret	Hoffman 1978
	Osprey	Poole et al. 2002
	Belted kingfisher	Salyer and Lagler 1946
Mammalia	River otter	Lagler and Ostenson 1942; Ryder 1955; Knudsen and Hale 1968; Toweill 1974

Table 16.2. Examples of vertebrates that typically consume at least 50% aquatic and wetland plants in their adult diets and are commonly associated with small impoundments.

Class	Common name	References
Reptilia	Red-eared slider	Clark and Gibbons 1969; Hart 1983
Aves	Gadwall	Mabbott 1920; Korschgen 1955; Anderson 1959; Kerwin and Webb 1971; Paulus 1982
Mammalia	Muskrat	Takos 1947; Bellrose 1950; Arata 1959
	Nutria	Atwood 1950; Willner et al. 1979

ample, forested buffers as narrow as 15–18 m wide support populations of edge and field-edge bird species (Thurmond et al. 1995). For management of forest-interior and interior-edge bird species (e.g., Acadian flycatcher, Kentucky warbler, northern parula), forested buffers should be greater than 50 m wide (Thurmond et al. 1995). Amphibians and reptiles also use terrestrial habitats adjacent to impoundments; thus, providing upland buffers is critical for disturbance intolerant communities (Gibbons 2003; Semlitsch and Bodie 2003). Gray and Smith (2005) found body size (a fitness correlate) of most amphibian species was larger at wetlands surrounded by grasslands than those surrounded by cultivated lands. Thus, buffer management needs to be considered when managing impoundments for wildlife.

In addition to land use, human activity around or in impoundments can affect wildlife use. Most wildlife species that use impoundments can tolerate some human presence (Cieminski and Flake 1997; Traut and Hostetler 2004; Newbrey et al. 2005) as long as humans do not directly harm or harass them. Observation and photography of birds from an appropriate distance does not seem to interfere with normal bird nesting behavior (DeMauro 1993). There are exceptions as some bird species are intolerant of human disturbance (e.g., short-billed dowitcher; Plauny 2000; Newbrey et al. 2005). Most wildlife species tend to avoid impoundments where they are frequently harassed or hunted by humans. For example, hunting activities decrease migratory waterfowl use of wetlands (Bellrose 1954; Evans and Day 2002). Thus, if hunting occurs at an impoundment, periods of nondisturbance should be incorporated into the management. For example, allowing hunting only twice per week can reduce disturbance and help maintain wildlife use. Shooting firearms with lead shot over impoundments can result in lead poisoning in water birds feeding in these areas (Anderson 1975); thus, a nontoxic shot should be used when hunting near impoundments.

16.3 IMPOUNDMENT MANAGEMENT TECHNIQUES

16.3.1 Water Level Management

Water-level manipulation to influence food production and availability is a fundamental component of managing impoundments for wildlife. Water-level manipulations include two processes: drawdown and flooding. To perform a drawdown, impoundments should contain a water control structure with a discharge pipe. Typically, a water control structure is located at the lowest elevation of the impoundment with the discharge pipe extending through a levee (Kelley et al. 1993). Placement of the water control structure at the lowest elevation permits complete drainage if necessary. Common types of water control structures used in wildlife management are gate valves, butterfly valves, drop-board structures, and risers with multiple capped inlets. Boards in drop-board structures usually consist of treated or plastic lumber and can vary in height to achieve target depths across an impoundment. For small impoundments, board heights usually should be less than 16 cm (Kelley et al. 1993).

Drawdowns in wildlife impoundments frequently are performed to stimulate seed germination and plant growth, provide mudflats or shallowly flooded habitat for resident and migratory waterbirds, and facilitate nutrient release by accelerating decomposition of detritus (Baldassarre and Bolen 2006). The rate, timing, and extent of a drawdown depend on wildlife management objectives. A slow drawdown (<2.5 cm per day) gradually exposes soil, consolidates food resources in shallow water for wildlife, and increases nutrient retention in impoundments (Fredrickson 1991). Plant diversity also tends to be greatest in impoundments when water is released gradually (Fredrickson and Taylor 1982). To achieve a slow drawdown rate, only one drop board should be removed per week. For valve structures, they should be opened partially for short duration while water levels are closely monitored. Drawdowns can be performed throughout the year, but typically occur during spring or summer (Fredrickson 1991). Spring drawdowns provide habitat for northward migrating waterbirds and typically result in high plant diversity, whereas plant communities germinating following a late summer drawdown tend to be dominated by only a few species of grasses and sedges (Fredrickson 1991). Drawdowns can be partial or complete dewatering. For small impoundments such as farm ponds, partial drawdowns that retain 25–75% of the water surface area are probably more appropriate than complete drawdowns. In fisheries impoundments, complete dewatering should only be performed when levee or water control structure repair is necessary or a particular management objective (e.g., fish removal) mandates it. Complete drawdown results in mortality of aquatic organisms and displaces resident wetland wildlife. When maintaining fish populations is an objective, a drawdown should not exceed 50% of an impoundment's surface area and should maintain at least 2.5 m of post drawdown water depth.

Plants that grow on exposed soil following a drawdown typically produce high-energy seed that can be consumed by wildlife. For waterfowl, this seed is relatively unavailable unless these zones are re-flooded (Fredrickson 1991). Flooding plants also stimulates production of aquatic invertebrates, which are utilized by various aquatic and wetland wildlife. Many small impoundments are catchment basins in watersheds, and flooding only occurs following rain events (Fredrickson 1991). Thus, drop boards removed during drawdown should be replaced in a water control structure at least 2 weeks prior to a target flooding date. In arid areas with lower and less predictable rainfall, boards can be replaced earlier. For impoundments with reliable water sources, impoundment flooding should correspond to desired use by target wildlife populations (Fredrickson 1991). Dependable water sources might include a reservoir, a perennial stream, or a groundwater well (Kelley et al. 1993). In these cases, water is typically moved to impoundments via supply channels or piping. Flooding typically should occur slowly to maximize the availability of cover and food resources (Fredrickson 1991). An alternative strategy to slow flooding or drawdown is to flood (or drawdown) in staggered 15-cm contour increments, with water levels held at each successive contour for at least 1 week. For drop-board structures, plastic sheeting can be placed or sawdust or pelleted bentonite clay (i.e., cat litter) deposited in front of the boards to reduce leaking between boards. The top board should be anchored with wedges so the boards seal better and do not float. Water control structure designs are available through Ducks Unlimited, Natural Resources Conservation Service (NRCS), and other natural resource management organizations (Strickland et al. 2009).

16.3.2 Mechanical Manipulations

Mechanical manipulations in wildlife impoundments are used to affect plant succession, increase nutrient release, and make food resources more available (Gray et al. 1999). Common mechanical manipulations include disking and mowing. In small impoundments, disking is typically performed along the shoreline or in areas that are exposed following a drawdown. The goal of disking is to affect plant community composition, which is accomplished by removing surface vegetation, scarifying the soil, and exposing buried plant propagules (Gray et al. 1999). Wetland vegetation changes over time through succession in zones of an impoundment that are not flooded permanently during the growing season (van der Valk 1981). Early stages of succession are dominated by herbaceous plants that produce large quantities of seed annually, whereas late stages are dominated by herbaceous and woody plants that reproduce vegetatively and have low seed production (van der Valk 1981; Fredrickson and Taylor 1982). Common early successional species include grasses (e.g., *Echinochloa* spp., *Panicum* spp., *Paspalum* spp.) and sedges (e.g., *Cyperus* spp., *Carex* spp.), while late successional species often include cattails, vines (e.g., *Ipomea* spp.), and woody saplings (Gray 1995). Biologists commonly manage for early successional plant communities because they produce greater seed resources for wildlife (Gray et al. 1999). However, landowners or biologists might consider maintaining a diversity of successional stages to increase overall wildlife diversity, which can be accomplished by leaving some impoundment sections undisturbed. On a small scale, disking can be performed using a garden or tractor-operated rototiller. Offset disks pulled by tractors are ideal because they scarify the soil in two directions. Mowing vegetation prior to tilling can facilitate soil scarification (Gray et al. 1999). Disking performed once every 3 years helps to maintain a plant community in early succession (Strader and Stinson 2005). Typically, multiple passes with a disk are necessary to adequately scarify the soil, which is characterized by exposed, broken soil with little surface vegetation or detritus. Disking can be performed after drawdowns or during autumn (Fredrickson and Taylor 1982; Gray et al. 1999).

Unlike disking, mowing is ineffective at setting back succession (Gray et al. 1999), but it can be used to affect plant community composition by moderating nuisance species. A nuisance plant is a species that conflicts with wildlife management objectives. If the objective is maintaining a plant community that produces seed for wildlife, a nuisance plant is any species that causes a reduction in seed consumed by wildlife. Common nuisance plants in wetlands include cockleburs *Xanthium* spp., coffeeweed *Sesbania herbacea*, common reed and cattails (Strader and Stinson 2005). Nuisance plants can affect seed production by germinating before target plants and outcompeting them for light and nutrient resources. Some species also have allelopathic effects that can inhibit growth of heterospecifics (van der Valk and Davis 1978). If nuisance plants establish and grow taller than desirable species, mowing at a height that targets nuisance species can reduce competition (R. Kaminski, Mississippi State University, personal communication). Mowing during autumn also is used occasionally to create openings in wetland vegetation to increase accessibility to food resources by waterbirds following flooding (Gray et al. 1999). Mowing small openings (e.g., 30 m x 30 m) is necessary only when dense and continuous vegetation prevents waterbirds from landing and foraging efficiently (Gray et al. 1999). Mowing is best accomplished using a tractor-operated mower (e.g., Bush Hog). Hunting over manipulated natural wetland vegetation is permitted (Gray et al. 1999); however, hunting over manipulated planted crops is not allowed for migratory waterfowl.

16.3.3 Herbicides

Nuisance plants also can be controlled in impoundments using aquatic-labeled herbicides. For nuisance plants with broad leaves (e.g., *Xanthium*, *Sesbania*, *Ipomea*), aquatic-labeled 2,4-D or triclopyr can be used (Strader and Stinson 2005). When used appropriately, these herbicides do not harm monocots. If complete mortality of the plant community is desired, a broad-spectrum herbicide such as aquatic-labeled glyphosate or imazapyr can be used (Strader and Stinson 2005). Fluridone can be particularly effective at controlling undesirable submersed aquatic plants in permanently flooded impoundments with minimal water exchange. Herbicide application should follow manufacturer label specifications and may require a permit in certain states (see Chapter 11).

16.3.4 Prescribed Fire

Prescribed fire is routinely used in wildlife management to maintain or improve habitat quality in upland landscapes (Wright and Bailey 1982; Moorman and Sharpe 2002). In wetlands, prescribed fire is less effective at setting back succession than disking. Most often, prescribed fire is used in impoundments to reduce nuisance plants, such as cattails and willows *Salix* spp. (Lee et al. 2005; Miao and Zou 2009), release nutrients (White et al. 2008), and increase disking effectiveness (Kostecke et al. 2004). Aquatic invertebrate biomass and nutrient content of plants can be greater following a prescribed burn (Smith et al. 1984; Kostecke et al. 2005; Davis and Bidwell 2008). Fire is typically used when impoundments are inaccessible by farm equipment (e.g., permanently flooded) or vegetation is too dense to operate a disk. Impoundments are typically burned during the dormant season when vegetation is senescent and litter loads are high (Gabrey et al. 2001). Disking following a prescribed burn can be effective at setting back plant succession (Kostecke et al. 2004). Prescribed fires should only be performed by trained personnel and follow state regulations.

16.3.5 Livestock Grazing

Private landowners may have multiple goals for impoundments, including providing water and forage for livestock. If providing livestock water is an objective, we recommend that landowners fence cattle from an impoundment and install a distribution pipe that can direct water to a water trough or limit livestock access to a small portion of an impoundment. Freeze-proof water troughs are available for impoundments at northern latitudes (Figure 16.1). When livestock are limited to a small water access point, fencing should extend into the water to prevent cattle from foraging around the entire impoundment (Figure 16.2a and 16.2b). If landowners wish to provide forage for cattle around a pond, grazing should be managed (e.g., duration, stocking rate) to maintain adequate plant biomass, height and composition, because overgrazing can negatively impact many wetland wildlife species. For example, Bull et al. (2001) showed fenced impoundments have higher density and diversity of birds than unfenced impoundments. Livestock can impact wildlife use of impoundments by increasing turbidity, siltation, phosphorus, and nitrogen in the water, and decreasing aquatic vegetation abundance and diversity (Knutson et al. 2004; Declerck et al. 2006; Schmutzer et al. 2008; Burton et al. 2009).

Allowing cattle access in impoundments can negatively impact amphibian populations. Species richness and diversity of amphibian larvae and relative abundance of some frog (Ranidae) species were negatively impacted by cattle grazing in Tennessee impoundments (Schmutzer et al. 2008; Burton et al. 2009). Average daily cattle density in these studies was around 100 head per hectare of impounded surface water. These studies suggested that the negative impacts of grazing on amphibians might disappear at ≤40 head per hectare of surface water. Presumably, the effects of grazing also can be reduced by spatially rotating cattle so no section of an impoundment receives excessive disturbance. Grazing impoundments during months when few amphibian larvae are developing (i.e., September–January) reduces potential negative effects on this community (Wells 2007).

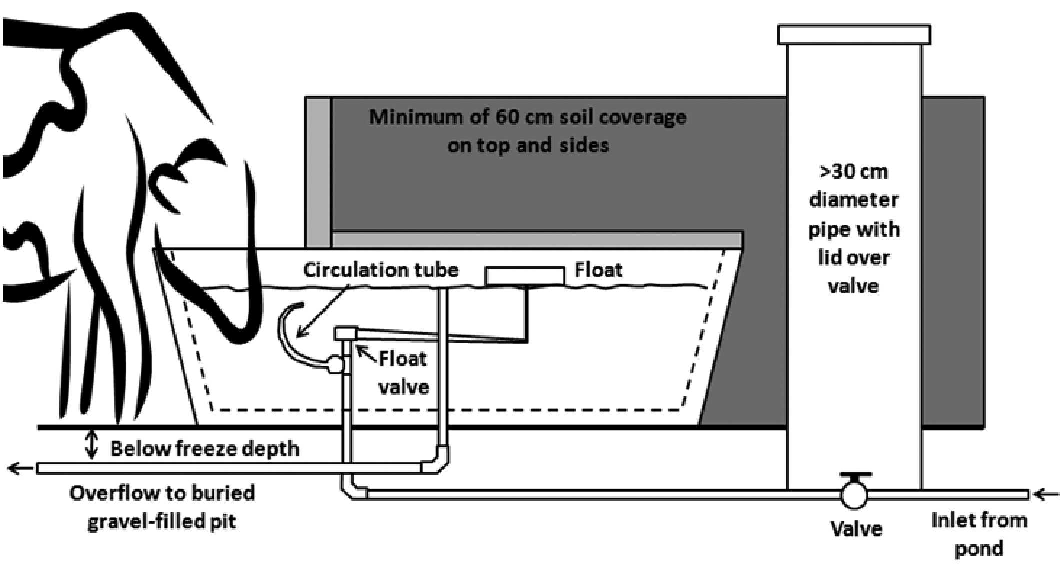

Figure 16.1. Freeze-proof water trough (Clark 1948; SCS 1984).

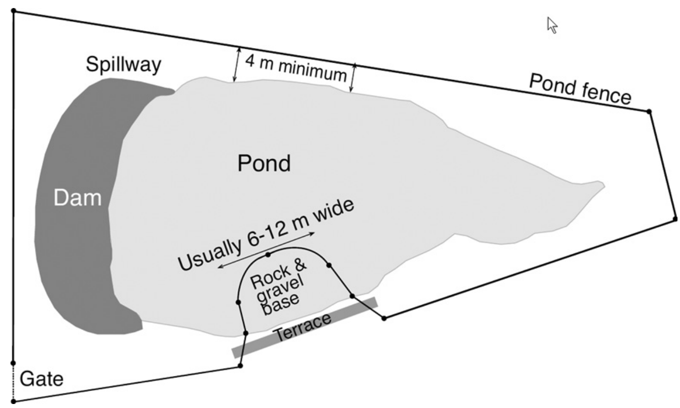

Figure 16.2a. Fenced pond with livestock water access point (Porter and McNeill 1996).

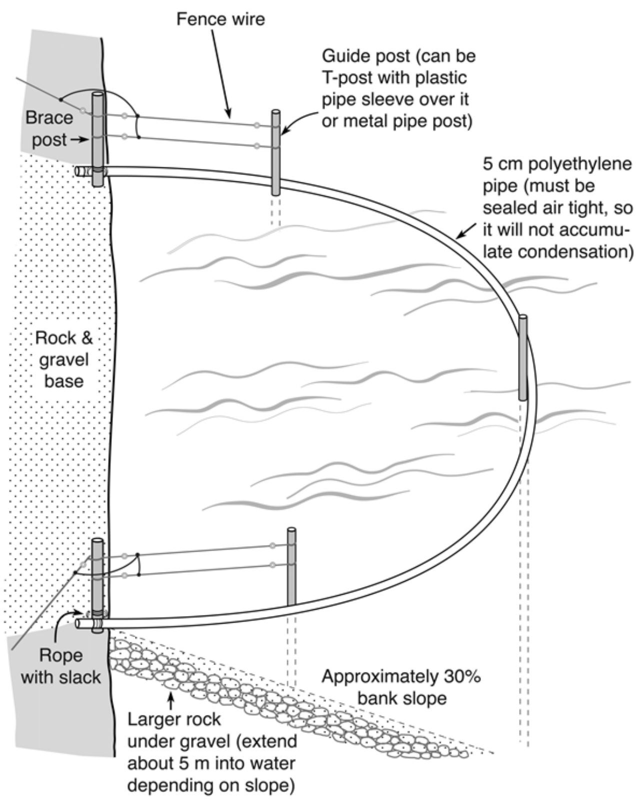

Figure 16.2b. Livestock water access point for a fenced pond (Porter and Ly 1997).

An important consideration to allowing livestock access in impoundments is the possibility of environmental contamination with zoonotic pathogens. Livestock are carriers of various pathogens (e.g., *Escherichia coli* O157:H7, *Mycobacterium avium*, *Cryptosporidium parvum*) that cause disease in humans (Kahrs 2003). Infected livestock that defecate in surface water can release pathogens into the environment (Collins 2004). Humans can be exposed to pathogens during water recreation or on food products that are irrigated with untreated water. This also is a concern if contaminated surface water in impoundments is released downstream during a drawdown. Moreover, aquatic wildlife may be suitable hosts of some zoonotic pathogens carried by livestock (CDC 2009). For example, Gray et al. (2007) demonstrated that bullfrogs are suitable hosts of *E. coli* O157:H7. In their continuing work, 23%, 35%, and 51% of bullfrog tadpoles exposed daily to an environmentally relevant concentration of *E. coli* O157:H7 in cattle feces became infected after 1, 2 and 4 weeks, respectively (M. Gray and four coauthors, unpublished data). Thus, the possibility exists that amphibians (and perhaps other aquatic vertebrates) can serve as a spill-over reservoir of zoonotic pathogens, which can facilitate re-infection of livestock and contribute to environmental contamination. Gray et al. (2007) recommended that livestock should be fenced from flooded zones of impoundments due to the possible public health risk. At least a 10-m wide vegetation buffer is recommended to reduce the likelihood of zoonotic pathogens contaminating impounded water (Collins et al. 2007). Various government cost-share programs are available that provide landowners financial and technical support to exclude livestock from impoundments and to provide alternate water sources (EPA 2001).

16.3.6 Piscicide

Depending on the objective of a wildlife impoundment, fish or other aquatic vertebrates may be considered a nuisance species. For example, fish can be voracious predators on amphibian eggs, tadpoles, and adults (Wells 2007). Thus fishless impoundments promote amphibian diversity. Fish can be eliminated from an impoundment by dewatering or applying a piscicide such as rotenone. Rotenone was described in Chapter 9; however, application may differ depending on wildlife management objectives. If the objective is fish removal without concern of other wildlife, we recommend following instructions in Chapter 9. If wildlife diversity is an objective (especially providing habitat for amphibians), rotenone should be applied during fall or winter months (e.g., October–December). These months typically correspond to the lowest abundances of amphibian larvae and adults at aquatic breeding sites in temperate regions (Wells 2007). An application rate of 1 L rotenone per 333 m^3 or 3 ppm is sufficient to cause mortality in most fish species. Partially dewatering an impoundment reduces water volume and the amount of rotenone required. Rotenone deactivates slowest in cold water, and thus it may take over a month before the chemical is eliminated from an impoundment when applied during fall or winter. Consult Chapter 9 for regulations on rotenone application in the USA.

16.3.7 Vegetative Plantings

Food plots are frequently used to attract or feed wildlife (Harper 2008). Wildlife food plots typically consist of agricultural crops that are high in energy or nutrients and produce seed or forage. Food plots can be planted in the upland adjacent to impoundments, or in upper impoundment contours that are exposed following a drawdown. Agricultural varieties of wetland plants (e.g., Japanese millet *Echinochloa frumentacea*, wild rice *Zizania* spp.) can be planted at lower contours near the water's edge and typically germinate following broadcasting on exposed moist soil. Agricultural crops commonly planted in impoundments for waterfowl include corn *Zea mays*, grain sorghum *Sorghum bicolor*, rice *Oryza sativa*, browntop millet *Urochloa ramosa*, foxtail millet *Setaria italica*, pearl millet *Pennisetum glaucum*, and buckwheat *Fagopyrum esculentum*.

After upper contours have dried sufficiently to support equipment, seed can be drilled directly into the exposed soil. Width between rows of planted crops can be increased in wildlife food plots to promote growth and production of natural wetland plants and seed (Kaminski and Brasher 2008; Strickland et al. 2009). Fertilization increases growth and yield of crops and wetland plants. Use of herbicides should be limited after crops reach 0.3 m in height to promote growth of natural plants (Kaminski and Brasher 2008). Given that a variety of terrestrial wildlife (e.g., white-tailed deer, mourning dove) use impoundments as watering sites, food plots can be placed in the upland to provide additional wildlife viewing and hunting opportunities. For details on planting specifications of food plots (i.e., seeding, fertilizer and herbicide rates, and costs) for a variety of wildlife species and plantings, we refer readers to regional University Extension Service publications (e.g., Harper 2008; Hamrick et al. 2010).

Planting also can be used to establish submerged, floating or emergent hydrophytes, and woody plants. Submerged and floating plants may include pondweeds *Potamogeton* spp., water lilies (Nymphaeaceae), and duckweeds (Lemnaceae). In addition to grasses, sedges, and cattail, common emergent plants include water plantain (Alismataceae), rushes (Juncaceae), spike sedges *Eleocharis* spp., burreeds *Sparganium* spp., and beggar-ticks *Bidens* spp. Tree species commonly established in impoundments include willows, eastern cottonwood *Populus deltoides*, bald cypress *Taxodium distichum*, and maples *Acer* spp. In addition to providing seed, rhizome, and browse food resources for wetland wildlife, these plants collectively provide cover for terrestrial wildlife from predators and inclement weather. Sowing native plants usually is unnecessary in natural wetlands because viable seeds for many plant species usually are present in the upper soil horizons (van der Valk and Davis 1978). However, planting may be necessary in constructed impoundments, especially when extensive herbicide application predated impoundment construction or for plant species that have low dispersal ability. If tree establishment is desired along the edges of impoundments, tree species that tolerate flooding should be planted, especially certain oaks (e.g., cherrybark oak *Quercus pagoda*, willow oak *Q. phellos*, overcup oak *Q. lyrata*, pin oak *Q. palustris*, swamp chestnut oak *Q. michauxii*) because acorns are an excellent source of energy for various wildlife (Kaminski et al. 2003). Treatments discussed earlier that maintain early successional stages typically hinder tree establishment; however, allowing portions of an impoundment to develop into woody cover can increase habitat complexity and overall wildlife diversity. Landowners and managers should plant species that are native or adapted to their region. Trees should not be planted on dams or levees, as the root systems can affect dam integrity.

16.3.8 Artificial Structures

A variety of resident wildlife can be attracted to impoundments by erecting structures for nesting or loafing. Resident waterfowl that nest naturally in tree cavities (e.g., wood duck, mergansers, goldeneyes) can be encouraged to nest at impoundments by erecting nest boxes (Bellrose and Holm 1994; Figure 16.3). The typical size of a nest box is 30 cm long × 30 cm

Figure 16.3. Wood duck nest box with predator guard (photo credit M. Porter).

wide × 61 cm high. Narrower and shorter boxes (18 cm long × 30 cm wide × 43 cm high) are recommended for wood ducks to reduce the occurrence of dump nesting (Stephens et al. 1998; Davis et al. 1999). Ideally, nest boxes should be placed on posts over water approximately 1.2 m above maximum flood level (McGilvrey 1968). A predator shield should be placed below the box, and any tree limbs within 2 m should be trimmed so predators cannot leap or drop onto boxes (Bellrose and Holm 1994). Boxes should be cleaned and approximately 8 cm of wood shavings added early to midwinter every year (Bellrose and Holm 1994). Nest box designs also are available for waterfowl species that nest over water (e.g., mallard, ruddy duck). To attract nesting Canada geese, a small island (e.g., 2.4 m × 2.4 m) can be constructed during initial construction or during a drawdown (Wolinsky 2006). Canada geese also use floating platforms for nesting (Figure 16.4). Various types of houses also can be erected near impoundments to attract nongame birds (e.g., purple martins, bluebirds) and bats. Many of these species are insectivores and feed on mosquitoes and other flying insects at impoundments.

16.4 WILDLIFE MANAGEMENT

16.4.1 Birds

16.4.1.1 Waterfowl

The annual life cycle of waterfowl can be summarized as nesting and brood-rearing (March–August), molting (June–September), fall migration (August–December), wintering

Figure 16.4. Floating goose nesting platform (photo credit B. Stearns).

(October–May), and spring migration (February–June; Bellrose 1980). Food resource needs change with life cycle. Most waterfowl eat primarily plant materials during fall and winter, but significant portions of their diets are comprised of invertebrates during spring and summer (Swanson et al. 1974; Serie and Swanson 1976; Drobney and Fredrickson 1979; Rodrigues et al. 2002). Waterfowl use small impoundments for feeding, nesting, brood-rearing, resting during migration, and winter roosting. Management of impoundments for waterfowl depends on geographic location and life cycle needs.

Ducks using breeding grounds in the north-central USA prairies will use small impoundments for nesting and brood-rearing. Small impoundments are used for feeding and resting during migration and on wintering grounds. Some ducks species such as wood ducks and hooded mergansers are year-round residents in the southern portions of their breeding ranges and can use managed impoundments for their entire life cycle. Additionally, some groups of Canada geese only make short distance migrations and many groups of giant Canada geese have become year-round residents (Baldassarre and Bolen 2006). Canada geese will use small impoundments year-round.

Most duck species prefer to nest in dry grasslands within 100 m of water (Teels 1985). Ducks can be encouraged to nest at impoundments by providing extensive areas of tall grass (>1 m) in uplands adjacent to impoundments, or by providing nesting islands in impoundments. Grasslands near impoundments should be left undisturbed during nesting. More duck nests are found in undisturbed herbaceous vegetation than in annually hayed or grazed areas (Kirsch et al. 1978; Klett et al. 1985; Messmer and Goetz 1985) and mallards have higher nesting success in undisturbed grassland, particularly brushy grassland, than grazed grassland, mowed grassland, hay land, cropland, woodland, and shrub land (Greenwood and Sargeant 1985; Klett et al. 1985).

A few duck species, such as canvasback, redhead, ring-necked duck, and ruddy duck, prefer to nest among emergent vegetation over water. Nests are typically constructed of vegetation over water 5–61 cm deep (Bellrose 1980). These ducks typically nest around impoundment edges with emergent vegetation such as cattails, bulrush *Schoenoplectus* spp., and sedges (Bellrose 1980). However, Kantrud (1986) reported that nesting decreased as emergent vegetation increased and burning of robust cattail stands increased abundance of breeding ducks. Duck species that nest in cavities, such as black-bellied whistling duck, wood duck, common goldeneye, Barrow's goldeneye, bufflehead, hooded merganser, and common merganser readily accept and use human-constructed nest boxes (Bellrose 1980; see Section 16.3.8).

Good brood habitat is necessary for optimum duckling survival. Duckling survival decreases with increasing distance traveled between nesting and brood sites (Ball et al. 1975; Bellrose 1980). Invertebrates are an important food source for waterfowl broods (Baldassarre and Bolen 2006) and tend to be more abundant and more easily obtained by ducks in shallow impoundments with emergent vegetation than in deeper, more permanent impoundments (Marks 2005, 2006). Puddle duck (Anatinae) broods prefer impoundments with the following characteristics: larger than 0.5 ha, more than 5 years old, irregular shorelines with brush and no or few trees along the edge, shorelines dominated by emergent herbaceous vegetation such as smartweeds and spike sedges, extensive shallow water areas with submerged vegetation, relatively clear water, and several nearby small impoundments or natural wetlands (Berg 1956; Lokemoen 1973; Evans and Kerbs 1977; Hudson 1983; Rumble and Flake 1983). Therefore, small impoundments managed for brood habitat should include these preferred characteristics and have nearby nesting cover.

Impoundments providing good quality wood duck brood habitat have: at least 4 ha of surface area which can be a single impoundment or multiple adjacent wetland impoundments that remain flooded throughout brood season (early March through mid September), irregular shoreline, shallow water (<1 m) over most of the impoundment area, about 75% (preferably not less than 30%) of the flooded area with cover comprised of approximately 40–70% flooded emergent herbaceous vegetation and approximately 30–50% flooded woody vegetation (e.g., buttonbush *Cephalanthus occidentalis*), about 25% (preferably not more than 70%) open water, several loafing sites such as logs or islands away from shore, and absence or scarcity of large predatory fish such as largemouth bass to minimize duckling depredation (McGilvrey 1968). Small impoundments managed for wood ducks should incorporate these habitat characteristics and have nest boxes or nearby natural cavities.

Canada goose is the only native goose species that nests in the contiguous USA. Geese are grazers and typically forage on dry land sites with good visibility (Bellrose 1980; Teels 1985). Small impoundments near feeding sites are frequently used for nesting and brood-rearing by giant Canada geese. Geese can be attracted by providing nesting islands or platforms over open water (see Section 16.3.8). However, geese can become nuisance species in impoundments due to fouling from waste and defense of nests and young.

Much waterfowl management in impoundments focuses on attracting or feeding migratory ducks. Puddle ducks, also called dabbling ducks, prefer to feed in the shallow portions of impoundments with water less than 30 cm deep (Fredrickson 1991; Riley and Bookhout 1993). Therefore, an impoundment should have abundant shallow water when attracting or feeding puddle ducks is desired. Puddle ducks favor impoundments with submersed aquatic vegetation (e.g., coontail *Ceratophyllum demersum*, naiads *Najas* spp., pondweeds), flooded terrestrial vegetation, and several species of emergent and floating aquatic vegetation. Shallow areas in impoundments can be managed to stimulate germination and growth of emergent aquatic and moist-soil plants that provide preferred duck foods using management techniques discussed in Sections 16.3.1–16.3.5. Wetlands managed for moist-soil in Texas increased preferred duck food production by more than 780% and increased fall and winter duck abundance by more than 1,600% (Haukos and Smith 1991). Migrating mallards preferred flooded moist-soil plants and flooded corn more than natural wetlands with emergent aquatic plants in Iowa (LaGrange and Dinsmore 1985). Shallow portions of impoundments are sometimes dried and planted to grain crops rather than managing moist-soil plants (see Section 16.3.7).

Diving ducks (Aythyinae) generally feed in deeper water (>50 cm) than puddle ducks (Bellrose 1980; Baldassarre and Bolen 2006). Small impoundments that lack water control structures, without gently sloping shorelines or shallow water, and abundant submergent vegetation will not provide much attraction to puddle ducks but can be managed to attract diving ducks. Often, management in impoundments without dependable water supplies is more consistently successful when impoundments are not drawn down and are managed for fully aquatic submerged, emergent or floating duck food plants.

Waterfowl spend 7–8 months migrating or on the wintering grounds. Therefore, managers should consider food needs during these time periods when planning management. For example, shallow impoundments with abundant invertebrates are important for waterfowl pair formation and nutrient assimilation during late winter and early spring (Marks 2005; Baldassarre and Bolen 2006). Timing drawdowns to coincide with these needs can concentrate invertebrates and increase use of impoundments. Ideally, flooding and draining of impoundments to attract and feed waterfowl should mimic typical natural hydrologic cycles when possible because waterfowl breeding, migration and feeding behaviors evolved to match natural cycles.

Waterfowl tend to favor deep (>1 m) and large (>4 ha) impoundments for roosting and loafing sites during migration and on wintering areas (Evans and Kerbs 1977; LaGrange and Dinsmore 1985). Larger impoundments afford more protection from mammalian predators and disturbances. Migrating ducks choose impoundments with minimal human disturbances (LaGrange and Dinsmore 1985). Presence of aquatic vegetation and good water quality do not seem to be important considerations at roost sites.

Canada goose is the primary goose species that roosts on and feeds in or along small impoundments. Other goose species, such as snow goose and white-fronted goose, occasionally roost on and feed in or around some of the larger impoundments during fall and winter. Canada geese primarily consume green terrestrial herbaceous vegetation, crop seeds, and moist soil plant parts, such as leaves, roots, stems and seeds (Korschgen 1955; Bellrose 1980). To attract and feed Canada geese during fall and winter, clovers or small grains (such as wheat *Triticum aestivum*, rye *Secale cereale*, oats *Avena sativa*, or triticale *Triticosecale rimpaui*) can be planted in fields adjacent to impoundments. Where cool-season perennial grasses and forbs such as orchard grass *Dactylis glomerata*, bluegrasses *Poa* spp., or white clover *Trifolium repens* are adapted, they can be managed to provide short, lush, green vegetation (see Section 16.3.7). Geese prefer to fly into and feed in large open areas devoid of trees and tall herbaceous vegetation (Teels 1985). Therefore, impoundments managed for geese should not have tall cover.

16.4.1.2 Shorebirds

Managing impoundments for shorebirds involves a drawdown that exposes mudflats and provides shallowly flooded habitat devoid of vegetation (Helmers 1993). Habitat can be provided either during northward or southward migration (Helmers 1992). For most shorebird species in North America, northward migration occurs March–May and southward migration occurs June–September. Peak migration depends on site latitude and species chronology, with overall peak migration occurring in August and September in the mid-continental USA (Laux 2008; Wirwa 2009). Long-distance migrants (e.g., American golden-plover, buff-breasted sandpiper) tend to migrate earlier than short-distance migrants (e.g., American avocet, common snipe), with several of the latter species wintering in the USA (Laux 2008; Wirwa 2009). If a spring drawdown is intended, the drawdown should start in April, with the duration lasting over a month. If a late drawdown is planned, the drawdown should be initiated and completed during late July and early September, respectively. Most shorebirds prefer newly exposed mudflats and shallow areas (<15 cm) without vegetation or detritus (Helmers 1992); thus, nonvegetated contours of the impoundment will be used most often following exposure. Mowing or disking vegetated contours followed immediately by flooding (>60 cm) can create mudflats during a subsequent drawdown. Shorebirds use impoundments primarily as feeding sites for aquatic invertebrates (Laux 2008; Wirwa 2009), which are essential to replenish and build energy reserves during migration. On average, short- and long-distance migratory shorebirds fly about 3,200 and 16,100 km, respectively, in one direction (Skagen and Knopf 1993). A limited number of refueling sites due to historic wetland destruction is one hypothesis for the current decline of many shorebird species (Brown et al. 2001). Properly managed impoundments can serve as critical shorebird conservation sites, and water level management techniques for shorebird habitat should be promoted among private pond managers.

16.4.1.3 Wading birds

Wading birds use impoundments primarily for foraging and nesting. Fish, invertebrates, and crustaceans are the primary foods consumed (USDA 2005). Managing impoundments for wading birds involves providing shallow water feeding areas less than 30 cm deep (Gawlik 2002; USDA 2005). Drawdowns concentrate food resources and increase wading bird use of impoundments (Kushlan 1976; Gawlik 2002). Drawdowns timed to coincide with peak fledging can be especially beneficial, which occurs April–June for most wading birds in the USA. Slow drawdowns resulting in water less than 13 cm deep provides optimum foraging habitat. Most wading bird species prefer to forage in areas with approximately 50% horizontal cover of emergent vegetation (White 2003). Wading bird foraging in wetlands increases typically as cattail density decreases (Bancroft et al. 2002). Some species, such as green heron, bitterns (Ardeidae) and rails (Rallidae), prefer areas with dense emergent vegetation. Managing for submergent vegetation near shore can concentrate prey and provide wading birds with increased foraging opportunities (White 2003; USDA 2005). Vegetation density and composition can be managed using the methods described in Sections 16.3.1–16.3.5.

Establishment or maintenance of shrubs such as willow along shorelines provides roosting and resting cover for wading birds (White 2003). Providing roosting habitat can be especially important in wintering areas (USDA 2005). Densely vegetated islands near centers of impoundments are suggested for solitary nesting species, like bitterns and rails, to escape predators (White 2003; USDA 2005). Livestock access should be precluded or controlled to protect water quality and shoreline vegetation.

16.4.1.4 Mourning Dove

Wildlife impoundments provide watering sites for mourning doves (Bartholomew and MacMillen 1960; Mirarchi 1993). Mourning doves prefer using water sources that are relatively free of vegetation near the water's edge (Madson 1978; George 1988; Lewis 1993; Mirarchi 1993; Tomlinson et al. 1994). Thus, late drawdowns that are performed to expose mudflats for shorebirds also provide drinking sites for doves. Livestock grazing and the other techniques discussed in Sections 16.3.1–16.3.3 can be used to reduce vegetation near the water line for doves. It is recommended that at least a 10-m band of bare ground exist between the shoreline vegetation and standing water to attract doves.

Although many mourning doves can fly straight to water, they seem to prefer landing in a nearby perch before flying down to drink (George 1988). Snags, trees, utility wires and fences are used as perches near water sources (Madson 1978; George 1988). Thus, mourning dove use of impoundments can be encouraged by maintaining or allowing perching trees to establish, or creating artificial perches.

Wildlife impoundments do not need to be large to attract mourning doves, but need to have adequate depth to provide a dependable water source. In the eastern USA, 1.8–3 m maximum depths probably are adequate for dependable water. However, in much of the arid and semiarid western USA, 3–5 m depths probably are necessary to provide dependable water due to high evaporation and low precipitation rates (Deal et al. 2000). When impoundments are constructed to increase dove hunting opportunities, they should be ideally placed at least 400 m away from a primary feeding site, but directly between feeding and roosting sites. Roosting sites are typically characterized as stands of trees or shrubs that provide protective cover; preference is often shown for conifers.

16.4.1.5 Other Birds

Many bird species use impoundments to acquire water, food resources and for cover. At least 115 species of birds other than waterfowl, shorebirds and wading birds have been reported to use agricultural impoundments in the USA (Evans and Kerbs 1977; Knutson et al. 2001). For many species, emergent vegetation and adjacent vegetated buffers should be encouraged for nesting and foraging habitat. A greater diversity of bird species is attracted by increased diversity of plant species. Many birds such as swallows (Hirundinidae), swifts (Apodidae), and nighthawks drink water while flying. Other species like kingfishers (Alcedinidae), osprey, and bald eagle catch prey while on the wing. Species that drink or catch fish on the wing require open water devoid of vegetation. When not foraging, aerial predators need shoreline perches from which to hunt, eat prey, and rest. These species utilize trees or constructed structures such as poles, fence posts, or telephone wires (White 2003).

16.4.2 Herpetofauna

16.4.2.1 Amphibians

Managing small impoundments for amphibians involves providing undisturbed habitat at aquatic breeding sites and in the adjacent uplands (Semlitsch 2000). Most amphibians that use lentic habitats have a biphasic life cycle where eggs are laid and larvae develop in the aquatic environment, and postmetamorphic juveniles and adults live in the terrestrial landscape (Wilbur 1984). Timing of amphibian breeding depends on latitude and species chronology, with most species breeding between February and July in North America (Wells 2007). Larval development lags breeding, with most species completing metamorphosis in 2–3 months (McDiarmid and Altig 1999). Common species that breed early in the year (February–April) include spotted and tiger salamanders, wood frog, spring peeper, and American toad, and ones that breed later (May–July) include green frog, bullfrog, spadefoots (Pelobatidae), and most tree frog (Hylidae) and toad species (Degenhardt et al. 1996; Dodd 2004). Successful breeding and survival of amphibian larvae are dependent on water availability and quality (Semlitsch 2000). Thus, impoundments should not be completely dewatered when providing amphibian habitat is a goal.

Fertilizers, nitrogenous waste from livestock, and pesticides can negatively affect amphibian survival. Concentrations of $NH_3 > 0.5$, $NO_2 > 2$, and $NO_3 > 30$ ppm can induce stress and cause mortality in larval amphibians (Jofre and Karasov 1999; Rouse et al. 1999). Low concentrations (<2 ppm) of many herbicides and insecticides can negatively influence tadpole survival (Jones et al. 2009; Relyea and Jones 2009), especially in the presence of aquatic predators (e.g., dragonfly larvae, fish) that naturally induce stress (Relyea and Mills 2001). A vegetative buffer should be established and maintained around impoundments to filter agricultural contaminants from runoff.

Some fish species are voracious predators of amphibians and can negatively impact species richness and abundance (Wells 2007). When providing amphibian habitat is the primary objective, fish should be eliminated using a complete drawdown or rotenone (see Chapter 9). When co-habitation of amphibian and fish is desired, dense, shallowly flooded herbaceous vegetation should be established to provide escape cover for breeding adults and larvae. In this case, we recommend no mechanical manipulations occur in at least 25% of an impoundment to facilitate establishment of persistent emergent vegetation (e.g., cattails, rushes). If impoundment contours are more closely spaced than 1-m vertical change across less than 10 m horizontal distance, a relatively narrow band of protective vegetation will establish, which may be insufficient to protect amphibians from fish. Topographic modification could be used to shape contours to a more gradual slope (e.g., 1-m vertical change across 30-m horizontal distance), and increase the width of protective shoreline vegetation. Occasionally, undisturbed zones should be burned to prevent growth of woody species unless tree establishment is an objective.

Very few amphibian species remain at aquatic sites yearlong. Following metamorphosis or breeding, amphibians use terrestrial landscapes to forage, estivate or hibernate, and disperse between aquatic breeding sites (Semlitsch 2000). Most species of pond-breeding amphibians use terrestrial habitats within 90 m of aquatic sites (Rittenhouse and Semlitsch 2007). Thus, it is conservatively recommended that terrestrial buffers be at least 90 m wide (Rittenhouse and Semlitsch 2007; Harper et al. 2008). No mechanical disturbance (e.g., disking) should occur in terrestrial buffers, but prescribed fire and moderate grazing can be performed. If grazing is necessary, livestock should occur at a density or duration that reduces vegetation biomass by less than 50%. Amphibians need intact vegetation that provides vertical cover (>60 cm in height) for protection from desiccation and predators (Wells 2007). Salamanders prefer forested habitats (Petranka 1998); thus, if managing these species is a primary objective, trees should be established or maintained. For amphibians, the undisturbed terrestrial buffer should be maintained for at least half of the circumference of an impoundment.

16.4.2.2 Reptiles

In general, managing impoundments for reptiles is congruent with amphibian management. Reptiles associated with wetlands prefer permanent water, undisturbed shorelines and uplands, and many species (e.g., aquatic turtles, snakes) eat amphibians. Additional recommendations include providing basking logs in flooded zones, compost, brush piles, and hibernacula (Wolinsky 2006). Compost and brush piles can be placed alternately (every 15–30 m) within 3–15 m of the impoundment shoreline (Wolinsky 2006). These areas provide nesting and foraging sites for lizards and snakes. Most freshwater turtles nest in undisturbed grasslands adjacent to impoundments, which can be maintained with prescribed burns once every 1–2 years (Masters et al. 1993). Brush piles should be at least 3–6 m in diameter and 1.2–2.4 m in height, with large hardwood logs placed on the bottom of the pile (Wolinsky 2006). Artificial snake hibernacula include a subterranean chamber with inside dimensions: 0.9 m long × 0.9 m wide × 0.6 m high made of cinderblocks or several layers of buried rocks more than 15 cm in diameter (D. Bryan, Cumberland University, personal communication). Ideally, the hibernaculum entrance should be on a south aspect, 5–8 cm in diameter, and constructed such that water does not flow into the chamber (D. Bryan, Cumberland University, personal communication). Entrances typically are constructed of flexible pipe and should turn 90 degrees after 15–30 cm to decrease cold air circulation in the chamber. Chamber bottoms should be lined with 8 cm of soil and tops buried >15 cm and >0.6 m at southern and northern latitudes, respectively, in the USA. Tops can be made of wood or metal sheeting. When snake conservation is an objective, one to two hibernacula per impoundment should be located 15–30 m from the shoreline and placed at least 90 m apart when two are installed.

16.4.3 Mammals

A wide variety of mammals use impoundments for water sources. Additionally, species such as raccoon, mink, and skunks (Mephitidae) use impoundments for food sources. There are 23 mammals in North America that are considered to be wetland species (May 2001). Larger impoundments can attract aquatic furbearers such as beaver, muskrat, and river otter when conditions are favorable. However, aquatic furbearers can be considered nuisance species in impoundments, because many excavate burrows which can damage levees and beavers can destroy nearby valuable tree resources.

Beaver and muskrat frequently excavate bank dens that extend above normal water levels, which are often used by river otter also. For this reason, these mammals prefer relatively stable hydrologic conditions (Boutin and Birkenholz 1999; Novak 1999; May 2001). They also prefer rock free, steep-sided shorelines for burrowing (Novak 1999). Banks covered in shrubs and vegetation greater than 1 m tall provide protection for burrows and feeding (Melquist and Dronkert 1999; Novak 1999). Beaver consume primarily woody vegetation during winter, but a wide variety of submerged and emergent plants are eaten by both muskrat and beaver (Takos 1947; Bellrose 1950; Arata 1959; Boutin and Birkenholz 1999; Novak 1999). Managing for a diversity of emergent and submerged vegetation should provide adequate food for muskrat and beaver. To deter muskrats and beavers from burrowing into impoundment levees, levee sides should be constructed with more gradual slope than 3:1, and woody vegetation should not be allowed to establish on them. Levees can also be riprapped from at least 1.3 m below water level to at least 0.3 m above water level to prevent tunneling. River otter eat mainly fish, but also feed on crustaceans and amphibians (Lagler and Ostenson 1942; Ryder 1955; Knudsen and Hale 1968; Toweill 1974; Melquist and Dronkert 1999).

All 45 species of bats within the USA must drink on the wing over open water (Taylor and Tuttle 2007). Many bat species such as little brown, silver-haired, gray, Yuma myotis, southeastern myotis, and Rafinesque's big-eared, prefer to feed over open water and wetlands. Impoundments can be improved for water and feeding needs of bats. Impoundments that are deep enough to provide yearlong water are ideal (Taylor and Tuttle 2007). Many bat species are agile flyers and can drink in short distances, but open water lengths of at least 30 m provide the greatest access for all species (Taylor and Tuttle 2007). Ideally, open water should be parallel to the prevailing winds or sheltered by vegetation. Tall trees, power lines or fencing across or adjacent to ponds can obstruct access for bats (Taylor and Tuttle 2007). However, large hollow trees or trees with flaky or exfoliating bark are used for roosting and should be protected (USDA 1999). When managing for bat foraging, emergent vegetation will provide substrate for insect prey and should be encouraged in shallow areas. Poor water quality can alter prey abundance and reduce aquatic insect hatches (USDA 1999).

Wildlife impoundments can be important watering sites for ungulates (McKinstry et al. 2004). The availability of water might limit white-tailed deer abundance because this species tends to avoid areas that are located farther than 1.2 km from water (Fulbright and Ortega-S. 2006; Heffelfinger 2006). Lack of water appears to limit mule deer (Urness 1981; Wallmo 1981; Ferguson 2005), bighorn sheep (Turner and Weaver 1980), and pronghorn (Yoakum 2004) abundances and distributions in arid portions of the western USA. Mule deer prefer to use areas that are located within 2.4 km of a water source (Heffelfinger 2006). Bighorn sheep seldom use areas farther than 5 km from water and optimum distance is probably no more than 1 km from water (Turner and Weaver 1980). Pronghorn seldom use areas that are located more than 6.4 km from water (Yoakum 2004). Thus, if attracting ungulates is a management objective, permanent water should be provided, especially in semiarid regions.

16.5 CONCLUSION

When properly constructed and managed, small impoundments can provide both fisheries and wildlife benefits. However, ponds designed solely for fisheries typically have deeper water and steeper shorelines (Deal et al. 2000). Impoundments with a wide range of water depths, especially shallow areas, and diversity of vegetation tend to support more wildlife species. Impoundments may be designed and managed primarily for wildlife or may provide wildlife benefits additional to other objectives. Because different wildlife species require different habitats, specific objectives should be determined prior to impoundment construction and development of a management plan. An impoundment should be designed and managed to include as many of the target species habitat characteristics as possible. Management strategies outlined herein can increase wildlife benefits of existing impoundments even though they may have been built with less than ideal features.

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