CURRENT CONDITIONS AND MANAGEMENT OF DUCK CREEK CA AND MINGO NWR

MANAGEMENT STRATEGIES - MINGO NWR

Habitats on Mingo NWR have been managed using manipulation of water levels; disturbance of herbaceous and woody vegetation in wetland impoundments; grazing, haying and mowing of open fields; occasional harvest of trees in BLH stands; fire; and pest plant control. Habitats within the 7,730-acre Wilderness Area on the NWR are not actively managed with the exception of seasonally manipulating water levels in the Monopoly Marsh and Stanley Creek areas. In contrast, habitats east of the Wilderness Area are actively managed with manipulation of water and vegetation. Eight permanently impounded water areas are present on Mingo NWR. Twelve moist-soil impoundments are present and are seasonally manipulated to produce herbaceous vegetation (Fig. 27).

Monopoly and Rockhouse Marshes. – The two largest wetland pools on Mingo NWR are Monopoly and Rockhouse marshes (Fig. 27). Water levels in these two areas are controlled by water-control structures or earthen plugs in ditches that drain them; neither area has surrounding levees, except for a small leveed area (Pool 6) in the northeast part of Rockhouse Marsh. From the early 1960s through 1986, Rockhouse and Monopoly marshes were managed on an alternate summer drawdown schedule (Table 12). The purpose of this rotational drawdown schedule was to encourage periodic regeneration of baldcypress and to provide moist-soil vegetation and foraging habitat for waterfowl (the drawn down site) simultaneously with providing at least some summer-flooded brood habitat for locally breeding wood ducks and hooded mergansers, wading bird habitat, and fish spawning and rearing areas each year (the summer flooded area).

The lowest elevation in Monopoly Marsh is about 333 feet amsl and when Monopoly is flooded to a full pool level of 335.5 feet it covers about 2,400 acres of herbaceous emergent wetland vegetation with baldcypress and S/S habitats along the edges. When water levels exceed 335 feet, the BLH around Monopoly start to flood, and when water rises above 336.5 feet, the high BLH ridges separating Monopoly and Rockhouse marshes are overtopped and the two areas fluctuate together. Traditionally, on years when Monopoly was flooded, water management sought to have a 335.5 to 336 foot level during summer with levels raised to 336.5 in winter. In years when Monopoly was drained, the drawdowns were initiated by early March to reduce stress on BLH and fish

Table 12. Draw-down schedules for Monopoly and Rockhouse marshes on Mingo National Wildlife Refuge, Puxico, MO, 1964-2005 (taken from unpublished Mingo annual narratives).

Year	Area drawn down
1964-65	Monopoly
1966-68	Rockhouse
1969-70	Monopoly
1971-74	Rockhouse
1975-78	Monopoly
1979-81	Rockhouse
1982	Monopoly
1983	Rockhouse
1984	Monopoly
1985	Rockhouse
1986	Monopoly
1987	None
1988	Rockhouse
1989	Monopoly
1990-95	Rockhouse
1996-98	Rockhouse and Monopoly
1999	Rockhouse
2000	Rockhouse and Monopoly
2001-2005	Rockhouse

(Fig. 33). Fish kills were reduced when drawdowns occurred early in spring prior to high summer water temperatures. Complete drainage of Monopoly often did not occur until late June, if it did at all (USFWS 1971-2002).

The lowest elevation in Rockhouse Marsh is about 334 feet amsl. At full pool of 335.5, water covers about 1,200 acres of herbaceous and S/S vegetation with baldcypress and other water tolerant trees scattered throughout the area. In years when Rockhouse was flooded, the target water level was 335.5 from May through November and then water levels were raised to 336.5 during winter and early spring (Fig. 33). When Rockhouse was drawn down, drainage typically occurred by early June. A June drawdown was implemented to reduce willow encroachment into the marsh. In recent years, drawdowns on Rockhouse have begun earlier, sometimes as early as March. Drainage of Rockhouse Marsh was slow until the early 2000s when silt was removed from Ditch 11 and a new bottom elevation was constructed for the radial-arm water-control structure on Ditch 11.

Various rotations occurred in flooding and draining Monopoly and Rockhouse marshes, but until 1982 rotations were on a 3-4 year schedule (Table 12). Prior to 1980, water-control structures were not present on ditches 5, 6, and 11 and earthen plugs were used to block ditches and flood either Rockhouse or Monopoly marsh. These plugs were difficult to construct or remove and drawdowns could not always be accomplished when desired because of high precipitation and poor access in some years. Long intervals of flooding also promoted extensive stands of aquatic emergent vegetation such as American lotus. Prolonged flooding tended to increase fish populations in flooded areas and if drawdowns were associated with high ambient temperatures fish kills occurred.

In 1980 a concrete radial-arm water-control structure was constructed in Ditch 11 to control flooding and draining of most of Mingo NWR. Two other concrete slide-gate structures were built on Ditches 5 and 6. These structures were poorly designed and sized, however, and independent flooding and efficient withdrawal of water levels in Monopoly and Rockhouse marshes never was achieved. From 1982 to 1986, Rockhouse and Monopoly were at least partly drawn down in successive years (Table 12). Both areas were continuously flooded in 1987, but rotated again in 1988 and 1989. American lotus began covering most of Monopoly in the mid 1980s and water levels were held continuously high (335-336 feet amsl) from 1990 to 1996 in an attempt to control it. Prolonged flooding also allowed giant cutgrass to expand its area in Monopoly, and by the late 1990s, it covered nearly 25 acres. Monopoly Marsh has been drawn down only once (in 2000) since 1996. In contrast, Rockhouse has been at least partly drained each summer since 1990 to promote baldcypress regeneration and moist-soil plant production and to control encroaching woody vegetation including black willow, red maple, buttonbush, and green ash.

Little physical disturbance of vegetation or soils occurred in Monopoly Marsh when it was drawn down because soils remained saturated even when surface water was removed and equipment could not be used in the area. In contrast, disking and mowing have been used regularly to control woody vegetation and stimulate moist-soil production in Rockhouse Marsh when it was drawn down. Fire also was used occasionally in small areas of Rockhouse Marsh.

Stanley Creek Impoundment. – The Stanley Creek impoundment area contains old channels of the Mingo River and Stanley Creek. Earthen plugs (installed in the early 1960s in Ditch 10 and the old Mingo River channel) and a concrete water-control structure (built in 1986 in the lower end of the old Mingo River near Flatbanks) allow management of shallow backwater flooding in this area. When the earthen plugs were present, water levels in this area have remained at or above 337 feet from December through June creating a 500-acre impoundment. During late summer evapotranspiration lowers water levels to < 336 feet but still inundates about 350-400 acres (Fig. 33). This impounded area now is mostly dead timber and S/S habitat. After the water-control structure was built on the old Mingo River, the impoundment has been managed for a 335.5 water level during summer, which essentially confines water to the old river channel and allows some moist-soil plant development in low elevation areas adjacent to the Mingo River and Stanley Creek.

Gum Stump Pool (Pool 3). – The Gum Stump Pool area is separated from the main part of the historic Monopoly Marsh area by a levee along Ditch 4 and has a pipe that allows water to flow between Gum Stump and Monopoly. Traditionally, Gum Stump has been managed as a permanently flooded pool and water fluctuates with the level of Monopoly except when Monopoly is drawn down. When Monopoly was drawn down, Gum Stump water levels were periodically maintained at a 335-335.5 level by plugging the pipe through the west levee to provide wood duck and hooded merganser brood habitat and fish habitat.

The bottom elevation of most of the Gum Stump Pool is 334 feet.

Pool 5. – Pool 5 is a BLH area bounded by road levees along Ditch 2 and Ditch 3 and the east-west levee along the northeast side of Rockhouse Marsh. Pool 5 is dry at a 335.5 foot elevation. Closing water-control structures on the southeast and southwest sides of this pool backs water up at a 338.5 foot elevation. In some dry years, water has been pumped from ditches and the Monopoly/Rockhouse marsh complex to impound about 100 acres at 337.2 feet.

Pool 6. – Pool 6 is a leveed area on the northeast corner of Rockhouse Marsh. It is managed as a moist-soil impoundment and is flooded from a pump in Ditch 2 and drained through a water-control structure in the north levee.

Pool 8. – Pool 8 is a GTR cooperatively managed with Duck Creek CA as a wade-and-shoot waterfowl hunting area. The pool is bounded by levees and high ground along Ditches 1 and 2 and water is impounded by closing water-control structures on Ditch 1 and in the southwest corner of the pool. Water to flood Pool 8 typically has been provided following heavy rains in fall by closing the radial gate structure on Ditch 1. In dry years, and often early in the fall prior to rains, water has been pumped from Ditch 2 into Pool 8 using a crisafulli pump. A water-control structure on the west side of the pool allows water to drain from Pool 8 into Ditch 2, and when Ditch 2 is high water, can be backed into Pool 8 from this structure. When Pool 8 is at a full pool level of 339.5 feet about 1,100 acres are flooded 1-3 feet deep. At 337 feet, Pool 8 area is essential dry. Water in Pool 8 usually has been drained following the close of duck season no later than 1 March. Water levels and timing of flooding in Pool 8 have been variable among years since the area was first managed for duck hunting in 1978. Little water was present in Pool 8 during several dry winters during the 1980s and 1990s. Since 2001, pool water levels have been allowed to fluctuate with rains and natural flood events. In 2003 flooding was delayed until early December to encourage survival of young regenerating red oak seedlings. Large windstorms and a tornado that occurred in 1984 damaged several areas of BLH in Pool 8; these areas have regenerated mostly to red maple and green ash.

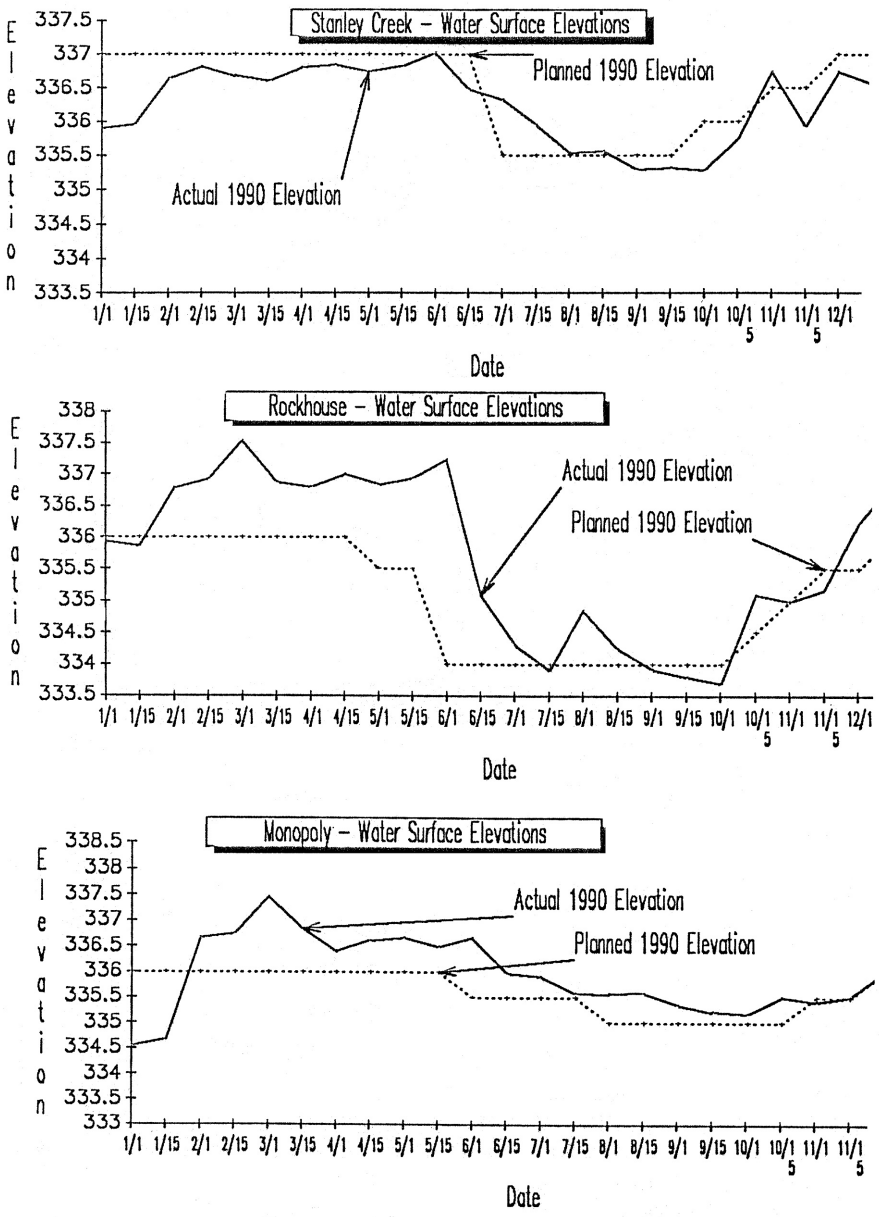


Figure 33. Examples of seasonal surface water levels in Stanley Creek Impoundment, Rockhouse Marsh, and Monopoly Marsh on Mingo National Wildlife Refuge in 1990 (data from Mingo National Wildlife Refuge unpublished annual narrative, 1990).

Red Mill Pond. – The Red Mill Pond area includes an old impounded area used for holding logs when the Red Line Lumber Company was in

operation in the early 1900s and about 40 acres of BLH that adjoined it on the west side. This combined area was leveed and impounded in the late 1960s to create a permanently flooded impoundment for wood duck and hooded merganser breeding and brood habitat, wintering waterfowl and wading birds, and for wildlife viewing by the public. Occasionally, Red Mill Pond has been partly drawn down in summer to encourage regeneration of baldcypress and to provide moist-soil habitats. Full pool elevation of Red Mill Pond is 336.9 feet.

Moist-soil Impoundments. – Twelve moist-soil impoundments on Mingo NWR contain about 705 acres (Figure 27) of fields formerly used for agricultural production, mostly rice. All of these impoundments have been developed to impound water by constructing levees and water-control structures in and around them. Flooding and draining capabilities and management schedules for these impoundments has varied widely since they were constructed in the 1970s (Fredrickson and Taylor 1982). In most years, impoundments have been drained in spring and early summer to promote germination of herbaceous annual and perennial plants and then they are shallowly reflooded in fall or early winter to provide habitat for migrant waterbirds. Woody vegetation is controlled in the impoundments by periodically farming the area or by discing, burning, or mowing. Typically, a few areas in the impoundments have been farmed for corn or milo to provide high carbohydrate foods and introduce soil disturbance about once every 3-5 years. This agricultural disturbance improves moist-soil production in subsequent years and provides additional control of invasive and undesirable woody and herbaceous plants. Many of the impoundments have been manipulated for experimental research (Fredrickson and Taylor 1982).

Moist-soil impoundments on Mingo NWR are flooded by natural rainfall, wells (e.g., MS 2-4), pumping from surrounding ditches (e.g., MS 5-9), or diverting water from nearby wetland impoundments (e.g., Luken Farm). Certain impoundments have relatively independent flooding and draining infrastructure, while others can only flood or drain through adjacent impoundments. Some impoundments are more difficult to manage because they have substantial subsurface connections to ditches.

Agricultural Fields and Grassy Openings. – When Mingo NWR was established, over 2,000 acres of open fields were actively farmed for annual row crop production or maintained as grassy fields for haying and pasture. Since that time, over 700 acres of fields have been converted to moist-soil impoundments and another 400 acres of fields were abandoned and allowed to revegetate by invasion of surrounding plants. In the past 30 years about 500 acres of agricultural fields (Fig. 27) have been planted annually with cereal grains (corn, milo, soybeans, winter wheat) or legumes (clover) to provide food for waterfowl, deer, turkey, and upland birds. Typically, most farming has been done by permittee farmers who harvest their share of the crop and leave the balance unharvested for the NWR share. Crops typically have been rotated in fields among years and usually farmers leave more corn, milo, and wheat unharvested and are compensated by harvesting a higher percentage of soybeans for their share.

Until 2001, many of the grassy openings were fenced and either grazing or haying was used to maintain grass-type habitats. Much of the grass habitat was dominated by fescue and other common hay production species including red top, orchard grass, and timothy. Occasionally, some openings were plowed or disked and reseeded to provide legume or new growth grasses and sedges for foraging waterfowl, deer, and other wildlife. Fire also was used to maintain grass habitats.

The Mingo NWR CCP (USFWS 2006) recommends maintaining 205 acres of grassy openings, 253 acres of cropland, and 73 acres of food plots and converting the remaining 449 acres to giant cane, oak savanna, and early successional BLH. Additionally, fescue would be replaced with native grass and prairie-type vegetation.

Invasive/Exotic/Nuisance Plants. – The most common invasive and exotic plants found on Mingo NWR are Johnson grass, sericea lespedeza, Japanese stiltgrass, reed canary grass, autumn olive, and multiflora rose. Many mechanical and chemical treatments have been employed on Mingo NWR to control these plant species including mowing, burning, disking or plowing, and chemical application. Biological control treatments have been limited. In most cases, treatments have been site-specific on small existing stands; preventive actions have been limited or ineffective.

Forest Management. – Active timber management using harvest or chemical/mechanical manipulation of forest stands has been limited on Mingo NWR. Timber harvest was extensive in the Mingo Basin prior to establishment of the Mingo NWR and the forest management strategy of the NWR has been to allow existing stands to mature

and regenerate to BLH communities. Further, active management and artificial manipulation of BLH stands has been prohibited in the 7,730-acre Wilderness Area. Outside of the Wilderness Area, BLH stands have been inventoried and some small timber harvest treatments have occurred. For example, in 1987 50.5 acres in seven small areas were clearcut in Pool 8 and an additional 34 acres of BLH in Pool 8 were thinned to promote regeneration of pin and willow oak. These cuts contained about 502,205 board feet, with over 50% pin oak (Mingo NWR 1987 unpublished Annual Narrative Report). These areas now have regenerated to red maple, green ash, and overcup oak. Recently, small areas in Pool 8 have been chemically treated to remove non-oak species and to study regeneration and survival of oaks.

Trees have been removed from levees and ditch banks at various times to repair damage and for ditch maintenance. Also, woody vegetation has been periodically removed in Monopoly and Rockhouse marshes, moist-soil units, and open fields to maintain herbaceous or grass habitats. In some open areas tree seedlings have been planted to reforest small openings and edges of existing BLH stands.

MANAGEMENT STRATEGIES - DUCK CREEK CA

Habitat management on Duck Creek CA traditionally has sought to provide waterfowl foraging habitat and associated hunting opportunity in GTRs, moist-soil impoundments, Pool 1, and agricultural cropland (MDC 1955-2000, 1999). When Pool 1 was converted to a water storage reservoir it developed an excellent fishery and since has been managed for dual, sometimes competing, purposes of water storage for flooding GTRs and sport fishing. Upland and BLH forests not in GTRs have been lightly managed for hunting and other public uses.

Pool 1. – Before Duck Creek CA was purchased and developed, the Pool 1 area was over 95% covered with BLH. After purchase, levees were built around the Pool 1 area with the intention of making it a GTR for waterfowl hunting. The original plan was to divert water from the Castor River down Ditch 111 to flood Pool 1 and subsequently store and move water through Pool 1 into the adjacent GTR Pools 2, 3, and 8. When it became apparent that flows in the Castor River were not sufficient to fill Pool 1 and the adjacent GTR pools in fall, Pool 1 was converted to a water storage reservoir. At that point, managers recognized that most of the BLH in Pool 1 would die and eventually it would become an open water pool.

Beginning in the mid-1950s, water levels in Pool 1 were managed to supply water to Pools 2 and 3 in early fall. After 1978, water from Pool 1 was used to partly flood Pool 8 in fall and winter for duck hunting. Pool 1 is filled and recharged from onsite precipitation and by diverting water from Ditch 111 into the pool. Diversion occurs by closing the water control structures in Ditch 111, which dams and raises water levels in Ditch 111 (height depends on water flow in Ditch 111) and creates head pressure to gravity flow water into Pool 1. If increased water is desired in Pool 1 and the Castor River is high, a water-control structure at the intersection of Ditch 111 and the Castor River is opened and water moves down Ditch 111 and into Pool 1 as above. Full pool level in Pool 1 now is considered 346 feet and about 1,800 acres are flooded ranging from 10-12 feet deep in borrow areas along levees to a few inches deep in BLH areas on the north end of the pool. At full pool, most water in Pool 1 is 4-6 feet deep.

Water is drained from Pool 1 into Pools 2 and 3 in fall using gravity flow water-control structures (Fig. 29). Historically, water in Pool 1 was not lowered to less than 341.5 feet to flood GTRs. After the fishery developed in Pool 1, water has not been lowered in the pool to < 342 feet so that a minimum water depth in borrow areas was at least eight feet deep during winter and ice periods. In recent years a minimum winter pool level of 343.5 feet has been discussed for fishery management concerns. To date, no substantial fish kills have occurred in Pool 1 when it has been lowered to a 342-343 level, however, water depth and storage capacity of the pool may be reduced from original levels because of siltation and accumulation of organic material on the bottom of the pool.

Boat lanes and 37 blind clearings were cut in BLH stands of Pool 1 in the early 1950s and these areas were hunted until 1975 when all waterfowl hunting in Pool 1 was closed and the pool became a refuge except for two blinds reserved for disabled hunters located on the levees at the north end. Beginning in 2000, two hunting parties were allowed to hunt the southern part of Pool 1 (one party each on the east and west ½ of the southern half of the pool) on four days of each week (Tuesday, Thursday, Saturday, and Sunday) during duck hunting season. The north end of Pool 1 has remained a waterfowl refuge since 1975, except for the handicap blinds on the exterior levees.

Fishery management in Pool 1 generally has offered public fishing, except from 15 October through the end of duck hunting season to reduce disturbance to refuging waterfowl. Also, an area around an active bald eagle nest has been closed to fishing access in late winter and spring. Fishing regulations in Pool 1 have reflected statewide regulations, but at various times, limits have been imposed for daily take of some species and length limitations have been in effect for harvesting largemouth bass. Creel checks and surveys of fishermen have been used to monitor fishing pressure and harvest. Fishing generally has been excellent in Pool 1 and pressure is heavy in spring and summer. Other fishery management has included treatment of areas in the south part of the pool with various herbicides to control submergent and floating-leaved aquatic vegetation and to improve access for fishermen. In recent years, about 10 acres of Pool 1 has been treated with herbicides annually. Four short (ca. 15 feet) rock and earthen jetties were constructed into Pool 1 in the 1990s to increase access for bank fishermen.

Other management on Pool 1 has created non-entry areas at various times to reduce disturbance to nesting giant Canada geese. Goose tubs and wood duck boxes have been placed in parts of the pool to encourage nesting. In the 1980s and 1990s, damage to the Pool 1 levees from burrowing rodents and erosion by persistent high water raised concerns about the integrity of the water holding capability of the pool. Additionally, periodic changes in turbidity and flow in Ditch 105 on the east side of Pool 1 during dry and low-flow periods raised questions about whether some water might be seeping from the Pool through levees or subsurface strata. Riprap was placed on the lake side of most of the Pool 1 levee to reduce rodent and erosion problems. Also, levee bank slopes were widened and repaired on the outside of the Pool 1 levee in the northeast part of the pool in the 1990s.

Pools 2 and 3.– Pools 2 and 3 have been managed as GTRs for public duck hunting since 1955. Both pools are surrounded by levees and they have water-control structures to flood and drain them. These pools have been flooded for at least some periods during fall and winter from Pool 1 (see Pool 1 section above) in every year since 1955 except in 2002 and 2004. In these years, water levels in Pool 1 were low in October (342-343 feet) and no water was taken from Pool 1 to flood Pool 3. Local precipitation flooded the low elevation Otter Pond area of Pool 3 in 2002 and 2004. In 2004, some water was pumped into Pool 3 in December from Ditch 1 using a crisafulli pump.

Timing of flooding and draining Pools 2 and 3 has varied among years. Until the mid 1980s, flooding usually was initiated in Pool 2 in early October. In a few years, flooding of Pool 2 began as early as mid September. Flooding was initiated in Pool 3 after Pool 2 was at least partly flooded, usually by late October. Since the mid 1980s, timing of flooding in both pools has been delayed until mid to late October. When Pool 2 is at full pool level of 341.5 about 709 acres are flooded up to three feet deep; a few high ridges in the east and southeast parts of the pool remain dry at this level. If the water-control structure from Pool 1 is completely open, Pool 2 can be flooded to full pool level in about two weeks. Two spur roads/levees were built into Pool 2 on the west side of the pool to access the "E" and "H" boat lanes and hunting blinds. Boat lanes also were constructed to access other blind areas from the exterior levees. Initially, 23 blind locations (clearings in the original BLH) were developed in Pool 2. Currently about 17 of these locations are hunted.

The original water-control structure that allowed water to gravity flow from Pool 1 into Pool 2 was a screw-gate pipe attached to the underside of the bridge that crossed Ditch 105. This pipe was at a 344 foot elevation and water could be moved into Pool 2 only when the Pool 1 water level exceeded that point. Consequently, Pool 2 was flooded before Pool 3 (which had a drain pipe at 342 feet elevation) to assure that adequate water levels in Pool 1 were available to flood both pools. In 1978 a new water-control structure and pipe were constructed from Pool 1 under Ditch 105 and into Pool 2 that enabled Pool 2 to be flooded at a 341-342 Pool 1 level. Even with this new capability, Pool 2 has always been flooded before Pool 3.

Pool 3 has a full pool level of 340.5 that floods about 575 acres up to four feet deep. Because Pool 3 has been flooded after Pool 2, timing and duration of its flooding has depended on water levels in Pool 1 after Pool 2 was filled. In some dry years, Pool 3 was only partly filled until rains or runoff provided recharge of Pool 1 levels and subsequent flooding of Pool 3. Boat lanes were constructed to 15 blind clearings. These lanes originate from exterior levees and extend into the interior of the pool. This pattern of excavation has influenced water movement into, through, and out of the pool. During gradual flooding in 2005, water levels were mapped. Water initially flowed into boat lanes and borrow areas followed by filling the Otter Pond depression (Fig. 34). As water levels increase to 339.5 feet, much of the lower elevation along boat lanes, blind clearings, and Otter

pond is shallowly flooded. At 340.5 feet, boat lanes continue to route water along these channels until water overtops spoil banks along the boat lanes or cross low ridges in the pool. Water drains from Pool 3 via boat lanes and borrow ditch paths in a reverse manner to flooding.

When Duck Creek CA was purchased, part of the BLH in the Pool 3 area had been recently thinned. Since that time, no additional timber harvest has occurred in the pool except for clearing along boat lanes and borrow areas, and small cuts that were made for an experimental study in the 1980s that examined effects of cutting and water regime on pin oak regeneration (Hoss 1983, Hamilton et al. 1991). This study included 48 circular two-acre treatment plots. In these categories, 16 control plots had no cutting, 16 plots were clear cut, and 16 plots had shelterwood cuts that reduced pin oak basal area to 30 ft^2/acre. One half of the treatment plots were in Pool 3 and the other half was in a BLH stand south of Ditch 106 in the Grimm Tract area of Duck Creek CA. A more recent study has injected some trees in Pools 3 and 8 with imapazyr to kill non-oak species, open canopies, and evaluate regeneration of red oaks. Blind clearings in Pool 3 have been maintained by annual mowing, disking, and occasionally planting with millet or agricultural crops.

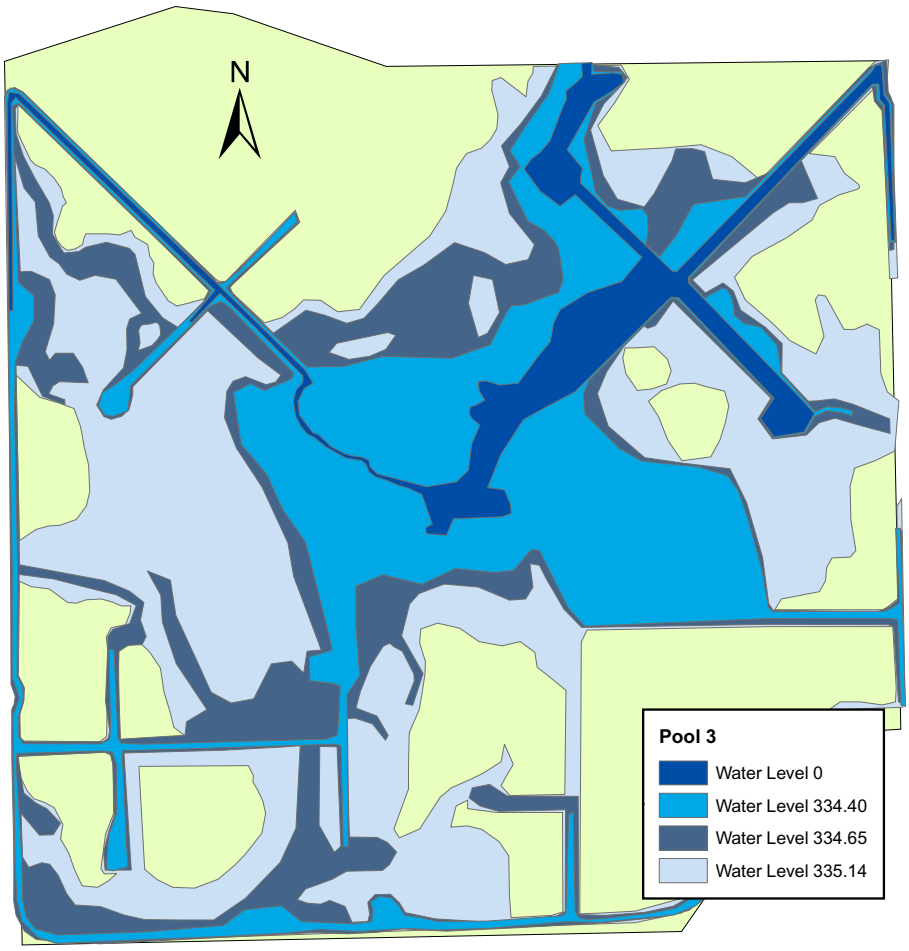


Figure 34. Pattern of surface flooding in Pool 3 on Duck Creek Conservation Area in fall 2005 as water levels rose from dry condition to a 335.14 feet above mean sea level.

Pool 2 contains an 80-acre field in the north end of the pool that typically has been managed for moist-soil vegetation and agricultural crops. Also, BLH in parts of Pool 2 were cleared in parallel "slashes" in the mid 1950s to create linear openings in BLH that were disked annually and planted to millet or agricultural crops. Maintenance of these slashes continued until the early 1980s by annually mowing, discing, or cutting seedlings and other vegetation. Since then, the slash areas have been left undisturbed and they are regenerating into younger BLH stands. In 1984 a tornado moved across Pool 2 and created an open "lane" through the northwest part of the pool. This area was cleared of fallen trees and debris and has been left undisturbed to regenerate into BLH. No timber harvest has occurred in Pool 2 except for clearings along boat lanes and roads around the pool (Hoss 1983).

Water typically was drained from Pools 2 and 3 soon after the close of duck hunting seasons. This schedule of drainage is influenced by agreements signed between MDC and LRDD in 1952 and 1962, which specify times of drainage. The 1962 agreement further specifies that the water-control structure in the lowered levee location on the east side of Pool 3 be kept open following the close of duck hunting season through summer to allow water from Ditch 105 to flow into and through the pool when Ditch 105 levels are above 341.5 feet. Since the early 1990s, drainage of both Pools 2 and 3 has been managed as gradual releases to increase availability of food and shallow water to ducks in late winter and during spring migration. After the pools are dried, and when water-

control structures are open, changes in water levels in ditches 104 and 105 occasionally cause water to rise and fall in these pools.

Waterfowl hunting has been allowed in Pools 2 and 3 since 1955. The number of hunters is controlled with a daily drawing for blinds and party size has not exceeded four hunters. No refuge areas have been designated in either pool, although hunting typically has been restricted to the blind site, its clearing, or a small zone around the blind. Area waterfowl hunting regulations have varied among years to reflect federal frameworks and limits and changes in CA management. In most years, hunting of Pools 2 and 3 was allowed all day and blinds were not "refilled" after a hunting party left for the day. Refilling blinds was common until the mid 1970s.

Non-GTR Forests and Open Fields. – Duck Creek CA contains several small areas of BLH that are not leveed or that do not have water management structures. These areas include the naturally flooded Thompson Ridge, Grimm Tract, McGee Tract, Unit B, Ditch 111 corridor, and Stilts Woods areas. Duck Creek also owns 20 acres of BLH, known as the "Lost Twenty" tract in the far northwest corner of Pool 8 and about 160 acres of upland and pine plantation forest in the northwest part of the CA. Since Duck Creek was purchased, no timber harvest has occurred in any of these areas (except for small experimental cuts in the Grimm Tract - see Pool 3 section above) nor has any timber been cut or managed for openings or agricultural plantings.

Duck Creek CA contains several small open fields in the north, east, and southeast parts of the CA. Fields northeast of Stilts Woods and Pool 1, and in the south area along Highway 51 traditionally have been farmed for agricultural crops by permittee farmers. Permittee farmers plant these crops and harvest a portion (amount varies by crop type and contractual agreement) and the remainder usually is left unharvested in fields for wildlife food. Other open fields on the CA have been managed for grass, forbs, and early successional trees and shrubs and to maintain a gas line right-of-way easement across the east side of the area.

Unit A. – When Duck Creek CA was purchased, Unit A was farmed and did not have levees in or around it. At that time, four small patches of BLH were present in Unit A. After purchase, two of the BLH patches were cleared and the area was managed primarily for agricultural and forage crops for migrant and wintering Canada geese. Later, levees were built in and around Unit A to subdivide the area into four pools (A, B, C, D) that have been managed as seasonal wetlands. Management of the pools in Unit A has varied among years, but they typically have been managed for moist-soil production and agricultural crops. Pools usually have been drained in spring and then they are flooded in early fall for waterfowl foraging habitat and public hunting. Unit A is flooded by pumping water from two wells in the southwest part of "B" pool, a well in "A" pool, and by pumping water from Ditch 111 into "C" pool. Flooding and draining of the four pools are not independent. Typically "B" pool has been flooded first and after it filled, water is pumped into "A" pool with a crisafulli pump, and then gravity flowed into "C" and " D" pools. The pump and water-control structure in Ditch 111 also is used to flood "C" and " D" pools. In some years, one of the four pools was left flooded for most of the summer to create more emergent and perennial vegetation habitats. "D" pool contains "I" and "L" woods and usually has been flooded later in fall and drained earlier in spring to maintain these small remnant BLH patches and to promote regeneration of red oaks in part of the area between the patches.

Unit A vegetation has been managed using many disturbance techniques including burning, disking and plowing, mowing, and periodic agricultural production. Woody vegetation in the impoundments has been contained by burning, mowing, and physical removal. Topography in Unit A gradually has been flattened from years of agricultural production and a desire to improve drainage. No restoration of historic topographic features such as sloughs or swales has occurred. Boat lanes and borrow areas have been excavated in and around the impoundment pools and they route flood and drain water. Unit A contains eight hunting blinds. Until 1998, waterfowl hunting was allowed all day in Unit A; since that time hunting has been closed after 1:00 p.m.

In 2004, four small fields on the northwest side of Unit A in the field 19 area were developed as moist-soil pools with surrounding levees and water-control structures. A well was dug in the northwest part of Unit A to flood these fields and to supplement flooding of "A" pool.

Unit B. –Unit B was mostly agricultural fields when it was purchased and most of this area has been maintained and managed for agriculture. BLH and riparian forest exist along McGee Creek and in small patches in the southern end of the area (Fig. 27). In the late 1980s, small levees were built along the south and east sides of the H-Pool, 48 South, and 48 North fields and water-control structures were installed to allow

some flooding of these areas for waterfowl habitat and hunting. These fields are flooded by pumping water from "A" pool of Unit A and have typically been in agricultural production and limited moist-soil production. Timing of flooding of Unit B pools depends on time of flooding Unit A. No wells currently exist in Unit B. Water is drained from Unit B fields into the ditch between Units A and B. A small area in field 54 was developed for flooding by constructing a small levee and water-control structure on the south side of the field along the access road. This field is flooded by local rainfall and runoff.

Historically, agricultural fields in Unit B were managed as dry-land foraging and hunting areas for geese. Each field had a "pit blind" that was available for hunting on a daily basis. These pits still are present, but low numbers of geese in recent years has reduced hunter use of these blinds and fields. At present, H-Pool, 48 South, and 48 North fields are hunted on a rotational basis; each field is hunted only 3-4 days/week until 1:00 p.m. Goose pits are available for hunting all day. Small areas of some Unit B fields have been planted in sunflowers, legumes, and other forage crops for upland game. These fields are open for archery deer and turkey hunting.

CONDITION OF GTR FORESTS

Pools 2 and 3 on Duck Creek CA have been flooded annually during fall and winter since 1955 and Pool 8 on Mingo NWR has been flooded in most years since 1978. GTRs throughout the MAV that have been flooded annually for duck hunting usually have altered tree and shrub species composition, damage and water stress to trees, increased mortality to red oaks, reduced acorn production, reduced or changed regeneration, and reduced herbaceous ground cover (e.g., Heitmeyer et al. 1991, 2004; King 1995, Fredrickson 2005b). Changes in BLH condition in GTRs are mostly related to prolonged and annually consistent flooding regimes that inundate, or create saturated soil conditions, from early fall through spring. This flooding regime is driven by the desire to have GTRs flooded throughout duck hunting seasons. Additionally, in many cases the levees and water-control structures that impound water in GTRs do not allow efficient or complete drainage of the impoundments and they either impound or prolong surface flooding and soil saturation in depressions, along levees, behind structures, and in drainages. Collectively, water management in GTRs creates artificial water regimes compared to the dynamics of natural BLH systems.

Water regimes in Pools 2, 3, and 8 have had artificial and prolonged flooding periodicity. From 1955 through the early 1990s, Pools 2 and 3 were almost always at least partly flooded by early to mid October. When water levels in Ditch 111 and Pool 1 were high, flooding also was initiated in Pool 8 in October or early November. Water-control structures usually were opened to drain Pools 2 and 3 soon after the close of duck hunting season, but drainage often was prolonged because of poor water flow around spoil banks of boat lanes, high elevations of drain structures, siltation in ditches and borrow areas, and beaver activity.

Forest inventories of BLH in Pools 2 and 3 in the 1960s and 1970s (Minkler and McDermott 1960, McQuilkin and Musbach 1978) indicated that 60-80% of mature trees in these GTRs were pin and willow oak. This high composition of red oaks reflects the relatively high and dry elevation of these areas in the northeast part of the Mingo Basin (Fig. 20) and regeneration following harvest of timber in these areas from the late 1800s through the mid 1900s (see earlier Regional Landscape Changes section). By the late 1980s, mortality of red oaks was apparent in many areas, especially in Pool 3 and low elevations of Pool 8. Further, with the exception of the "slash" areas in Pool 2, little red oak regeneration (< 3" dbh seedlings) was occurring in the GTR pools. Additionally, the experimental timber harvest study conducted on Duck Creek and Mingo NWR in the 1980s, with followup evaluations in the 1990s and 2004, indicated little regeneration of red oaks regardless of harvest method or amount of cutting (clear cuts, shelterwood cuts, control, no cutting) (Hamilton et al. 1991). All of these sites eventually became populated by more water tolerant species, especially green ash, red maple, buttonbush, and swamp privet along with scattered baldcypress and overcup oak.

In late summer 2005, we sampled 250 1/10-acre plots in Pools 2 ($N = 90$), 3 ($N = 60$), and 8 ($N = 100$) to determine composition and health of BLH stands in these GTRs. At each plot, data were collected on size (dbh) and composition of trees, indicators of water stress (basal swelling, tip die-back, leaf chlorosis), herbaceous ground and canopy coverage, mortality of trees and whether dead trees were recently dead and standing or older fallen trees, number of dead stems, and regeneration of trees (seedlings < 3" dbh and at least 0.5 m tall). These data indicated that Pool

2 currently is a more "open" and younger stand of BLH in part because of the "slash" management that occurred in parts of the pool until the early 1980s and effects of a tornado in 1984. About 1/3 of the trees in Pool 2 are pin oak and they cover about 28 ft^2/acre basal area (Table 13). Overcup oak, cherrybark oak, and red maple each compose about 10-11% of the trees in Pool 2. Pool 2 has less dead oaks, dead stems, and lower indicators of water stress than Pools 3 or 8 (Tables 14, 15). Regeneration of young trees in Pool 2 contains many pin oak along with overcup oak and red maple seedlings (Figs. 35, 36). Most young pin and willow oak are in the former "slash" areas of Pool 2 and in higher elevations on the east side of the pool that flood for shorter periods, if at all, during fall and winter (Fig. 36). In contrast, more red maple, overcup oak, and green ash now are present in deeper parts of the pool and along boat lanes and borrow areas.

Pool 3 is an older, more closed canopy, BLH stand than Pools 2 or 8. BLH stands in Pool 3 have high mortality of red oaks (about 1/3 are dead) (Tables 13-15). Despite high mortality, pin oak remains the most common tree in Pool 3, but overcup oak and red maple now compose more than 30% of the stand compared to < 20% in the mid 1970s. About 45% of living pin and willow oaks in Pool 3 have basal swelling and 27% have large amounts of tip die-back. Regeneration of trees in Pool 3 is dominated by 3-6 inch dbh American elm, green ash, and red maple along with scattered patches of water locust, swamp privet, and buttonbush (Figs. 35, 36).

Pool 8 appears to be a BLH stand in transition from an older closed canopy forest dominated by pin oak to a younger stand dominated by red maple and overcup oak (Tables 13-15). Total basal area of all trees combined is higher in Pool 8 than in Pools 2 or 3 and represents a dichotomy of large mature pin oaks in higher elevations vs. mixed-age overcup oak and red maple in lower elevations that have more prolonged flooding (Table 13). Many dead stems are present in lower elevations of Pool 8 and about 20% of pin oaks now are dead (Table 15). Regeneration in Pool 8 is dominated by dense stands of young red maple in many areas, although large numbers of young willow oak are present in higher elevation in the north end and overcup oak seedlings are scattered throughout the pool (Figs. 35, 36).

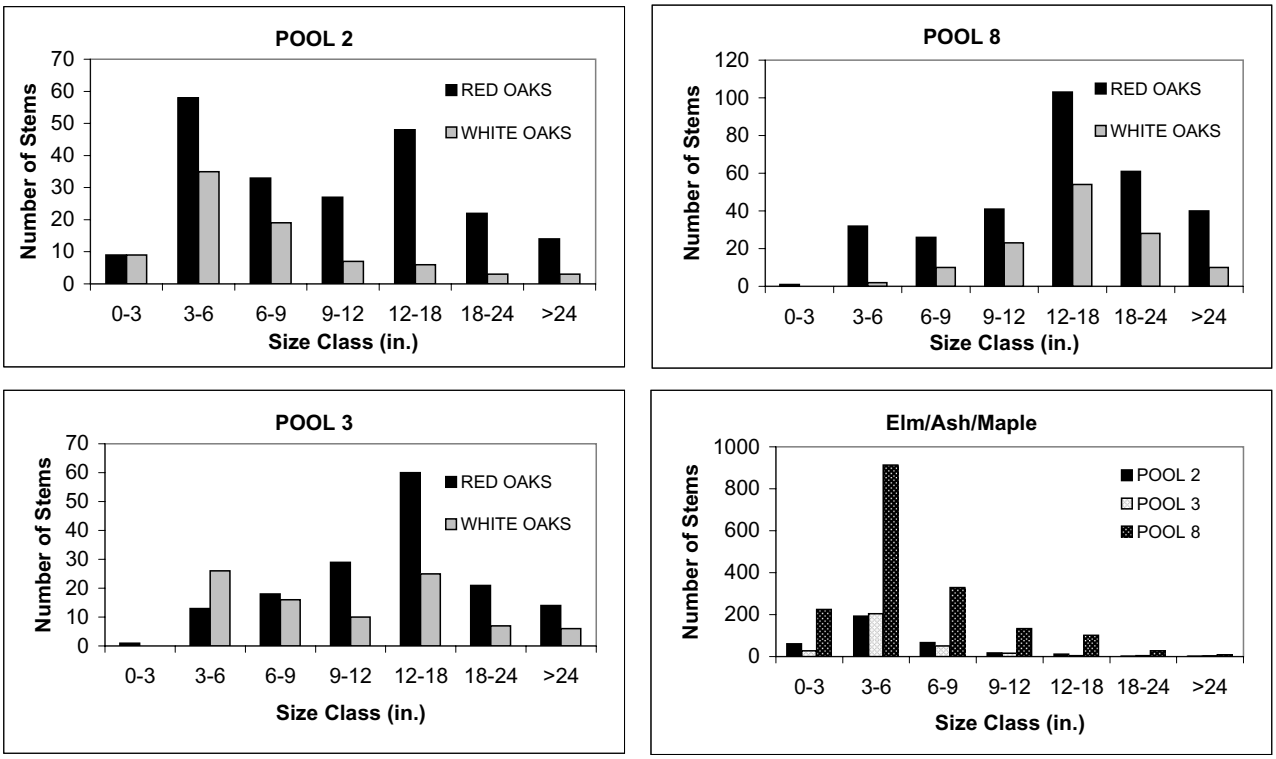


Figure 35. Size class of trees in Pools 2, 3, and 8 in the Mingo Basin in fall 2005. White oaks include overcup, swamp white, and white oaks. Red oaks include pin, Nuttall, willow, water, and cherrybark oaks. Elm/Ash/Maple includes American and winged elm, green and pumpkin ash, and red and sugar maple.

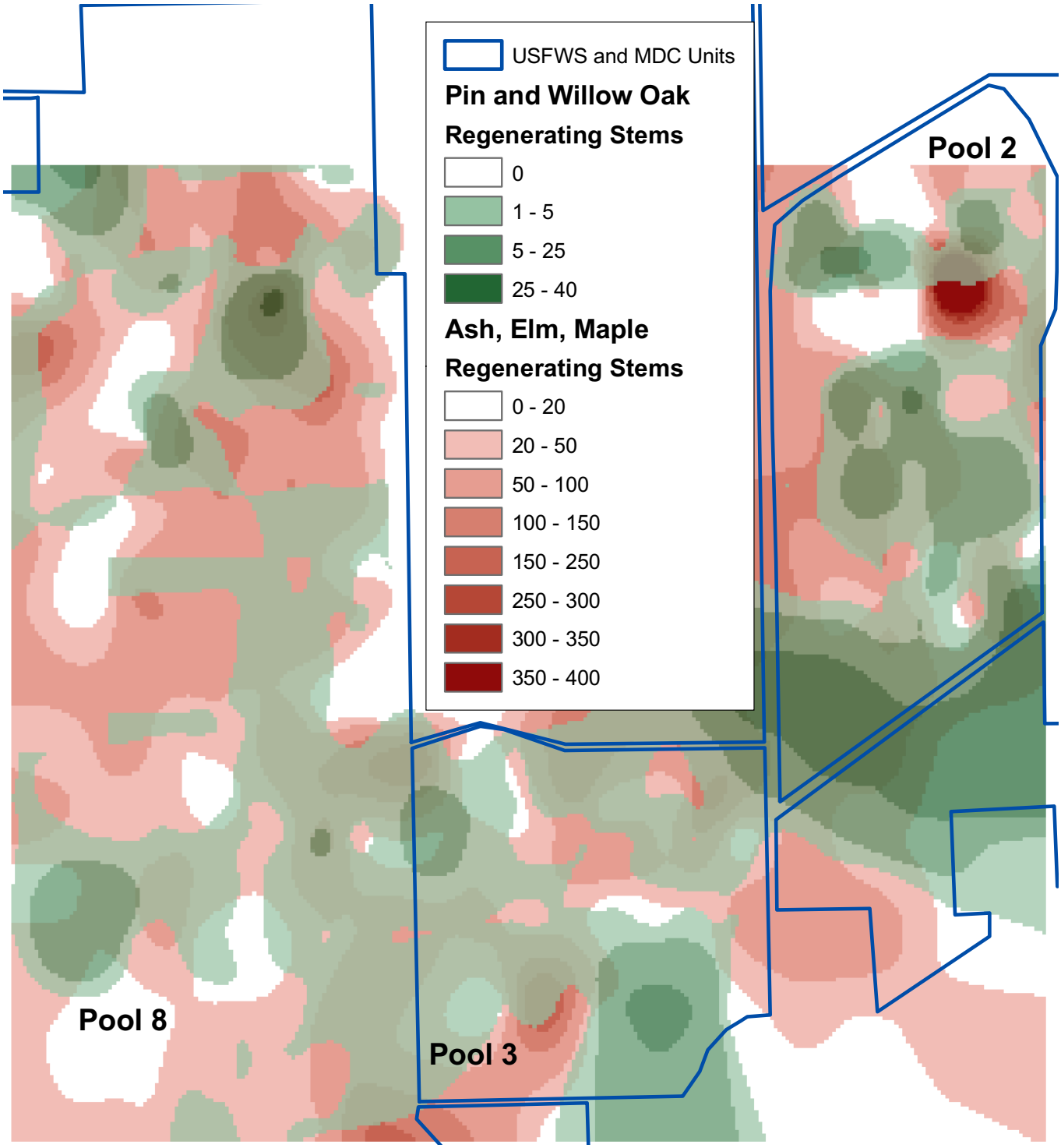


Figure 36. Distribution of regenerating red oaks, ash, elm, and maple in Pools 2, 3, and 8 modeled from data obtained on 250 random plots. Data are regenerating stems > 1.5 feet tall/tenth-acre.

Table 13. Basal area (sq ft/acre) and relative basal area (in parentheses; % of total) of trees >= 3" dbh in Pools 2, 3, and 8 on Duck Creek Conservation Area and Mingo National Wildlife Refuge, 2005.

Species[a]	Pool 2	Pool 3	Pool 8	Combined
ASH	3.1 (4.0)	3.4 (2.6)	4.0 (3.0)	3.6 (3.1)
CO	8.4 (10.6)	3.7 (2.7)	4.2 (3.2)	5.1 (4.3)
OO	8.7 (11.0)	21.4 (15.6)	16.5 (12.7)	15.5 (13.1)
PO	27.9 (35.3)	41.5 (30.2)	30.0 (23.1)	31.8 (26.8)
WHO			1.7 (1.3)	0.9 (0.8)
WO	3.2 (4.1)	4.6 (3.4)	10.8 (8.3)	7.6 (6.5)
ELM	2.1 (2.7)	3.1 (2.3)	7.8 (6.0)	5.4 (4.6)
HICK	2.8 (3.6)	2.4 (1.8)	0.4 (0.3)	1.4 (1.2)
PER	1.1 (1.4)	1.9 (1.4)	1.5 (1.2)	1.5 (1.3)
RM	8.6 (10.9)	14.8 (10.8)	34.7 (26.6)	24.0 (20.3)
SC	0.6 (0.7)	0.5 (0.4)	3.1 (2.4)	2.0 (1.7)
SG	9.1 (11.5)	10.0 (7.3)	11.8 (9.1)	10.7 (9.1)
SYC			0.6 (0.5)	0.3 (0.3)
WH	0.2 (0.2)	1.2 (0.9)	0.1 (< 0.1)	0.3 (0.3)
WT	0.1 (0.1)	4.0 (2.9)	0.1 (0.1)	0.9 (0.7)
Total	79.1 (100)	137.2 (100)	130.2 (100)	118.4 (100)

[a] ASH – pumpkin and green ash, CO – cherrybark oak, ELM – American and winged elm, HICK – shagbark and shellbark hickory, OO – overcup oak, PER – persimmon, PO – pin oak, RM – red maple, SC – swamp cottonwood, SG – sweetgum, SYC – sycamore, WH – water hickory, WHO – white oak, WO – willow oak, WT – water tupelo.





Table 14. Stress indicators in red oaks[a] ≥ 3" dbh in Pools 2, 3, and 8 on Duck Creek Conservation Area and Mingo National Wildlife Refuge, 2005.

Variable	Pool 2	Pool 3	Pool 8	Combined
Number Red Oaks (# plots)	213 (47)	153 (35)	304 (91)	670 (173)
Number w/ Basal Swelling (# plots)	59 (21)	69 (17)	110 (60)	238 (98)
Percent Red Oaks w/ Basal Swelling	27.7	45.1	36.2	35.5
Number w/ Tip Dieback (# plots)	34 (23)	41 (15)	94 (55)	169 (93)
Percent Red Oaks w/ Tip Dieback	16.0	26.8	30.9	25.2

Stress indicators by species. (These numbers include 8 plots on which the species stressed was not identified and there was more than one species of red oak on that plot.)

Species	Total	Number (percent) w/ Basal Swelling	Number (percent) w/ Tip Dieback
CO	83	14 (16.9)	7 (8.4)
NO	3	0	0
PO	425	183 (43.1)	135 (31.8)
WO	159	33 (20.8)	21 (13.2)
Unidentified		8	6

Stress indicators by species. (These numbers exclude the 8 plots above.)

Species	Total	Number (percent) w/ Basal Swelling	Number (percent) w/ Tip Dieback
CO	74	14 (18.9)	6 (8.1)
NO	3	0	0
PO	399	183 (45.9)	133 (33.3)
WO	150	33 (22.0)	21 (14.0)

[a] Red oaks include pin oak (PO), cherrybark oak (CO), Nuttall oak (NO), and willow oak (WO).

Table 15. Number of dead stems > 12 inches dbh (down and standing) on forest plots within Pool 2, 3, and 8 on Duck Creek Conservation Area and Mingo National Wildlife Refuge, 2005.

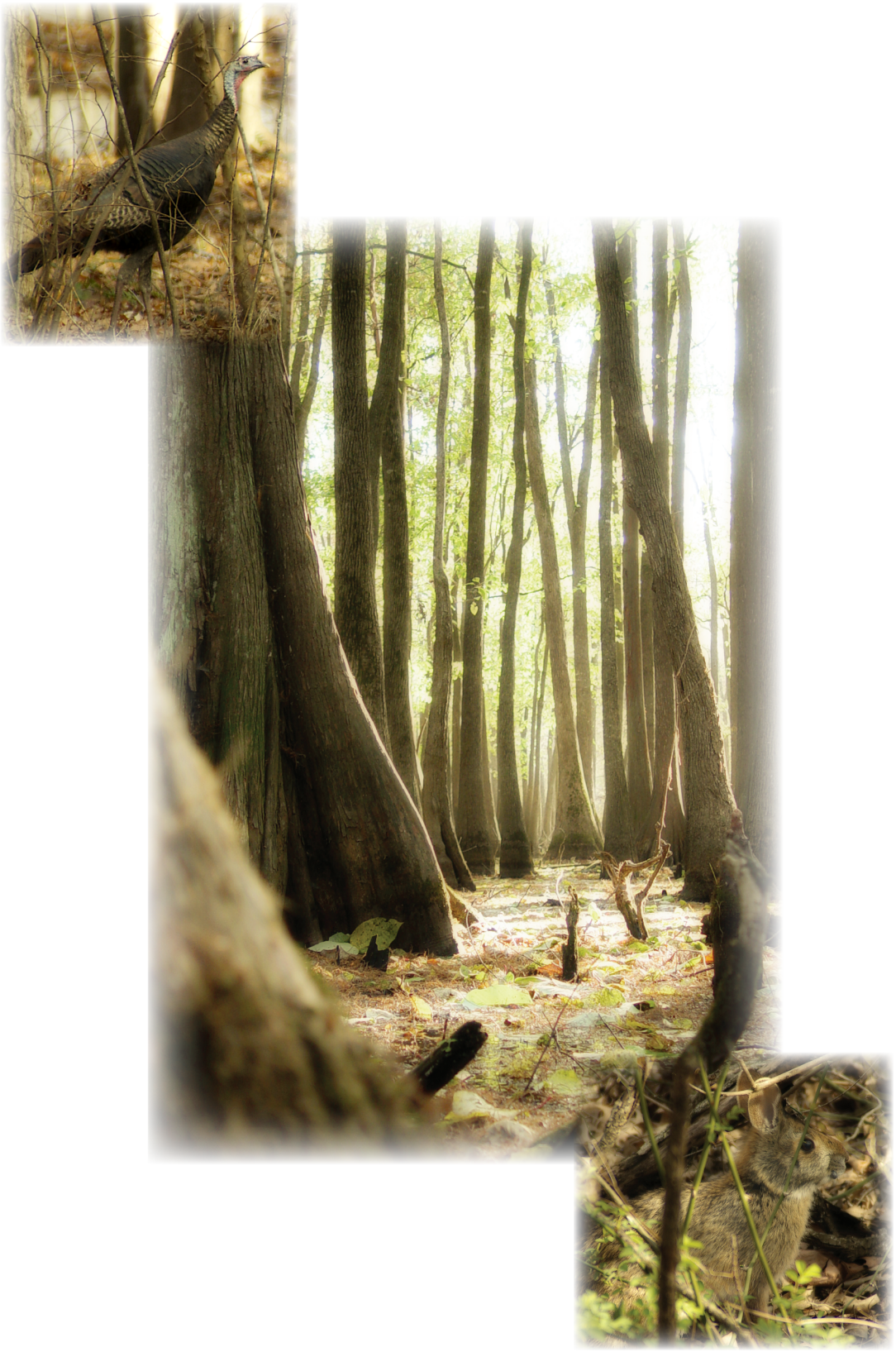
Pool 2						
	Down		Standing		Combined Down and Standing	
Species[a]	Number	Percent	Number	Percent	Number	Percent
PO			4		4	2.72
WO			1	4.76	1	4.76
ASH			2	2.47	2	2.47
ELM			2	2.78	2	2.78
OO						0.00
RM			7	3.68	7	3.68

Pool 3						
	Down		Standing		Combined Down and Standing	
Species[a]	Number	Percent	Number	Percent	Number	Percent
PO	19	12.34	13	8.44	32	20.78
WO						0.00
ASH			4	4.49	4	4.49
ELM			9	11.54	9	11.54
OO			3	3.23	3	3.23
RM	3	2.16			3	2.16

Pool 8						
	Down		Standing		Combined Down and Standing	
Species[a]	Number	Percent	Number	Percent	Number	Percent
PO	17	8.76	17	8.76	34	17.53
WO			5	4.03	5	4.03
ASH	1	0.71	10	7.14	11	7.86
ELM			14	2.64	14	2.64
OO			3	2.56	3	2.56
RM			22	2.02	22	2.02

[a] PO - Pin oak, WO - Willow Oak, ASH - Pumpkin and Green Ash, ELM - American and Winged Elm, OO - Overcup Oak, RM - Red Maple





RESTORATION AND MANAGEMENT RECOMMENDATIONS

GENERAL

Despite many alterations, the Mingo Basin remains one of the largest remnant BLH ecosystems in the Upper MAV and provides many important functions and values, including supporting a diverse, highly productive, and abundant community of endemic plants and animals. Most of the Mingo Basin is in public ownership and managed by the Mingo NWR and Duck Creek CA. This public ownership and management offers opportunities to restore and enhance many historic communities and the ecological processes that sustained them. Public ownership also includes mandates to accommodate multiple, and sometimes competing, public uses. Management mandates are different between Mingo NWR and Duck Creek CA. For example, the National Wildlife Refuge Improvement Act of 1997 specifically includes these mandates: 1) wildlife has first priority in the management of refuges; 2) wildlife-dependent recreation activities of hunting, fishing, wildlife observation, wildlife photography, environmental education and interpretation are the priority public uses of the refuge system; these uses will be facilitated when they do not interfere with a refuge's purposes or the mission of the refuge system; and 3) other uses of a refuge will only be allowed when they are determined to be appropriate and compatible with refuge purposes and mission of the Refuge System. The challenge for restoration and management of Mingo NWR and Duck Creek CA is to identify the best locations for restoration of critical habitats and resources, and attempting to restore the key ecological processes that created and maintained them while still allowing many public uses.

With this in mind, future management of Duck Creek CA and Mingo NWR must seek to: 1) protect existing BLH forests and associated habitats from further clearing, fragmentation, and degradation of hydrological processes; 2) maintain plant and animal community structure and health in relationship to topographic and geomorphic landscape position; 3) restore BLH and associated habitats that have been highly degraded or destroyed; and 4) serve as a "core" of critical and sometimes limiting resources that can complement and encourage restoration and management on adjacent and regional private lands.

Key summary data and information obtained during this study of the Mingo Basin indicate:

1. The Mingo Basin is a relatively "closed" basin formed by an abandoned channel and floodplain of the historic Mississippi River and by alluvial fans along the St. Francis and Castor rivers. The basin contains mostly Holocene-derived geomorphic surfaces and soils with numerous braided channel "ridge-and-swale" topographic complexes distributed in a low elevation relatively flat "sump" or "bowl."

2. Most water input to the Mingo Basin is from local precipitation and drainage from small streams that originate in the adjacent Ozark Escarpment and Crowley's Ridge.

3. The Mingo River is the only natural water outlet or drainage for the Mingo Basin. It originates in the low elevation Monopoly Marsh area and historically drained into the St. Francis River. Historically, when St. Francis River levels were high, this drainage outlet was effectively "dammed" and incoming water from other sources was trapped in the basin. This outlet now is disconnected from the St. Francis River at its

original confluence site and is diverted 20 miles south through a drainage ditch to the St. Francis River below Fisk, Missouri.

4. The Castor River is located at the northeast end of the Mingo Basin. Historic river gauge data indicates there were regular flood events and high water levels that crossed the alluvial fan along its banks and caused "headwater" flooding into the Mingo Basin about once every 4-6 years, usually in late winter and early spring. Similar historic gauge data from the St. Francis River suggest it had high water levels and flooding that caused "backwater" to collect in the basin about once every 2-3 years.

5. Historic and current flooding patterns in the Mingo Basin were/are correlated with regional precipitation patterns and were/are highly dynamic seasonally and annually. Low elevations in the basin typically begin to flood from groundwater discharge and on-site precipitation and local runoff in early fall. Waters gradually rise from late fall through spring and then decline from late spring to lows in late summer and early fall. Long-term precipitation data indicate somewhat regular peaks of more extensive and prolonged flooding in the basin followed by declines to drier years of shorter duration and less extensive flooding on a 5-7 year pattern.

6. A labyrinth of interconnected sloughs, swales, and depressions historically caused water to move into and across the Mingo Basin from northeast to southwest. When waters rose in winter, it overtopped small natural levees along drainages and across "ridges" to move across the basin in a "sheetflow" manner.

7. Heterogeneous topography created by residual Mississippi River floodplain surfaces created a diverse gradient of elevations and consequently extensive diversity in timing, depth, and duration of flooding in the Mingo Basin. This diverse topography and associated hydroperiods created a mosaic of BLH habitats and associated vegetation communities.

8. Nine major natural vegetation community types are present in the Mingo Basin: 1) seasonal herbaceous wetland, 2) bottomland prairie, 3) savanna, 4) open waters of sloughs and deeper depressions, 5) shrub/scrub, 6) cypress/tupelo, 7) low elevation BLH, 8) intermediate elevation BLH, and 9) high elevation BLH. Other minor communities include giant cane "brakes", sedge meadow, dead timber, and upland fringe deciduous forest.

9. Vegetation community types are distributed along elevation and flooding gradients. Low elevations with more prolonged flooding during the growing season support open water, S/S, and cypress/tupelo habitats while higher elevations with short duration, usually dormant season flooding, support BLH, bottomland prairie, and savanna habitats. BLH forests covered over 80% of the Mingo Basin in the late 1800s, but BLH has declined to about 45% of the basin at present. Cypress/tupelo habitats historically covered about 11% of the basin. This habitat type has remained relatively constant in area with some increase in lower elevations. Sloughs and S/S historically covered about 3% of the basin; S/S area has increased to about 8% coverage at present. Seasonal herbaceous wetland and savanna each covered less than 2% of the basin in the late 1880s. Savanna is essentially eliminated from the basin. Seasonal herbaceous wetland has expanded to about 10% of the basin along edges of S/S and deeper water areas and in managed moist-soil impoundments.

10. A high diversity of fish and wildlife species are present in the Mingo Basin and are adapted to seasonal dynamics of key resources, especially pulses in many food types following flooding

11. European settlement of the basin began in the mid-1800s and greatly increased from 1860 to 1880 when railroads were built in the basin and the lumber industry expanded. Most presettlement BLH timber was cut from 1880 to 1920, following these developments. Extensive harvest of residual trees

and second growth continued through the late 1940s.

12. By 1914, most lands in southeast Missouri, including the Mingo Basin, were included in drainage districts. The Mingo Drainage District encompassed most of the Mingo Basin. The district dug seven large north-south ditches in the basin from 1914-1920 a mile apart and four cross and lateral ditches moved water from the basin. Material excavated from these ditches was deposited in continuous spoil banks along the ditches. These ditches and spoil banks severely altered natural water flow patterns through the basin.

13. The LRDD joined the Mingo Drainage District on the northeast side of the basin and connected LRDD Ditch 111 with the Mingo District's Ditch 1. Other LRDD ditches also diverted water from the Castor River watershed into the Mingo Basin and further altered flow of water through the basin.

14. The Mingo NWR was established in 1945. Since establishment, nearly 100 miles of roads and levees and their associated embankments and borrow areas have been built on the NWR. Other developments on the refuge include 12 moist-soil impoundments, over 40 water-control structures, buildings, and parking lots. These developments, often built for management or public access purposes, have further altered water regimes and flow patterns in the basin.

15. In 1976, Congress designated 7,730 acres of Mingo NWR as a Wilderness Area where active management and physical manipulations are restricted. These restrictions in the Wilderness Area affect water management and restoration opportunities.

16. Duck Creek CA was established in 1950, primarily to provide public waterfowl hunting opportunity next to Mingo NWR. Since establishment, the CA has been developed for two GTRs, an 1,800-acre water storage reservoir (Pool 1), and moist-soil impoundments.

17. Most of the private lands surrounding Mingo NWR and Duck Creek CA historically were BLH forests. Over 95% of these lands have been cleared, ditched, and leveled for agricultural production. Upland forests on the Ozark Escarpment and Crowley's Ridge adjacent the Mingo Basin have been heavily cut-over or cleared for pasture and agricultural crop production. This clearing and tillage has increased erosion with corresponding siltation and contaminants/chemicals that enter the basin.

18. BLH habitats in GTRs in the Mingo Basin have become degraded and shifted to wetter forest communities since they were established. GTRs are at higher elevations in the northeast part of the basin that historically were Intermediate and High BLH communities. Water management of the GTRs has flooded these sites earlier and for more prolonged periods than historically occurred. Also, drainage of the GTRs has often been poor and compromised by exterior levees, interior roads and boat lanes, borrow areas, and spoil banks.

19. Pool 1 has been the primary water source for flooding GTRs on Duck Creek CA in fall. In some dry years, not enough water has been available in Pool 1 to flood all GTRs. Water management of Pool 1 and attempts to recharge it after water has been drained or evaporated from the pool has influenced water levels in Ditch 111 (the primary source for refilling Pool 1) and subsequent flooding on upstream private lands. Other conflicts have arisen among user groups, especially fishermen who want higher levels year round vs. waterfowl hunters who want predictable water in GTRs throughout fall and winter.

20. Water management on Mingo NWR traditionally attempted to flood large parts of the refuge from late fall through spring. Water levels in Monopoly and Rockhouse marshes have been held high in summer on a rotational basis until the late 1970s. Since the early 1990s, summer drawdowns of Monopoly have been limited to a few years. Rockhouse has been drained each summer to promote moist-soil vegetation and to create drier conditions

to allow heavy equipment operators to control encroachment of woody vegetation. Summer water levels in Monopoly have been managed for a 335.5 foot level, but at 335.5 large areas of the BLH adjacent to Monopoly have been flooded for extended periods in early summer and have shifted BLH to wetter S/S and Cypress/tupelo communities. Furthermore, keeping water at this level keeps a large area of saturated soil above the 335.5 water level because of the flat topography. Even formerly low and wet areas have been shifted to buttonbush and water elm.

21. The 11 large drainage ditches dug in the Mingo Basin in the early 1900s have had continual siltation problems. The deposition of 2-5 feet of silt in these ditches has restricted drainage of lower elevations of the basin. Poor drainage, coupled with the higher summer water levels in Monopoly, have expanded the area of S/S, open water and cypress/tupelo habitat and conversely reduced area of BLH on Mingo NWR.

22. Abundance, diversity, and distribution of fish and wildlife species in the Mingo Basin has changed. Some species now have reduced numbers and other key groups, such as waterfowl, now use the basin in lower numbers and for shorter periods.

23. Several invasive plant and invasive animal species now are present in the Mingo Basin.

24. Many water-control structures and other infrastructure on Mingo NWR and Duck Creek CA are mostly old, of inadequate capability, incorrectly placed, and have high and recurring annual maintenance costs.

Based on this information, we recommend the following general restoration and management goals for the Mingo Basin.

1. *Restore natural water flow patterns.*

After the Mississippi River changed course and abandoned its former channel through the Mingo Basin (14,500 to 16,000 BP), the primary hydrological process that sustained the basin's ecosystem was seasonal flooding from local precipitation and runoff, headwater flow from regional streams, and backwater flooding when St. Francis River levels were high. Water entered the basin at many points and then slowly moved through the basin. The paths of water flow followed numerous interconnected sloughs and as water rose, it moved across the basin as sheetflow. Entry, flow through, and exit of waters in the basin have been highly altered because of regional land use changes and physical developments and by alterations to topography from developments on Mingo NWR and Duck Creek CA (e.g., Fredrickson 1979b). Physical features on these areas should be evaluated to determine if natural flow patterns can be restored, at least in part (Fig. 37).

2. *Emulate natural flooding and drainage regimes related to elevation and habitat types.*

The BLH ecosystem in the Mingo Basin has developed under, and is adapted to, a strongly seasonal flooding regime. In general, the system is dominated by winter and early spring flooding and summer and fall drying. Superimposed on this strongly seasonal pattern are long-term dynamics in winter and spring precipitation that cause a 5-7 year pattern of regular peaks and lows in extent and duration of flooding during a year. Annual variation in precipitation and regional runoff from Ozark and Crowley's Ridge streams, in combination with flooding of the Castor and St. Francis rivers, created this dynamic pattern.

Management of water levels in the Mingo Basin has not emulated seasonal or long-term annual dynamics in flooding either in time or among different habitat types. The Mingo Basin currently is "wetter" than in historic times and vegetation communities are shifting to more water tolerant species. This shift has reduced BLH habitat area and distribution, especially Intermediate and High BLH types, and correspondingly increased open water, dead timber, S/S, and cypress/tupelo area and distribution. Unnatural water regimes have been fostered by desires to restore water in the basin following establishment of Mingo NWR, to provide more predictable water levels to support waterfowl hunting, to compartmentalize areas for intensive management, and to create larger areas of deeper and more permanent flooding for fishing and other recreational activities. If the Mingo Basin ecosystem is to be sustained and restored, attempts must be made to more closely emulate both the seasonal and long-term flooding and drainage dynamics of the basin.

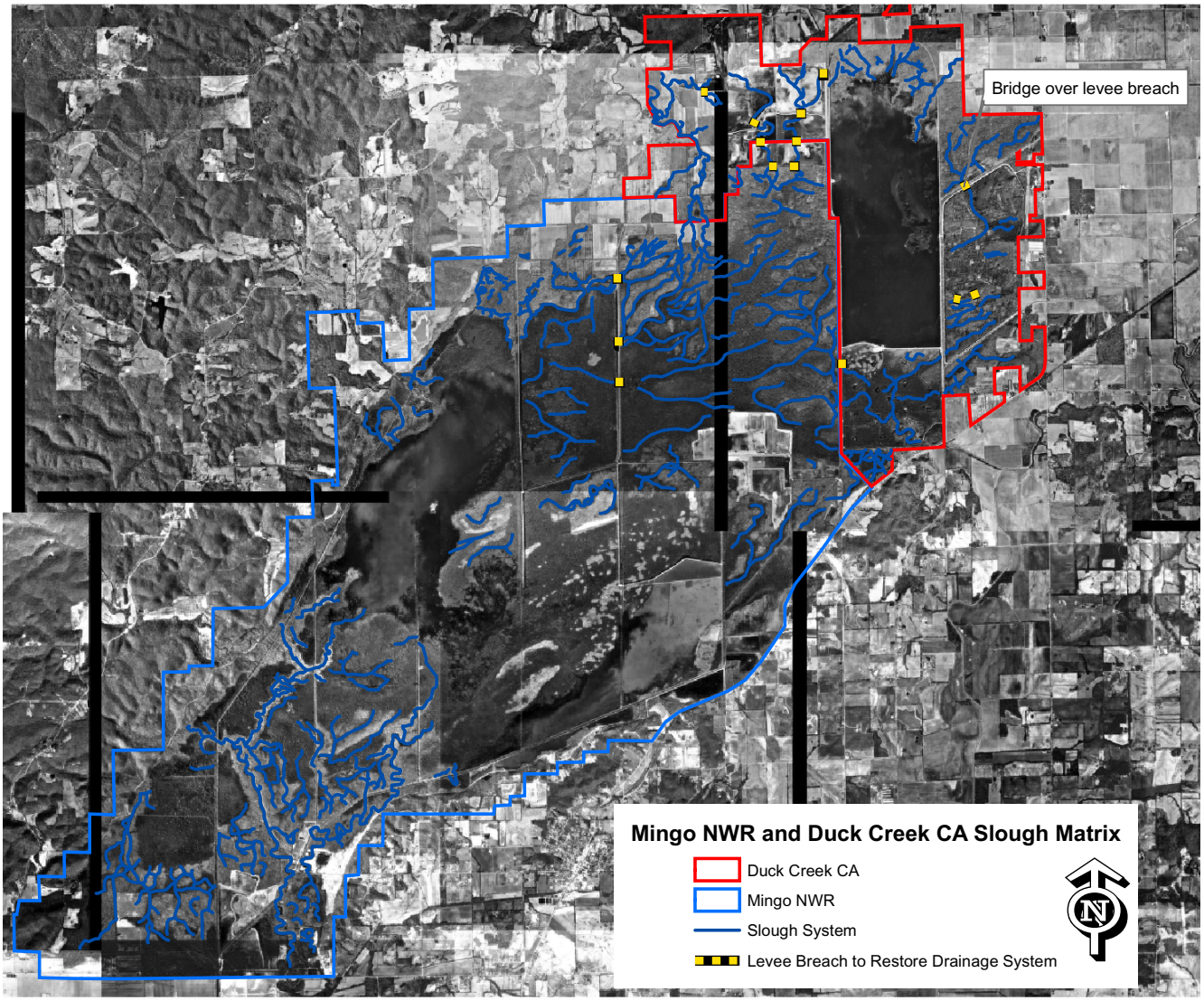


Figure 37. Locations of potential sloughs and natural drainages that can be restored and reconnected in the Mingo Basin.

3. *Restore and maintain the diversity, composition, distribution, and regenerating mechanisms of vegetation communities in relationship to topographic and geomorphic landscape position.*

The distribution of vegetation communities in the Upper MAV, including Mingo Basin, is determined by geomorphic surface, elevation, and hydrological regime (e.g., Klimas et al. 2005). BLH forests covered over 80% of the basin during the late 1880s, but wetter conditions and altered water flow (see above) have degraded or converted much of this BLH. Restoring more natural distribution and composition of BLH in the Mingo Basin will require a return to shorter duration dormant season flooding regimes. Rehabilitation of badly degraded BLH, especially in GTRs, also will require changes in the management infrastructure and in management strategies. Relatively minor habitat types such as savanna, bottomland prairie, giant canebrakes, and sedge meadows have been greatly reduced in area or eliminated. Maintaining the complete diversity of habitats in the Mingo Basin is important for sustaining plant and animal communities in southeast Missouri and the Upper MAV (Heitmeyer et al. 2005). Clearly, some areas in the basin are so highly disrupted or destroyed that they cannot be restored to native communities and topography in the near term (e.g., Pool 1 on Duck Creek CA). In contrast, many areas offer good restoration opportunity. Also, some degraded sites may not be able to be restored to historic types because of more permanent changes in topography or hydrology, but they can be managed

to replicate another historic basin community, including some types that have been severely degraded or destroyed. Here, management should seek to emulate dynamics, structure, and processes of the "new" type. Collectively, restoring processes and structure to the Mingo Basin is desirable and will help more communities to be represented and functional.

4. *Restore and maintain natural patterns of resource availability and abundance, including nutrient cycling, seasonal energy flow, and key food, cover, reproductive, and refuge resources for endemic animal species.*

Annual primary and secondary productivity and biomass of BLH and associated communities, such as in the Mingo Basin, are among the greatest of any ecosystem in North America. This production depends on seasonal and long-term flooding regimes coupled with regular disturbance, such as tillage and fire. High primary production is possible because of the fertility of the alluvial-derived floodplain surfaces and soils, a nearly subtropical climate, and regular inputs of sediments and nutrients. Nutrients cycle relatively quickly in the Mingo Basin, but historically were conserved and slowly dispersed through the system because of the closed nature and sheetflow of water across the basin. High secondary production is created primarily by a large diverse input of flowering plant twigs and leaves from woody vegetation. Maintaining the natural patterns of hydrology (Goals #1 and 2 above) and vegetation communities (Goal #3 above) is critical to maintaining rich seasonal pulses of resources with many potential foods and ecological niches for fish and wildlife species.

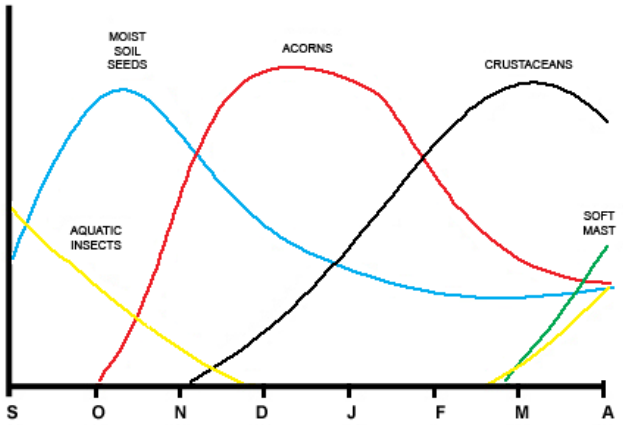


Figure 38. General chronology of food types available in bottomland hardwood forests.

Food webs in BLH systems are complex. Most animals rely on multiple food sources during the year, or they are present only during seasons when specific resources (e.g, detrital invertebrates, arboreal arthropods, acorns, seeds, etc.) are present. Consequently, most common animal species in the Mingo Basin are omnivorous and mobile. Connected water flow in the basin enables many mobile species, such as fish, to move throughout the system during flood periods and facilitates disbursal of nutrients in various habitats. Connectivity of habitat patches further aids disbursement and distribution of nutrients and animals, such as small mammals, neotropical birds, amphibians, and reptiles. Maintaining or restoring connectivity of water flow and habitats in the Mingo Basin is critical for sustaining "traditions" of use by seasonal animal visitors; securing critical resources to meet needs of annual events, and reducing disturbance, predation and other mortality agents.

The diversity of vegetation communities in the Mingo Basin assured that many food types were present and abundant in all seasons (Fig. 38). Changes in distribution and extent of some habitats (e.g., marked declines in Intermediate and High BLH) has altered amount and availability of some foods. Where declines in key resources and foods are identified, attempts should be made to either restore that component of the system or replace the resource with another similar type. Managers must recognize, however, that long-term sustainability of animal communities in the basin will require restoration of key plant communities in appropriate locations throughout the basin.

5. *Accommodate multiple public uses when and where they do not compromise primary ecosystem and resource objectives.*

In an ecosystem that is as diverse, productive, and visually spectacular as the Mingo Basin, it is expected and desirable for the public to visit and use its resources. Managers are challenged, however, with providing opportunities for both consumptive and nonconsumptive uses without compromising restoration and management of system processes, resources, and composition. Further, consumptive uses require regulations and enforcement. Providing public access is difficult in the Mingo Basin because of its natural topographic and hydrological nature. Considerable data suggest the extensive road and levee system in the basin (that serves in part as public access) has contributed to degradation of community

types and area, nutrient and energy flow, and fish and wildlife populations. For example, the network of existing roads and levees often cross topographic and hydrologic gradients and disrupt water flow patterns and habitat connectivity. This has caused wetter conditions on some sites and degraded or destroyed BLH habitats resulting in reduced use and distribution of many animal species. In another example, holding high water levels in Monopoly Marsh and Pool 1 for fisheries and viewing purposes has compromised habitat types and distribution and reduced food availability for many migrant waterbirds. Other spatial and temporal disturbances to waterfowl refuges, foraging areas, nest or reproductive sites of amphibians and forest wildlife, winter hibernacula of reptiles, etc. are disruptive and counter to primary purposes of the Mingo NWR and Duck Creek CA Many conflicts in uses can occur in the basin and priorities must be based on resource management goals that assure natural processes will not be compromised.





SPECIFIC RECOMMENDATIONS FOR MANAGEMENT AND RESTORATION OF THE MINGO BASIN

RESTORING NATURAL WATER FLOW PATTERNS

1. *Reconnect water flow corridors where possible.*

Restoration of water flow corridors in the Mingo Basin is important to allow natural patterns of nutrient and energy flow through the system and to simulate hydroperiods that developed and sustained native vegetation communities. Additionally, restoring flow paths has the potential to improve drainage of the basin and reduce prolonged flooding in drainage corridors. Some flow corridors cannot be restored because of major physical alterations such as ditches, roads, and dams including Wappapello Reservoir that changed backwater flood events. Nonetheless, some natural slough and drainage paths and corridors may be partly restored (Fig. 37). These opportunities include:

- Reconnect natural sloughs in the northeast part of the basin where feasible (Fig. 37). Some levees and roads that bisect former channels can be breached, slough channels can be cleared by removing debris or silt, and filled channel sections can be cleared. Where possible, the integrity of sloughs should be restored for as long a distance as possible. If possible, drainage routes ultimately should allow water to move into Monopoly and Rockhouse marshes and exit through the old Mingo River channel. Levees in GTR pools can be lowered to an elevation that still allows 1-2 foot water depth, vehicle passage during normal water level management and dry periods, and water flow through the pool during flood events.
- Reroute water through the old McGee Creek channel in Unit B of Duck Creek CA (Fig. 39). This can be accomplished by blocking the current diversion ditch from McGee Creek and clearing the historic creek channel to the point that it drains into Mingo NWR and Ditch 2.
- If sloughs are reconnected, a complete plan with flows and directions must be designed. Some type of flow measurement is needed at key locations in the system to verify that the design operates as intended. Drainage of BLH stands will be critical where sheet flow is re-established.
- Evaluate constructing a bridge and water-control structure on the north end of Pool 2 and a road/levee breach on the south or west side of Pool 2 to route water from Ditch 104 through natural slough channels in Pool 2 during high water events.
- Evaluate restoring water flow into the north end of Pool 1 from natural drainages and Ditch 111. Natural water flow into Pool 1 by gravity from the north side could be improved during certain rainfall events by widening the existing intake and/or adding an additional intake. Due to the water elevations of Pool 1 in relation to drainage elevations on the north side, it is not feasible for constant natural flow during dry months. Because Pool 1 is man-made, it is an above-ground pool and water elevations in Ditch 111 must overcome the static head of Pool 1 for water to flow into Pool 1.

2. *Remove obstructions to sheetflow through, and drainage of, the Mingo Basin.*

When surface water rose in the Mingo Basin, it overtopped small natural levees along sloughs and natural drainages and moved across depressions and BLH flats in a "sheetflow" manner. Eventually, the rising water connected most of the Mingo Basin. Restoring sheetflow in the basin is important in conjunction with restoring flow corridors so that energy and nutrients can be transported and cycled in the basin, resources can be made available to animals, and prolonged flooding and shifts in vegetation communities to wetter types can be avoided. Many opportunities exist to improve sheetflow and drainage including:

- Remove unnecessary roads, levees, and ditches. These include some E-W roads and levees in Mingo NWR and spur levees and roads in GTRs.
- Breach continuous spoil banks along ditches, boat lanes, and other borrow areas. Breaching is especially needed along boat lanes in Pools 2 and 3 to allow more natural patterns of flooding and drainage in these GTRs.
- Where roads cannot be removed, construct low water "spillway" breaches at regular intervals of historic drainages. These low breaches should be 400-500 foot in length to encourage sheetflow across BLH flats.

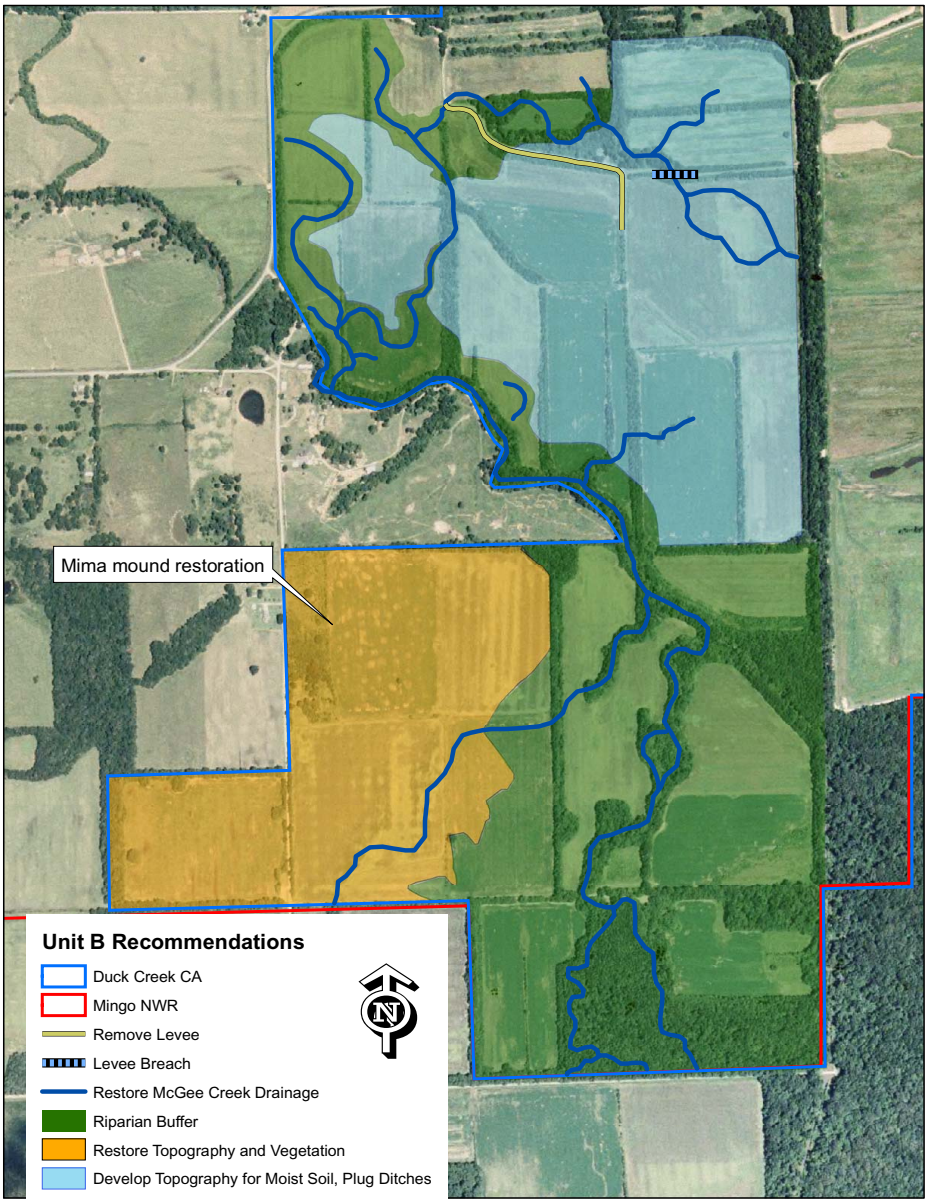


Figure 39. Locations of potential restoration and development projects in Unit B of Duck Creek Conservation Area.

- Remove debris, beaver and silt "dams" in natural slough and drainage corridors and in other depressional flats. Continued beaver control and removal of their dams will be necessary as an annual maintenance item for both Duck Creek CA and Mingo NWR.
- Monitoring the long-term success of restoring sheet flow patterns must include a way to physically measure water flow at critical lpoints during and after flood events. Water gauges and water flow measuring devices should be incorporated in the plan, and records kept so that there is no question as to how much water is where in the basin.

3. *Restore the integrity of the Monopoly/Rockhouse marsh complex.*

The largest depressions in the Mingo Basin are the Monopoly and Rockhouse marsh areas. These two depressions are naturally connected when surface waters in the basin are above 336 feet and cross small

natural ridges and flow through old slough channels. The historic Monopoly Marsh area is currently fragmented into two areas (Monopoly and Gum Stump pools) by the road and levee along Ditch 4. Water flows between Monopoly and Gum Stump through a 36-inch concrete culvert and no interconnecting sheetflow is possible. The Ditch 4 road also acts as a levee that prolongs flooding of the Gum Stump pool, has destroyed BLH, and shifted much of the area to S/S and baldcypress communities. Water connectivity between Monopoly and Rockhouse marshes also is compromised by spoil banks, the old Ditch 4 channel, and by obstructions in interconnecting sloughs. Reconnecting water and nutrient flow in this large and important complex in the Mingo Basin should be a high priority and include:

- Remove and/or breach the Ditch 4 road. Also, the levee along the south side of Gum Stump pool should be removed or breached in multiple low water spillway locations.

- Clean out sloughs interconnecting Rockhouse and Monopoly marshes.

- Breach the road and levee on the east side of Gum Stump pool along Ditch 3 at locations where natural slough paths connected Pool 7 and Gum Stump.

- Remove debris and obstructions in the old Mingo River channel and Ditch 5 that drain the Monopoly depression.

4. *Reduce the incidences of flooding on private lands surrounding Duck Creek CA and Mingo NWR.*

Mingo NWR and Duck Creek CA do not own all lands in the Mingo Basin nor do they have flowage easements across adjacent private lands. Some flooding of private lands in the basin is inevitable and occurs naturally following large precipitation and runoff events. However, alterations of topography and water control on Mingo NWR and Duck Creek CA have altered water movement, extent, and duration of flooding and may have increased occasional flooding of private lands. Attempts should be made to minimize this flooding of private lands when possible. Several potential options exist to not only improve drainage and reduce flooding of these private lands, but also to restore water flow corridors and BLH habitats in the basin. They include:

- Construct a breach/spillway or a water-control structure on the northeast side of Unit A along Ditch 111 to allow water from Ditch 111 to flow into and through Unit A when desired. Restore the natural slough corridor through Unit A and the Luken Farm starting at this breach/water-control location (Fig. 40). Connecting the old slough paths will require breaching or construction of water-control structures in the internal cross-levees in Unit A, the south Unit A levee, and removing or breaching the large levee on the south side of the Luken Farm. Collectively, this work would allow water from Ditch 111 to flow through Unit A and the Luken Farm into Pool 8 during high water periods and reduce potential flooding of private lands north along Ditch 111. Lowering sections of the Unit A levees would still allow water manipulations for moist-soil management and 1-2 foot flooding of the area during duck hunting season. It also would improve water source capability for Pool 8.

- Pursue opportunities to purchase out-right title or flowage easements on adjacent private lands that may be subject to periodic flooding when water is being moved and managed on Duck Creek CA and Mingo NWR.

- Evaluate restoring water flow paths from Ditch 104 through Pool 2 during high flow periods. Groundwater levels and surface flooding of Pool 2 is needed to determine effects of hydrology on BLH.

- Maintain the levee breach on the east side of Pool 3 that allows high flows in Ditch 105 to flow through Pool 3.

EMULATING NATURAL HYDROLOGICAL REGIMES

1. *Restore natural flooding dynamics to Mingo NWR depressions and flats*

The key to maintaining and restoring abundance, distribution, and diversity of functional

plant and animal communities in the Mingo Basin is restoring natural seasonal and long-term dynamics of flooding and drainage. Prior to alterations in basin topography and water flow, surface waters rose in the basin following rainfall and local runoff in fall. Waters continued to rise throughout fall and winter to peak levels in late winter or early spring, followed by gradual declines to dry conditions in mid-late summer. Superimposed on the seasonal patterns were long-term fluctuations in precipitation and flooding that created regular peaks and lows in a 5-7 year pattern. This variable long-term and seasonal flow of water meandered and spread out over the basin complex topography. Water management in the Mingo Basin must seek to emulate these dynamics by careful manipulations of water in respective habitat areas and by developing water control capabilities to do so. Recommendations include:

- Water levels in the lower elevations of Mingo NWR are controlled primarily by opening or closing the water-control structures at the Spillway and in Ditches 5 and 11. Closing these structures causes water to be retained in Monopoly and Rockhouse marshes and backs water onto higher elevations that support BLH communities. These structures must have the discharge capacity to completely drain these areas periodically. Management restrictions in the Wilderness Area may complicate needed restorations that include reconnecting the Mingo River through Ditch 6 and into Monopoly Marsh. Water management should allow gradual flooding of the Mingo Basin beginning in early fall and then to gradually drain the basin in late winter and spring. In wet years, these structures can be partly opened and then reclosed 2-3 times during winter to emulate natural "pulses" of water levels. In dry years, the basin will flood and then dry related to whatever rainfall and runoff occurs. To emulate longer term dynamics, the structures can be managed to create more consistent and prolonged flooding, or conversely extended dry conditions, about once every 5-7 years. This would help emulate the periodic "backwater" flood events that historically were caused by high water levels in the St. Francis River in late winter and spring. Managing for extended wet or dry conditions should take advantage of yearly precipitation and not try to "force" a dry period when winters are wet, or vice versa.

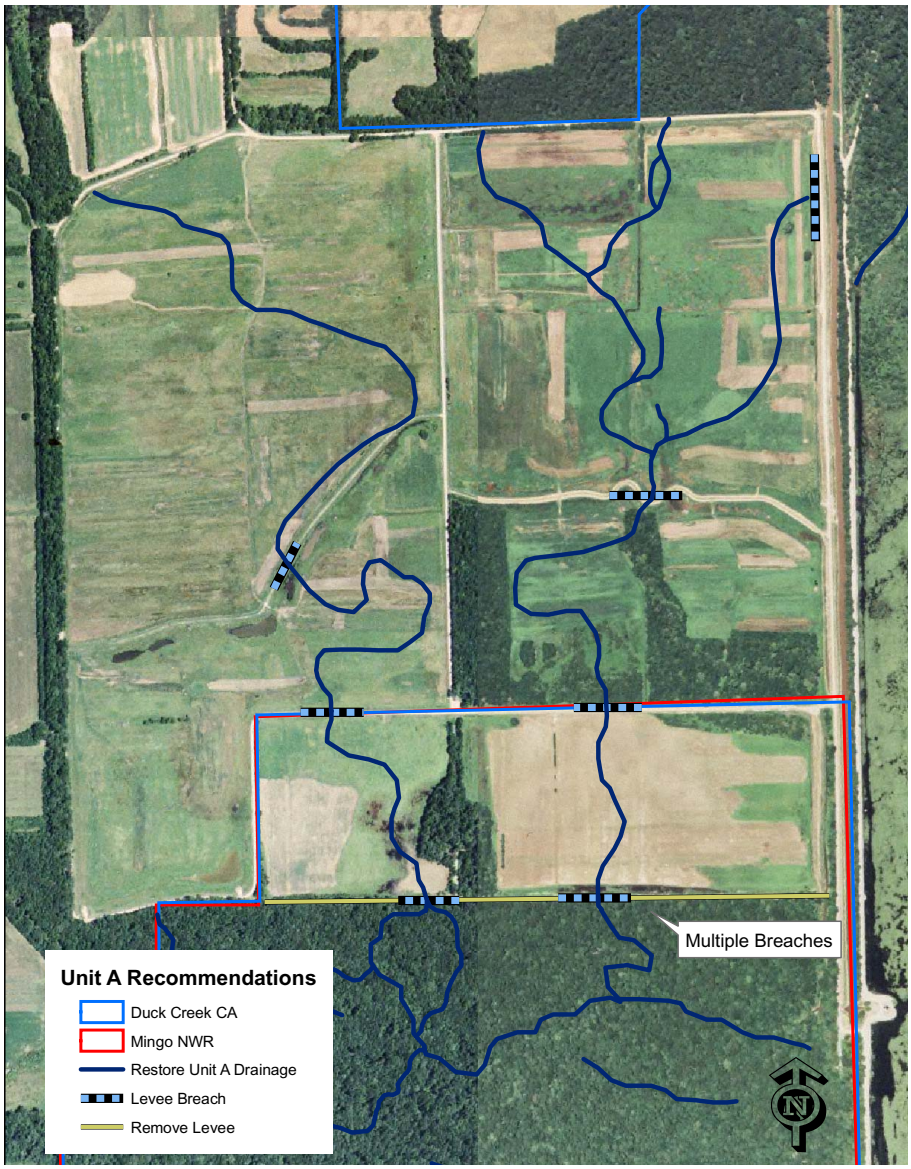


Figure 40. Locations of potential restoration and development projects in Unit A of Duck Creek Conservation Area and in the Luken Farm of Mingo National Wildlife Refuge.

- Summer water levels in Monopoly and Rockhouse marshes

must be fluctuated within and among years to provide some areas with more permanent water in summer for waterfowl broods, fish, etc. In recent years, Rockhouse has been at least partly drained each summer, but Monopoly has been held at 335.5 feet in most summers since the 1990s. To better emulate natural dynamics, water levels in both areas should be gradually lowered from spring to late summer in most years. Long-term precipitation patterns that influence water levels in the basin suggest one of these areas should be held high in summer (but not necessarily at full pool) in about one of every five years. Similarily, these areas should be kept dry from early spring until fall in at least one of every five years. In wet years, more water is connected throughout the basin, whereas in dry years, summer water is retained only in deeper sloughs, depressions, and drainages. Animals in the basin are adapted to these regular seasonal patterns. Extended flooding, or high connectivity of water, in the basin in summer is not necessary.

- Regular drawdowns of Rockhouse Marsh should be continued, as they more closely emulate natural hydroperiods in the Mingo Basin. Historically, Rockhouse Marsh was a complex of Open Water, S/S, Cypress/tupelo, and Low BLH. In dry years, extensive areas of herbaceous (moist-soil) vegetation was present. Maintaining some areas of Rockhouse as moist-soil vegetation seems desirable and consistent with restoration and resource objectives. This management will require regular disturbance (including mechanical and water level management) and control of encroaching woody vegetation.

- Water levels in Monopoly Marsh should not be held > 335 feet in summer more often than about once every five years. When water is > 335 feet, it floods or creates saturated soil conditions in BLH around Monopoly and creates conditions that shift community composition away from BLH types and to S/S, baldcypress, and open water. At water levels > 336 feet, Monopoly and Rockhouse marshes are connected; this naturally occurred only during higher water periods in winter, and rarely, if ever, during summer. Management in the Mingo Basin should attempt to restore BLH to natural distributions and elevations and not encourage more water tolerant communities.

- The integrity of the historic Monopoly Marsh depression has been compromised by the Ditch 4 and Ditch 6 levees and roads. The Ditch 4 levee and road should be breached or removed (see above recommendation to restore the Monopoly/Rockhouse complex) to reconnect the depression. Monopoly and Gum Stump should be managed as a unit, not as separate compartments.

2. *Change water management in GTRs and BLH communities to match natural hydroperiods.*

BLH resources in GTRs and other manipulated areas such as in Pools 4, 5, 7, and 8 on Mingo NWR are subject to continued long-term degradation if water regimes are wetter, and more consistent, than historic conditions for the site (Karr et al. 1990, Fredrickson and Batema 1992, Heitmeyer et al. 2004, Fredrickson 2005b). GTRs and some BLH pools in the Mingo Basin have levees and water-control structures that allow managed flooding, but they also restrict water flow in, through, and out of the site. Past flooding and draining schedules for GTRs (to provide predictable duck hunting opportunity) usually were earlier, and deeper, than normally occurred in the area (Fredrickson and Batema 1992, Heitmeyer et al. 1989, 1991). This was especially true in Pools 2 and 3 on Duck Creek CA, which set at higher elevations in the Mingo Basin and historically were flooded only for short durations in winter. Flooding Pools 2 and 3 for duck hunting on Duck Creek CA at times began as early as late September. This flooding occurred before most BLH species (especially the less water-tolerant willow, cherrybark, and pin oaks) became dormant and caused extensive damage such as basal swelling, leaf chlorosis, and tip die-back. Consistent early flooding (before November) in fall, coupled with poor or late drainage in late winter and spring, ultimately caused severe damage and mortality of red oaks and shifted species composition to wetter communities dominated by overcup oak, baldcypress, tupelo, green ash, red maple, buttonbush, and water locust.

Water management strategies for GTRs and other manipulated BLH areas need to be changed to more closely emulate natural dynamics. For this to occur, flooding and drainage schedules must be

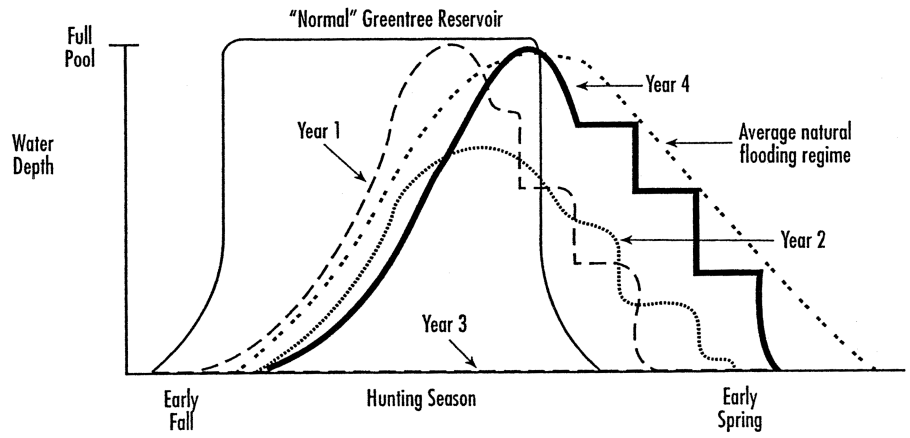


Figure 41. Hypothetical model of recommended flooding regimes for greentree reservoirs that emulate natural winter flooding patterns in the Mingo Basin (modified from Fredrickson and Reid 1988 and Heitmeyer et al. 1996).

changed and infrastructure and water sources must be renovated to allow more efficient and timely flooding and drainage. Specific recommendations include:

- Vary flooding and drainage schedules in Pools 2 and3, among years in 5-7 year patterns (Fig. 41, Table 16). Long-term data from the Mingo Basin suggest relatively regular dynamics of peaks and lows of flooding of higher elevations on these 5-7 year patterns (Heitmeyer et al. 1989, and precipitation and river gauge data in this report). GTRs should be managed for annually variable flooding schedules.

- Delay flooding any GTRs until at least late October (within the above annual variation) and begin draining them by late-February.

3. *Manage Pool 1 water levels for more natural hydroperiods while retaining its water storage and fishery functions.*

Pool 1 was converted to a water storage reservoir for flooding GTRs soon after original development. Pool 1 was not designed to support long-term storage capacity, but it has become an integral part of meeting both waterfowl and fishery objectives for Duck Creek CA. Pool 1 can be retained as a water storage reservoir, but water management should attempt to more closely emulate natural hydroperiods of the Mingo Basin. This can be accomplished by:

- Annually raise water levels in Pool 1 to full pool levels (346 feet) some time from early winter through early spring. Allow water levels to gradually decline from spring through summer, while retaining enough water storage capacity to flood Pool 2 in late October or November, and not lower Pool 1 water levels to less than 342 feet in winter. This annual fluctuation will more closely emulate seasonal dynamics, provide important habitats for waterfowl foraging and fish spawning, and supply some water for flooding GTRs. In wet years, more water from Pool 1 can be used for flooding GTRs, whereas in dry years, a smaller amount of water will be available for this flooding.

4. *Improve water source and management capabilities.*

Both Mingo NWR and Duck Creek CA are over 50 years old and much infrastructure and original engineering design are outdated or in a state of decline. Degradations in topography, regional land use, drainage and water flow, and siltation/contamination have occurred since the area was established. Also, expectations for expanded public use have influenced water management objectives and strategies. Specific items that will improve capabilities for emulating natural flooding and drainage patterns in the Mingo Basin include:

- Restore the integrity of Pool 1 levees to allow fall and winter flooding to 346 feet. The most imperiled area of Pool 1 is the northwest levee adjacent to Ditch 111, which has been damaged by rodents, erosion, and tree roots. This levee section should be resloped and secured with rock or other armourment.

- Evaluate potential leaks or seepage of water from Pool 1.

- Evaluate placement of groundwater wells to provide additional water flooding capability

Table 16. Indicators of flooding stress on bottomland hardwood trees and potential for recovery (from King and Fredrickson 1998).

Condition	Probably cause	Potential for recovery
Yellowing of leaves (Chlorosis)	Saturated soil and/or shallow flooding during the growing season	Good if flooding frequency and duration reduced. Do not flood for at least 2-3 years or longer if trees do not recover.
Loss of flowering	Saturated soils and/or shallow flooding for extended period during dormant and growing season	Good if flooding frequency and duration reduced
Canopy thinning (fewer leaves produced)	Saturated soils and/or shallow flooding for part of the growing season for 2 or more years	Fair if flooding frequency, duration reduced. Do not flood for at least 2-3 years or longer if trees do not recover
Butt swelling on red oaks	Dormant season flooding at same depth, duration and timing for 10 or more years	Fair if flooding frequency, duration, and depth is changed to be dynamic within and among years
Tip die-back	Long-deep flooding in dormant season and extended flooding in 2 or more growing seasons	Fair when first noticed, but trees most likely have reduced vigor and will have increased mortality in next 5 to 7 years. Do not flood for at least 2-3 years or longer if trees do not recover
Large dead branches (2” or more in diameter)	Long-deep flooding in dormant season and well into and during the growing season	No reversal possible

for Pools 1, 2, and 3. The location of these wells should be determined by groundwater evaluations and opportunities for multiple uses. For example, wells located at the northwest side of Pool 1 could provide water to Pool 1, Unit A, and enhance gravity flow of water from Pool 1 into Pools 2 and 3 with a mixture of well and surface water. These wells also could provide some water, if needed, for flooding of Pool 8 in winter and to replenish minimum water level in Pool 1.

- Determine the current water storage capacity of Pool 1 and the extent of sedimentation or organic accumulation. With this information, determine how much water is needed annually to achieve objectives of Pool 1 water level management and GTR flooding and seasonal flows in Ditch 111. Further, determine pumping capabilities of the relift pump station on the northwest side of Pool 1 to pump water from Ditch 111 into Pool 1. If analyses determine that a bigger relift pump is needed, then it should be replaced.

- USACE hydraulic analysis of Ditch 111 indicates that the elevation of the invert of Highway C culvert (350.5) and debris and trees in the upper end of Ditch 111 are the main impediments to water flow down Ditch 111. A design is currently underway to replace the culvert through the levee at the upper end of Ditch 111. This culvert has a planned invert elevation on the downstream end of 345.5. The Highway C culvert is five feet higher and flow through the levee culvert will not occur until Castor River elevations overcome the elevation of the Highway C culvert. The Missouri Department of Transportation (MODOT) should be contacted about future plans for Highway C. Recommendations to lower the invert elevation of the structure

for Ditch 111 under Highway C to the same elevation as the culvert through the levee (345.5) should be communicated to MODOT. Gravity flow of water from Ditch 111 into Pool 1 is complicated by the pool elevation of Pool 1 and the relative flat topography between the levee culvert and Pool 1 (invert elevation 345.5 verses Pool 1 max elevation of 346). Flow from Ditch 111 into Pool 1 by gravity could be increased by adding additional diversion structures between Ditch 111 and Pool 1.

- Continue to clean debris and silt from major drainage ditches through the Mingo Basin. While several ditches (2, 3, 11) have been cleaned out, critical sections of Ditches 1 and 111 have not been redredged.

- Monitor silt and contaminant levels in water moving into the Mingo Basin from major ditches (e.g., 111) and tributaries (e.g, McGee Creek) to determine if silt basins, or other structures are needed to reduce or divert possible degrading silt and contaminant loads.

- Improve internal water flow in GTRs by restoring water flow paths, breaching boat lane spoil banks, and controlling beavers (previous recommendation section on restoring natural water flow patterns) and by replacing, resizing, or relocating many water-control structures and adding a few new drain structures.

RESTORING NATURAL VEGETATION COMMUNITIES AND KEY RESOURCES

1. *Expand and restore Intermediate and High BLH communities.*

BLH communities covered over 80% of the Mingo Basin in the late 1800s. Currently, BLH covers about 45% of the basin and the once contiguous stand of BLH is fragmented and degraded in many locations. Over 2/3 of historic BLH in the basin was Intermediate and High BLH types that had a high composition of red oaks. When Mingo NWR and Duck Creek CA were purchased, pin oak composed over 60% of the basal area of these sites. Now, pin and willow oak combined compose only about 1/3 of intermediate and high BLH communities. Because the Mingo Basin represents the largest remaining BLH area in southeast Missouri and one of the largest areas of BLH in the entire Upper MAV, and because Intermediate and High BLH habitats have been destroyed at a higher rate than other BLH types, it is important to restore as much BLH habitat as possible in the Mingo Basin. Important needs include:

- Restore natural water flow in the basin and emulate natural seasonal and long term hydroperiods as identified in the specific recommendations above. In essence, attempt to create a drier growing season condition in the Mingo Basin.

- Do not construct additional GTRs or other physical features such as roads, levees, ditches, and water-control structures in existing BLH areas that will further fragment, compartmentalize, or alter stand continuity and natural hydrology.

- Reconnect fragmented patches of BLH where possible by reforesting cleared fields, removing unnecessary roads and reforesting road corridors, and reforesting openings in BLH stands (Allen et al. 2001, Schoenholz et al. 2005). The Mingo CCP (USFWS 2006) identifies several open fields that could be restored to BLH habitats, including giant canebrakes (Brantley and Platt 2001). These plans should be implemented, including restoring natural topography in these fields that have been altered by ditches, leveling, roads, etc.

- Reforest the McGee Creek corridor in Unit B (Fig. 39).

- Rehabilitate larger "dead timber" areas that have the potential for drier, and more efficiently drained water regimes by removing obstructions to drainage, changing site hydrology to drier regimes, and planting (if needed) BLH species capable of surviving in the "new" water regime environment. Natural regeneration of desirable oak species should be encouraged where possible. Treatment of expanding areas of undesirable species such as green ash, water locust, red maple, sugar-

berry, and other early successional and water tolerant species can be done using imazapyr injection (Ezell et al. 1999).

2. *Improve "health" of existing BLH stands and encourage regeneration of red oaks.*

Data from this study and previous work in the Mingo Basin (e.g., Heitmeyer et al. 1989, 1991, Hamilton et al. 1991) indicate that BLH stands have shifted to wetter species composition and that remaining red oaks are heavily damaged from water stress and have little regeneration. If the goal is to restore a more natural composition of BLH communities in the Mingo Basin (see #1 immediately above) then existing BLH stands must be managed to improve their "health." The potential for recovery of BLH forests depends on the degree and type of damage (Table 16).

- Change GTR water management schedules to emulate more natural patterns of flooding and drainage (see recommendations in #2 of Emulating Natural Hydrological Regimes above).

- Change water regimes in BLH areas throughout the Mingo Basin to drier and more variable hydroperiods.

- Develop an active timber management plan to sustain a > 60% red oak composition in Intermediate and High BLH locations. This will include conservative periodic harvest in small openings (gap-phase dynamics) rotated among the timber management compartments (e.g., Denman and Karnuth 2005, Hodges et al. 2005). Historically, BLH in the Mingo Basin and other similar areas in the Upper MAV had 3-5% of total area in open tree gaps caused by death and windfall of trees (Heitmeyer et al. 1989). Managing for this type and extent of openings seems appropriate for sustaining long-term regeneration of BLH in the Mingo Basin. Harvest of red oaks should be restricted in areas where considerable mortality of red oaks has occurred and many "openings" already exist (e.g., in GTRs). Certain openings created for duck hunting management could be allowed to regenerate to a red-oak dominated condition (e.g., slash areas in Pool 2)

- Determine what timber and water management is authorized in the Wilderness Area on Mingo NWR and develop proposals and plans for more active management, if possible.

- Maintain some naturally flooded sites as "controls" where no harvest occurs. These controls or reference sites should be periodically monitored for composition, regeneration, and growth rates to determine relative health and comparison with treatment areas.

3. *Restore a diverse mix of historic tree species in BLH habitats.*

The exact composition of BLH habitats in the Mingo Basin in the Presettlement period is unknown, but apparently contained a diverse mixture of many species. Current composition of BLH may contain more oaks than at former times because of extensive timber harvest and drainage in the basin in the late 1800s and early 1900s, and subsequent regeneration of disturbance tree species such as red oaks. Other historical information also suggests that many BLH habitats in the MAV may have formerly contained a more diverse species composition including more sugarberry, sweetgum, and elm than is present in current BLH forests (Ouchley et al. 2000, King et al. 2005). Restoration efforts should:

- Encourage a diverse composition and age structure of tree, shrub, and understory species.

- Include some soft-mast and other fast-growing "pioneer-type" trees in plantings of oak seedlings to promote diversity and natural competition.

- Plant tree mixtures that naturally were associated with different elevation, soil, and hydrological locations.

4. *Restore minor habitat types in appropriate areas.*

The Mingo Basin historically contained a diversity of "minor" habitat types associated with the larger BLH community. These habitats included wet bottomland prairie, savanna, sedge meadow, giant canebrakes, early successional riparian forest,

and outcrops of sand-based grass and forb communities. These habitats provided key resources for many animal species, including several species of concern. Most of these minor habitat types have been eliminated or greatly reduced in area. Where possible, these habitats should be restored in appropriate locations (see Fig. 20). Specific opportunities include:

- Restore savanna on higher ridges on the northeast part of the Mingo Basin near Highway 51 and along edges of Crowley's Ridge.

- Restore wet bottomland prairie on the Castor River alluvial fan in the northeast part of the basin, in select transition areas between upland forest and lowland BLH, and in some open grass fields.

- Restore sedge meadows along small stream corridors, such as Cow Creek, that drain into the Mingo Basin and in fields along natural drainages.

- Restore topographic features to open fields that have potential to support minor habitat types.

- Restore riparian forest in the reforestation "zone" immediately adjacent to McGee Creek on old natural levees (Fig. 39).

- Protect and encourage natural vegetation communities on "sand blows" and sand outcrops (See Fig. 8 for location of sandy outcrop soils on slight ridges in Mingo NWR).

- Do not alter remnant natural topographic features including natural levees on slough and creek banks, mima mounds, ridges, and depressions. Where possible, restore natural topography to such sites that have been altered (e.g., see opportunities for restoring topography and drainage patterns in Unit A, recommendation #4 Emulating Natural Hydrological Regimes).

5. *Maintain management of moist-soil impoundments and some agricultural fields.*

Historically, the Mingo Basin contained seasonal herbaceous wetland vegetation in many scattered locations, including tree gaps, edges of larger depressions, edges and inclusions in S/S, and open water areas that became dry during years of drought or low precipitation. Some of these areas continue to support seasonal herbaceous communities, but others now are wetter or drier than in previous times and do not provide natural distribution, diversity, and production of this habitat type. Moist-soil impoundments help supplement and replace food and structural resources naturally found in seasonal herbaceous vegetation (Fredrickson and Taylor 1982). Seeds, tubers, and rootlets of moist-soil vegetation, along with acorns from oaks, historically supplied large quantities of high-energy food to migrant waterfowl and many other species. With the marked decline in area and health of BLH forests (see above), the Mingo Basin no longer supplies the historic amount of high-energy foods it formerly did. Providing this high-energy food is important to replicate seasonal energy patterns in this system (Fig. 38) and to meet annual cycle needs of waterfowl and other species. Moist-soil vegetation and agricultural crops are important resources in the Mingo Basin and efforts should be made to:

- Manage existing moist-soil impoundments (Fig. 27) for seasonal herbaceous vegetation according to topographic and hydrologic gradients along restored drainages within these impoundments. Integrate agricultural crops within and among moist-soil impoundments to provide periodic soil disturbance, control woody vegetation, and provide high-energy foods.

- Retain at least some fields that are devoted to rotational agricultural production for high-energy foods for wildlife species.

- Develop hydrologic capabilities of the northeast part of Unit B for seasonal flooding along topographic contours (Fig. 39). Developments should restore and maintain natural topography if possible, fill existing field ditches, remove unnecessary levees and berms, construct new low-level levees along natural contours, and installation of groundwater wells for a water source. These developed fields will benefit public hunting

opportunity and expand existing management capabilities.

- Evaluate the potential to develop fields in the Grimm Tract of Duck Creek as moist-soil impoundments, in conjunction with restoring BLH to part of this area.

- Evaluate opportunities to encourage seasonal herbaceous vegetation in the north end of Pool 1 if water management restores a more natural seasonal pattern of water levels, including summer and early fall drawdown, followed immediately by reflooding in fall and winter.

6. *Control invasive plant and animal species and evaluate opportunities to reintroduce native species.*

Currently, invasive plants (Sericea lespedeza, Johnson grass, reed canary grass, multiflora rose, autumn olive) and animals (feral hog, nutria) species are expanding their range and abundance in the Mingo Basin. These species threaten to replace or redistribute some native plant communities and should be controlled where possible. Many methods of control are possible including chemical application, mechanical disturbance, physical removal, killing (animals), and biological control. All methods should be evaluated for use in the Mingo Basin.

As the above species have invaded the Mingo Basin, other plant and animal species have become extirpated including alligator gar, black bear, etc. Reintroduction of at least some of these species might be possible and should be evaluated. Successful reintroduction of some species may depend, however, on restoring key habitat components, water flow patterns and dynamic water regimes as recommended above. With this in mind, restoration of ecological processes and community structure and natural distribution probably is a prerequisite to any reintroduction.

7. *Use Mingo NWR and Duck Creek CA as a "core" of BLH ecosystem resources and communities that can act as a foundation for additional restoration and management on adjacent and regional lands.*

If restoration of key topographic and physical features (e.g, topography, water flow paths), ecological processes (e.g., natural hydrological regimes), and community structure (e.g., historic vegetation distribution and diversity) can occur in the Mingo Basin, then the Mingo NWR and Duck Creek CA can become a sustainable "core" of BLH resources and habitats to support expansion of the BLH-based ecosystem on adjacent and regional lands. Already, other public lands and wetland easements exist within 10 miles of the Mingo Basin and represent extension of the former Mississippi River floodplain and BLH ecosystem northeast along the Castor River and LRDD Diversion Channel area and southwest along the St. Francis River. These include the Dark Cypress CA areas, WRP properties, USACE lands along the St. Francis River, and small, scattered upland forest tracts on the Ozark Escarpment and Crowley's Ridge. Additionally, the Duck Creek drainage corridor offers opportunity to connect the area around Otter Slough CA with the Mingo Basin.

- Evaluate opportunities to purchase fee-title ownership of private lands adjacent to existing boundaries to reduce in-holdings or three-sided parcels, to reconnect BLH corridors, to reduce flooding and water impacts on private land, and to secure critical habitats.

- Evaluate opportunities to purchase fee-title ownership of regional lands that can form the basis for reestablishing corridors of wetland and BLH habitat northeast along the Castor River and LRDD Diversion channel, southwest along the St. Francis River, and south in the Duck Creek drainage.

- Support expansion and continuation of WRP, CRP, and other USDA conservation programs to restore BLH wetlands and habitats in the above landscape corridors.

- Provide financial and technical support to private landowners in the above corridors that can restore critical habitats and provide resources for regional animal populations through Private Lands programs of USFWS and MDC.

ACCOMMODATING MULTIPLE PUBLIC USES CONSISTENT WITH RESOURCE OBJECTIVES

1. *Continue active waterfowl hunting programs.*

Waterfowl management should remain a priority for Duck Creek CA and Mingo NWR. The original establishing purposes of both areas was to provide habitat and refuge for migratory birds, including waterfowl, and Duck Creek CA was developed to provide public waterfowl hunting opportunity. Changes in habitat conditions in and adjacent to the Mingo Basin have gradually reduced waterfowl use of the basin and quality and quantity of waterfowl hunting. Despite reduced waterfowl use and hunting success, demands for expanded public waterfowl hunting opportunies are increasing and exceed current capacity in the Mingo Basin. Further, demands for other public uses and increased access also are increasing and potentially compromise wetland management capability and ultimately waterfowl use.

Much information has been obtained on annual cycle physiological, nutritional, and behavioral needs of waterfowl (e.g., Heitmeyer 1988); resource provision and use of BLH resources (e.g., Heitmeyer et al. 1989, Heitmeyer 2001); impacts of disturbance and the critical importance of refuges (Raasch 1976); hunting methods (MDC unpublished Duck Creek CA annual harvest records); and regional and local waterfowl movement patterns (e.g., Heitmeyer 1985) in the Mingo Basin. This information should form the basis for waterfowl management objectives in the basin and suggests the following:

- Intensive wetland management of Duck Creek CA and Mingo NWR is needed to maintain historic population numbers, and supply resources to meet annual cycle needs of waterfowl in the region. Water and habitat management recommendations listed in previous sections should be implemented.

- Public waterfowl hunting in the Mingo Basin is a traditional and desirable use. To maintain quality hunting and meet needs of waterfowl, a controlled hunting program should be maintained on Duck CA and in Pool 8 of Mingo NWR.

- Refuges are critical components of habitats used and needed by waterfowl in the Mingo Basin. Spatial refuge area has declined and disturbance has increased in fall and winter on Duck Creek CA. The integrity (large area of inviolate, low disturbance refuge) and success (measured as waterfowl use days) of the refuge on Pool 1 was degraded when the southern part of Pool 1 was opened to some hunting in 2000. Further, duck use and hunting success in the west side of Pool 2 and all of Pool 3 also declined after part of Pool 1 was opened to hunting. The entire area of Pool 1 should be restored to an inviolate refuge by closing all of the pool to all waterfowl hunting. Two hunting positions would be sacrificed for four days/week if Pool 1 is closed, however, a greater total waterfowl use and hunting quality in nearly 20 blind locations would be improved if it returned to a refuge. Blinds for disabled hunters located on the levees in the north end of Pool 1 should be removed and alternate opportunities for disabled hunters should be provided in other locations. Fishing and other public use of Pool 1 should be restricted from mid October through the end of hunting seasons.

- Temporal refuge also has been reduced on Duck Creek CA. Currently, Pools 2 and 3 are hunted all day, despite the fact that hunter numbers and their success decline sharply after noon (e.g. < 5% of hunting and birds harvested in these pools occurs after 1:00 p.m.) We suggest closing all waterfowl hunting areas on Duck Creek CA at 1:00 p.m. for at least 3-5 years and monitoring waterfowl use and harvest.

- Restoring water movement, water regimes, and BLH habitats in the Mingo Basin requires changes in timing, depth, and duration of surface water during fall and winter (see above recommendations on emulating natural hydrological regimes). To sustain and restore communities in the Mingo Basin, flooding of BLH should be later in fall, variable among years, fluctuate in depth over winter, and generally, depths should be lower. Waterfowl hunting programs in the Mingo Basin should accommodate these needs by varying flooding schedules in GTRs, fluctuating water depths depending on precipitation events, and generally decreasing water depths.

These changes may reduce total hunting parties at times and change access routes or hunting styles. Some declines in predictable hunting opportunity in GTRs may be offset by providing additional opportunities in habitats developed in Unit B of Duck Creek CA and other regional lands.

2. *Manage restrictive public accesses*

The Mingo Basin is an exceptional ecosystem and provides many opportunities for consumptive and nonconsumptive use by the public. The basin also provides unique educational services and is an excellent location for research, extension, and training. These uses are important and should be encouraged where they do not conflict with primary objectives of sustaining and restoring system resources. The public should be encouraged to visit and use the Mingo Basin, but access must be controlled and some areas must be left undisturbed at least in some seasons when important annual events of biota are occurring. Excessive access causes disturbance, contamination of vegetation along roads, redistribution of invasive species, mortality or removal of species, requisites for maintained roads and ditches, and costly facilities. Restoring communities in the Mingo Basin will require many changes to road systems in the basin including removal, rerouting, and breaching roads. During wet periods, water must flow through the basin more naturally, thus some roads will be unaccessible. These restorations, along with better understanding of plant and animal species requirements and impacts of disturbance, indicates a need for changes in public access including:

- Remove unnecessary roads and breach other roads to encourage water flow throughout the Mingo Basin. Public access on these breached roads will be eliminated or restricted to dry periods.

- Additional roads or public access points to the basin should not be developed.

- Interior and sensitive habitats in the basin should be protected from public access, except under highly controlled periods.

- Important reproductive sites, hibernacula, and foraging areas should be identified for key plant, fish, and wildlife species and access to these areas should be limited by area, season, and/or time of day.

- Access routes for hunting and fishing areas should be reevaluated to reduce disturbance to interior areas and key resources. For example, access in and around Pool 1 on Duck Creek should be limited to registered hunters and conservation/management needs.

3. *Manage public fishing opportunities*

The Mingo Basin supports an abundant and diverse fishery and offers many opportunities for public fishing. As stated above, access to fishing areas should be restricted in some cases by area, season, and time of day. Recommendations for restoring the Mingo Basin previously identified in this report will change water management and connectivity in many areas of the basin and in the long term will improve resources and fish populations. These changes may mean, however, that some wetland areas are dry or at lower water level on regular seasonal and long-term intervals. Management issues that need to be considered include:

- Change water management in Monopoly and Rockhouse marshes by having more regular seasonal drawdowns and reduced public fishing opportunity in these areas.

- Change Pool 1 water regimes to encourage more regular seasonal decline of water levels in summer and early fall, but higher water levels in fall, winter, and spring. Restrict fishing and public use of Pool 1 in fall and winter as stated above.

- Aquatic vegetation in Pool 1 becomes dense and restricts access to fishermen in summer, yet this vegetation is the basis for sustaining large and diverse fish populations. Natural patterns of openings in bottomland wetlands, where dense submergent and floating-leaved vegetation is present, occurs in scattered small pockets. Future attempts to control aquatic vegetation in at least some areas of Pool 1 should evaluate possible treatment to create small openings in scattered locations and providing access routes to various areas in the pool.

- Monitor fish populations annually to evaluate population dynamics, fishing regulations, reintroduction of native species, and water management strategies.

- More information is required to successfully manage Pool 1 for fish and as a source of water for GTR hunting pools. Questions such as rates and distribution of sedimentation, seasonal dynamics of oxygen levels, and decomposition of aquatic vegetation under different water level management scenerios must be addressed.



MONITORING AND EVALUATION

The status and decline of certain habitats and resources in, and adjacent to, the Mingo Basin requires periodic monitoring to document ecological changes and to understand effects of implementing the recommendations identified in this report. Many uncertainties exist about how changes in water flow and management in the basin will change BLH and other associated habitats and how resources and fish and wildlife populations will respond to these changes. For example, a major uncertainty is how, or if, siltation and contaminants may change if water flow corridors are restored. Methods of restoration of BLH and other habitats such as rehabilitating dead timber and GTRs, initiating timber harvest, reforesting fields and riparian corridors, and planting giant cane need to be evaluated. Populations of plants and animals in the Mingo Basin should be regularly monitored, especially in relationship to public use, hunting programs, and other disturbances. Invasive plant and animal species need to be monitored regularly. Perhaps most importantly, the basic hydro-geo-chemical processes that sustain basin ecosystem structure, functions, and values should be monitored. These include aspects of surface and groundwater levels, flow and chemistry; soil and substrate chemistry and nutrient cycling; and energy flow throughout the biota of the system.

WATER FLOW PATTERNS, GROUNDWATER DYNAMICS, SILTATION AND CONTAMINANTS

This report recommends many changes to water flow patterns in the Mingo Basin. Most changes involve restoration of natural drainages and surface water "sheetflow" by removing obstructions to natural flow patterns. A monitoring program should be initiated to regularly monitor: 1) surface water movements, including measures of discharge and storage in key locations in the basin, 2) water quality, including measures of contaminants and silt loads, and 3) groundwater levels. A series of permanent monitoring locations should be established with staff gauges, peziometers, and regular water quality analyses to document changes. Also, siltation rates should be monitored in restored sloughs, sheetflow areas, and ditches. Key locations for monitoring include multiple locations on BLH sloughs restored in Pools 3-8, levee breach sites and restored sloughs in Unit A, the Monopoly/Rockhouse marsh complex, the Mingo River, Stanley Creek, and Pool 1.

LONG-TERM CHANGES IN BLH HABITATS RELATED TO FLOODING AND ELEVATION

Periodic monitoring of BLH and associated habitats within the Mingo Basin is needed to understand how the composition, distribution, health, and regeneration of tree species are being sustained or changed in relation to changes in water flow and other management activities. Gross-level landscape evaluations can be conducted by comparing general habitat distribution over time using aerial photographs, landsat satellite imagery, and periodic visits to permanent plots established in the basin (see e.g., Table 7). We also recommend that the random 1/10-acre plots in Pools 2, 3, and 8 (Tables 13-15) be revisited at regular intervals to monitor changes. Other permanent plots should be established in BLH areas on Mingo NWR. The areas around Monopoly and Rockhouse marshes that are above 335 feet should be evaluated to determine if BLH communities are being restored or are continuing to shift to S/S, dead timber, and cypress/tupelo communities. Data from all areas should be collected on leading indicators of forest composition and health related to

water stress (Heitmeyer et al. 2004, Covington and Laubhan 2005).

Existing water elevation staff gauges in key locations in the Mingo Basin should be maintained and new gauges should be installed in management impoundments where they do not exist and in representative naturally flooded sites. A comprehensive topographic survey of at least one foot (preferably 6 inch) contour intervals is needed for the entire Mingo Basin. These elevation maps would provide critical information on distribution, depth, and duration of flooding in the basin related to natural and managed water dynamics and refine community models of habitat distribution and composition.

The effects of flooding GTRs on different sites and at different times must be monitored. Changes in soil temperature and moisture in relation to these management actions is critical to understand the flexibility managers have in maintaining a viable forest where there is high demand for public hunting. Research on the response of bottomland tree roots to abiotic changes should be encouraged.

ENDEMIC AND INVASIVE PLANT AND ANIMAL SPECIES

Complete inventories are needed for all plant and animal species and populations in the Mingo Basin related to distribution, habitats used, and seasonal dynamics. Baseline data exist for some species and seasons, but little is known about others such as many amphibians, reptiles, fish, and mammals. In addition to inventories, key species groups should be regularly monitored to determine abundance, distribution, and habitat use related to changes in water flow and management, water quality, disturbance, and public uses. The distribution of invasive plant and animal species also should be monitored.

WATERFOWL POPULATIONS AND HUNTING PROGRAMS

A primary goal of past management for both Mingo NWR and Duck Creek CA has been to provide resources required by migrating and wintering ducks, especially mallards and wood ducks. Mallard use of the Mingo Basin has fluctuated over time, but peak numbers have gradually declined despite substantial increases in continental and Mississippi Flyway populations in the 1990s and 2000s. This decline probably is related to many factors, at least part of which appears to be degraded BLH habitats, reduced food and refuge resources, and increased disturbance. Past water management of GTRs and Pool 1 on Duck Creek CA has created earlier and more prolonged water levels that have damaged (Pools 2, 3, and 8) or killed (Pool 1) trees and decreased acorn, seed, and invertebrate production. If GTR and BLH water regimes are returned to more natural patterns, then BLH "health" and corresponding waterfowl use should improve. Long-term data on both duck populations and harvest have been extremely valuable to understanding waterfowl use patterns and trends in the Mingo Basin and in relationship to hunting programs. For example, changes in hunting programs and reductions in effective refuge area (spatial and temporal) on Duck Creek CA, especially Pool 1, have apparently contributed to reduced duck use on Duck Creek CA and poorer hunting success in GTR pools. In contrast, closing hunting at 1:00 p.m. in Unit A and maintaining an inviolate refuge on the north end of Pool 1 has increased duck use and hunting success and demand in Unit A and Unit B pools. Regular waterfowl surveys and daily harvest records and checks should be continued. Also, more detailed studies are needed to determine changes in waterfowl use of specific habitats and in relation to specific habitat management changes in GTRs, moist-soil impoundments, agricultural programs, etc.



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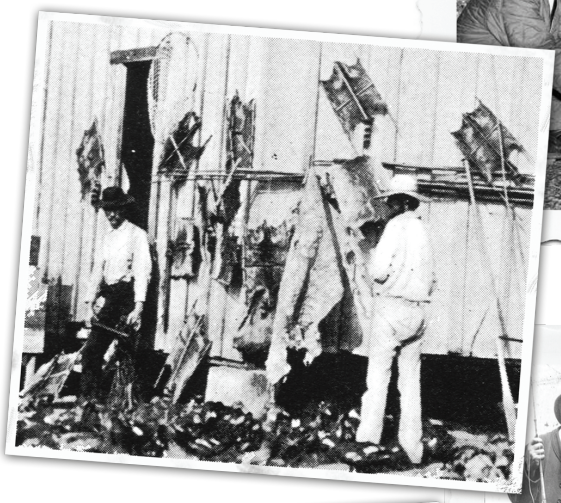



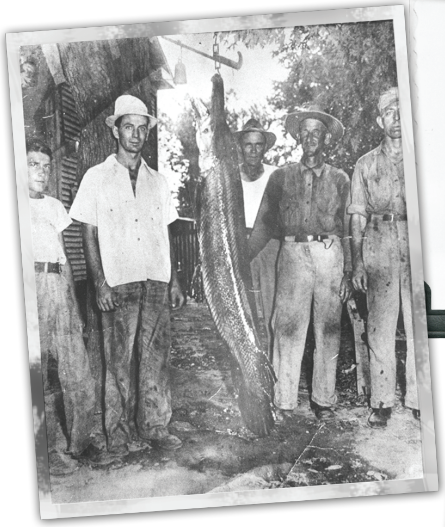


QUALITY MEATS
MARKET





APPENDICES

Appendix A. Common vines, ferns, and trees in forested habitats in the Mingo Basin. Information from Godfrey and Wooten (1979ab), and Steyermark (1963).

Species name	Common Name	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo
Vines					
Apios americana	Groundnut	X	X		
Bigonia capreolata	Cross Vine	X	X		
Brunmichia cirrmossa	Ladies Eardrops			X	
Campis radicans	Trumpet Creeper	X	X	X	
Celastrus scandens	American Bittersweet	X	X		
Clematis crispa	Swamp Leather Flower	X	X		
Clematis virginiana	Virgin's Bower	X	X		
Clitoria mariana	Butterfly Pea	X			
Cuscuta sp.	Dodder	X			
Dioscorea guaternata	Wild Yam	X	X		
Ionicera japonica	Japanese Honeysuckle	X			
Ipomea hederacca	Blue Morning Glory	X			
Ipomea lacunosa	Small White Morning Glory	X			
Ipomea pandurata	White Potato Vine	X			
Mikania scandens	Climbing Hempweed	X	X	X	
Parthenocissus quinquefolia	Virginia Creeper	X	X		
Passiflora lutea	Passion Flower	X			
Polygonum scanders	False Buckwheat Vine	X			
Rhus radicans	Poision Ivy	X	X		
Smilax glauca	Glaucous Greenbriar	X	X		
Smilax retundifolia	Common Greenbriar	X	X	X	
Smilax tamnoides	Bristly Greenbriar	X	X	X	
Solanum dulcamara	Climbing Nightshade	X	X		
Trachelospermum dirrorme	Climbing Dogbane	X			
Vitis aestivalis	Summer Grape	X	X		
Vitis cinera	Greyback Grape	X			
Vitis palmata	Cat Grape	X			
Wisteria crutescens	Wisteria	X			
Ferns					
Adiantum pedatum	Maidenhair		X		
Asplenium platyneuron	Ebony Spleenwort	X			
Athyrium pycnocarpon	Narrow-leaved Spleenwort	X	X	X	
Botrychium dissectum	Cut-leaved Grape Fern	X	X		
Botrychium virginianum	Rattlesnake Fern	X	X		
Camptosorus rhizophyllus	Walking Fern	X	X		
Cystopteris bulbifera	Bulblet	X	X		
Cystopteris fragilis	Fragile Fern	X	X		
Pellaea atropurpurea	Purple-stemmed Cliffbrake	X	X		
Polypodium polypodioides	Little Gray Polypody	X	X		
Polystichum acrostichoides	Christmas Fern	X	X		
Thelypteris hexaponoptera	Broad Beach	X	X		

(Appendix A, cont'd.)

Species name	Common Name	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo
Trees					
Acer negundo	Box-elder	X	X		
Acer rubrum drummondii	Drummond Red Maple	X	X		
Acer saccharinum	Silver Maple	X	X		
Amelanchier spp.	Serviceberry	X	X	X	
Aralia spinosa	Hercules Club	X	X		
Asimina triloba	Pawpaw	X	X	X	
Carpinus caroliniana	Blue Beech	X	X		
Carya aquatica	Water Hickory			X	
Carya cordiformis	Bitternut Hickory	X			
Carya laciniosa	Shellbark Hickory	X			
Carya ovata	Shagbark Hickory	X			
Carya spp.	Unknown Hickory				
Carya tomentosa	Mockernut Hickory	X	X		
Celtis laevigata	Sugarberry	X	X		
Cephalanthus occidentalis	Buttonbush			X	X
Cercis canadensis	Redbud	X			
Cornus spp.	Dogwood		X	X	
Corylus americana	American Hazelnut	X	X		
Cretaegus spp.	Hawthorn	X	X		
Diospyros virginiana	Persimmon	X	X		
Forestiera acuminata	Swamp Privet			X	X
Fraxinus americana	White Ash	X			
Fraxinus pennsylvanica	Green Ash		X	X	
Fraxinus tomentosa	Pumpkin Ash	X	X		
Gleditsia triacanthos	Honey Locust	X			
Gleitsia aquatica	Water Locust			X	
Ilex decidua	Deciduous Holly	X	X		
Lindera benzoin	Spicebush		X	X	
Liquidambar styraciflua	Sweetgum	X	X	X	
Morus rubra	Red Mulberry	X			
Nyssa sylvatica	Black Gum	X	X		
Platanus occidentalis	Eastern Sycamore	X	X		
Populus deltoides	Eastern Cottonwood	X			
Populus heterophylla	Swamp Cottonwood		X	X	X
Quercus alba	White Oak	X	X		
Quercus bicolor	Swamp White Oak	X	X	X	
Quercus lyrata	Overcup Oak			X	
Quercus nuttallii	Nutall Oak		X		
Quercus pagoda	Cherrybark Oak	X			
Quercus phellos	Willow Oak	X	X		
Quercus plaustris	Pin Oak		X		
Rhus copallina	Winged Sumac	X	X		
Robinia pseudoacacia	Black Locust	X			
Salix nigra	Black Willow		X	X	X
Sassafras albidum	Sassafras	X	X		
Taxodium distichum	Bald Cypress	X	X	X	X
Tilia americana	Basswood		X	X	
Ulmus alata	Winged Elm	X	X		
Ulmus americana	American Elm	X	X		
Ulmus rubra	Slippery Elm	X	X		
Viburnum spp.	Viburnum	X	X		
Nyssa aquatica	Water Tupelo		X	X	X

Appendix B. Native fish species in habitat types in the Mingo Basin. Information from unpublished data for Duck Creek Conservation Area and Mingo National Wildlife Refuge and range maps and habitat descriptions in Pflieger (1997).

Species name	Common name	Habitat							
		State & Federal status	SHW/BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
FISHES									
SUNFISHES									
Centrarchus macropterus	Flier Sunfish					X	X	X	X
Elassoma zonatum	Banded Pygmy Sunfish					X	X	X	X
Lepomis cyanellus	Green Sunfish					X	X	X	X
Lepomis gulosus	Warmouth Sunfish					X	X	X	X
Lepomis humilis	Orange Spotted Sunfish					X	X	X	X
Lepomis macropterus	Bluegill Sunfish					X	X	X	X
Lepomis marginatus	Dollar Sunfish					X	X	X	X
Lepomis megalotis	Longear Sunfish					X	X	X	X
Lepomis symmatricus	Bantom Sunfish	S2 G5				X	X	X	X
Micropterus punctulatus	Spotted Bass					X	?	X	X
Micropterus salmoides	Largemouth Bass					X	X	X	X
Pomoxis annularis	White Crappie					X	X	X	X
Pomoxis nigromaculatus	Black Crappie					X	X	X	X
PERCH									
Etheostoma nigrum	Johnny Darter					X	X	X	X
PIRATE PERCH									
Aphredoderus sayanus	Pirate Perch					X	X	X	X
CATFISH									
Ictalurus melas	Black Bullhead					X	X	X	X
Ictalurus natalis	Yellow Bullhead					X	X	X	X
Ictalurus nebulosus	Brown Bullhead	S3 G5				X	X	X	X
Ictalurus punctuatus	Channel Catfish					X	X	X	X
Noturus gyrinus	Tadpole Madtom					X	X	X	X
SUCKER									
Ictiobus bubalus	Smallmouth Buffalofish					X	?	X	X
Ictiobus cyrinellus	Largemouth Buffalofish					X	?	X	X
Minytrema melanops	Spotted Sucker					X	X	X	X
Erimyzonsucetta	Lake Chub Sucker								
MINNOW									
Cyprinus carpio	Carp					X	X	X	X
Dionda nubila	Ozark Minnow					X	?	X	X
Notemigonus crysoleucas	Golden Shiner					X	X	X	X
Notropis emilae	Pugnose Minnow	S4 G5				X	X	X	X
BOWFIN									
Amia calva	Bowfin					X	X	X	X
GAR									
Lepisosteus oculatus	Spotted Gar					X	X	X	X
Lepisosteus osseus	Longnose Gar								
Lepisosteus platostomus	Shortnose Gar					X	X	X	X
Lepisosteus spatula	Alligator Gar	SU G3 G4				X	X	X	X
DRUM									
Aplodinotus grunniens	Drum					X	X	X	X



(Appendix B, cont'd.)

Species name	Common name	Habitat							
		State & Federal status	SHW/BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
HERRING									
Dorosoma cepedianum	Gizzard Shad					X	X	X	X
PIKE									
Esox americanus vermiculatus	Grass Pickrel					X	X	X	X
Esox niger	Chain Pickerel					X	X	X	X
KILLIFISH									
Fundulus notatus	Black-Stripe Topminnow					X	X	X	X
Fundulus notti	Starhead Topminnow	S2 G4				X	X	X	X
Fundulus olivaceus	Black-Spotted Topminnow					X	X	X	X
TOPMINNOW									
Gambusia affinis	Mosquitofish					X	X	X	X
Etheostoma nigrum	Johnny Darter								X
Etheostoma fusiforme	Swamp Darter					X	X	X	X
Etheostoma Prochare	Cypress Darter					X	X	X	X
Etheostoma gracile	Slough Darter					X	X	X	X
Notropis amnis	Pallid Shiner					X	X	X	X
Notropis maculates	Taillight Shiner					X	X	X	X
SILVERSIDES									
Labidesthes sicculus	Brook Silverside					X	X	X	X

Status taken from MDC Conservation Concern List 2005

* State Endangered (MOFWIS)
** Federally Endangered
*** State Threatened
**** Federally Threatened
State Rank (S1-S5)
S1: Critically Imperiled, <1000 individuals
S2: Imperiled, 1000-3000 individuals
S3: Vulnerable, 3000-10,000 individuals
S4: Apparently Secure, 10,000+ individuals
SU: Unrankable due to conflicting data
Global Rank (G3-G5)
G3: Vulnerable, 3000-10,000 individuals
G4: Apparently Secure, 10,000+ individuals
G5: Secure, 10,000+ individuals
SHW/BP: Seasonal Herbaceous Wetland/ Bottomland Prairie
S/S: Shrub/Scrub



Appendix C. Native amphibian and reptile species in habitat types in the Mingo Basin. Information from unpublished data for Duck Creek Conservation Area and Mingo National Wildlife Refuge and range maps and habitat description in Johnson (2000).

Species name	Common name	State & Federal status	Habitat						
			SHW/ BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
AMPHIBIANS									
SALAMANDERS									
Ambystoma maculatum	Spotted Salamander		X	X	X	X			
Ambystoma opacum	Marbled Salamander		X	X	X	X			
Ambystoma talpoideum	Mole Salamander	S2 G5		X	X	X			
Ambystoma texanaum	Small-mouthed Salamander		X	X	X	X	X		
Ambystoma tigrinum	Eastern Tiger Salamander	SU G5 T5	X	X	X				
Eurycea longicauda	Long-tailed Salamander		X	X	X	X	X		
Necturus maculosus	Mudpuppy	SU G5 T5					X	X	X
Plethodon albagula	Western Slimy Salamander		X	X	X	X	X		
Plethodon cinereus	Red-backed Salamander		X	X	X	X	X		
Plethodon doralis	Zigzag Salamander			X	X	X	X		
Plethodon glutinosus	Slimy Salamander		X	X	X	X	X		
Plethodon serratus	Southern Red-backed Salamander		X	X	X	X	X		
NEWTS									
Notophalmus viridescens louisianensis	Central Newt						X	X	X
AMPHIUMAS									
Amphiuma tridactylum	Three-toed Amphiuma	S2 G5					X	X	X
SIRENS									
Siren intermedia nettingi	Lesser Siren						X	X	X
FROGS									
Acris crepitans blanchari	Blanchard's Cricket Frog		X	X	X	X	X		
Acris crepitans crepitans	Northern Cricket Frog		X	X	X	X	X		
Hyla chrysoscelis	Eastern Green Treefrog		X	X	X	X	X		
Hyla cinerea	Green Treefrog		X	X	X	X	X		
Hyla crucifer	Northern Spring Peeper			X	X	X	X		
Hyla versicolor	Eastern Gray Treefrog			X	X	X	X		
Pseudacris streckeri illinoensis	Illinois Chorus Frog			X	X	X	X		
Pseudacris triseriata feriarum	Upland Chorus Frog			X	X	X	X		
Rana catesbeiana	Bullfrog			X	X	X	X		
Rana clamitans clamitans	Bronze Frog			X	X	X	X		
Rana clamitans melanota	Northern Green Frog				X	X	X		
Rana palustris	Pickerel Frog			X	X	X	X		
Rana sphenocephala	Southern Leopard Frog			X	X	X	X	X	X
Rana sylvatica	Wood Frog	S3 G5		X	X	X	X		
TOADS									
Bufo americanus	American Toad		X	X	X	X			
Bufo woodhousei fowleri	Fowler's Toad		X	X	X	X	X		
Gastrophryne carolinensis	Eastern Narrow-mouthed			X	X	X	X	X	
Scaphiopus holbrooki holbrooki	Eastern Spadefoot Toad	S2 G5	X						
REPTILES									
LIZARDS									
Cnemidophorus sexlineatus	Six-lined Race Runner		X	X	X	X			
Eumeces anthracinus	Coal Skink		X	X	X				
Eumeces fasciatus	Five-lined Skink		X	X	X				
Eumeces laticeps	Broad-head Skink		X	X	X				
Sceloporus undulatus hyacinthinus	Northern Fence Lizard		X	X	X				
Scincella lateralis	Ground Skink		X	X	X	X			
SNAKES (non-venomous)									
Carphophis vermis	Western Worm		X	X	X	X			
Cnemidophorus sexlineatus	Race Runner								
Coluber constrictor flaviventris	Eastern yellow-bellied racer		X	X	X	X			
Coluber constrictor foxi	Blue Racer		X	X	X				
Coluber constrictor priapus	Southern Black Racer		X	X	X	X			
Diadophis punctatus	Prairie Ring-neck		X	X	X	X			
Elaphe obsoleta obsoleta	Black Rat		X	X	X	X	X	X	X
Farancia abacura reinwardtii	Western Mud	S2 G5 T5				X	X	X	X
Heterodon platyrhinos	Eastern Hognose		X	X					
Lampropeltis calligaster calligaster	Prairie King		X	X	X				

(Appendix C, cont'd.)

Species name	Common name	State & Federal status	Habitat: SHW/ BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
REPTILES									
Lampropeltis getulus holbrooki	Speckled King		X	X	X	X			
Lampropeltis getulus niger	Black King		X	X	X				
Lampropeltis triangulum syspila	Red Milk		X	X	X				
Nerodia cyclopion	Green Water Snake						X	X	X
Nerodia erythrogaster flavigaster	Yellow-bellied Water			X	X	X	X	X	X
Nerodia fasciata	Broad-banded Water			X	X	X	X	X	X
Nerodia rhombifera	Diamond-backed Water			X	X	X	X	X	X
Nerodia sipedon sipedon	Northern Water			X	X	X	X	X	X
Opheodrys aestivus	Rough Green			X	X	X	X	X	X
Regina grahamii	Graham's Water Snake				X	X	X	X	X
Storeria dekayi wrightorum	Midland Brown		X	X	X	X			
Storeria occipitomaculata	Red-bellied		X	X	X	X			
Tantilla gracilis	Flathead		X	X	X	X			
Thamnophis proximus	Western Ribbon		X	X					
Thamnophis sirtalis	Eastern Garter		X	X	X				
Virginia valeriae elegans	Western Earth		X	X	X	X			
SNAKES (venomous)									
Agkistrodon contortrix contortrix	Southern Copperhead		X	X					
Agkistrodon piscivorus leucostoma	Western Cottonmouth			X	X	X	X	X	X
Croaltus horridus atricaudatus	Canebrake Rattler		X	X	X				
Croaltus horridus horridus	Timber Rattler		X	X	X				
TURTLES									
Apalone muticus muticus	Midland Smooth Softshell						X	X	X
Apalone spiniferus spiniferus	Eastern Spiny Softshell						X	X	X
Chelydra serpentina serpentina	Common Snapping						X	X	X
Chrysemys concinna concinna	River Cooter						X	X	X
Chrysemys picta doralis	Southern Painted						X	X	X
Chrysemys scripta elegans	Red-eared Slider						X	X	X
Deirochelys reticularia miaria	Western Chicken *	S1 G5 T5					X	X	X
Graptemys geographica	Map						X	X	X
Graptemys ouachitensis ouachitensis	Ouachita Map						X	X	X
Graptemys pseudogeographica	False Map						X	X	X
Kinosternon subrubrum hippocrepis	Mississippi Mud						X	X	X
Macroclemys temmincki	Alligator Snapping	S2 G3 G4					X	X	X
Pseudemys concinna/Chrysemys floridana	Cooter								
Sternotherus odoratus	Stinkpot						X	X	X
Terrapene carolina triunguis	Three-toed Box		X	X	X				

Status taken from MDC Conservation Concern List 2005
* State Endangered (MOFWIS)
** Federally Endangered
*** State Threatened
**** Federally Threatened
State Rank (S1-S5)
S1: Critically Imperiled, <1000 individuals
S2: Imperiled, 1000-3000 individuals
S3: Vulnerable, 3000-10,000 individuals
S4: Apparently Secure, 10,000+ individuals
SU: Unrankable due to conflicting data
Global Rank (G3-G5)
G3: Vulnerable, 3000-10,000 individuals
G4: Apparently Secure, 10,000+ individuals
G5: Secure, 10,000+ individuals
Prairie
S/S: Shrub/Scrub



Appendix D. Mammal species in habitat types in the Mingo Basin. Information from unpublished data for Duck Creek Conservation Area and Mingo National Wildlife Refuge and range maps and habitat description in Schwartz and Schwartz (1959).

Species name	Common name	State & Federal status	Habitat						
			SHW/BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
MAMMALS									
POUCHED MAMMALS									
Didelphis virginiana	Opossum		X	X	X	X			
SHREWS AND MOLES									
Blarina brevicauda	Shorttail Shrew		X	X	X				
Cryptotis parva	Least Shrew		X	X	X				
Scalopus aquaticus	Eastern Mole		X	X	X				
Sorex longirostris	Southeastern Shrew		X	X	X				
BATS									
Eptesicus fuscus	Big Brown Bat		X	X	X	X	X	X	X
Lasiurus seminolus	Red Bat		X	X	X	X	X	X	X
Myotis lucifugus	Little Brown Bat		X	X	X	X	X	X	X
Myotis sodalis	Indiana Bat	S1 G2	X	X	X	X	X	X	X
Pipistrellus subflavus	Eastern Pipistrelle		X	X	X	X	X	X	X
ARMADILLOS									
Dasypus novemcinctus	Nine banded Armadillo		X	X					
RABBITS									
Sylvilagus aquaticus	Swamp Rabbit	S2 G5	X	X	X	X			
Sylvilagus floridana	Eastern Cottontail		X						
RODENTS									
Castor canadensis	Beaver			X	X	X	X	X	X
Glaucomys volans	Flying Squirrel			X	X				
Marmota monax	Woodchuck		X	X					
Microtus ochrogaster	Prairie Vole		X						
Microtus pinetorum	Pine Vole		X	X					
Mus musculus	House Mouse		X	X					
Myocastor coypus	Nutria	INVASIVE					X	X	X
Mys palustris	Rice Rat		X	X					
Neotoma floridana	Eastern Woodrat		X	X					
Ochrotomys nuttalli	Golden Mouse		X	X					
Ondatra zibethicus	Muskrat					X	X	X	X
Peromyscus gossypinus	Cotton Mouse		X	X					
Peromyscus leucopus	White-footed Mouse		X	X					
Peromyscus maniculatus	Deer Mouse		X	X					
Rattus norvegicus	Norway Rat		X	X					
Reithrodontomys megalotis	Western Harvest Mouse		X						
Sciurus carolinensis	Eastern Gray Squirrel		X	X	X	X			
Sciurus niger	Eastern Fox Squirrel		X	X	X	X			
Sigmodon hispidus	Hispid Cotton Rat		X	X					
Synaptomys cooperi	Southern Bog Lemming								
Tamias striata	Chipmunk		X	X					



(Appendix D, cont'd.)

Species name	Common name	State & Federal status	Habitat						
			SHW/BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
CARNIVOROUS MAMMALS									
Canis latrans	Coyote		X	X	X				
Euarctos americanus	Black Bear	S3 G5 Extirpated	X	X	X	X	X		
Lutra canadensis	River Otter				X	X	X	X	X
Lynx rufus	Bobcat		X	X	X				
Mephitis mephitis	Striped skunk		X	X	X				
Mustela frenata	Longtail Weasel		X	X					
Mustela vison	Mink		X	X	X	X	X	X	X
Procyon lotor	Raccoon		X	X	X	X	X	X	X
Urocyon cinereoargenteus	Gray Fox		X	X					
Vulpes fulva	Red Fox		X						
HOOFED MAMMALS									
Odocoileus virginianus	Whitetail Deer		X	X	X	X			
Sus scrofa	Feral Hog		X	X	X	X			

Status taken from MDC Conservation Concern List 2005
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*** State Threatened
**** Federally Threatened
State Rank (S1-S5)
S1: Critically Imperiled, <1000 individuals
S2: Imperiled, 1000-3000 individuals
S3: Vulnerable, 3000-10,000 individuals
S4: Apparently Secure, 10,000+ individuals
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Global Rank (G3-G5)
G3: Vulnerable, 3000-10,000 individuals
G4: Apparently Secure, 10,000+ individuals
G5: Secure, 10,000+ individuals

SHW/BP: Seasonal Herbaceous Wetland/ Bottomland Prairie
S/S: Shrub/Scrub



Appendix E. Common bird species in habitat types in the Mingo Basin. Information from unpublished data for Duck Creek Conservation Area and Mingo National Wildlife Refuge maps and habitat description in Jacobs (2001).

Species name	Common name	State & Federal status	Habitat						
			SHW/ BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
BIRDS									
SHOREBIRDS									
Calidris melanotos	Pectoral Sandpiper		XM						
Charadrius vociferus	Killdeer		XM						
Tringa melanoleuca	Lesser Yellowlegs		XM						
Tringa solitaria	Solitary Sandpiper		XM						
WATERFOWL									
Aix sponsa	Wood Duck			S	S	S	Y	Y	Y
Anas acuta	Pintail		M		M	M	M	M	M
Anas clypeata	Shoveler		M			M	M	M	M
Anas crecca	Green-winged Teal		M				M	M	M
Anas discors	Blue-Winged Teal		M		S	S			
Anas platyrhynchos	Mallard		W	W	W	W	W	W	W
Anas strepera	Gadwall		M			M	W	W	W
Aythya affinis	Lesser Scaup				M	M			
Aythya americana	Redhead					W			
Aythya collaris	Ring-Necked Duck					M	M	M	
Aythya valisineria	Canvasback					M		M	
Branta canadensis	Canada Goose		W			Y	W	W	
Lophodytes cucullatus	Hooded Merganser					Y	Y	Y	Y
OWLS									
Bubo virginianus	Great Horned Owl			Y	Y	Y	Y		
Otus asio	Screech Owl			Y	Y	Y	Y		
Strix varia	Barred Owl			Y	Y	Y	Y		
HERON AND ALLIES									
Ardea herodias	Great Blue Heron		S		S	S			
Botaurus lentiginosus	American Bittern *	S1 G4	M				M		
Butorides virescens	Green Heron		S		S	S	S		
Casmerodius albus egretta	American Egret		S		S	S			
Florida coerulea	Little Blue-Heron	S3 G5	S		S	S			
Nyctanassa violecea	Yellow-Crowned Night Heron			S	S	S	S	S	
Ardea Alba	Great Egret		s				s	s	s
Ixobrychus exilis	Least Bittern						S	S	S
GREBES									
Podilymbus podiceps	Pied-Billed Grebe		M				M	M	M
RAPTORS									
Accipiter cooperii	Cooper's Hawk			Y	Y	Y			
Accipiter gentilis	Goshawk			W	W	W	W		
Accipiter striatus	Sharp-shinned hawk								
Buteo lineatus	Red-shouldered Hawk		Y	Y	Y	Y	Y	Y	
Buteo jamaicensis	Red-tailed Hawk		Y	Y	Y	Y			
Buteo platypterus	Broad-Winged Hawk			Y	Y	Y			
Cathartes aura	Turkey Vulture		S	S	S	S	S		
Circus cyaneus	Marsh hawk	S3 G	M		M	M	M	M	
Coragyps atratus	Black Vulture	S3 G	Y	Y	Y	Y	Y		
Falco sparverius	American Kestrel		Y	Y	Y	Y			
Haliaeetus leucocephalus	Bald Eagle * - ****	S3 G4	Y	Y	Y	Y	Y	Y	Y

(Appendix E, cont'd.)

Species name	Common name	State & Federal status	Habitat						
			SHW/ BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
QUAIL AND TURKEY									
Colinus virginianus	Bob-white Quail		Y						
Meleagris gallopavo	Turkey		Y	Y	Y	Y			
CRANES AND ALLIES									
Fulica americana	American Coot		M			M	M	M	M
DOVES									
Columba livia	Rock Dove		Y	Y					
Zenaidura macroura	Mourning Dove		Y	Y					
	Collared Dove		Y	Y					
CUCKOOS									
Coccyzus americanus	Yellow-Billed Cuckoo		S	S	S				
GOATSUCKERS									
Chordeiles minor	Nighthawk		S	S					
Caprimulgus carolinensis	Chuck-will's-widow			S					
SWIFTS AND HUMMINGBIRDS									
Archilochus colubris	Ruby-throated Hummingbird		S	S	S	S			
KINGFISHERS									
Megaceryle alcyon	Belted Kingfisher					Y	Y	Y	Y
WOODPECKERS									
Colaptes auratus	Flicker			Y	Y	Y	Y		
Dendrocopus pubescens	Downy Woodpecker			Y	Y	Y	Y		
Hylatomus pileatus	Pileated Woodpecker			Y	Y	Y	Y		
Melanerpes erythrocephalus	Red-Headed Woodpecker			Y	Y	Y			
Picoides villosus	Hairy Woodpecker			Y	Y	Y			
Sphyrapicus varius	Yellow-bellied Sapsucker			W	W	W	W		
FLYCATCHERS									
Contopus virens	Wood Pewee		S	S	S	S			
Myiarchus crinitus	Crested Flycatcher		S	S	S	S	S		
Sayarnis phoebe	Phoebe		Y	Y	Y	Y			
Tyrannus tyrannus	Eastern Kingbird		S	S	S				
Empidonax virescens	Acadian Flycatcer			S	S	S			
LARKS									
Sturnella magna	Meadowlark		Y						
SWALLOWS									
Hirundo rustica erythrogaster	Barn Swallow		S			S			
Iridoprocne bicolor	Tree Swallow		S			S	S	S	S
JAYS AND CROWS									
Corvus brachyrhynchos	Common Crow		Y	Y	Y	Y	Y		
Cyanocitta cristata	Bluejay		Y	Y	Y	Y			
Corvus ossifragus	Fish Crow		Y	Y	Y	Y	Y		
CHICKADEES									
Parus carolinensis	Carolina Chickadee		Y	Y	Y	Y			

(Appendix E, cont'd.)

Species name	Common name	Habitat							
		State & Federal status	SHW/ BP	High BLH	Int. BLH	Low BLH	Cypress/ Tupelo	S/S	River/ Slough
NUTHATCHES									
Sitta carolinensis	White-breasted nuthatch			Y	Y	Y	Y		
CREEPERS									
Certhia americana	Brown Creeper	SU G5		W	W	W	W		
MOCKINGBIRDS									
Dumetella carolinensis	Catbird			Y					
Mimus polyglottos	Mockingbird			Y	Y				
THRUSHES									
Catharus fuscescens	Veery			M	M	M			
Catharus mustelinus	Wood Thrush			S	S				
Sialia sialis	Bluebird		Y	Y	Y				
Turdus migratorius	Robin		Y	Y					
KINGLETS									
Regulus calendula	Ruby-Crowned Kinglet		W	W	W				
Regulus satrapa	Golden-Crowned Kinglet		W	W	W	W			
SHRIKES									
Lanius ludovicianus	Loggerhead Shrike	S2 G4	Y	Y					
BLACKBIRDS									
Agelaius phoeniceus	Red-Winged Blackbird		Y	Y	Y	Y	Y	Y	
Euphagus carolinus	Rusty Blackbird		W						
Molothrus ater ater	Cowbird		S	S	S	S			
Quiscalus quiscula	Purple Grackle		Y	Y					
STARLINGS									
Sturnus vulgaris	Starling		Y	Y	Y	Y	Y		
WOODWARBLERS									
Dendroica dominica	Yellow-Throated Warbler			S	S	S	S		
Geothlypis trichas	Yellow Throat		S						
WEAVER FINCHES									
Passer domesticus	House Sparrow		Y	Y	Y	Y	Y		
TANAGERS									
Piranga olivacea	Scarlet Tanager			S	S	S			
FINCHES, SPARROWS, AND LONGSPURS									
Junco hyemalis	Dark-Eyed Junco		Y	Y	Y				
Melospiza georgiana	Swamp Sparrow		W	W					
Melospiza melodia	Song Sparrow		W	W					
Passerina eyanea	Indigo Bunting		S	S	S	S			
Pipilo erythrophtha linus	Towhee		Y	Y					
Richmondena cardinalis	Cardinal		Y	Y	Y	Y			
Spinus tristis tristis	American Goldfinch		Y						
Spizella pusilla	Field Sparrow		Y						
Zonotrichia albicollis	White-Throated Sparrow		W	W					

