Establishing ground cover in reservoir mudflats to foster fish assemblages

A. Applicant Information

Leandro E. Miranda
US Geological Survey Cooperative Fish and Wildlife Research Unit
Box 9690
Mississippi State, MS 39762
Phone: 662-325-3217
smiranda@usgs.gov

Marcus Lashley
Mississippi State University
Wildlife, Fisheries, and Aquaculture Department
Box 9690
Mississippi State, MS 39762
Phone: 662-325-3113
mal75@msstate.edu

Michael E. Colvin
Mississippi State University
Wildlife, Fisheries, and Aquaculture Department
Box 9690
Mississippi State, MS 39762
Phone: 662-325-3592
michael.colvin@msstate.edu

B. Project Information

Title:
Establishing ground cover in reservoir mudflats to foster fish assemblages

Location:
Grenada Lake, Mississippi (33,49,52 N; 89,43,52 W). The reservoir is located in the Coastal Plains ecoregion. Alternative locations include Enid, Sardis, and Arkabutla reservoirs, all in the Coastal Plains ecoregion and mapped in Figure 1. Site selection will be made in consultation with cooperators.

U.S. Congressional District:
MS-1, MS-2

Project objectives:

- seed vegetation in mudflats to promote ground cover, provide structural habitat for fish, improve food availability for fish assemblages, and reduce water turbidity by minimizing wave-induced sediment resuspension
- identify practical seeding management practices applicable to the study reservoirs and elsewhere

Estimated on-the-ground start and end dates: June 2016- November 2017

Amount of grant and estimated total cost of project:

- $20,000 requested from RFHP
- $189,000 estimated total cost of project

List of partners:
Reservoir Fish Habitat Partnership
Mississippi Department of Wildlife, Fisheries and Parks
Mississippi State University
US Army Corps of Engineers
US Geological Survey
Magnolia Fishing Club
Ducks Unlimited

C. Project Description

1. **Project overview:**

   Many reservoirs are characterized by large seasonal or long-term water level fluctuations. These fluctuations generally occur over elevation contours that were once uplands and are now artificially submerged. These uplands have soils, slopes, and seed banks that are different from natural floodplains, and therefore are unable to support the vegetation assemblages that commonly develop in natural floodplains. As a result, the regulated zone of a reservoir (i.e., the contour elevations between conservation and normal pool) are often barren mudflats (Figure 2, 3). Excessive mudflats are a problem in reservoirs nationwide, and has been identified by MDWFP as a major issue limiting fish production in flood control reservoirs in north Mississippi (see attached MDWFP's Grenada Lake management plan).

   Mudflats are undesirable for various reasons. First, at low water levels they can detract from site attractiveness, influencing participation levels over a broad spectrum of recreation activities. Second, mudflats promote erosion and contribute to reservoir turbidity and siltation as wind-induced waves resuspend benthic sediment, hit against soft mudflat banks during winter low waters and as heavy precipitation falls over soft unprotected soils. Third, barren mudflats limit biological productivity at various levels, including development of healthy fish assemblages and fisheries.

To improve fish habitat in mudflats biologists have investigated the efficacy of seeding barren shorelines with monocultures of annual terrestrial grasses. A limited number of efforts have suggested that seeding exposed shorelines with annual terrestrial grasses can produce lush stands of vegetation that depending on latitude can grow through fall and winter. However, seeding the vegetation often does not persist once inundated, and in some cases it may not last long enough to produce the desired benefits. Moreover, applicability of this management practice has been limited by the difficulties associated with distributing seeds over exposed mudflats.

We propose to seed 250-500 acres of mudflats in the regulated zone of major arms of Grenada Lake. Seeding will include multiple plant species seeded at diverse time periods (e.g., late summer, fall, or late winter just before mudflats are reflooded) to promote plant survival and structural diversity. We will seed selected plant species in monocultures, and as suites of multiple harmonious species (polycultures) that have demonstrated synergistic effects on their survival and growth, or on the benefits they provide fish. Below we summarize proposed plantings and evaluation.

We identified 16 candidate annual plants for seeding mudflats, six warm-season and ten cool-season plants (Table 1). All of the plants can be sown with a conventional cyclone spreader mounted to a tractor, all-terrain-vehicle, or watercraft. Also, candidate plants have a wide range of adaptations to soils and climates allowing plantings to be adjusted to a wide variety of conditions. The study reservoir, like many flood-control reservoirs in the US, is typically at high water level beginning in spring, throughout the growing season, and begins receding in late summer. Each of the warm-season candidate plants were selected because (1) they could be planted during February with enough time to establish before flooding, or (2) have a short growth cycle (i.e., <70 d) and can be planted on exposed mudflats in late summer. Cool-season plantings can be sown much later in the year (i.e., mid-October) effectively growing through the winter and maturing before inundation in the spring. This diversity of plantings promotes planting success and allows us to evaluate the best management practices regarding the timing of planting and associated costs relative to the resulting improvement in the fish assemblages and in relation to water management strategies.

We selected plants with several characteristics that allow successful sowing on mudflats. First, all candidate plants have relatively small seeds and shallow planting depths. This is an important characteristic because such seeds can be sown directly on bare soil without the need for disking the soil. Second, candidate plants are adapted to a wide range of soils. Also, we identified plants that are drought-tolerant and useable in more arid regions. Late-summer to early-fall is often a dry period in many parts of the Southeastern U.S. Lastly, many of the candidate plants are adapted to tolerate poor fertility and a wide range of pH, cutting the need for soil amendments. These characteristics are essential to minimize overall costs of growing plants in mudflats that are generally unfavorable planting environments with poor accessibility to planting.

The candidate plants also have unique characteristics that may differentially affect fish habitat. For example, broad-leaved forbs (i.e., flowering plants) and narrow-leaved graminoids (i.e., grasses) are structurally variable and complex. Moreover, within the forb and graminoid growth forms, a variety of heights and horizontal architecture are present. Also, the plants have varying levels of lignin which may affect the persistence of structure when inundated. Thus, differing structural characteristics could influence fish use substantially depending on the desirability of the cover for various species and life stages. The date of planting affects the availability of planting contour elevation within reservoirs, which in turn affects the length of time needed for the plant structure to remain stable. Inevitably, nutrients and aquatic invertebrates affect the quality and attractiveness of the habitat to fish. Thus, another consideration of the plantings is how candidate plants may affect nutrient cycling and aquatic invertebrate communities associated with the plants. The plants selected have a considerable range of lignin which along with planting elevation (which affect timing and duration of inundation) influences the rate of decay. Moreover, the range of nitrogen in the proposed plants varies shaping nutrient cycling and related aquatic invertebrates production. Thus, interactions between structural integrity, rate of decay, planting elevation, and nutrient composition will likely influence the fish habitat quality of the plantings.

Many of the candidate plants serve well as companion plants. For example, the cereal grains grow very well with clovers, where the cereal grains germinate and establish quickly creating a relatively high moisture and cool environment that promotes the establishment of the clovers. In a mutualistic relationship, the clovers then begin fixing nitrogen at a rate greater than they can use it leaving excess nitrogen for use by the cereal grains. Not only does this increase the likelihood of a successful planting but may also benefit fish assemblages by adding structural complexity to the planting. To our knowledge, sowing mixtures of companion plants have not been evaluated for the purpose of improving mudflats, but has proven effective in terrestrial applications.

We expect a large number of fish species to benefit from the habitat and food subsidies provided by vegetated shores. Perhaps the biggest beneficiaries will be crappies and black basses that make up the bulk of the recreational fisheries in the study reservoirs. Crappies in particular represent an important economic resource to the region, as they attract anglers from Memphis, Saint Louis, Chicago, and various Midwestern states.

As an aside, we expect that plantings may attract deer when not flooded and waterfowl when flooded. Several of the plant species under consideration are recommended when developing food plots to attract deer, and food plots with direct access to water are particularly attractive. When flooded, the plantings may attract waterfowl. In northern Mississippi waterfowl use wetlands in fall, and again in late-winter to early spring.

2. **Monitoring plan overview**

Monitoring will focus on estimating sowing success (e.g., plant survival, growth), persistence after inundation (e.g., length of time suitable fish habitat remains), macroinvertebrate abundance (e.g., density, biomass, species composition), and juvenile fish abundance (e.g., density, biomass, species composition). To estimate sowing success, the number, height, and biomass of plants will be monitored through the growing season at predetermined time intervals within replicated plots established at various elevation contours in the mudflats. Persistence after flooding will be estimated by measuring the biomass and plant structure at various time intervals following first inundation. Macroinvertebrate abundance will be estimated using active sampling (e.g., sweep-net samples) and passive gears (e.g., colonization plates) beginning after inundation and continuing until the mudflats are dewatered. Juvenile fish abundance will be estimated from electrofishing and/or Wegener ring samples during spawning and post-spawning season until dewatering. For fish, we will also evaluate the value of seeding mudflats by comparing abundances at treatment sites with abundances at control sites (i.e., sites similar to seeded sites, but left untreated and positioned sufficiently apart from seeded sites to represent independent locations).

3. **Outreach plan overview**

Outreach will include involvement of a local fishing club and a chapter of Ducks Unlimited in the seeding effort, as well as development of an extension “how-to” publication. The proposed planting efforts require sowing seeds with conventional cyclone spreaders mounted to all-terrain-vehicles, tractors, or watercrafts. Efforts will be made to involve local stakeholders in seeding and monitoring activities as much as possible. Sustained success of a mudflat seeding will depend on stakeholder involvement, so practical ways in which to engage stakeholders is an integral aspect of this project. Moreover, an extension publication will be developed and made available through MSUcares.com, a web-based source of various wildlife and fisheries extension pamphlets widely accessed nationwide. This publication will be developed in cooperation with an extension specialist and will focus on how reservoir management agencies may cooperate with stakeholders to improve mudflat habitats in reservoirs.

4. **Provisions to protect the restoration project site after project completion**

Seeding mudflats is a recurrent activity. Some of the plants we are considering have the potential of enduring for longer periods than others after they are submerged, and will be identified during our evaluation. Nevertheless, recurrent seeding will be required every 3-5 years to produce the habitat conditions that can promote strong year classes of key reservoir fish species.

5. **List of required permits**

The only approvals needed to seed mudflats within the study reservoirs are those required by the US Army Corps of Engineers. This agency is a partner in this effort and we will be coordinating with them to obtain required permits.

6. **Project timeline**

Mudflats will be seeded in late summer and fall 2016, and late winter 2017 (i.e., Jan-Feb). Monitoring of sowing success will begin soon after plants are seeded starting in 2016. Plant persistence after flooding, macroinvertebrate abundance, and juvenile fish abundance will be evaluated through spring and summer 2017.

D. Budget:

1. **Amount requested** through Reservoir Fisheries Habitat Partnership: $20,000.

2. **Amount of partner** contributions: $163,000

3. **Timeline**: see table below

Categories	Partner Contribution Amount	Cash or In-Kind	Timeline (anticipated date of expenditures)
Reservoir Fisheries Habitat Partnership			
Administrative/Technical Services			
Construction Costs/Materials			
Labor (paid)	20,000	cash	6/16-11/17
Labor (volunteer)			
Miscellaneous (outreach materials)			
Mississippi Dep Wildl Fish Parks			
Administrative/Technical Services	19,000	In-kind	6/16-12/18
Construction Costs/Materials	5,000	cash	6/16-12/18
Labor (paid)	72,000	In-kind	6/16-12/18
Labor (volunteer)			
Miscellaneous (outreach materials)			
Mississippi State University			
Administrative/Technical Services	39,000	in-kind	6/16-12/18
Construction Costs/Materials			
Labor (paid)			
Labor (volunteer)			

Miscellaneous (outreach materials)			
US Geological Survey			
Administrative/Technical Services	2,000	in-kind	6/16-12/18
Construction Costs/Materials			
Labor (paid)			
Labor (volunteer)			
Miscellaneous (outreach materials)			
US Army Corps of Engineers			
Administrative/Technical Services			
Construction Costs/Materials	3,500	in-kind	6/16-9/18
Labor (paid)			
Labor (volunteer)			
Miscellaneous (outreach materials)			
Magnolia Fishing Club			
Administrative/Technical Services			
Construction Costs/Materials			
Labor (paid)			
Labor (volunteer)	2,500	in-kind	6/16-12/18
Miscellaneous (outreach materials)			
Ducks Unlimited			
Administrative/Technical Services			
Construction Costs/Materials			
Labor (paid)			
Labor (volunteer)	2,500	in-kind	6/16-12/18
Miscellaneous (outreach materials)			
Total Direct Costs	165,500		6/16-12/18

* Volunteer labor calculated at $10/hr for age 16 and under; 18/hr other volunteers; agency staff labor rates @ $24/hr

4. **Budget narrative**

The funding requested from the RFHP will be used to pay for wages of graduate students at Mississippi State University. Students will lead the seeding effort in cooperation with local fish and wildlife organizations, and will conduct the monitoring required to evaluate the management practices. No equipment will be purchased with RFHP funds. Equipment is available from partners including US Geological Survey and Mississippi State University. We are asking the US Army Corps of Engineers to contribute funding to buy the seeds, or simply buy the seeds and make them available. The Mississippi Department of Wildlife, Fisheries and Parks is being asked to fund other field expenses and additional graduate student wages. Mississippi State University is waving their normal 45% overhead rate.

Table 1. Candidate plant species for sowing mudflats in the regulated zone of drawdown reservoirs. Maturation is measured in days from germination to viable seed, lignin as acid detergent fiber percentage dry matter, N as percentage dry matter, seeding rate as lbs/acre, and cost as US dollars.

Species	Planting dates	Growth form	Legume	Maturation	Lignin	N	Seeding rate	Cost	Soil adaptations and notes
Buckwheat	Apr 15-Aug 15	Forb	No	60	27	5.9	50	80	Widely adapted to all soils
Browntop millet	Apr 15-Aug 15	Grass	No	65	30	2.3	30	38	Well-drained soils; moderate fertility
Pearl millet	Apr 15-Aug 15	Grass	No	70	32	2.7	35	67	Well-drained soils; moderate fertility
Wild millet	Apr 15-Aug 15	Grass	No	55	34	3.2	30	36	Loams and clays; flooding; moderate fertility
Kobe lespedeza	Feb 15 - Apr 1	Forb	Yes	100	30	4.5	20	40	Widely adapted to soils
Partridge pea	Feb 15 - Jun 1	Forb	Yes	110	26	4.1	15	248	Sandy loam to clay
Crimson clover	Aug 15-Oct 15	Forb	Yes	120	15	6.3	30	39	Sandy loam to heavy clay
Berseem clover	Aug 15-Oct 15	Forb	Yes	150	17	5.7	25	125	Poor drainage; high fertility
Arrowleaf clover	Aug 15-Oct 15	Forb	Yes	180	20	7.0	13	49	Sandy loams to light clay
Red clover	Sep 1-Oct 15 (Feb 15 -Apr 1)	Forb	Yes	150	27	5.4	20	71	Sandy loam to clay; wide range of moisture regimes
Rose clover	Aug 15-Oct 15	Forb	Yes	150	25	5.2	25	125	Sandy loam to heavy clay; low fertility; drought
Winter wheat	Aug 15-Oct 15	Grass	No	180	21	5.7	125	63	Light-textured soils
Rye	Aug 15-Oct 15	Grass	No	180	23	5.4	125	90	Sandy loam to clay; well drained
Oats	Aug 15-Oct 15 (Feb 15 -Mar 15)	Grass	No	170	18	6.1	125	63	Sandy loam to clay; well drained
Triticale	Aug 15-Oct 15	Grass	No	180	26	4.8	125	69	Sandy loam to clay; well drained.
Ryegrass	Aug 15-Oct 15 (Feb 15 -Mar 15)	Grass	No	150	24	2.7	35	96	Poor drainage; drought; moderate fertility.

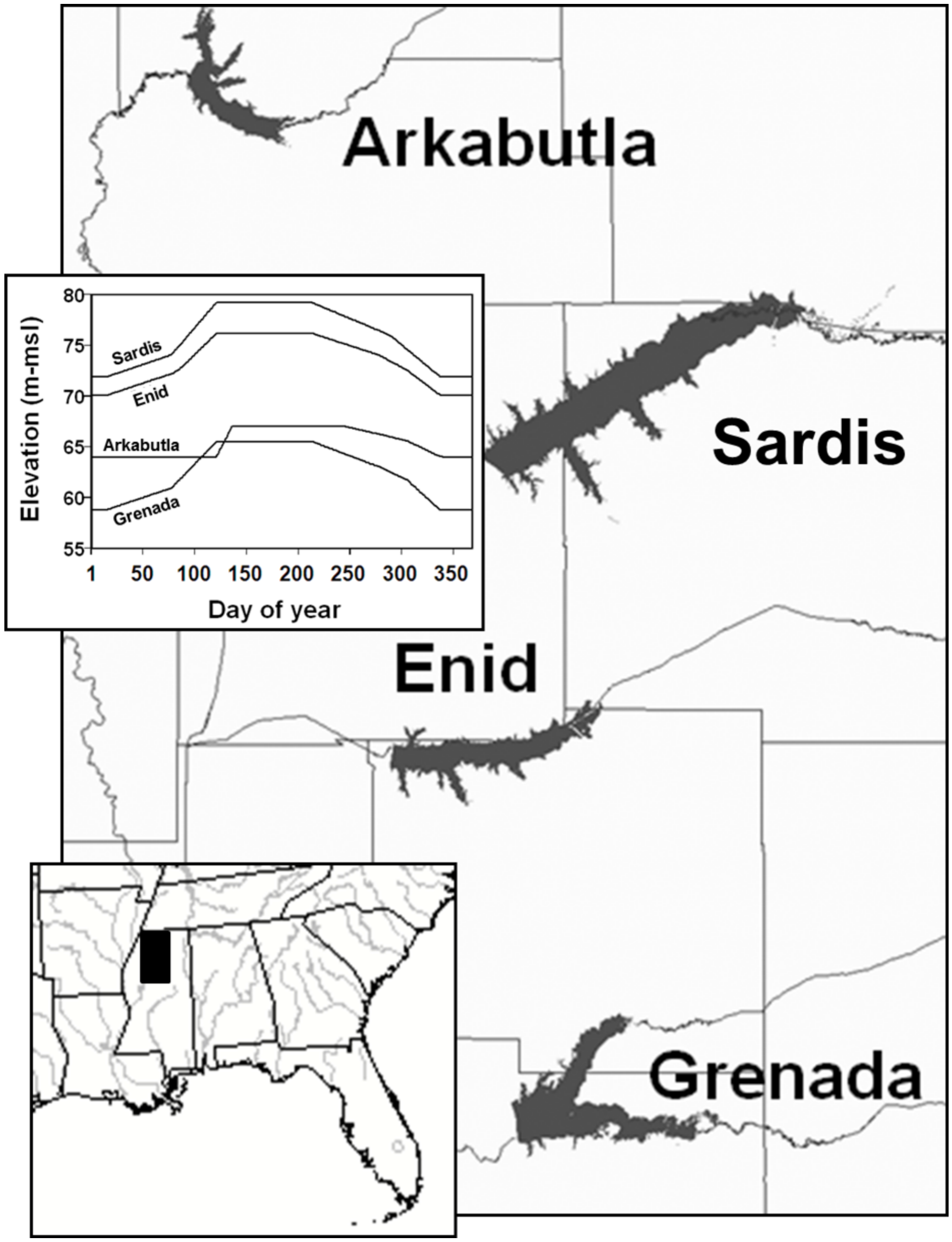

Figure 1. Location of Grenada Lake and three other potential study reservoirs in northwest Mississippi. Also shown are the guide curves used to manage water levels in the reservoirs.

Figure 2. Satellite photo of mudflats in an embayment of Grenada Lake, Mississippi. Photo taken in November 2013.

Figure 3. Mudflats in an embayment of Grenada Lake, Mississippi. Photo taken in August 2012.