Research Proposal

For

Hunter R. Hatcher

Candidate for Degree of

Master of Science

In

Wildlife, Fisheries, and Aquaculture

2016

Title: Establishing and evaluating agricultural plantings on reservoir mudflats as a means to increase juvenile game fish abundance and growth.

Objectives: **1.** Assess growth of agricultural plantings on reservoir mudflats.

2. Evaluate the benefit of agricultural plantings on reservoir mudflats to juvenile gamefish growth and abundance.

Approval:

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Dr. Leandro E. Miranda, Co-Major Professor Date

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Dr. Michael E. Colvin, Co-Major Professor Date

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Dr. Marcus Lashley, Co-Major Professor Date

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Dr. Kevin M. Hunt, Graduate Coordinator Date

Introduction

Aging reservoirs throughout the country pose a major obstacle for resource managers in maintaining desirable recreational fisheries. Degradation of shorelines and nearshore areas through erosion, sedimentation, loss of submerged structure, and widespread substrate homogenization all have become a common concern for reservoir managers because they may decrease habitat complexity (Allen and Aggus 1983; Miranda and Krogman 2015; Pegg et al. 2015). Decreasing habitat complexity can negatively impact fish diversity, simplify fish communities, alter species composition, and reduce recruitment of fish species that support key recreational fisheries (Valley et al. 2004; Smokorowski and Pratt 2007).

Reservoirs can experience dramatically different hydrologic conditions from those that existed in the river prior to impoundment. During flood events rivers escape their banks inundating the surrounding floodplains generally during the late winter through spring. Inundation allows fish access to terrestrial vegetation that provides novel habitat and a boost in productivity (Petry et al. 2003). While impounded systems provide permanent exposure to floodplain habitats, the unnatural water cycle allowing flooding to persist during the growing season limits the growth of terrestrial vegetation and slowly degrades the productive capacity of floodplains (Agostinho et al. 1999; Miranda 2008).

Habitat manipulation and enhancement is a potential solution to mitigate the impacts of reduced habitat complexity. Methods for slowing the rate or reversing reservoir senescence exist and could help restore and preserve habitat (Allen and Aggus 1983; Miranda and Krogman 2015; Pegg et al. 2015). These methods include the creation of habitat components using both artificial structures and naturally occurring materials as well as through the use of both terrestrial and aquatic vegetation. Restoration of degraded ecosystem goods and services, and providing opportunities for resource users, are primary goals of habitat management (Pegg and Chick 2010).

Submersed terrestrial vegetation in the floodplain of a river serves as an important structure for many fish species adapted to exploit seasonally-inundated floodplains. These include various species that provide socially and economically important recreational fisheries (USFWS 2011; Hutt et al. 2013). Studies consistently report that fishes exhibit greater species diversity in vegetated than in non-vegetated areas (Dibble et al. 1996; Cross and McInerny 2001; Pratt and Smokorowski 2003). Vegetation can benefit fish through various mechanisms, often varying across and within a species at different stages of development. For example, forage species use vegetation as protection from predators and predatory fish have reduced foraging success in heavy cover (Savino and Stein 1988, 1989). Vegetation also provides a substrate for growth of epiphytic plants and invertebrates (Keast 1984; Rooke 1986; Chilton 1990; Humphries 1996), which provide forage for juveniles and adult fish (Moxley and Langford 1982). Many fishes depend on vegetation for nest building and spawning as well as structure for young of year (Poe et al. 1986; Bryan and Scarnecchia 1992).

The regulated zone of reservoirs (i.e., the elevation band between the range of annual water level fluctuation) often becomes devoid of vegetation due to the artificial seasonality of the water level fluctuations creating a barren contour often known as mudflats. The water cycle is artificial because mudflats are inundated during the growing season and few native plants are adapted to invading the exposed mudflats during the winter. Thus, mudflats devoid of vegetation provide little cover once inundated. Cool-season agricultural plants provide a potential solution to establish vegetation through the winter which may provide structure for fish following spring inundation. Barley (*Hordeum*) has been tested for this application on the regulated zone of

Shasta Lake reservoir, California yielding minimal effects on black bass (*Micropterus*) populations (Ratcliff et al. 2009). Also, cereal rye (*Secale*) was tested on the mudflats of Lake Nottely reservoir, Georgia and researchers concluded that only temporary and modest benefits to fish populations result from seeding mudflats (Strange et al. 1982). Although those 2 plant species did not yield major benefit in those lakes, numerous other plant species are readily available and have not been tested. Also, because plant adaptations vary widely among these species, there still is need to explore their applicability for submerged structure. For this reason we have chosen specific treatments likely to perform well on reservoir mudflats. For example, Ryegrass (*Lolium*) has been documented to tolerate a variety of soil textures as well as poorly drained soils with only moderate fertility requirements (Harper 2008). Triticale (*x Triticosecale sp.*) is also documented as having a fast germination rate with an excellent resistance to grazing (Harper 2008).

Research Hypotheses and Objectives

Two primary research objectives will drive this project: (1) to determine growth and survival of agricultural plantings seeded in reservoir mudflats, and (2) to determine density and growth of juvenile Largemouth Bass (*Micropterus salmoides*), Black Crappie (*Pomoxis nigromaculatus*), and White Crappie (*Pomoxis annularis*) in sites with and sites without agricultural plantings. I hypothesize that selected agricultural plantings will establish and grow successfully on reservoir mudflats. I also hypothesize that the three focus fish species will exhibit increased growth and abundance over conspecifics at sites without agricultural plantings.

Study Area

This study will occur in two embayments: Long Branch Creek (hereafter experimental embayment) and Billy’s Creek (hereafter control embayment), on Enid Lake reservoir in

Northwest Mississippi. Enid Lake encompasses a surface area of over 6,500 hectares in Yalobusha, Panola, and Lafayette counties, Mississippi formed by the impoundment of the Yocona River. This reservoir was impounded in 1952 as part of the U.S. Army Corps of Engineers Yazoo Headwater Project, with the aim of preventing flooding in the Mississippi Delta region in western Mississippi.

Enid Lake's water level varies seasonally but generally follows a guide curve created by the U.S. Army Corps of Engineers. The guide curve (Figure 1) provides a target pool elevation level given the day of the year. The guide curve suggests that in a normal year the reservoir fluctuates 6.1 m, which results in a change in area of approximately 4,000 ha (i.e., from 2,476 ha at 70.1 m elevation to 6,527 ha at 76.2 m elevation) (Figure 2). These temporal changes in water level interact with seasonal temperature changes to influence how much of the mudflats are exposed, for how long, and at what temperature conditions. Thus, the 74-76 m contour region, for example, encompasses an area of approximately 1,700 ha that is exposed for an average of 225 days per year (Figure 3), and to an average temperature of 13.7° C (Figure 4) when the midpoint of this elevation range (75 m) is used as a threshold. In contrast, the 71-72 m contour region encompasses an area of approximately 500 ha, is exposed for an average of 104 days per year (Figure 3), and to an average temperature of 6.7° C (Figure 4) when the midpoint of this elevation range (71.5m) is used as a threshold. Because the first frost usually occurs around 28 October, the 74-76 m contour is exposed for an average of 53 frost-free days in the fall, whereas the 71-72 m contour is exposed for an average of 0 frost-free days (Figure 5). Thus, the guide curve and local temperature conditions limit the length of time native warm season plants will grow in the mudflats, although the length of the growing season can be extended if cool season agricultural plantings are seeded.

Methods

Experimental design

We will plant experimental agricultural plots in the experimental embayment during the first two weeks of October. A total of 35 plots of 0.5 ha each will be assigned using stratified systematic assignment between 74 and 76 m pool elevation. Treatments will include 4 single species plantings, 2 seed mixes, and an unplanted control. Marshall Ryegrass (*Lolium*), Triticale (*x Triticosecale sp.*), Balansa Clover (*Trifolium michelianum*), and Frosty Berseem Clover (*Trifolium alexandrinum*) will make up the monoculture plantings. Mixed plantings will consist of a Rye Grass and Balansa Clover mix or Triticale and Balansa Clover mix at a 30% grass to 70% clover seeding rate. In 2016 we will sow five additional 0.0125 ha plots to evaluate other species of agricultural crops on mudflats to adjust to the optimal plant composition for 2017 plantings. Additional plots will consist of the following crops: Wheat (*Triticum sp.*), Oats (*Avena sativa*), Crimson Clover (*Trifolium incarnatum*), Arrowleaf Clover (*Trifolium vesiculosum Savi*), and Winter Rape (*Brassica napus*). Plots will be seeded using seeding rates prescribed by the seed supplier and labelled on the seed containers (Table 1).We will plant plots using two planting implements, a Plotmaster Hunter 300 and a Plotmaster Hunter 400 both pulled behind Honda Foreman 500 ATVs. The plotmaster Hunter 300 and 400 planting implements each have disking, spreading, dragging, and culti-packing capabilities. Seeding rate of the implements will be calibrated prior to plantings to ensure optimal seeding based on plot composition. Control plots will receive disking using planting implements but will not be seeded. In 2017, the experiment will be repeated and plant species may be adjusted based on 2016 performance.

Sampling design

Agricultural Plantings

We will monitor the growth of experimental agricultural plantings on a monthly basis from planting (October) through inundation (March-April). Plantings will be evaluated using a point-intercept sampling method (Caratti 2006). A total of 3 transects each 30 meters in length will be assigned radiating from the midpoint of each plot (Figure 6). Along these transects a pole will be used to evaluate ground cover at every meter of the transect. At each point the types of plants intersecting the pole will be recorded. Point intercept sampling will allow for analysis of ground coverage and plot composition. We will take biomass clippings for analysis of dry weight from 1 m^2 exclosures randomly distributed in the plot (Figure 6). Samples will then be dried in an oven with weights recorded every 12 hours until values are stable. Biomass clippings will allow for calculations of dry biomass production for each plot.

Fish Growth and Abundance

Sampling to evaluate fish use and potential benefits derived from vegetation will involve two spatial scales (i.e., within and across embayments). The first spatial scale (microscale) will involve sampling fishes at each of the 35 plots during spring to evaluate plant use. The second spatial scale (macroscale) will involve comparing population characteristics of juvenile fishes between the embayment with the plantings and control embayment that was not planted. Thus, while the microscale investigates differences among plots of the various study plants, the macroscale investigates vegetated versus unvegetated embayments.

Sampling for microscale evaluations will occur in the spring following inundation of experimental plots in April or May of 2017 and 2018. Fish sampling in the experimental embayment will occur over planted and control plots. We expect to use boat electrofishing, Wegner rings, and light traps. Boat electrofishing will be conducted in transects using standard techniques described by Miranda and Boxrucker (2009).Wegner rings consist of a circular net with both a weighted and float line which can be thrown and used to entrap fishes within an entire portion of the water column. A backpack shocker or a fish toxicant will be used in coordination with the Wegner ring to collect fish present within the Wegner ring. Light traps are lighted structures that attract and capture positively phototaxic juvenile fishes, or those that move toward light sources. We will identify all fish to species when possible and record a total length measurement for each individual. Additionally, otoliths will be extracted from a subsample for use in growth assessments of target species. All plots will be sampled in at least one sampling event, and each sampling event will be limited to a narrow time window (e.g., 3 days). Sampling gear and number of replicates will be determined by the water regime, which is expected to follow the guide curve, but could deviate depending on seasonal weather conditions.

Fish sampling for the macroscale will occur in August of 2016 (before) and 2017 (after). A total effort of 30 boat electrofishing transects each lasting 250-400 sec, and 33 trap net nights, will be applied in each embayment (experimental and control) during the before and after periods. All fishes captured will be enumerated by species and a total length will be recorded for each individual.

Data Analysis

Vegetation and fish population metrics will be evaluated using analysis of variance and covariance models (traditional or permutational). For plants, these models will test whether ground cover, height of growth, and biomass differ among treatments while considering time since planting and other relevant covariates (e.g., soil quality). For fish at the microscale, these models will use relative abundance, absolute abundance, growth, and size metrics relative to treatment, while considering relevant covariates (e.g., depth of plot). For fish at the macroscale, an analysis of variance with an interaction term will evaluate if fish relative abundance and size was influenced by the treatment using a before-after-control-impact (BACI) design (Smith et al. 1993). The cost of plantings mudflats in large scales can be high, so investing in plantings demands a rigorous test to evaluate if plants truly benefit fish populations. Thus, all statistical tests will be conducted at the strict $p < 0.05$ level of significance.

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Tables and Figures

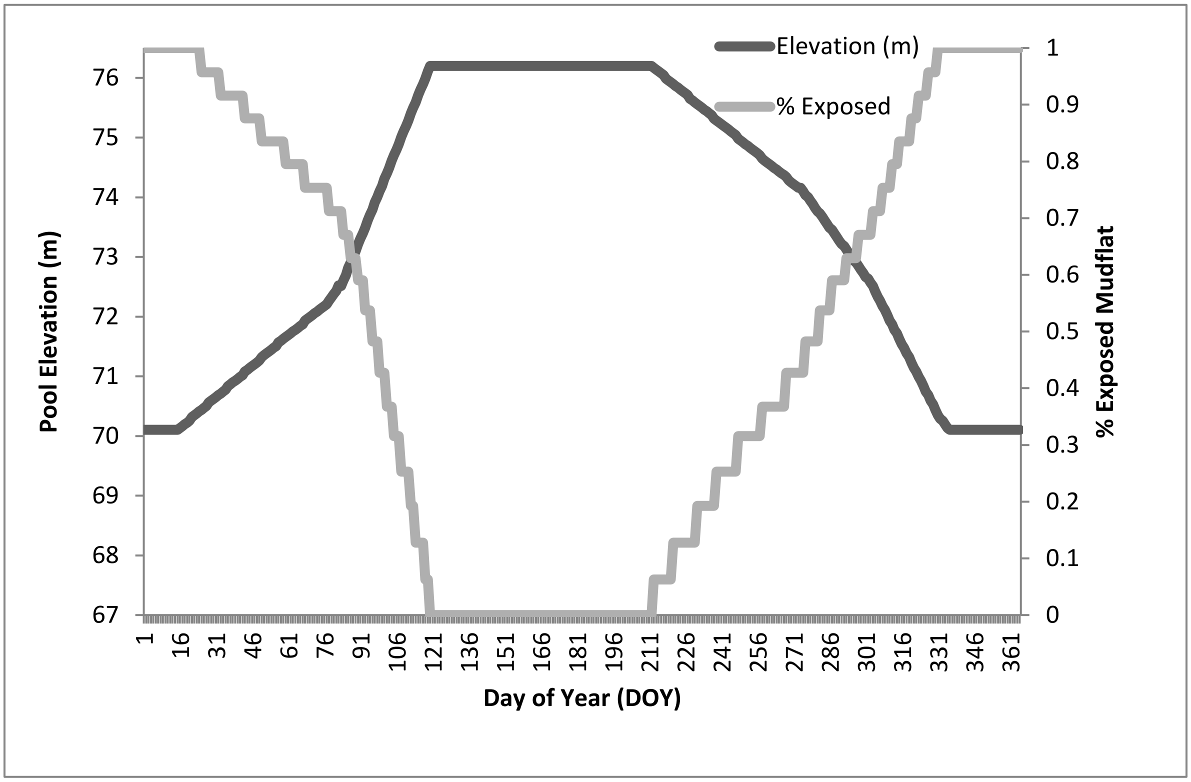

Figure 1. Enid Lake pool elevation in meters (left y-axis) and % of exposed mudflat (right y-axis) plotted against day of the year.

Figure 2. Experimental embayment embayment on Enid Lake on 28 November 2013 at 71.35 m pool elevation (Left) and 9 August 2010 at 76 m pool elevation (Right).

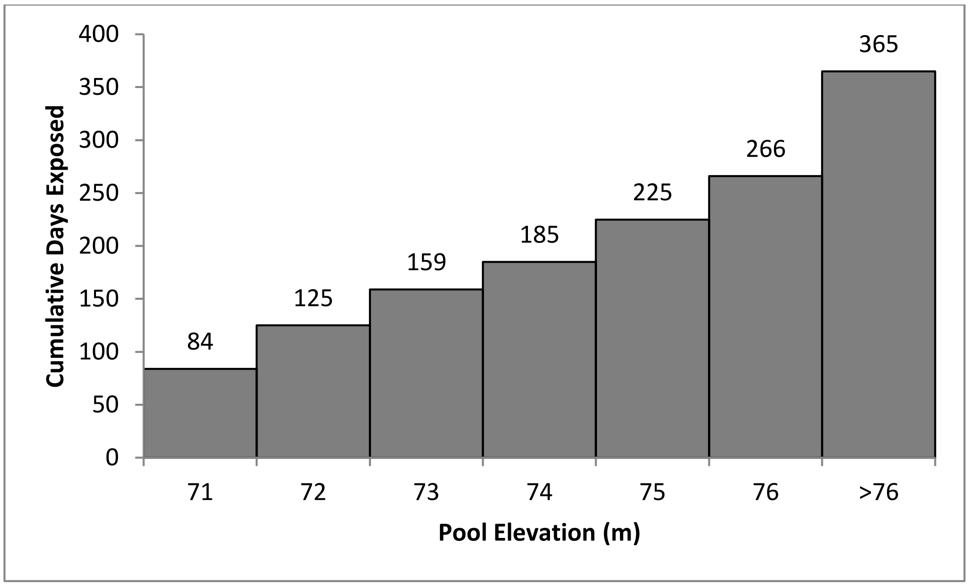

Figure 3. Cumulative days of exposure per year relative to pool elevations in Enid Lake, Mississippi.

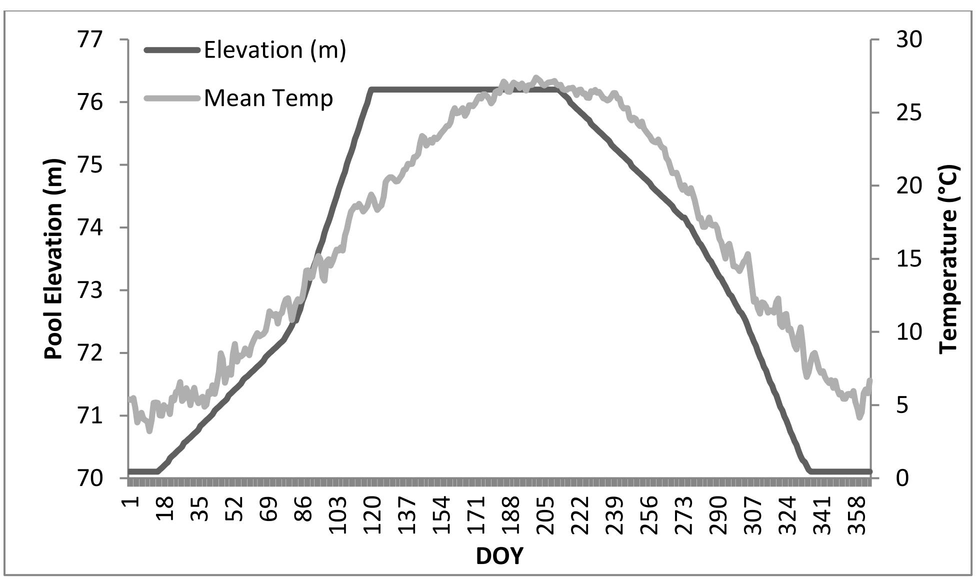

Figure 4. Pool elevation in m (left y-axis) at Enid Lake, Mississippi, and mean daily temperature in °C at Batesville, Mississippi (right y-axis) plotted against day of year.

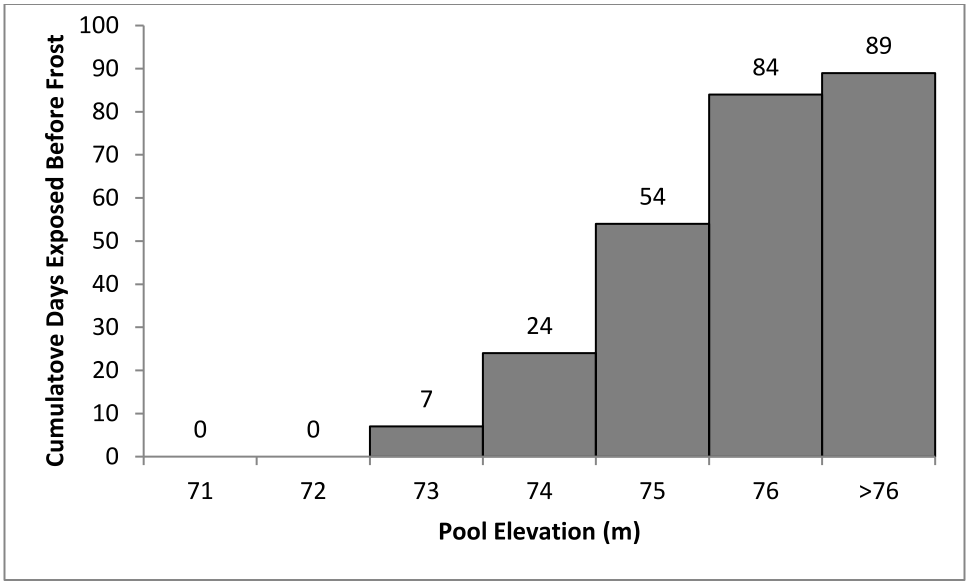

Figure 5. Average cumulative days of mudflat exposure before first frost at Enid Lake, Mississippi. On average, first frost occurs on 28 October (DOY 301).

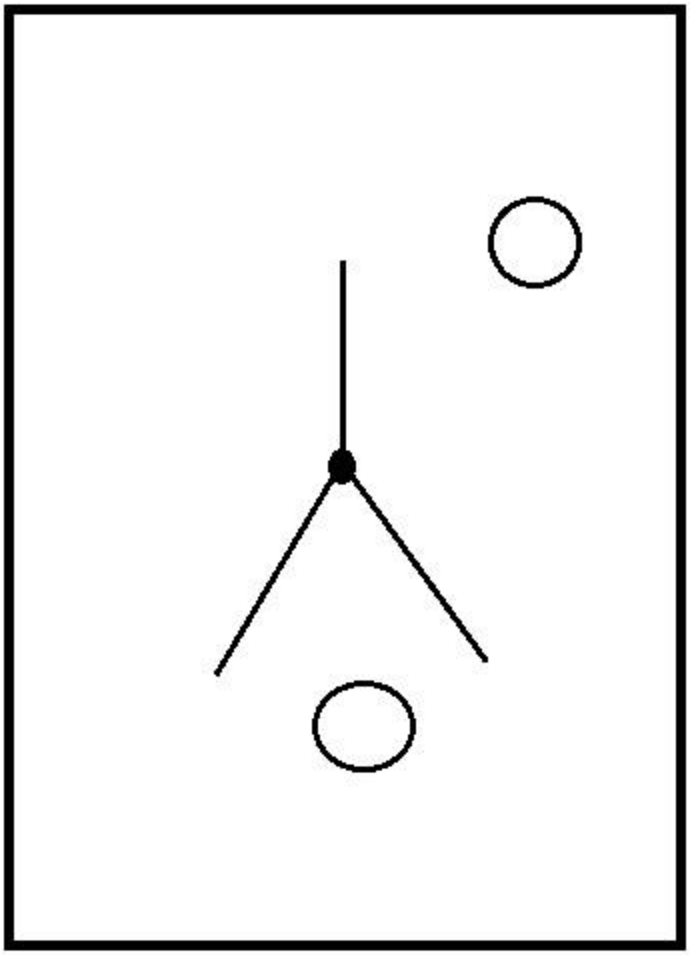

Figure 6. Procedure for agricultural planting growth assesments. Showing the planted plot (rectangle), midpoint (dark circle), point intercept transects (lines radiating from midpoint), and exclosures (empty circles).

Table 1. Seeding rates for plantings by species. These rates were taken from labels provided by the distributors. Distributors included BWI Companies Inc. , Jackson, Mississippi.

Species	lb/acre	lb/ha	**lb/0.5 ha**
Frosty Berseem Clover	25	61.8	**31.0**
Balansa Clover	16	39.5	**19.8**
Marshall Ryegrass	35	86.5	**43.4**
Triticale	125	308.8	**155.0**
Wheat	125	308.8	**155.0**
Oats	125	308.8	**155.0**
Crimson Clover	30	74.1	**37.2**
Winter Rape	16	39.5	**19.8**
Arrowleaf Clover	13	32.1	**16.1**

Graduate Plan of Study

for

Hunter Hatcher

Course Number	Course Name	Semester
WFA 8273	Advanced Fisheries Management	Fall 2016
WFA 8433	Natural Resource and Conservation Decision Making	Spring 2017
WFA 8413	Advanced Fishery Science	Spring 2017
ST 8114	Statistical Methods	Spring 2017
GR 6303	Principles of GIS	Fall 2017
WFA 6223	Wildlife Plant ID	Fall 2017
WFA 8223	Management of Impounded Rivers	Spring 2018
WFA 8212	W&F Communication	Spring 2018