WATERSHED CONSERVATION

A CASE STUDY ON THE REDBUD-CATALPA CREEK WATERSHED

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TABLE OF CONTENTS

PROJECT OVERVIEW

The Redbud-Catalpa Creek watershed is located in northeast Mississippi and drains nearly 29,000 acres of land in Oktibbeha and Lowndes Counties. Rainfall in the watershed flows into 31 miles of streams and creeks on its way to Columbus Lake and the Tennessee-Tombigbee Waterway. Portions of the city of Starkville and the Mississippi State University campus and farm facilities are located within the watershed, as are privately owned lands.

Research and monitoring have shown university activities and development in the city and on campus are contributing to stream, ecosystem, and water quality degradation in the watershed. The Mississippi Department of Environmental Quality (MDEQ) currently lists Catalpa Creek as impaired and in need of restoration. Agricultural resource concerns identified for the watershed include sedimentation, grazing, sustainable forestry, and declining wildlife habitat. Urban storm water management is also a key need.

In response to these issues, the Catalpa Creek Watershed Restoration and Protection Project was initiated. The goals of the project were: (1) restore and protect ecosystem health, ecosystem services, quality of life, and water resources within the watershed; (2) develop an informed citizenry in the watershed and beyond; and (3) create experiential learning opportunities for students, educators, and practitioners.

A collaborative group of faculty and staff from Mississippi State University (MSU), Mississippi Department of Environmental Quality (MDEQ), USDA Natural Resources Conservation Service (NRCS), Mississippi Soil & Water Conservation Commission, and Oktibbeha County Soil and Water Conservation District worked together to develop the Water Resources Management Plan for the Redbud-Catalpa Creek Watershed, a comprehensive document that addresses resource concerns within the watershed.

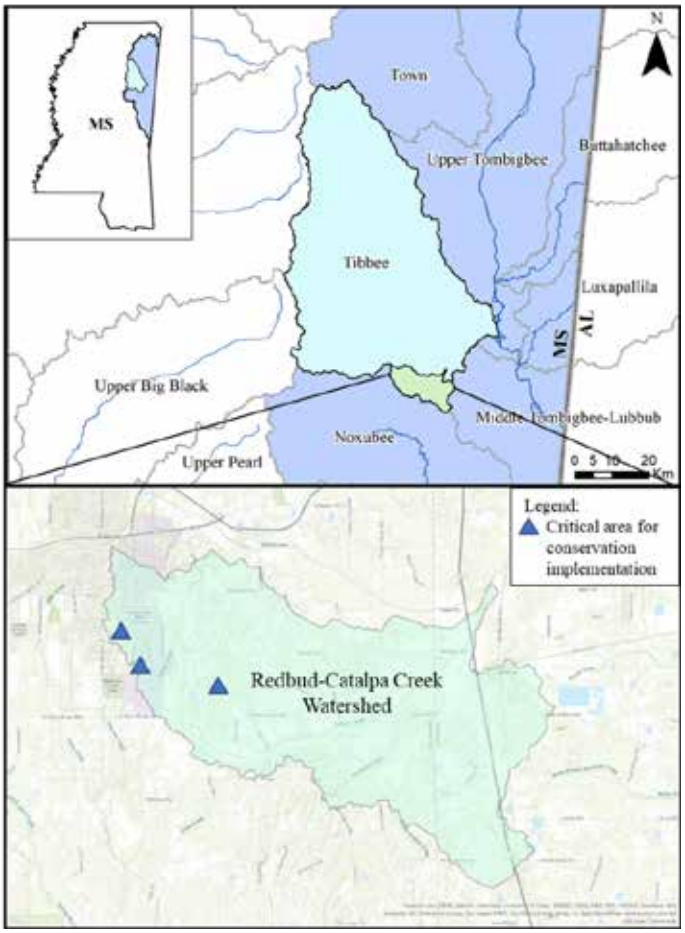

Figure 1. Map of watersheds in northeast Mississippi, including the Redbud-Catalpa Creek watershed (indicated by the green fill).

PROJECT OVERVIEW

BY THE NUMBERS

FROM 2018–2021

24
CONSERVATION PRACTICES INSTALLED

10.3
ACRES OF BUFFER INSTALLED

1700
LINEAR FEET OF FENCING INSTALLED

247
ENVIRONMENTAL DATA SAMPLES COLLECTED

173
WATER SAMPLES

18
VEGETATION TRANSECTS

33
STREAM CROSS-SECTIONS

24
UAS FLIGHTS TO BUILD 3D MODELS OF THE WATERSHED

$135,254
IN LEVERAGED FUNDS

22
EDUCATIONAL EVENTS

25
SCIENTIFIC PRESENTATIONS

244
STAKEHOLDERS EDUCATED THROUGH OUTREACH EFFORTS

Additional research projects were leveraged by the Water Resources Management Plan. This increased assessment of the impacts of conservation practices in and surrounding the Catalpa Creek. It also increased local awareness of restoration and conservation efforts, and the different approaches for measuring conservation success.

The collaborative effort between MSU, MDEQ, and NRCS led to many opportunities to use the conservation practices implemented to improve water quality. The newly installed practices were also used to educate and engage stakeholders in the conservation implementation process.

CONSERVATION PRACTICES IN THE CATALPA CREEK WATERSHED

The Water Resources Management Plan for the Redbud-Catalpa Creek Watershed was written to address the resource concerns within the watershed. Funds were obtained from the MDEQ 319 program to support Phase I of the Catalpa Creek Watershed Implementation Plan. Phase I activities addressed conservation issues within three critical areas defined by MSU project personnel in collaboration with MSU farm operators, USDA NRCS engineers and conservationists, and MDEQ staff. It also included engagement activities with the City of Starkville and Oktibbeha County to address storm water issues.

These funds, leveraged with MSU equipment operators and faculty effort, allowed for best management practices (BMPs) to be installed, including protective fencing (NRCS Practice 382), heavy use protection (NRCS Practice 561), bank and shoreline stabilization, livestock shade structures (NRCS Practice 576), and riparian and native grass plantings (NRCS Practices 342 and 512).

Vegetated buffers were installed as a streamside conservation practice at the Forage Unit on the MAFES H. H. Leveck Animal Research Center and at the MAFES Bearden Dairy. Native warm season grasses and wildflowers were planted as the dominant species, with oaks and other riparian forest species added in the buffers at the dairy. Banks damaged from gully erosion were reshaped, and fencing was installed to protect streams and drainages from livestock movement. Heavy use pads were established at water troughs and high travel areas to improve ground conditions and reduce erosion. Culvert banks were armored to improve flow and reduce head-cutting. Weirs or check-dams were installed to slow water and soil loss from pasture drainages. Moveable shade structures were added to pastures to reduce cattle use of tree shade and protect ground cover in these low-sun areas.

Figure 2. Stream conditions prior to implementation of best management practices.

Figure 3. Fencing and heavy use protection (stream crossing) were implemented to address conditions shown in Figure 2.

CONSERVATION PRACTICES IN THE CATALPA CREEK WATERSHED

Figure 4. Heavy use pads under water troughs allow water to percolate through the gravel and geotextile cloth surface and keep livestock out of mud.

Figure 5. Vegetative strips in combination with weirs slow water and reduce erosion.

Figure 6. A major travel corridor for animals and equipment was reinforced.

Figure 7. An area under a drainage pile was reinforced to stop erosion.

Figure 8. Pre-treatment bank conditions at a farm culvert.

Figure 9. Bank conditions after installation of streamside stabilization practices.

RESEARCH ACTIVITIES IN THE CATALPA CREEK WATERSHED

CONSERVATION IMPACTS ON WATER QUALITY:

A central component of the project was water quality monitoring. This was necessary to understand existing water quality impairments and any improvements resulting from implementation of the various conservation practices outlined in the management plan. Graduate student Audrey McCrary worked with the project team to conduct water monitoring during storms to measure nutrient, sediment, and pathogens in pasture runoff. All monitored sites had concentrations of storm-event pollutants (total nitrogen and phosphorus) that were above MDEQ recommended guidelines for the region (Ecoregion 65a). Sampling sites associated with conservation practices generally had no reduction in pollutants one-year post construction when compared to upstream reference sites. However, this was attributed to lag times between water quality sampling and reestablishment of vegetation in drainages where conservation practice implementation occurred, as well as above-average rainfall throughout the study period. Also, the conservation practices targeted land use-based resource concerns, but soil erosion in the stream drainage is likely to be a primary source of pollutant loading in this system. Total nitrogen concentrations were significantly lower after conservation practices were established near the headwaters of a tributary drainage, highlighting the benefits that can occur when practices can treat runoff water in an area.

Figure 10. Water quality monitoring station.

STREAMBANK EROSION AND IMPACT ON MAIN CHANNEL WATER QUALITY:

Scientists from the Mississippi Agricultural and Forestry Experiment Station (MAFES) use unmanned aerial systems (UAS) to develop new rapid-assessment methods for characterizing soil erosion and identifying critical areas. MAFES scientists on the project team used UAS to gather aerial images of a heavily eroded drainage channel of Catalpa Creek. Successive images were used to construct 3D surface models and model erosion over the course of the project period.

In addition to the surface modeling, characteristics of the mainstream channel and three headwater tributaries were assessed using hydrologic and hydraulic characteristics (for example, flow velocity and depth). Results identified streambank erosion processes and channel changes within

Figure 11. Image of erosion within the Catalpa Creek watershed taken from an unmanned aerial vehicle.

RESEARCH ACTIVITIES IN THE CATALPA CREEK WATERSHED

STREAMBANK EROSION AND IMPACT ON MAIN CHANNEL WATER QUALITY (CONTINUED):

the entire watershed and found streambank erosion to be a driving mechanism of sediment supply to the watershed. Other research in the watershed documented stream water characteristics such as pH, turbidity, temperature, dissolved oxygen, and macroinvertebrates as bioindicators of water quality. Results indicated water quality changed over time and space. For example, water temperature, dissolved oxygen levels, and suspended solids were affected by season and characteristics of the land surrounding the stream (forested vs grassed). The biological assessment showed macroinvertebrate biodiversity in the study sites was good, and some of the species detected were ones which do not occur in highly polluted waters.

STREAMBANK VEGETATION:

Invasive plant species are problematic on the banks of Catalpa Creek with Chinese Privet, Johnsongrass, and Japanese Honeysuckle making up more than one-third of the cover. However, vegetation sampling documented more than 40 native species, as well. To manage the vegetation, three methods to control Chinese Privet were investigated, and the hack-and-squirt method was found to be the most cost-effective method. Johnsongrass is being controlled with selective application of a non-selective herbicide (glyphosate), and research scientists and managers anticipate competition from seeded native species will help to control Japanese Honeysuckle.

Figure 12: Streamside buffer dominated by grasses and forbs.

EDUCATION & OUTREACH OUTCOMES

An objective of the project was educational outreach on watershed conservation to diverse stakeholders. During the project, MSU personnel conducted workshops, classes, field tours and other learning events for landowners, conservation professionals, extension personnel, foresters, urban planners, landscapers, university students, K-12 students, and Mississippi Department of Agriculture and Commerce administrators.

EXTENSION AGENT SURVEYS:

Evaluations of extension agents participating in project workshops showed they gained knowledge (1 point on 5-point scale) on topics such as sustainability, erosion, heavy-use protection, critical planting areas, total maximum daily loads, stream crossings, NRCS programs, and more.

LANDOWNER SURVEYS:

At a November 2019 landowner field day, participants reported the content was relevant to their needs and that they gained knowledge on NRCS landowner programs, private lands management, conservation benefits to soil, water, and habitat, and Farm Service Agency programs. After attending the program, respondents' intentions to implement conservation on their land (a combined 843 acres) improved an average of 0.6 points on a 5-point scale.

REGIONAL SURVEY:

A web-based survey was designed to assess extension agents' understanding of water resources conservation. Eleven land management topics were chosen based on their relevance to water resource conservation in the southeastern United States. Seven states participated in the survey (Alabama, Arkansas, Kentucky, Mississippi, Oklahoma, South Carolina, and Virginia) for a total of 246 responses. Overall, participating extension agents rated the importance of land management topics greater than their perceived ability to educate landowners in these topic areas, which signals a need for further professional development on these topics and water resource conservation. The top three topics identified by agents as educational needs were water quality in streams or ponds, pathogen pollution in waterways, and water conservation.

Figure 13. Experiential learning on water conservation in Catalpa Creek.

Figure 14. Field-based workshop on watershed conservation for landowners and natural resources professionals.

EDUCATION & OUTREACH RESOURCES

In addition to education and outreach events, the project team developed several web-based products that will expand the long-term capacity of the project, providing science-based information on watershed planning, conservation implementation, conservation impacts on water quality, and landscape changes due to conservation implementation.

THESE ITEMS INCLUDE:

- A thesis entitled: *Assessing the environmental and educational value of an agricultural watershed restoration project in Mississippi*
- A virtual presentation of the Water Resources Management Plan for the Redbud-Catalpa Creek Watershed that can be used to deliver presentations to stakeholders.
- A virtual conservation demonstration site and a watershed planning teaching tool in the form of a web-based ArcGIS Storymap: *A Watershed Management Plan for Catalpa Creek*.
- A video clip of 3-dimensional flyby models of a watershed.
- A youth educational manual was developed to support watershed education entitled: *Water Science and Stewardship*.
- A temporary website was built to document conservation implementation and landscape change for education and outreach: Catalpa Creek Restoration - Phase 1 Picture & Video Library.

Figure 15. Meeting with Catalpa Creek stakeholders.

COLLABORATION

A project of this size and scope would not have been possible without numerous collaborators. Many Mississippi State University faculty, staff, and administrators from multiple units across the university helped to develop and implement this watershed restoration plan. The collaborations formed with multiple agencies were the keys to success in this project, and their support was instrumental in project planning, identifying resource concerns and solutions, designing technical specifications of conservation practices, assisting with water analysis, education, and outreach events, and providing funding support.

KEY COLLABORATORS:

- Mississippi Department of Environmental Quality
- USDA Natural Resources Conservation Service - Mississippi
- Mississippi Agricultural and Forestry Experiment Station
- Mississippi State University Extension Service

LOOKING AHEAD

With the implementation of Phase 1 of the Catalpa Creek Watershed Restoration plan, Mississippi State University now has a conservation demonstration site for future education and outreach to a variety of stakeholders. We anticipate continued training of conservation professionals, providing conservation tours to landowners and government officials, and educating students on watershed science, environmental protection, ecology, water resource protection, and a variety of monitoring methods. We anticipate continued research and conservation efforts through funding from the USDA-NRCS Conservation Innovation Grant Program to implement and assess the efficacy of utilizing slag and biochar bioreactors as another water quality protection practice. We expect to continue outreach, community engagement, and monitoring efforts through the new Mississippi Water Stewards program, which will be training monitors in the Tombigbee watershed to build local capacity for watershed protection.

PROJECT OUTPUTS

EDUCATIONAL EVENTS:

- Two Conservation Camps, June 2018
- Urban forestry workshop, July 2018
- Tour for Mississippi legislative leaders, August 2018
- Workshop for MSU Extension agents, October 2018
- Undergraduate student education Fall 2018-Fall 2019 included six courses from four departments:
  - Agricultural & Biological Engineering
  - Forestry
  - Landscape Architecture
  - Wildlife, Fisheries & Aquaculture
- Workshop for 4-H volunteer leaders, February 2019
- Meeting with Starkville city leadership, September 2019
- Workshop for landowners, November 2019
- Water Resource Conservation Needs Assessment Survey, 2020
- Watershed Planning & Virtual Field Tour webinar, February 2021
- Field tour for private landowners and stakeholders within the Redbud-Catalpa Creek, June 2021
- Undergraduate student experiential learning projects (throughout project period)

LEVERAGED FUNDING:

1. Applied use of unmanned aerial vehicles in surface water quality protection. United States Geological Survey. Czarnecki, J. (Principal), Ramirez-Avila, J. (Co-Principal). $45,676. Jul 1, 2017 – Jun 30, 2018.

2. Assessing soil erosion with unmanned aerial vehicles for precision conservation, Year 2. Mississippi Agricultural and Forestry Experiment Station Strategic Research Initiative. **Czarnecki, J.** (Principal), Linhoss, A. (Co Principal). $33,298. Jan 1, 2018 – Dec 31, 2018.

3. Assessing soil erosion with unmanned aerial vehicles for precision conservation, Year 1. Mississippi Agricultural and Forestry Experiment Station Strategic Research Initiative. **Czarnecki, J.** (Principal), Linhoss, A. (Co-Principal). $17,980. Jan 1, 2017 – Dec 31, 2017.

4. A hydraulic model to support conservation and ecosystem restoration efforts within an impaired, priority watershed. Mississippi Agricultural and Forestry Experiment Station Strategic Research Initiative. Schauwecker, T. (Principal), Czarnecki, J. (Co-Principal). $33,300. Jan 1, 2017 – Dec 31, 2017.

5. Comparative analysis of watershed management planning and processes. MSU ORED International Working Group. Schauwecker, T. (Principal), Czarnecki, J. (Co-Principal), Ramirez-Avila, J. (Co-Principal), Gravango, F. (Co-Principal – University of Catania, Italy), Pappalardo, G. (Co-Principal – University of Catania, Italy). $5,000. Jan 1, 2016 – Dec 31, 2016.

PROJECT OUTPUTS

SCIENTIFIC PRESENTATIONS:

1. Czarnecki, J. M. 2018. Best practices and lessons learned in creating 3D structure from UAV imagery. MAST Mississippi Geospatial Conference 6, Long Beach, MS.

2. Czarnecki, J. M., A. C. Linhoss, L. A. Hathcock, J. J. Ramirez-Avila, T. J. Schauwecker. 2018. Assessing soil erosion with unmanned aerial vehicles for precision conservation. 73rd Soil and Water Conservation Society international annual conference, Albuquerque, NM.

3. Czarnecki, J. M., J. J. Ramirez-Avila, A. C. Linhoss, T. J. Schauwecker, L. A. Hathcock. 2019. Best practices and lessons learned in using low-cost unmanned aerial vehicles for assessing erosion. Mississippi Water Resources Conference, Jackson, MS.

4. Czarnecki, J. M., J. J. Ramirez-Avila, L. A. Hathcock. 2018. Structure from motion with unmanned aerial vehicles: A best practices guide for new users. Geosystems Research Institute Technical Report No. 5081, Mississippi State University.

5. Czarnecki, J. M., J. van der Zwaag, J. J. Ramirez-Avila, A. C. Linhoss, T. J. Schauwecker. 2020. Augmented reality as a tool for technology-driven conservation. 75th Soil and Water Conservation Society International Annual Conference.

6. Grafe, J., J. J. Ramirez-Avila, T. J. Schauwecker, S. Ortega-Achury, J. M. Prince Czarnecki, E. Langendoen. 2018. Understanding relations between streamflow, turbidity, and suspended-sediment concentration in an impaired Mississippian stream. Mississippi Water Resources Conference, Jackson, MS.

7. Linhoss, A. C., J. M. Czarnecki. 2018. A magnetic and fluorescent particle tracer applied to a coastal sand system. American Society of Agricultural and Biological Engineers Annual International Meeting, Detroit, MI.

8. Linhoss, A. C., J. M. Czarnecki, S. Samiappan. 2019. Remotely sensing sediment tracers. Mississippi Water Resources Conference, Jackson, MS.

9. Linhoss, A. C., S. Samiappan, J. M. Czarnecki. 2019. Remotely sensing sediment tracers. American Society of Agricultural and Biological Engineers Annual International Meeting, Boston, MA.

10. McCrary, A., B. Baker, L. M. Burger. 2019. Assessing the environmental and educational value of an agricultural stream restoration. Mississippi Water Resources Conference, Mississippi Water Resources Research Institute, Jackson, MS.

11. McCrary, A., B. Baker, L. M. Burger. 2019. Assessing the environmental and educational value of an agricultural stream restoration. Mississippi Academy of Sciences, Mississippi State, MS.

12. McCrary, A., B. Baker, L. M. Burger. 2019. Assessing the environmental and educational value of an agricultural stream restoration. Mississippi Chapter of The Wildlife Society Annual Conference, Vicksburg, MS.

13. Ramirez-Avila, J. J., J. Grafe, T. J. Schauwecker, S. Ortega-Achury, J. L. Martin, T. Noble, J. M. Prince Czarnecki. 2018. Impacts of riparian buffer zones on stream water quality: A quantitative assessment in the Catalpa Creek Watershed. Mississippi Water Resources Conference, Jackson, MS.

14. Ramirez-Avila, J. J., J. M. Czarnecki, T. J. Schauwecker, S. Ortega-Achury, E. J. Langendoen. 2019. Streambank erosion assessment in the Catalpa Creek in Mississippi. SEDHYD 2019 11th Federal Interagency Sedimentation Conference and 6th Federal Interagency Hydrologic Modeling Conference, Reno, NV.

PROJECT OUTPUTS

15. Ramirez-Avila, J. J., J. M. Czarnecki, T. J. Schauwecker, S. Ortega-Achury, E. J. Langendoen. 2019. Streambank erosion assessment in the Catalpa Creek in Mississippi. SEDHYD 2019 11th Federal Interagency Sedimentation Conference and 6th Federal Interagency Hydrologic Modeling Conference, Reno, NV.

16. Ramirez-Avila, J. J., L. Chavarro-Chaux, S. Ortega-Achury, B. Richardson, J. M. Czarnecki, T. J. Schauwecker. 2020. Stream health and water quality conditions associated to livestock production in the Catalpa Creek. Proceedings of the 2020 Mississippi Water Resources Conference.

17. Ramirez-Avila, J. J., S. Ortega-Achury, T. J. Schauwecker, J. M. Czarnecki, J. L. Martin. 2019. Evaluation of spatial and temporal variation in stream water quality: A case study for a Mississippi urban headwater. Mississippi Water Resources Conference, Jackson, MS.

18. Ramirez-Avila, J. J., T. J. Schauwecker, J. L. Martin, S. Ortega-Achury, J. M. Prince Czarnecki. 2018. A project based learning study oriented to develop a natural stream restoration design. Mississippi Water Resources Conference, Jackson, MS.

19. Ramirez-Avila, J. J., T. J. Schauwecker, J. M. Czarnecki, E. J. Langendoen, S. Ortega-Achury. 2018. Quantifying and modeling in-stream processes: A first step to restore the Catalpa Creek. World Environmental and Water Resources Congress, Minneapolis, MN.

20. Ramirez-Avila, J. J., T. J. Schauwecker, J. M. Czarnecki, S. Ortega-Achury. 2019. Physical, chemical and biological assessment of the Catalpa Creek in Mississippi: Preliminary results. World Environmental and Water Resources Congress, Pittsburgh, PA.

21. Ramirez-Avila, J. J., T. J. Schauwecker, J. M. Czarnecki, S. Ortega-Achury, E. Langendoen, J. L. Martin. 2018. Identification and assessment of stream processes within the Catalpa Creek in Mississippi. EcoStream Stream Ecology and Restoration Conference, Asheville, NC.

22. Schauwecker, T. J., J. J. Ramirez-Avila, J. M. Czarnecki, B. Baker. 2018. Hydraulic and vegetative modeling for the restoration design of the upper reach of catalpa creek, an impaired stream in northeast Mississippi. National Conference on Ecosystem Restoration, New Orleans, LA.

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