Modeling Invasive Carp Passage Risk in the Mississippi River

Caleb Bush

cbush6@bellarmine.edu

1/21/2026

Executive Summary

Invasive Asian Carp have become a major threat to the Mississippi River by competing with native fish and damaging their habitat. Lock and Dam systems on the Mississippi control upstream movement which can increase the risk of the carps expansion. Figuring out which conditions invasive carp are most likely to spawn and move in is essential for effective wildlife management prevention efforts. This project would use data collected from Lock and Dam 19 through acoustic telemetry to analyze and predict invasive carp movements. With variables such as water temperature and indicators of passage figuring out when and where the carp would move can be done. Using spatial, risk-based, and random forest model approaches will help with predictions and also deciding which variables or factors are most relevant to carps movement. The findings in this project will provide insight for wildlife management to more effectively capture and get rid of the invasive species. Utilizing the telemetry data, this project will demonstrate the application of predictive analysis to efforts trying to limit the continued spread of these invasive carp in the Mississippi and surrounding water systems.

Project Idea

This project aims to analyze and predict invasive carp movement in the Mississippi using data collected from Lock and Dam 19 near Keokuk, Iowa which borders Illinois and Missouri. The invasive Asian carp are a threat to native fish populations as well as the habitat those fish reside in. Through the examination of fish level characteristics in tandem with environmental variables, this project will seek to identify the hotspots of carp activity when at which times carp are most active.

Using predictive models to identify high risk river conditions as well as models that will try and link carp movement to Lock and Dam conditions as well predictions could be made. Along with those, mapping out high activity spots within this stretch of the Mississippi will be useful in order to pinpoint where they will move in accordance with the when and why. The combination of these approaches are intended to support data driven insights that would be beneficial for wildlife management groups that watch over the Mississippi and neighboring river systems.

Background

Invasive carp species such as the bighead and silver carp are a major environmental threat to the Mississippi by competing with the native fish for food and habitat. They have grown at a rapid rate and have spread through interconnected waterways, most commonly at locks and dams. These locks and dams unintentionally allow upstream movement which increases the risk of carp infiltrating new river sections. Effective management of these carp requires understanding of where carp are as well as knowing the factors and conditions that influence their movement.

Some current management strategies to deal with these carp can include commercial harvesting along with paying individuals for catching these carp. Physical barriers have also been used to try and prevent movement. More recently technology has become a more prevalent strategy. The new approaches use electric barriers or acoustic barriers. These approaches have some success but not enough to fully counteract the rapid growth of carp populations. The use of environmental data in predictive models can help identify the conditions for movement.

The environmental data that will be used was collected in 2017-2018 by the U.S Army Corps of Engineers at Lock and Dam 19 on the Mississippi river near Keokuk, Iowa. The dataset may be old by some standards however it is still useful as fish movement behavior remains consistent today. The river's infrastructure is unchanged as well. Along with that the predictions revolve around trying to determine under what conditions carp will move which still are applicable now. It is also hard to acquire recent wildlife studies data as it takes lots of time and money to collect high quality data. This dataset has 3043 entries and 35 variables. Some of the most important of these are fish species length, weight, tagging location, and water temperature. It also includes indicators of upstream and downstream passage events with time-based information for each detection.

Modeling

This project plans to apply multiple predictive modeling approaches to understand invasive carp movement in the Mississippi River. One of these models would be a random forest. The random forest model would be used to help determine which variables are most important when it comes to predicting invasive carp movement and passage. Feature importance metrics will provide insights into which factors should be prioritized in prevention efforts.

Another model that would be used is a risk based predictive model that would be developed to estimate the probability of upstream passage under varying conditions. Predictor variables could include water temperature, river stage, and season. The response variable in this case would be upstream passage occurrence. This allows identification of high-risk conditions and would help support preemptive wildlife management strategies.

The last model would be a spatial analysis model using Kernel Density Estimation. This will be used to identify areas and times with increased carp activity. Detection events could be aggregated by location and time to map out movement within the study area. This model will help visualize spatial and seasonal patterns of carp activity near Lock and Dam 19 where the data is focused.

Tools

This project will be done using R, which is well suited for the chosen models. R provides a wide range of packages for data manipulation, statistical modeling, and visualization. For visualization ggplot2 will be used to produce clear plots and maps. Along with that Tableau will be used for more interactive visualizations than R can produce. These visualizations will support model outputs and spatial patterns. For the random forest model, the randomForest package is going to be implemented to capture relationships and assess variable importance in predicting carp movement and upstream passage. When predicting using time-based variables the tidyverse packages will allow for reproducible data preparation. The Kernel Density Estimation analysis will be implemented using spatstat and sf. This package will allow for the identification of invasive carp hotspots.

Conclusion

Invasive Asian carp have created an ongoing threat to the Mississippi, in particular through their ability to move upstream and disturb native fish. This project will use a predictive data driven approach to try and understand conditions in the river that influence the carp movement by analyzing data collected at Lock and Dam 19. Through models such as spatial analysis, risk based, and random forest, this project will aim to identify high movement areas, estimate upstream passage risk, and determine which factors are most important and most influential. The insights gained from these predictive models can provide actionable insights for management.

References

Fritts, A., & Knights, B. (2020, November 30). *2017-2018 telemetry data for Asian carp and native fish species at lock and dam 19 in the upper mississippi river basin*. sciencebase.gov. https://www.sciencebase.gov/catalog/file/get/5fbe7c1ad34e4b9faad7e8cc?f=__disk__14%2F2a%2F6b%2F142a6bfa9ab133230a0c0a6e45f2b278541dde1c&transform=1&allowOpen=true

Geographyrealms. (2024, August 13). *R packages for spatial analysis*. Geography Realm. https://www.geographyrealm.com/r-packages-for-spatial-analysis/

Görög, L. (2022, September 5). *R packages for Predictive Analytics*. Predictea Digital Care - AI Strategy, Predictions, Data Analysis. https://www.predictea.com/r-packages-for-predictive-analytics/