As a follow-up to Michael Hayslett's article regarding the Purple Loosestrife, which ran in the Winter 2019 issue of THE RIVER RUNS, we would like to continue that theme with a scientific paper written by Rob Slusser. Rob is a senior at Radford University in the Geospatial Science Department, and he presented his research to those of us who attended the most recent CRPA Annual Meeting at Camp Mont Shenandoah on May 18, 2019.

Predicting The Potential Future Spread of *Lythrum salicaria* Using GIS and Remote Sensing in the Allegheny Highlands, Virginia

by Robert K. Slusser
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Abstract

The Allegheny Highlands are known for their breathtaking natural Virginian countryside, which is home to a broad watercourse that collectively drain south into the James River in northern Botetourt County. In recent decades, an invasive wetland perennial known as the Purple Loosestrife (Lythrum salicaria) has made its appearance in close proximity to the waterways which flow directly into the James. This violet-flowered noxious weed threatens indigenous biodiversity of a top tier ecosystem primarily due to lack of natural enemies on the North American continent. The purpose of this research is to estimate the most vulnerable wetlands in the area of study. Geographic information systems (GIS) and remote sensing technologies were used to find the location of ongoing stands of *L. salicaria*. Data also collected from accredited sources was used to analyze the vulnerability of non-infected wetland areas. Suitability modeling techniques were used to create a predictive modeling of the spatial distribution of Purple Loosestrife. This is a new approach to understand the spread of invasive and non-indigenous vegetation.

Introduction

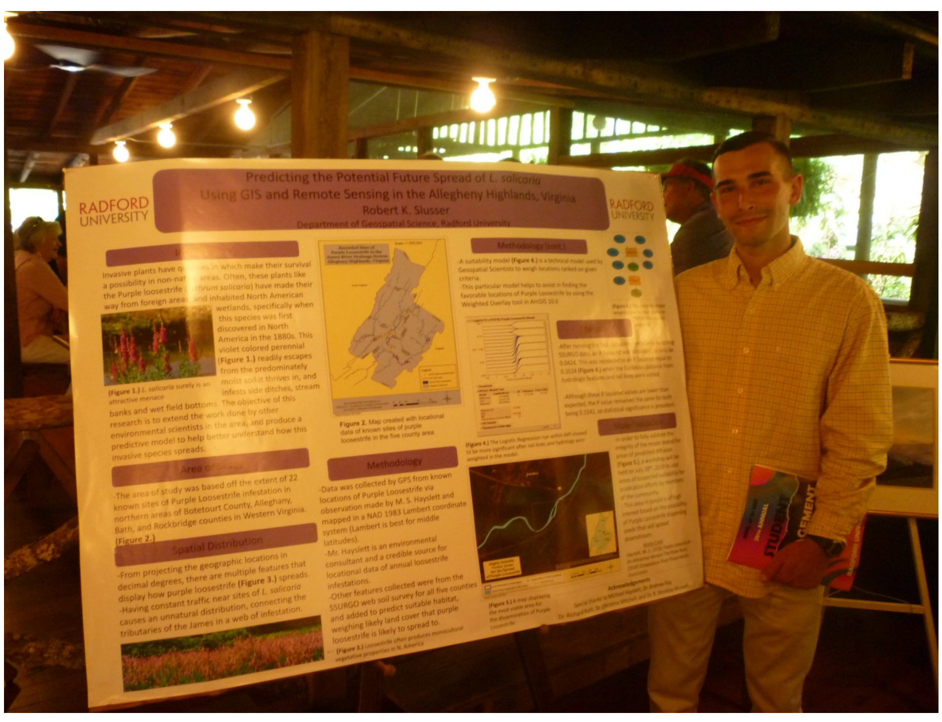
Invasive plants have qualities in which make their survival a possibility in non-native areas. Often, these plants like the Purple Loosestrife (*Lythrum salicaria*) have made their way from foreign areas and inhabited our wetlands here in North America, specifically when this species was first discovered in North America in the 1880s. This violet-colored flower readily escapes from its normally ornamental plant setting around houses or in irrigation ditches, and spreads via water flow along rivers and streams, creating a homogeneous "purple desert," primarily because the plant has no known vegetative competitors in North America, whereas human impact also unintentionally disperses seeds.

In the Allegheny Highlands (western Virginia), this plant has made its explosion as an invasive species, at times completely smothering the original vegetation seen decades before. Some efforts can be made to neutralize infestations of *L. salicaria,* and at times can be useful to an extent, but an individual plant can produce up to 2.7 million seeds annually. Often these seeds are spread mechanically by getting seeds carried by animals or physical properties like wind, water, and agricultural use where *L. salicaria* has infested a geographic location. The problem lies within controlling this "attractive menace" and restricting the spread of its seeds downstream, as well as physical dispersal of potential spread of Purple Loosestrife.

Efforts to alleviate the growing abundance of this invasive species in the Allegheny Highlands are growing in popularity thanks to Conservation Biologist Michael S. Hayslett of VA Vernal Pools LLC. The major ambition for this study comes from his initial response to the sighting of Purple Loosestrife in the Lynchburg area farther southeast from the Alleghany Highlands on the James River (Hayslett, 2018). Though this is an ongoing problem for the Cowpasture River Preservation Association (CRPA), knowing that *L. salicaria* is prevalent in the Allegheny Highlands is a great first step in controlling the spread of its invasive qualities. The purpose of this study is to apply the use of Geospatial technologies made available by Radford University and how they can be adopted into Purple Loosestrife eradication efforts by using the geospatial technology made readily available by the Radford University Department of Geospatial Science.

Literature Review

The Purple Loosestrife is a common plant across the North American continent, Europe and Asia. Although there are many news articles, periodicals, and enough YouTube videos about the plant to understand where, why, how, and when it grows, the most helpful knowledge on protecting our native biodiversity from this plant was found by using online search engines to find critically reviewed articles about the controlling of this “Beautiful Killer.” In an article by the Research Journal of Agricultural Sciences starting on page 96, the authors discuss how the plant originates in east northern Africa, Turkey, extending to Palestine and Lebanon. Even Japan and China have their own problem with the invasive flora. But it wasn’t until the early 1800s that *L. salicaria* had been introduced to the marsh wetlands of the southeastern United States. We find in this journal that Purple Loosestrife can be found all around the world, except for high mountain areas at northern latitudes (Neacsu, Arsene, Imbrea & Nicolin 2016). Although all plants have natural enemies, this study was conducted to find what biological factors inhibit the reversal effect of the invasiveness of the Purple Loosestrife. In the study, they found 59 insects which were feeding on this plant. 50 were eating on leaves, 3 on stems, and 6 on nreproductive organs (Neacsu, Arsene, Imbrea & Nicolin 2016**).** Summarizing this article, the researchers saw the plant as a problem with no apparent solution. Control methods are done by mechanical means (disking, mowing and pull-and-bag methods), all of which help in assisting the spread of Purple Loosestrife seed banks. In order to properly remove these populations, this actions needs to be done before the plant



Rob Slusser and his presentation board at the 2019 CRPA Annual Meeting at Camp Mont Shenandoah.

blooms (MALECKI & RAWINSKI, 1985, in PASIECZNIK, 2007) as to not facilitate the spread of the species.

Before getting to know how to analyze the abundance of Purple Loosestrife using Geospatial Information Systems (GIS) and Remote Sensing, a better understanding of a possible solution for the areas that my model will predict was needed, as well as what action needs to be taken in order to validate my entire study. So from my literature, I call upon an article from the Cambridge University Press. This article refers to the effects of the *Galecrucella susilla*, a beetle in which feeds and reproduces on the leaves and stems of this wetland plant, eating away at the foliage and killing the plant (Katovich, Becker, Ragsdale, 1999). Research by these authors shows that this beetle is an efficient way to fight back the Purple Loosestrife in our hometown area as opposed to chemical plant control or mechanical needs to eliminate Purple Loosestrife. This serves as a possible question to ask at the end of my study: “Will *Galerucella Spp.* help fix the problem of Purple Loosestrife in the Allegheny Highlands?”

From the main source of reference for this research, and what drew attention to this marshy monster, was the research of one Clifton Forge’s own Michael S. Hayslett. Proud member of the CRPA, Principal of VA Vernal Pools, LLC, and rare mountain wetland specialist, Mike studies *Lythrum salicaria* intensively in his article available in the CRPA’s Winter 2019 Issue of *The River Runs* (CRPA, 2019, p. 8-12). Described in the article entitled “*Purple Loosestrife - An Attractive Menace”* (Hayslett, 2019), Mike describes the importance of Purple Loosestrife control in the Cowpasture River basin because of its homogeneous overtake of typically native plant biodiversity, which is known for being a pristine ecosystem. He delivers concise locational data in his write-up, describing in detail where exactly these known Purple Loosestrife sites are along the James River Drainage Basin (JRDB). The rivers which drain into the James River are the Jackson, Cowpasture and Maury Rivers. In this study, the specific tributaries of the James refer only to the Jackson and Cowpasture River drainage systems. On pages 10-12, Michael refers to his monitoring efforts in these rivers’ tributary streams in great detail. Numbers 13- 19 seem to be the main points of interest for my specific study because they all reside in an area with a high concentration, and data available for analysis of the flood plain and soil type are, as well as the others, in a different area of drainage for the Jackson River. Mike goes on to describe how it is not surprising to find this plant in our area, for its original ornamental setting (Hayslett, 2019). Referring to this plant as an “alien invader,” Michael really gives a good insight as to how relevant this problem is in my area of study.

Flowering spikes of Purple Loosestrife in the Mill Creek valley of Bath County on July 26, 2018.

Materials and Methods

The objective in this project is to continue research on the species by others and to find the locational data of known Purple Loosestrife sites. Through research we understand what soil types, soil moisture, vicinity to different types of hydrology, and type of land cover are the most suitable for the growth of *Lyrthum salicaria* in the area in proximity to confluence of the James River (Cowpasture/Jackson/Maury Rivers). The integrity of this project relies on the accuracy of each: GIS, GPS, Remote Sensing and the predictive model to find the most suitable areas that Purple Loosestrife will blossom in the summer. Relating to the locational data of previous Purple Loosestrife sites, the values of suitability are found through the correct model which is built within the ArcGIS 10.6 model-builder. This model includes the correct analytical variables, as well as any other tools necessary to create a project workflow adequate to present with confidence in my methodologies and materials. This model will be known as the Purple Loosestrife Invasive Suitability Model (PLISM).

To start this project after all literature is acquainted for, plans were made to obtain locational data of all known Purple Loosestrife blossoming sites recorded by conservation biologist Michael Hayslett. These known sites will be important because they hold the key to predicting where certain suitability values will occur in the event of seed dispersal. From there, the location at which a considerable amount of Purple Loosestrife sites are apparent will be used in creating an area of study. This area of study planned to meet the extent of a general five-county designated area in order to focus on the streams that converge into the Cowpasture, Jackson, and Maury rivers. This scale is needed because Purple Loosestrife manifests in clusters of wetland areas and will be easily analyzed by digitization of my dataset. To label these sights, users had to digitize a dataset on ArcMap 10.6 from using aerial imagery of an apparent blooming season. Having a general area of study (The Allegheny Highlands) allows for us to conceptually understand the context of where this problem is occurring without having to digress about it in discussion.

When making a model, the software package used was ESRI's ModelBuilder. This is a quick way to streamline computations, using tools and datasets to analyze spatial phenomenon. In order to correctly arrange a suitability model, there needs to be variables put in place. These variables for the PLISM include SSURGO data from the SSURGO soil data viewer toolset made available by the USGS. The soil variables include: a high Hydric Ranking, close proximity to the Depth of Water Table (<16 meters), high Flooding Frequency, as well as high Ponding Frequency. From there, a Euclidean distance tool was ran to calculate proximity to water, as well as proximity to the CSX railroad right-of -way. These two variables are extensive vectors for the dispersal of Purple Loosestrife seeds, mainly because they have constant or frequent sources of moist hydric soil. Once the Euclidean distance had been found for both, that layer was also input into the model.

A weighted overlay tool is used to weigh variables by their influence to exist in certain spaces or not able to exist in certain locations. All of these variables were weighed as follows: 16% influence for Ponding Frequency, 16% influence for Flooding Frequency, 16% influence on Hydric Ranking, 16% influence on Depth to the Water Table, 18% influence on proximity to water, and 18% influence on proximity to railroad right-of-ways, with each of the six variables as being suitable places for Purple Loosestrife to invade. After building the weighted overlay, values needed to be extracted to also weigh in the previous year's known Purple Loosestrife locations (Figure 1—next page.)

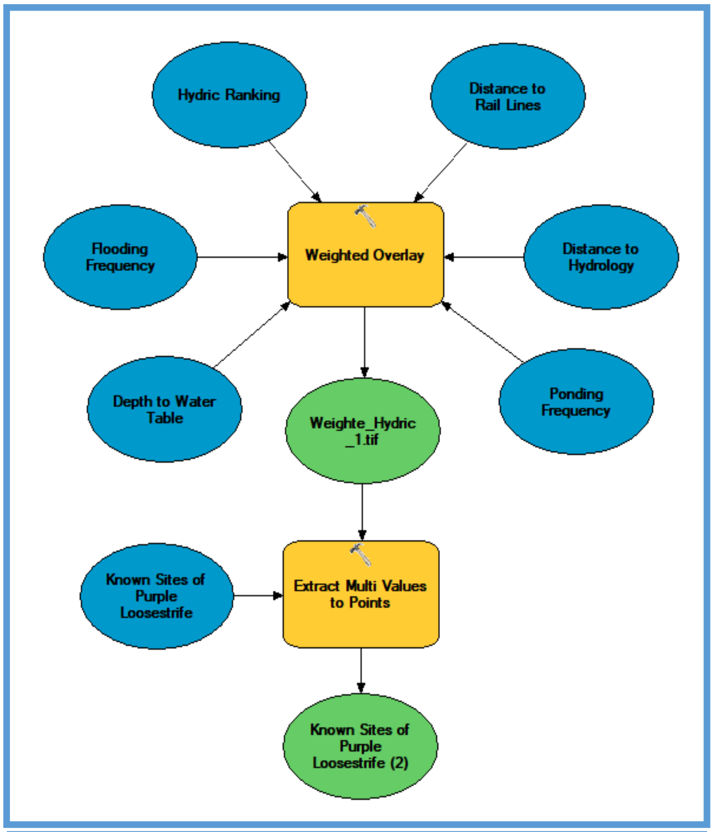


Figure 1. The completed PLISM.

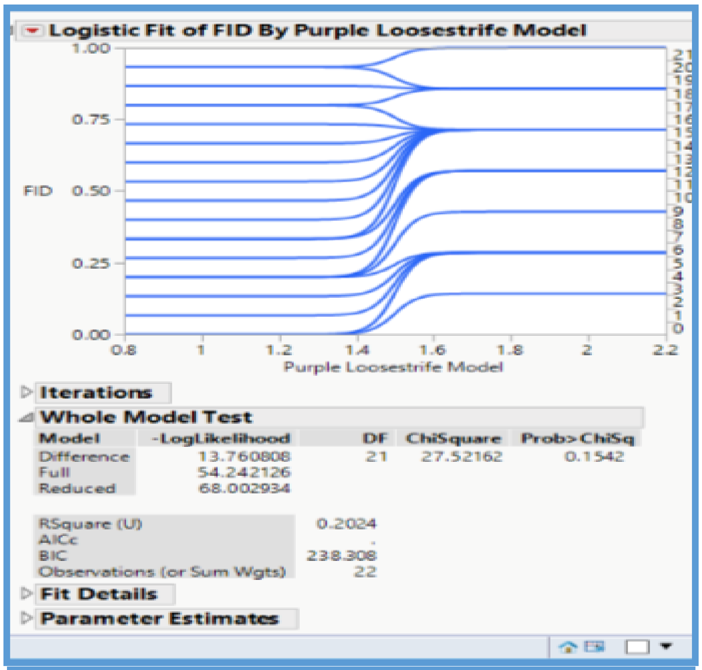


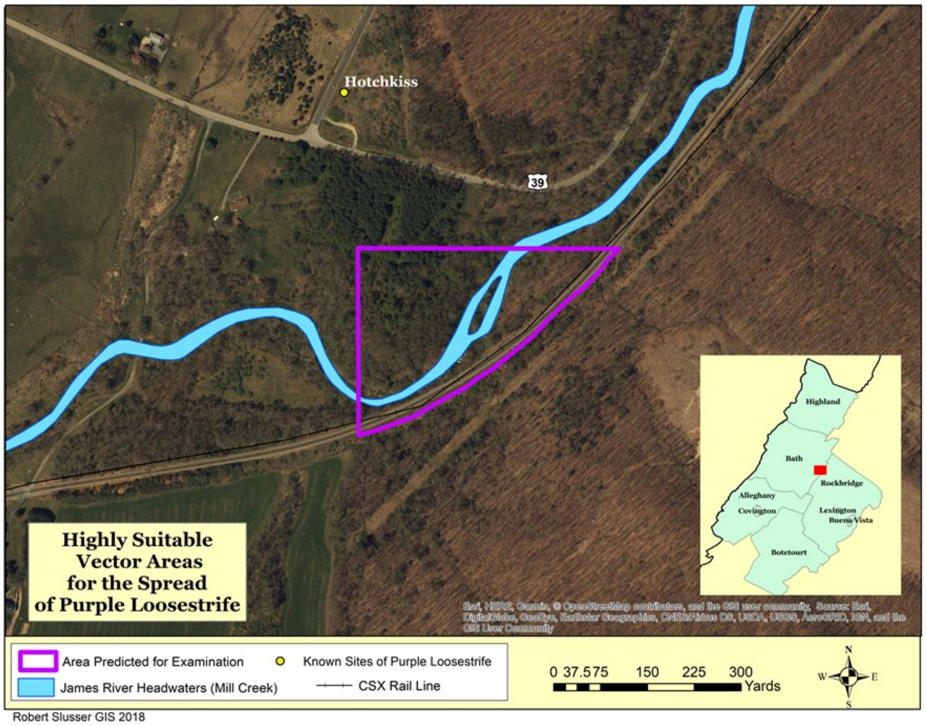
Figure 2. The logistic regression, showing the R Squared value to be .2024, meaning 20% of the data is statistically significant.

The Purple Loosestrife Invasive Suitability Model allows for a binary outcome of site-specific possibility that Purple Loosestrife will either A) Likely grow in the location predicted, or B) Not grow in the location. These are shown by polygons that have all the influential factors needed for the spread of this invasive perennial. In order to test this model's statistical significance, a JMP analysis is required. Because this is a binary model, predicting either a zero or a 1, a Logistic Regression (Figure 2.) is the best statistical analysis because this is a predictive regression allowing the dependent variable (the PLISM) to be categorical data.

Discussion

In discussion, a future model could be created using more variables suitable for Purple Loosestrife's invasive qualities. The six variables used could either be weighted differently, or more variables like a tree canopy layer, availability to sunlight, or simply going out and collecting more known Purple Loosestrife sites. However, for validation of the model's results and integrity, a field trip was planned for July 20th, 2019 by M. S. Hayslett and R. K. Slusser, as well as other volunteers in the community to obtain more locational data of Purple Loosestrife stands, and correctly pull-and-bag the existing plants. The area predicted for the highest suitability (Figure 3 on next page) displays what outcome was made available by the PLISM, specifically in the Allegheny Highlands subset.

The area labeled in purple portrays the highest suitable area for the potential future spread of *L. salicaria.* Although the significance of the Logistic Regression represents an R Squared value less than what would normally be satisfactory, it would be in the best interest of conservationists to visit the area most possible to spread from stand-to-vector to eradicate this invasive species, not only for the risk of current biota, but for future populations of endemic species native to the Allegheny Highlands that are driven out by this "Asian invasion."



Conclusions

As alluded to in the main article "*Purple Loosestrife - An Attractive Menace" (*Hayslett, 2018), this plant is a real-life problem for naturalists across North America. Being that there are massive infestations lower than the James River in Iron Gate and Eagle Rock, VA, it is our duty to predict where Purple Loosestrife will emerge, and literally "nip it in the bud" with this invasive perennial. There is much work to be done in order to eliminate how much area this species has already infested. Probably 20 years of no action on conservationist parts will take at least another 10 to see a change in the effects of *Lythrum salicaria.* But with efforts like this research, and the eradication efforts of the community, a fully biodiverse and indigenous list of biota may once emerge in the absence of this "Marsh Monster."

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