Effects of New Development on the Surface Runoff Production and its Potential Impacts on the Habitat of the Bunched Arrowhead (*Saggitaria fasciculata*)

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Abstract

Furman University is host to one of the federally endangered species of plant (Bunched Arrowhead), and a new proposal to build retirement community in the headwater regions of the protected site threatens the plant species. The area housing the plants is a Heritage Trust Site, managed by the South Carolina Department of Natural Resources, so the impact of the development on the area needs to be taken into consideration. In order to assess whether the new development will cause a major changes in the hydrologic conditions, especially the surface runoff, I used L-THIA model to determine the amount of surface runoff that is produced by current landuse and compared it to the future landuse conditions including the proposed changes.

Results from the study indicate that the significance of runoff changes depend on the study area scale. At large scale, the results show 800% increase in runoff volume where as at small scale, the increase is only 3%. For this specific study, the large scale results will be more important.

Background

The administration at Furman University is considering a proposal to build a retirement community on property located very close to the forest behind Furman Lake, which is home to the Bunched Arrowhead. This project will hopefully aid the administration and developers in determining the best way to proceed with the development.

The Bunched Arrowhead (Saggitaria fasciculata) is a federally endangered species which is only found in Henderson County, North Carolina and Greenville County, South Carolina. There are currently only five extant populations, and reintroducing the plant to a new habitat has proven almost impossible. The Bunched Arrowhead requires an aquatic habitat with no stagnation and continuous seepage of cool and clear water. According to the Southern Appalachian Species Viability Project (as read at www.natureserve.org), "The extremely limited distribution of this species makes it highly threatened by land-use conversion, habitat fragmentation, and forest management practices; its habitat requirements make it especially vulnerable to sedimentation and succession."

Methods

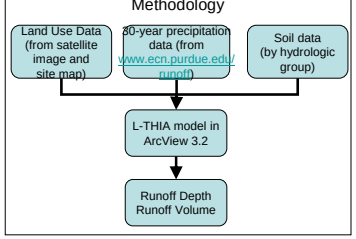
I collected data from several sources. The soils data came from USC, and the precipitation data came from the L-THIA website at Purdue. Dr. Muthukrishnan developed the land-use map from a satellite image of the campus.

To calculate the results shown here, I used the L-THIA extension in ArcView 3.2. The model uses legal land use classifications, 30 year precipitation data, and hydrologic soil group data to calculate the curve number for each grid, and then uses the CN to calculate runoff depth. I then calculated runoff volume by multiplying the area of total number of grids with the runoff depth using Microsoft Excel to create charts and tables of the data.

Some of the areas in the land-use map are misclassified due to cloud cover and shadows present in the original satellite data. Cloud cover got misclassified as an impervious surface due to its high reflectivity, and shadows are misclassified as water due to their low reflectivity.

I classified the future development area as high density residential due to lack of exact boundaries of the proposed buildings. I did this because residential areas assume a mix of impervious cover and green areas.

Methodology



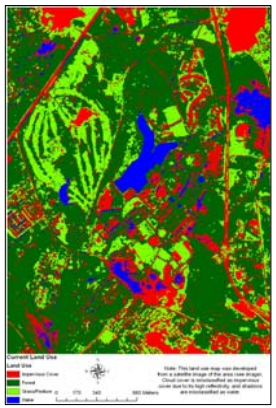


Fig. 1. Current Land Use Map of the Furman University Area

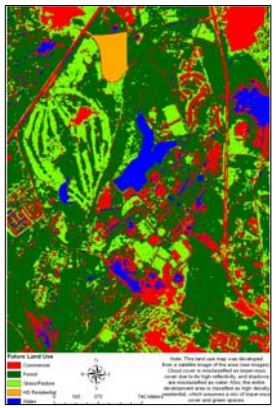


Fig. 2. Land Use Map with New Development

Fig. 3. Satellite Image of the Furman University Area

Results: The Impact of Scale on the Study

By looking at the runoff depth and volume data that were calculated using the L-THIA model, it is clear that the future development will create much more runoff than the previous forest cover. The large scale maps (Fig. 1 and 2) show the development in its context of mixed forest and impervious cover. Fig. 1 represents the current land use (taken from the satellite imagery shown in Fig. 3), and Fig. 2 represents the land use with the proposed development. Fig. 4 and 5 show the runoff depth as calculated using the L-THIA model. Note that the proposed development site changes runoff depth from 1.1 cm (current) to 21.95 cm (Fig. 4). Runoff volume increases by 3% over this large area due to the change in landuse. Although 3% is a small number, it is important to remember that we are looking at a much larger area than that which changes land-use. The numbers change greatly when only the development site is considered (Fig. 7-11). Considering only the proposed development site, the total runoff volume increases by over 800% with respect to the current landuse conditions (Fig. 11). Since the objective of this study is to look at how the increased runoff will affect the Bunched Arrowhead species that is limited to very small area, the scale of study becomes significant.

Applicability of L-THIA Model Results

The L-THIA model uses land use data, soil type data, and long-term precipitation data to calculate average annual surface runoff. This model does not account for topographical influences, and groundwater changes, both of which could also have a major impact in this situation. The misclassified areas in the land-use maps do introduce error, but because they are the same in both maps and this study is looking primarily at the difference in runoff produced between the scenarios, the error does not affect my results. In addition, only surface runoff is accounted for, and there are other ways in which the development could alter the hydrology of the area.

Keeping these limitations in mind, the results presented here should be used as an initial indicator of changes and if necessary, a more detailed hydrological studies should be implemented.

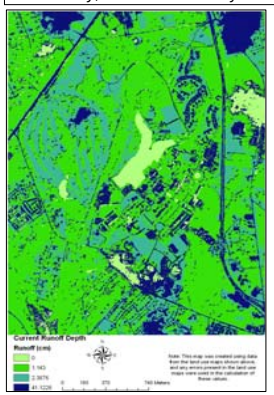


Fig. 4. Current Runoff Depth

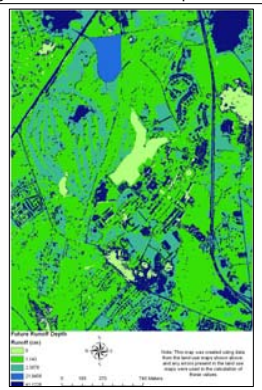


Fig. 5. Projected Runoff Depth

Acknowledgements

Projection: UTM NAD83
Data Layers used:
Furman land use map, created by Dr. Suresh Muthukrishnan
30 year precipitation data from http://www.ecn.purdue.edu/runoff
Soil data from http://www.cas.sc.edu/gis
Satellite Image
L-THIA model information from http://www.ecn.purdue.edu/runoff (see website for information about the model)

Information on the Bunched Arrowhead came from http://www.natureserve.org/explorer

This project would not have been possible without the help of Dr. Muthukrishnan, my EES 24 professor. Thanks also go to Randy Eggenspiller in Facilities Services for providing me with a site map of the new development.

Conclusions

This study has provided a foundation for further research into this issue. I believe it is crucial that the future of the Bunched Arrowhead be taken into account when planning this development. I have provided some recommendations for development if the plan goes forward. I would also like to stress that this study is far from complete. Without a thorough study of the impacts on groundwater and through flow, it is impossible to determine what the effects of the development will be.

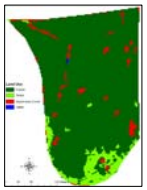


Fig. 7. Current Land Use for Development Area

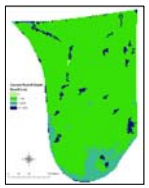


Fig. 8. Current Runoff Depth for Development Area

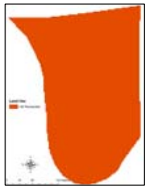


Fig. 9. Projected Land Use for Development Area

Fig. 10. Projected Runoff Depth for Development Area

Recommendations

Because much of the runoff from the site runs naturally into the area behind Furman Lake, developers should remain very aware of the impact on the Bunched Arrowhead.

- The development sits on a topographic high, which would mark the boundary between two watersheds, and one possible plan would be to direct the majority of the increased runoff away from the Bunched Arrowhead's habitat through drainage connecting to the golf course stream.
- In addition, I would recommend the conservation of as much natural forest habitat on the site as possible. Leaving some of the natural vegetation will prevent compaction of the soil, allowing water to infiltrate into the ground and thus create less runoff.
- A further recommendation would be to create some artificial wetlands along the path of the runoff; wetlands have the ability both to absorb pollutants and to mitigate flood events. This would help prevent flooding and pollution downstream.

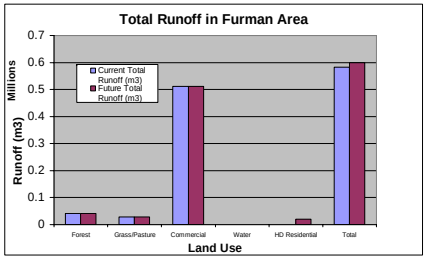


Fig. 6. Total Runoff in the Furman Area

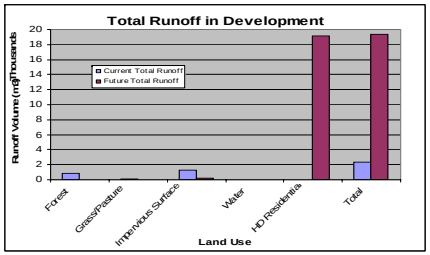


Fig. 11. Total Runoff in the Development Area