

Feasibility Case Study of InVEST Modeling Approaches in the Lower Delaware and Niobrara National Wild and Scenic Rivers

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Sponsor: Susan Rosebrough of The National Parks Service

1. Recommended Course of Action

The sponsor's stated goals for this project were to develop a tool that River Managers of National Wild and Scenic Rivers could use to assess the ecosystem services of their river. They would like to include information on socioeconomic benefits from visitor use as well as ecological benefits of clean water, fish, wildlife, cultural resources, and aesthetics. Given the vast scope of this request it is this group's recommendation that a technical committee be formed for the designated river sections that are a combination of local stakeholders and recreational users. The technical committee would designate the main objective of modeling a recreational framework for the National Wild and Scenic River. The committee would perform a SWOT (Strength, Weaknesses, Obstacles and Threat) analysis on the modeling design which would help determine specifics of the request to better inform the GIS specialist exactly what the expectations are. Included in those expectations must be a decision on how to quantify the Outstanding Remarkable Values that are needed to designate a river as Wild and Scenic. A rating system of some sort that is quantifiable would be needed if the committee decides to avoid assigning a monetary value to the different aspects (especially the recreation portion). From there it should be clear what data collection would need to be done (whether it would be finding existing datasets or needing to organize raw data collection to obtain what is needed).

The committee, with input from the GIS specialist, would need to decide on an approach that either does or does not utilize the InVEST models. An approach that does utilize the InVEST models is likely to be time consuming and yield results that aren't exactly what the group needs. Utilizing other models available will also be time consuming to decide if the models available fit the needs of the group. If a model or models is identified as having potential, only edits would need to be made to create the desired output. Building a model from scratch would by far be the most time consuming and therefore the most costly, however yield exactly what the group needs. A talented group of GIS specialists would be able to take the needs of the group and either create a tool or tweak an existing one to meet the goals of the project.

No matter the chosen approach, it is recommended that a Story Map be utilized to display the final results as they are effective communication and educational tools. They allow the presenter to interact with the information and create a visually appealing display for any audience. They also have the added perk of the audience being able to interact with them after a presentation is complete.

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3. Introduction

“It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations.” (Wild and Scenic Rivers Act, P.L. 90-542; 16 U.S.C. 1271 et seq., October 2, 1968)

“Let us have a splendid legacy for our children . . . let us turn to them and say ‘this you inherit and guard it well, for it is far more precious than money . . . and once it is destroyed, nature’s beauty cannot be repurchased at any price.’” — (Ansel Adams, Speech in Monterey County (Date Unknown))

The Wild and Scenic Rivers Act created by Congress in 1968 enabled a framework for protection in perpetuity of the United States notable rivers and streams. This Act enabled the preservation of these rivers, to disallow development and preserve the scenic qualities. The natural free flowing conditions of the river are to be conserved as well as water quality. This Act was a collaborative approach to manage complex scenic and wild rivers across jurisdictional boundaries.

The Niobrara River is a tributary of the Missouri River. The Niobrara name was derived from the Ponca language meaning “spread out horizontal”. The influences of this river have impacted many cultures, including the Ponca tribe, Sioux tribes, and homesteads along the river. The Niobrara river was designated in 1991 as a National Wild & Scenic River, preserving the unique geological, biological, cultural and recreational values of this 76 mile stretch.

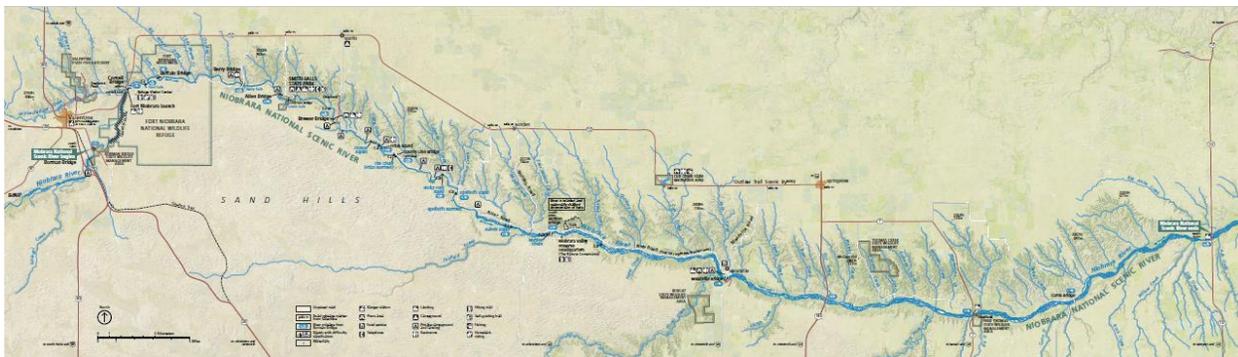


Figure 1: Niobrara National Wild & Scenic River National Park Service Map

The designated National Wild and Scenic River section offers many Fish and Wildlife, Scenery, Fossil Resources, High Water Quality, and Recreation values to the public and surrounding areas. Recreational uses of this river are related to floating and canoeing the river and about 80% of these activities occur on Saturday (Economic and Social Values of Recreational Floating on the Niobrara National Scenic River, July 2009). Recreation occurs on all stretches on the Niobrara, however, floating is most concentrated from Cornell Dam to Norden Bridge near Valentine, Nebraska, a stretch of approximately thirty miles. This area is a favorable area for floating due to the season-long flows, clear water, geologic formations, and other scenic features including small tributary waterfalls, and scenically diverse ecosystems. In the past twelve years, approximately 860,533 people have visited the Niobrara National Wild & Scenic River.

Year	Recreation Visitors
2004	54,385
2005	58,750
2006	60,397
2007	79,942
2008	70,270
2009	68,058
2010	69,705
2011	65,785
2012	65,999
2013	71,876
2014	53,443
2015	68,110
2016	73,813
Total	860,533

Figure 2: Niobrara Wild & Scenic River Recreational Visitors - National Park Service

Niobrara NSR			7/2017	6630
	July 2017			Calendar YTD
	Recreational	Non-Recreational	Total	
Visits	4,167	0	4,167	13,809
Visitor Hours	33,340	0	33,340	98,207
				Fiscal YTD
Total Fiscal YTD Visitor Days				9,277
Recreation O/N stays				
	Current Month	Year-To-Date		
Concessioner Lodging	0	0	NPS Campgrounds	
Concessioner Campgrounds	0	0	Tents	0
NPS Campgrounds	0	0	RV's	0
NPS Backcountry	0	0	Total	0
NPS Miscellaneous	0	0		
Non-Recreational O/N stays	0	0		
Total Overnight stays	0	0		
Comparison				
	This Month	Same Month Last Year	Percent Change	
Total Rec	4,167	26,554	-84.31%	
Total Non-Rec	0	0	0.00%	
Total Visits	4,167	26,554	-84.31%	
Total YTD	13,809	47,665	-71.03%	

Figure 3: Niobrara National Wild & Scenic River Visitation July 2017 Comparison - National Park Service

Although the Niobrara National Wild & Scenic River visitation is low for July 2017, it is clearly used by many people. This stretch of area contributes to the experience of the users, due to the diverse landscape and variety of wildlife. Quantifying these factors are extraordinarily difficult due to variables and data collection methods.

The Lower Delaware River was the second study area of the National Scenic and Recreational River designations. The Lower Delaware River is located in the Chesapeake Bay Watershed and is the largest free flowing river in the eastern United States. The Delaware River runs through many types of land use including crops, forests, and urban areas. The National Scenic and Recreational River System designated portions of the lower Delaware River include different jurisdictions, however, the National Park Service plays a large role in managing these portions of the rivers.

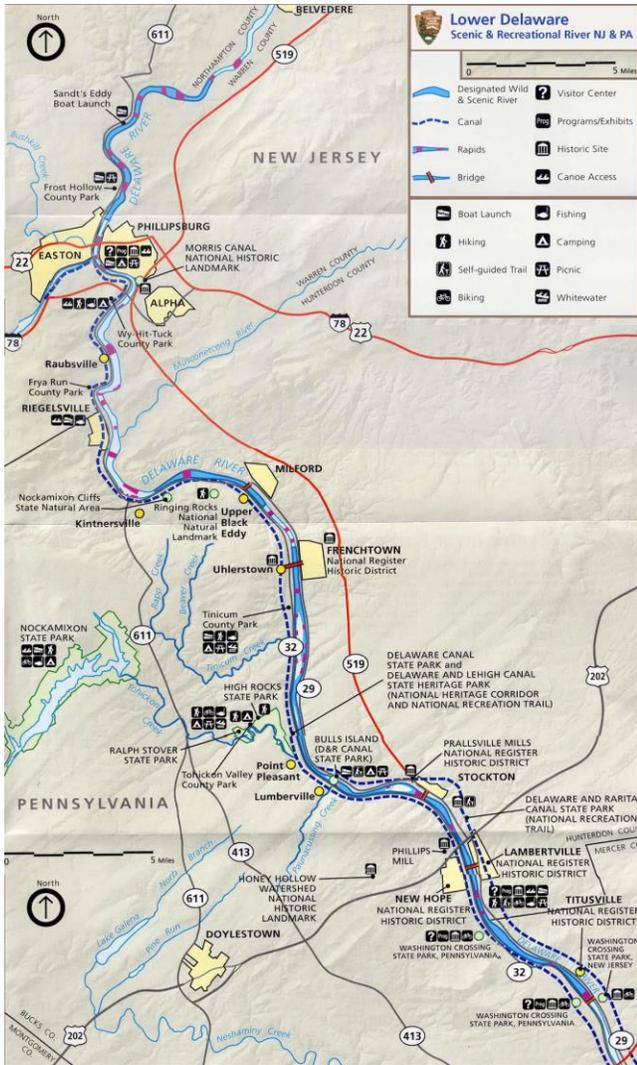


Figure 4: Lower Delaware River National Scenic and Recreational River - National Park Service

This map illustrates two segments along the main stem of the Delaware River and other segments that are tributaries of the Delaware in Pennsylvania which spans approximately twenty-eight miles. These designations have been incorporated into a total of 150 miles of the Delaware River that are in the National Scenic and Recreational Rivers. The rich history of the Delaware River has been a pillar in the cultural values of the nation in events such as the historic Washington’s famous crossing. The natural beauty of this area (cliffs and other unique landscape features) has also contributed to the outstanding and remarkable values. While the Lower Delaware river provides the foundation of the rich diverse cultural and biologic

values, it is urbanized with large populations and industry. With a threat of the free-flowing areas to be developed and industrialized, protections were enacted to preserve this area.

Both National Scenic Rivers have drastically different variables that contribute to the unique characteristics of each river. While they are drastically different, the commonality of these characteristics is that they are unique culturally and geologically with different scenic values. While the Niobrara is vastly rural, with wide panoramic views of the rural landscape, the Lower Delaware river offers scenic views that span cultural events and dramatic cliffs. Examining the rivers closely, a Social-Ecological table was constructed to examine common concerns even though the landscapes may be vastly different.

Niobrara & Lower Delaware River National Scenic River			
Spatial-Temporal Scale	Environmental	Social	Economic
National Wild & Scenic Rivers in the United States	Climate and land use changes impact the rivers	Preserve NWSR for public use	Recreational water users are impacted economically and individual quality of life
National Wild & Scenic Rivers Designation : Lower Delaware River & Niobrara River	With increased development and changing climate, the focal rivers water flow are impacted	NWSR joint management approach to include future economic and social impacts (all stakeholders/agencies in river system)	Increased development reduce and inhibit use and flow of the rivers
All streams and tributaries in the Lower Delaware River and Niobrara River NWSR designation	With increased development and changing climate, the focal rivers water flow are impacted	Collaborative Adaptive Water Management strategies implemented across all jurisdictional boundaries	Water availability impact all users of the tributary and streams

Table 1: Social-Ecological Systems Table

3. Design & Methods

Two models from the InVEST suite were selected to prioritize and focus on by the group collectively. The primary goal of the models would be assisting River Managers for river management and ultimately decision management. The group chose prioritize the “Visitation: Recreation and Tourism” model and the “Unobstructed Views: Scenic Quality Provision” model. Other models from the suite were considered, however, it was determined that these two InVEST models would provide the best output for River

Managers to assess at least a few of the ecosystem services of their rivers. The InVEST models require an abundance of work to obtain and prepare the datasets before are ready to be used as inputs within the model.

The Visitation model required few inputs and proved to be a challenge. The model uses geotagged photos from Flickr to visualize the amount of visitation that a location has. The program uses geotagged photos on the site Flickr to create a display that shows where the “hot spots” of activity are. The hot spots are calculated by finding the photo user days in each location where one photo user day at one location is the equivalent of one photographer who took at least one photo on a specific day. For each cell the model sums the photo user days and creates an average for the year as well as breaks the data down by month in the date range defined by the user. Knowing the region of study, the user can then make inferences about the area. In the case of Wild and Scenic rivers the National Parks Service can visualize each river’s visitation rates which correlates to the public’s interest in the area.

The input requirements of the model include a polygon shapefile of the area of interest, a date range of interest between 2005 and 2014, a decision on cell size for the grid dividing the area of interest, and the shape of the grid cells. The sponsor provided a shapefile that contained all of the Wild and Scenic River boundaries and we decided to use these for our areas of interest. The boundaries of the rivers were included to allow a larger area on each bank to be studied as the model uses geotagged photos. The area of interest was not limited to the line segment of the river since the river banks and riparian areas include recreational uses, such as pictures from the bank of the river in addition to pictures taken while floating the river.

From the given dataset, we selected our rivers of interest one at a time and exported them to new layers of their own. Each river was treated as an individual layer. Upon reading the online guide for the Visitation model it was determined that the new layers were not in the correct projected coordinate system. The model requires the use of a UTM coordinate system, which had to be fixed before the shapefile was used in

the model. Using ArcMap the two shapefiles were run through the “Project” tool to transform them to the correct coordinate system. The Delaware River was re-projected to WGS 1984 UTM Zone 18N and the Niobrara River was re-projected to WGS 1984 UTM Zone 10N.

Each new area of interest was run through the Visitation model with “100” as the cell size. It was determined that because the two different rivers are in two very different regions (the Niobrara being very rural and the Delaware being urban), the cell size of 100 shows enough detail to determine where the hot spots of activity are.

There were multiple iterations run for each river that attempted to capture any variations in years or seasons. The first run consisted of a date range of 2005-2014 to see the overall interest areas through the years. The sponsors requested further manipulation to determine if the early years (2005-2007) showed a vast difference between the later years (2012-2014), and to see differences in seasons. The second and third runs were ran for the two date ranges and each dataset was then manipulated to include new fields with calculations for each season’s year average.

We created static maps at first in ArcGIS to give the sponsors an idea of the output that the model produced. We also made a point that in order to see the output clearly static maps were not very useful, an interactive map where the user can zoom in to desired areas to view the output is ideal.



Figure 5: Recreation & Tourism Web Map - Niobrara River

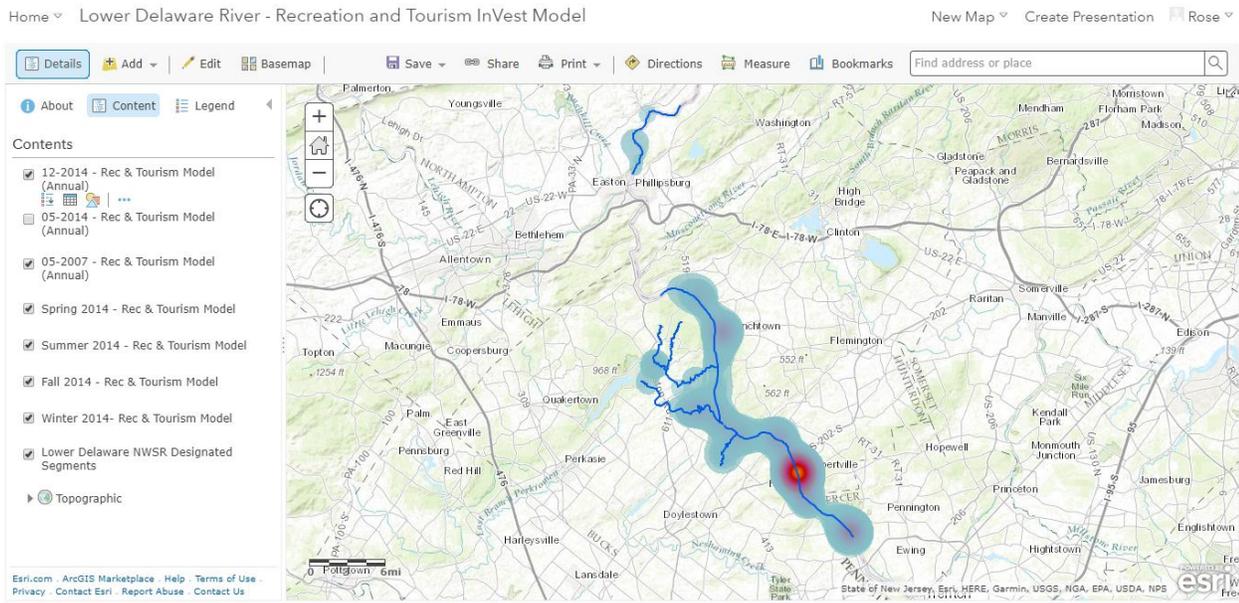


Figure 6: Recreation & Tourism Model Web Map - Lower Delaware River

The Unobstructed Views model was even more complex and is still producing a variety of errors. Data collection for this model was much more research intensive. Datasets that had to be located specifically for this model included: area of interest (in DEM form), features impacting scenic quality (as a point shapefile), a digital elevation model (they recommend a global raster layer), a population raster (they recommend a global raster layer), and if desired an overlap analysis features layer (a shapefile used to determine the impact of points on visual quality).

Once we obtained all the necessary data we once again had to project it in to the correct coordinate system (same as the Visitation model above). Once this was completed we started trying to run the model. In the beginning, Indexing errors occurred and after research on different forums we weren't able to resolve the problem. Dr. Withers provided a contact and he provided some insight to other errors and he in turn suggested we contact David Fisher at the Natural Capital Project who was a primary contact for errors with InVest. Time limitation forced the problem to remain unresolved.

This group decided to use Story Maps to further display the output of the Visitation model as well as incorporate the brochures that the National Parks Service has for each of the Wild and Scenic Rivers. Story

Maps are very aesthetically appealing and it was decided that they would be the best GIS product to provide River Managers an instructive tool, with the intent of educating the public and others within the organization. Story maps provide a narrative to continue making an investment in already designated Wild and Scenic Rivers and designate new rivers as Wild and Scenic in the future. The story maps provide a context, background and spatial relationships of how the National Wild and Scenic rivers impact recreation, tourism, life and work in the landscape.

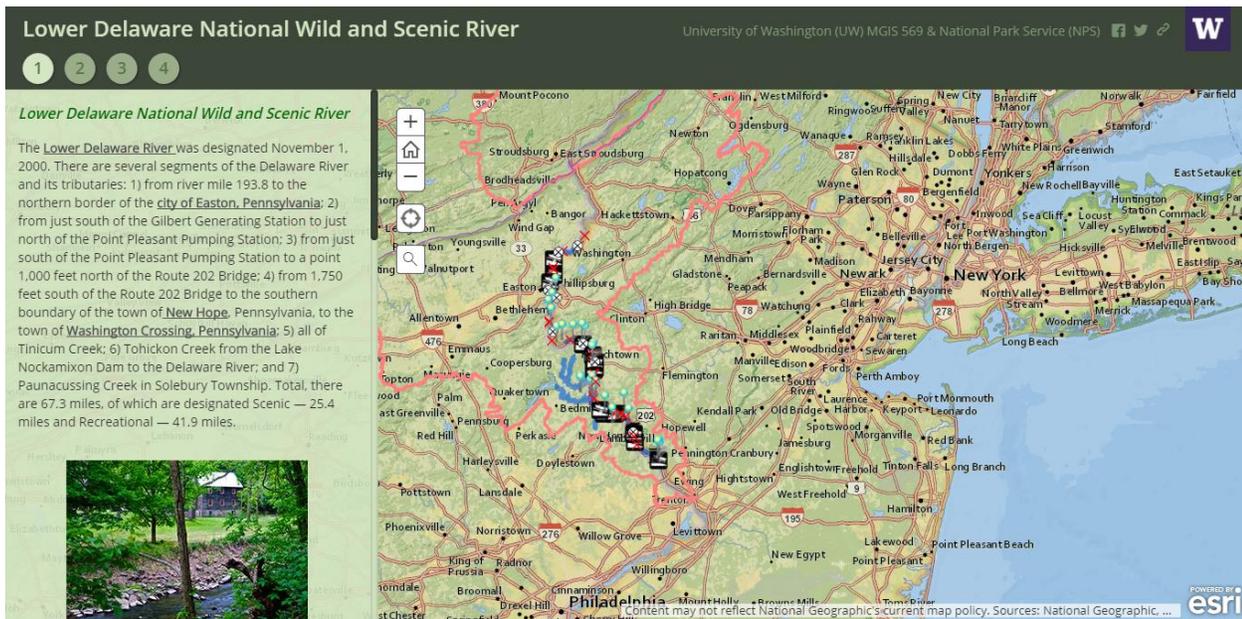


Figure 7: Lower Delaware Web Story Map

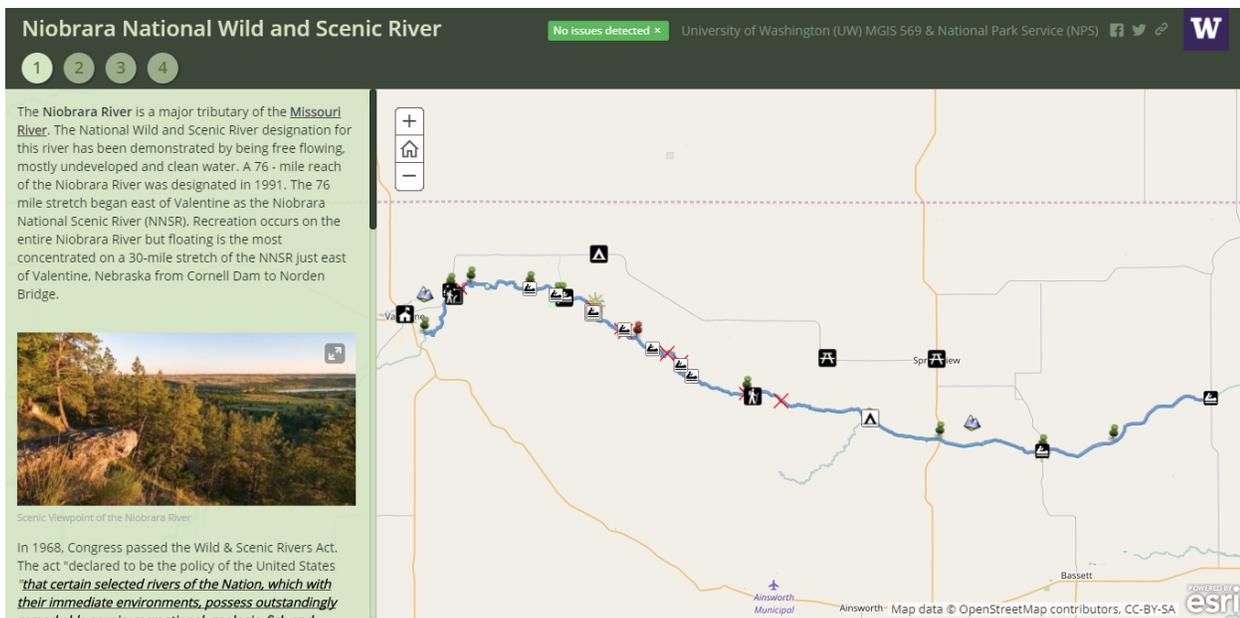


Figure 8: Niobrara Web Story Map

From the output of the Visitation model that ran in ArcMap, we created web maps that visualize the outputs and allowed the map to be spatially interactive. The Unobstructed Views output did not run without any errors, so a product was never able to be featured in any of the web maps. The brochures from the National Parks Service for each river were the basis of each Story Map. They each have a brief description of the featured river as well as an outline of what the necessary criteria are for designating a river as Wild and Scenic. They outline the Natural, Geologic, and Cultural benefits of each river as well as the Recreational and Scenic attributes. The merging of the National Parks Service brochure with the web maps created from our results from the Visitation model allow for a clear picture of the values of the rivers and why these designations play a significant role in their use by people and wildlife.

4. Results

In the Visitation model, multiple date ranges were entered in attempt to see if visitation had changed over the years. Each river was run from 2005-2007 and 2012-2014 and a side by side comparison was done. It was determined that there wasn't a huge difference in visitation in the two date ranges. The seasonal calculations that were run showed a predictable rise in visitation during the summer months although the increase was slight for the Niobrara as there isn't much visitation overall. The two rivers themselves

couldn't have more different results. The Niobrara has very little activity (presumably because it's very rural and is surrounded mostly by private land and has few public access points) while the Lower Delaware has more public access and therefore more activity. The Niobrara areas that do have higher instances of visitation tend to cluster around access points or interesting geologic features. The Lower Delaware has a more evenly spread visitation due to its accessibility and that it's surrounded by an urban setting with many interesting sites directly surrounding it.

Unfortunately the Unobstructed Views model did not produce any results because of errors encountered while trying to run the model. Because of this the following sections outline an approach to the project as a whole that includes suggestions on how to approach the problem (using InVEST or other options).

5. Discussion

Given the goal of the sponsors, this group recommends that any course of action for future implementation include a reassessment of whether they'd like to use the InVEST models or try another approach. The InVEST models are notoriously error-ridden and can be hard to work with if the goal is a quick outcome. Once they are run properly they give meaningful output that can be used and manipulated in different ways. In this instance, the Unobstructed Views model would have yielded a significant output, however, due to errors, it was not produced. The manual labor that it takes to gather the data necessary and troubleshoot any errors that occur is intensive. Therefore, if using the InVEST models is important to the sponsors this group recommends allotting a significant amount of time for a dedicated GIS specialist to extensively research and work with the issues that may present themselves. This would include raw data collection if available datasets aren't suitable for the models and their overarching goal of the GIS River Management decision tool.

Depending on the allotted budget and labor the sponsor can invest in this project, creating a custom tool, with a framework and design specifically for the River Managers would be a viable option. The output produced would meet their goals and while this course of action would be the most time consuming and

presumably most expensive upfront, the output can be tailored to what the sponsor needs. This is discussed more in the next section as part of a few different scenarios of business plans and implementation plans.

Regardless of model or product are used for river managers, story maps are an effective way for communication for river managers to educate the public and other audiences within the organization about Wild, Scenic and Recreational designations. They allow for an interactive approach since the areas of interest are usually large and can't properly be displayed in a static map with an ability to captivate their users into their own educational experience.

6. Business Case and Implementation Plan

This concept needs to establish clear direction to benefit the sponsor agency. Developing a steering committee would be helpful to establish goals and objectives of this analysis. **Option A** includes a subject domain expert, a GIS specialist and a programmer as the ideal technical team to develop and build a new tool, specific for the project. This technical team will need to collect raw data (scenic quality, recreational and visitation), develop an in-house tool specifically for river managers, and is ground truthed by the subject domain expert. The budget for this to be implemented would be approximately \$50,000. **Option B** would be to manipulate the current data and re-code the InVEST models to reflect the rivers specific need for that manager. Cost would be dependent upon the time allotted for InVEST manipulation, which could range from \$10,000-\$100,000 dependent on the detail and specificity determined by the steering committee. **Option C** would be to continue researching existing scenic and recreational and tourism models to adapt to the steering committees need. This would likely be the best option if the time and funds are available. It would require a skilled specialist to be able to identify and manipulate existing models however it would presumably be more time-effective than starting from scratch.

Each provide a benefit to the organization, by providing the river managers a decision tool that can help implement new designations or implement different preservation managers for the current designations.

Option A has the most upfront cost, however, the benefit to the end user could save them time and labor for implementing or finding an alternative. Option B is dependent on the personnel chosen to continue working with InVEST. This study recommends strongly that if this action is taken, then a person with a strong background in InVEST and programming would be utilized. Option C is variable and may be the cheapest option for research, but depending on the results and models chosen, can have a significant cost.

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