Using spatial decision support systems to integrate visual and environmental consideration for visual resource management

Student:
Matthew T. Salava
Master's Student
Department of Geography/Environment & Natural Resources
University of Wyoming
Laramie, Wyoming

Advisor:
Dr. Steven D. Prager
Assistant Professor
Department of Geography
University of Wyoming
Laramie, Wyoming

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Abstract

Landscape change in Wyoming is increasing due in part to large scale anthropogenic developments. Often these developments are mitigated for aesthetic consequences but fail to take into account environmental considerations in the decision making process. This study aims to combine the management of visual resources with measures of environmental integrity through the use of a spatial decision support system (SDSS) framework. Remote sensing and GIS will be used to integrate these measure into the frame work of an SDSS that takes into consideration both visual integrity and the currently lacking environmental integrity measures. The results of this study will provide a decision support framework for natural resource managers as well as provide a foundation for future research on integrating visual and environmental consideration.

I) Description of the Proposed Research

Landscape change in Wyoming has accelerated due to a variety of factors, especially increased energy development (Sawyer et al. 2006). Landscape condition and environmental integrity is strongly tied to the amount of human activity in general (Brown 2005) and the effects of human activity are potentially exacerbated when there are driving factors such as energy and related developments. In many cases however, land management decisions are made in a context that only addresses non-environmental factors. One example of this is the Bureau of Land Management (BLM) Visual Resource Management program. When development occurs on BLM land, the BLM is mandated to use a set of complex visual resource management (VRM) techniques to help mitigate the visual impact of projects that have the potential to affect the visual landscape. Though this approach does serve to help minimize the visual consequences of proposed development, the documented approaches to visual resource management do not directly incorporate consideration of environmental integrity. There is thus a need to better understand the relationship of decisions made with aesthetics in mind to the environmental consequences of those decisions. Consideration of both aesthetic and environmental concerns will help resource managers make better decisions on placement of development projects by combining concern for both the visual and environmental consequences into the decision making process (Sheppard 2001).

This proposal takes an interdisciplinary approach by combing the BLM's established approach to managing the landscape aesthetic with environmental integrity measures using a spatial decision support system framework. With increasing populations, increased natural resource demands, increased habitat fragmentation, and global climate change dilemma on the for-front of scientific thought, approaches that merge consideration of environmental factors into land management decisions are vitally needed. The need to demonstrate linkages between, "landscape pattern and specific environmental and socio-economic landscape functions" (Herzog et al. 2001) is well established and particularly important considering the changes occurring to Wyoming's natural environment. This research will thus serve as the basis to integrate methods and interpretations across disciplines in order to balance visual and environmental concerns.

Scientific Approach

Spatial decision support techniques are commonly utilized when land managers must balance multiple objectives in a decision making process (Malczewski 1999). In the context of integrating consideration of both visual and environmental concerns, spatial decision support systems (SDSS) represent a powerful way to combine visual and environmental parameters in a way that would serve to enable natural resource managers to make better decisions based on both sets of variables. This research will leverage a combination of remote sensing as a means of deriving information about environmental integrity and geographic information systems (GIS) to facilitate the integration of spatial variables. The result is as SDSS that is capable of integrating concern for both visual and environmental parameters. Spatial decision support systems have been proven feasible in a natural resource management context (Crossland, Wynne, and Perkins 1995), and the integration of aesthetic *and* environmental concerns represent a logical extension to the natural resource management paradigm.

Remotely sensed data will form the basis for integrating measures of environmental integrity into the decision making process. Remotely sensed data has been successfully used for landscape change analysis (Southworth, Nagendra, and Tucker 2002) and is often the basis for calculating landscape metrics. Landscape metrics offer one means by which to positively measure environmental integrity through the characterization factors such as landscape patchiness, connectivity and arrangement (Lausch and Herzog 2002). Landscape metrics have proved useful in monitoring changes in landscape brought on by human induced change (Herzog et al. 2001). Given the concerns associated with habitat fragmentation and energy development, the metrics regarding habitat configuration derived from Landsat data will be utilized in this study.

Issues regarding aesthetic concerns will be based on the aforementioned BLM approach to visual resource management. A common practice in the natural resource extractive industries is to use VRM strategies such as visual buffers to shield activities from the public view (Hull 2000). Often front country is used as a buffer for viewing while backcountry and core areas are exploited as they remain invisible from common observation points (Hull 2000). The typical approach is to hide visually significant projects from view, but this decision is often made in isolation of the corresponding environmental considerations. As such, this research will utilize GIS techniques commonly used to perform viewshed analysis calculations and buffer placement around projects, but will serve to expand the consideration of the resultant site suitability variables by including the environmental variables in the spatial decision support process.

Research Goals and Approach

In the 2007 NASA Science plan Chapter 4 Strategic Goal for Earth Science, the need for understanding changes to the earth systems is clearly articulated. This project addresses a deficit in an important coarse scale land management approach that does not explicitly account for how decisions made from a visual perspective have the potential to affect the characteristic function of the Earth's system. The goal of this project is therefore to:

1) Develop an approach to use remote sensing to directly integrate measures of earth system function into the visual resource management process, and:

2) Use the developed approach to support decision making with regard to the landscape consequences of visual resource management decisions.

Understanding the requirements for a decision support system that is capable of integrating visual and environmental consideration is the primary focus on this research. While the proposed research emphasizes the use of landscape metrics, it is anticipated that this research will result in a framework capable of supporting nearly any spatial measure characterizing the environment.

<u>Materials and Methods</u>

This research shall integrate the results of an ongoing visual resource inventory project currently being conducted via cooperative agreement with the Lander, Wyoming BLM Field Office. The Lander Field Office encompasses approximately 2.7 million acres and is currently in the process of performing a new Visual Resource Inventory. The office is receiving increased

interest in energy development (Oakleaf 2007). With consultation of the field office, a site or sites will be chosen that reflects a current or potential development location.

Standard visual resource management and visual resource inventory techniques will be utilized to establish the visual baseline information for the decision support system. This approach will utilize the BLM Visual Resource Management Manual 8400-Visual Resource Inventory. ArcGIS will be utilized to store data and perform raster based viewshed analysis for the key observation points identified within the specific study site. This will provide base line data for the selected study site and provide a representation of the areas within the unit that are visible and invisible from the key observation points. In addition the viewshed analysis will be the basis for the areas within the unit of where a potential development could be located out of view.

Landsat 30 meter resolution imagery obtained from the WyomingView database will serve as the basis for the environmental representation. The imagery will be geo-referenced and preprocessed for atmospheric correction. The imagery will be classified for land cover and an accuracy assessment will be performed during the 2008 summer field season. Landscape metrics characterizing habitat fragmentation will be calculated using extensions to the standard GIS software. The resultant information will serve as the proxy for environmental integrity and will serve as the baseline dataset for evaluating the environmental consequences of the simulated development activity.

The key emphasis of this effort is the development of the spatial decision support system to integrate the VRM and environmental data. The focus will be to understand how decisions might be made that address both visual concerns and environmental concerns. Given that some sites might be visually optimal but environmentally suboptimal and others might be visually suboptimal but environmentally ideal, an approach is required to balance these concerns within a decision making framework. One common technique applied to such problems include the analytic hierarchy process (AHP) which is a structured technique for selecting among decision alternatives (Saaty 1980). Another common approach is weighted linear combination (WLC) which is often used to make composite maps in GIS environments, but in which important assumptions are also violated (Malczewski 2000). Given the general lack of understanding the requirements of making decisions that balance visual and environmental concerns, this research will focus on understanding the best decision support framework that is sufficiently flexibility to accommodate a variety of environmental information into the decision making process.

This study will utilize a simulated land development scenario. This study will look at the affects from a simulated anthropogenic disturbance (e.g., gas field development) to quantify changes in landscape function. Landscape metrics characterizing the resultant change to the environment will be recalculated for each potential site location and the resultant information will be used as a proxy for the relative implications on environmental integrity with each potential site. Iterations will be performed testing with respect to visual combine with environmental considerations for each possible site.

The proposed framework will allow the decision makers to differentially prioritize visual and environmental concerns.

II. Relationship to NASA Goals

The goals in this proposal share a common interest with several NASA goals and missions. The Science Mission Directorate Strategic Plan, Science Roadmaps: Application Roadmap for Ecological Forecasting States: Nasa is between "Initial integration of remote sensing observations with environmental models and visualization tools and Nasa Earth science observations seamlessly integrated into visualization systems that generate "if-then" scenarios of ecosystem response to change with estimates of error". The simulations scenario of this program does just that, it takes remote sensing combines it with a decision support tool and a realistic visualization/simulation to predict ecosystem response to a common human-induced change mechanism. Generating and identifying error is an important part of this project and will be reported for all applicable pieces. This project is in affect trying to bridge the gap between observations, models, and visualization tools to a predictive scenario with "if-then" capacity using simulations of earth surface disturbances.

III. Products

I anticipate that this study will lead to at least one peer reviewed paper in the area of integrating earth observation data and concern for landscape function into the VRM process. This paper will be submitted for peer review to Landscape and Urban Planning (or other applicable journal) and will be presented at the 2009 University of Wyoming Graduate Symposium as well as the 2009 meeting of the American Association of Geographers. Additional presentations are anticipated at the WyGISC weekly forum and the UW Geography departmental presentations.

A decision support tool for a GIS will be developed that could be used by natural resource managers. A workflow will be documented that is peer reviewed and replicable for other researchers and natural resource managers to use for similar projects.

IV. Timeline

The summer 2008 field season will be used to develop the project and perform the necessary field work. The fall 2008 academic year will focus on the research and integration of the multiple objectives. The spring 2009 Academic year will focus analysis of data and methods and reporting of research.

Summer 2008	**Fall 2008**
Methodological Development	Investigate alternative decision making frameworks
Identify Study Sites	Select appropriate framework
Classify Satellite Imagery	Implement SDSS
Accuracy Assessment of Classification	Evaluate Scenario
Spring 2008	
Analyze strengths and weaknesses of approach	Report Results
Analysis of Results	Prepare for publication and presentation

V.) References Cited

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Budget:

DESCRIPTION	COST
Labor:	
Student Stipend	**13,500.00**
Summer Funding	**1,500.00**
Other Costs:	
Supplies: UW Computers/software	**0.00**
Travel: Mileage	**432.62**
Faculty Mentor Hours: Dr. Steve Prager	**2,000.00**
GPS Rental: WyGISC	**480.00**
Landsat Imagery: WyomingView	**640.00**
Total Project Costs:	**18,552.62**
Less Proposed Non-Federal Cost Sharing	
Faculty Mentor Hours--Dr. Steve Prager	**-2,000.00**
GPS Rental: WyGISC	**-480.00**
Landsat Imagery: WyomingView	**-640.00**
Less Proposed Federal Cost Sharing:	**-3,120.00**
TOTAL AMOUNT REQUESTED	**15,432.62**

Budget Narrative

1. Labor: The budget reflects the funding request for student tuition, fee, and stipend for one academic year. Additionally, funding for summer 2008 is requested. The summer funding will be used to work on the initial remote sensing work as well as an in-field accuracy assessment.

2. Other Costs:

Supplies: The required computer use and software to complete the project will be provided by the University of Wyoming. Work will also be done in the Lab of Dr. Steven D. Prager on a computer funded under a previous faculty NASA grant.

Travel: The amount requested reflects two trips to Lander, Wyoming. Each trip is 446 miles round trip from Laramie, Wyoming with the government mileage rate of .485. Travel from Lander, Wyoming into the field and any additional trips will be paid for by the student.

Faculty Mentor Hours: This amount is based on the estimated time that Dr. Prager expects to be directly mentoring this project.

GPS Rental: WyGISC has provide a GPS unit for use with the in-field accuracy assessment and future field validation. The rate listed is based on the rental of a Trimble ProXRS GPS unit for one month.

Landsat Imagery: Remote sensing data will be obtained through the WyomingView database. Although it is anticipated that all of the Landsat imagery for this project will be available for free, the amount in the budget is representative of one scene of Landsat 7 Terrain Corrected imagery with the 20% cost share to WyomingView figured in.

3. Total Project Costs: Total direct costs is the sum of the student stipend, summer funding, travel, faculty mentor, GPS rental, and Landsat imagery.

4. Non-Federal Cost Sharing: This will entail, faculty mentoring, GPS rental, and Landsat imagery.

5. Federal Cost-Sharing: Although none is specifically listed, the Visual Resource Management Inventory data collection will be completed and provided through a cooperative agreement with the Lander, Wyoming BLM. This data is integral to the proposed NASA Grant but the NASA grant has no direct relation to the BLM VRM cooperative agreement. I am simply leveraging the data that will be available from that project.

6. Total Amount Requested: The total amount requested is $15,432. 62. This reflects the total direct costs less the non-federal cost sharing. I recognize that this amount is above the maximum award of $ 15,000.00. I would propose, that if awarded a grant, the $ 432.62 dollars for travel funds be taken out of the student stipend or be absorbed by the student.

Faculty Advisor's Current Funding

Funded Projects as PI

2007-2009 Automated Visual Distance Zones and Spatial Decision Support for Visual Resource Management, Bureau of Land Management, $43,657. (UW = 100%)

2007-2008 Integrating GPS/GIS Into K-12 Standards-Based Curriculum with Focus in the Core Academic Subjects of Mathematics and Science, Wyoming Department of Education and Bighorn School District, with Jeff Hamerlinck (CoPI) and Bill Gribb (CoPI), $10,795. (UW = 100%)

2007 Network Approaches for Understanding the Structure and Dynamics of the Next Generation Air Transportation System, NASA Wyoming Space Grant Consortium, $14,829. (UW = 100%)

2006 A Preliminary Investigation Regarding the Prospects for Using GIS to Enhance Opportunities for Sustainable Development in East Africa, UWYO International Programs Travel Grant, $2000. (UW = 100%)

2004-05 A New Approach to the Visualization and Analysis of Complex Spatial Relationships, UWYO A&S Basic Research Grant, $2500. (UW = 100%)

Funded Projects as CoPI

2005 Sage in Laramie Basin, with Teal Wyckoff (student PI), Ken Driese (CoPI), NASA Wyoming Space Grant Consortium, $4880. (UW = 100%)

2006 Visualizing Earth System Processes in 3-D: An Educational Enhancement Grant for a New Course in Geographic and Scientific Visualization, with Jacqueline Shinker (PI), Jeffrey Hamerlinck (CoPI), NASA Wyoming Space Grant Consortium, $5000. (UW = 100%)

2005-06 Framework Standards Training Material Development, Phase I, with Jeffrey Hamerlinck (PI), FGDC, $151,000. (UW = 100%)

2005-06 Remote Sensing of Sagebrush Structure: A Systematic Test of Methods and Data, with Ramesh Sivanpillai (PI), Ken Driese (CoPI), NFWF, $42,174. (UW = 100%)

2005 Remote Identification of Fluvial and Eolian Benches and Terraces in the Laramie Valley, Scott Kelley (student PI), Mike Daniels (CoPI), NASA Wyoming Space Grant Consortium, $4880. (UW = 100%)