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Identifying Potential Wilderness Areas on the Fremont-Winema National Forest with ArcGIS ModelBuilder

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Abstract
The Fremont-Winema National Forest administers over two million acres in south central Oregon. Part of managing this landscape includes overseeing existing wilderness areas and identifying new potential wilderness areas. In the past this process has been cumbersome, with little thought given to standardizing the effort across the administrative area. This project was an effort to develop a geospatial model that incorporates U.S. Forest Service spatial datasets ultimately standardizing the potential wilderness identification process during site specific NEPA analysis.

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IDENTIFYING POTENTIAL WILDERNESS AREAS ON THE FREMONT-WINEMA NATIONAL FOREST WITH ARCGIS MODELBUILDER

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Capstone Project

For

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ABSTRACT

The Fremont-Winema National Forest administers over two million acres in south central Oregon. Part of managing this landscape includes overseeing existing wilderness areas and identifying new potential wilderness areas. In the past this process has been cumbersome, with little thought given to standardizing the effort across the administrative area. This project was an effort to develop a geospatial model that incorporates U.S. Forest Service spatial datasets ultimately standardizing the potential wilderness identification process during site specific NEPA analysis.

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Abbreviations

BLM	Bureau of Land Management
CE	Categorical Exclusion
EA	Environmental Assessment
EIS	Environmental Impact Statement
FWNF	Fremont-Winema National Forest
GI	Geospatial Interface
GIS	Geographic Information System
IDT	Interdisciplinary Team
IRA	Inventoried Roadless Area
LRMP	Land and Resource Management Plan
NEPA	National Environmental Policy Act
NWPS	National Wilderness Preservation System
PWA	Potential Wilderness Area
RHSI	Recreation Habitat Suitability Index
USFS	United States Forest Service
WSA	Wilderness Study Area

Introduction

The Wilderness Act of 1964 established the National Wilderness Preservation System (NWPS) through which lands of unique natural character were to be preserved for the future enjoyment of the American people. The Act designated wilderness on over 9 million acres of preserved lands. Since the original designations an additional 100 million acres of wilderness have been added to the system. As landscapes evolve over time, federal lands continue to be assessed for possible incorporation into the NWPS (Echohawk 2002). Written policy for land management agencies such as the Bureau of Land Management (BLM), National Park Service, U.S. Fish & Wildlife Service, and the U.S. Forest Service (USFS) includes direction for each administrative unit to establish and implement methods for the identification of potential wilderness for later evaluation as part of local Management Plan revisions.

USFS Handbooks provide general direction from the Washington Office to all National Forests as to how this progression should occur. Potential Wilderness Areas (PWAs) are to be identified during project-specific analysis at the forest level as part of the National Environmental Policy Act (NEPA) process (Westlund, 2012). As the Interdisciplinary Team (IDT) goes through the NEPA process for each project, the team is charged with identifying PWAs based on Handbook criteria, and evaluating the effects of project-related actions on such areas. Identification results will be documented and forwarded to a qualitative assessment of wilderness characteristics that will be completed during Land & Resource Management Plan (LRMP) revision.

In recent years the use of GIS has become commonplace, if not ubiquitous, for use in the various types of spatial analyses required for USFS NEPA projects. While many natural resource specialists are beginning to understand the powerful potential in GIS-based analyses, wilderness managers may not fully understand the benefits and limitations of this technology. The ready availability of project planning information generated with traditional methods of analysis has historically been problematic (Peter Landres 2001). The use of GIS in an enterprise environment, along with consistently-structured and broadly-accessible file structure, has addressed many of these problems. GIS provides a mechanism for relatively quick evaluations of standardized datasets to create products for alternative development and for use by the resource specialists in their effects analyses and resulting specialty area-specific reports. Additionally, GIS allows for more robust analysis methodology, and replicability through the use of metadata, modeling and workflow documentation (Gregory Brown 2005). Replicability is an important factor for streamlining similar analysis in future projects and as the foundation for defensible decisions that will withstand frequently occurring legal challenges such as appeals or litigation.

Extending the use of GIS through the potential wilderness identification process in a systematic, repeatable approach is the next logical step. When combined with the experience, observations and professional judgment of wilderness managers and other natural resource subject matter experts, a GIS model can effectively identify PWAs during project analysis.

NEPA and associated regulations require project-level analysis to evaluate a reasonable array of alternatives to a proposed action which may have potentially significant effects on the project area. A major element of this process is public involvement through comment periods and appeals. Other government agencies, the public, and special interest groups are all solicited equally for input during the scoping process. Over time, the defensibility and replicablity of the results of NEPA analyses evaluating ground-disturbing activities on federal lands have become even more of an issue as the threat of litigation by special interest groups is ever-present in the minds of managers and IDT members.

Background

In recent years environmental groups such as Oregon Wild, Oregon Natural Desert Association, and The Wilderness Society have become more vocal and involved in the NEPA process on federally-managed lands, especially where wilderness and PWAs are involved. Each of these groups has been very forthcoming in providing the results of their independent inventories of federal and state lands that were developed with the specific intent of finding areas that could be included in the wilderness evaluation process (Westlund, 2012). When agency analysis results do not align with input from environmental interests, appeals to the project and litigation often result.

The most recent USFS planning rule included language in response to this trend in public involvement:

> *"Analysis requires the use of the best available scientific information to inform the planning process and documentation of how science was used in the project."*

The irrefutable mounting necessity for solid NEPA project documentation and replicable analytical results will require a much more systematic approach to analysis. The effective use of well-developed and maintained models will aid in generating quality, defensible project reports and well-informed decisions by federal land management officials.

Current Issues

As of now there is no process standardized throughout the Forest Service for the identification of PWAs at levels of either the forest, or the Pacific Northwest region (Region 6). Upon speaking with Glen Westlund, the FWNF Environmental Coordinator, he expressed a position that this stems from a lack of detailed direction from the regional office to the forests in terms of what they expect NEPA documents to contain with regard to potential wilderness analysis. As a result, each of the 18 national forests and grasslands in Region 6 has their own interpretation on how to fulfill the requirements of Handbook direction.

Any process that I comprised of at least twenty different process perspectives runs contrary to the principles of creating well-documented, repeatable, and defensible analysis results throughout the Region (Westlund, 2012). The spatial model discussed in this paper will standardize the identification process across the Fremont-Winema National Forests (FWNF), providing for consistency that is currently absent in project NEPA analyses and strengthening the forest's position during appeals and litigation.

Purpose

The purpose of this project is to develop a model using ArcGIS 10 which, through manipulation of USFS corporate datasets, will isolate all geographic areas that fall within established quantitative criteria for identification of PWAs during site-specific NEPA analysis. Once identified in GIS, these areas will be organized and stored within the project file structure where they can be validated by the IDT and cataloged for later wilderness character evaluation during LRMP revision.

Literature Review

All ground disturbing activities now require some sort of documented NEPA analysis disclosing and evaluating the impacts of associated activities on the environment, much of which is derived through the use of GIS. This literature review describes some of the challenges facing the USFS because of its obligations under NEPA and highlights two GIS projects which demonstrate the application of geospatial models. These models are used successfully to identify areas of interest during project development and are, in fact, a critical step to creating a complete tool for land managers to use when developing strategies for the implementation of policy. GIS provides a standard foundation on which standardized analyses can be built for all administrative units.

NEPA in the Forest Service

USFS obligations under the NEPA have become ingrained in the everyday business of the USFS. In some cases, even activities like mowing district office lawns may require a categorical exclusion document to be in place beforehand in order to ensure the agency is compliant with the law.

In 2010 the Forest Service's Pacific Northwest Research Station group published a report detailing financial impacts of the NEPA process on the agency. In addition to analyzing financial effects, the report also explored some of the foremost reasons managers and IDT leaders chose the most elaborate of the three types of NEPA documents, the Environmental Impact Statement (EIS), over the other simpler and generally more cost effective Environmental Assessment (EA) or Categorical Exclusion (CE) (Mortimer et al. 2001).

The report found that the USFS produces more EISs than any other federal agency, completing more individual NEPA documents annually than all other federal agencies combined. Because completion of an EIS involves IDTs that are normally double the size of IDTs producing EAs, production of an EIS creates a real drain on limited personal and budgetary resources. The report also stated that in 2006 alone the USFS spent over $365 million on the production of NEPA documents.

A second point of focus for the report was the overwhelming impression that an EIS was inherently more defensible in litigation when compared to the other NEPA documents. This perception does not necessarily reflect the intent of the NEPA process. Use of an EIS is only intended when the analysis results in projections of unmitigated significant environmental effects. Therefore, the defensibility of the document is determined by the documentation of the results of the analysis, not by the type of NEPA document, no matter how prevalent this impression is within the USFS.

The report found that this mistaken impression is the result of different uncertainties about:

- The social acceptability of ecological impacts.
- Whether or not litigation will follow the decision.
- The outcome of judicial review.
- Whether or not an EIS is more legally robust than an EA.

The listed uncertainties support the report's conclusion that process risk, the risk associated with external pressures, tends to dominate the decisions of USFS personnel when determining whether to prepare an EA or EIS rather than the discrete environmental impacts of what the agency is considering on the ground (Mortimer et al. 2001).

To combat the feelings of insecurity that the USFS seems to have established by convention in association with the NEPA process, additional standardization needs to be built into NEPA effects analysis. A more robust and defensible analysis will contribute significantly to a more complete document no matter which of the three formats is selected - CE, EA or EIS. GIS creates this capacity by offering standard process and geospatial models that will produce consistent quality in results, fortifying any NEPA document to withstand expected rigorous scrutiny (Eric Gustafson 2001).

Multi-Criteria GIS Models

With the passing of the American Recovery and Reinvestment Act, renewable energy sources have been at the forefront of new large-scale energy infrastructure development. Wind and solar developments have become the short-term focus for a long-term strategy of transitioning energy production from fossil fuels to more renewable sources.

GIS has become an important tool to be used during suitability studies when companies go through the process of determining where large-scale wind and solar farms could be located. These mapping efforts involve numerous data sources often weighted to represent the relative importance of predetermined criteria.

In 2010 Jason Janke of the Metropolitan State College in Denver developed a multi-criteria GIS model to identify areas within Colorado which are suitable for wind or solar farm development. This analysis required the following vector and raster inputs:

- Wind Potential
- Solar Potential
- Transmission Lines
- Cities
- Population Density
- Transportation System
- Federal lands
- Landcover (vegetation)

To prepare these datasets for analysis the wind and solar potential raster datasets were resampled to allow the production of weighted outputs. Additionally, the vector datasets were buffered to reduce the opportunity for interaction with existing infrastructure and to avoid highly populated areas. These vector feature classes were then converted to raster datasets and then standardized in a fashion similar to the wind and solar potential GRIDs.

The GIS model was able to locate areas that were ideal locations for wind farms and for solar farms. The process was able to determine this by eliminating areas with vegetation and geomorphological characteristics that were not suitable for development then comparing the remaining areas with wind and solar potential (Janke 2010).

The results of the model showed ideal wind farm locations running north and south between Estes Park and Alamosa Colorado, as well as in the majority of the northeast corner of the state. The ideal solar farm locations were much more limited. Areas showing promise were only located in the northwest corner of the state and in a narrow corridor north of Limon and east of Denver (Janke 2010).

The results of this analysis would still need to undergo ground truthing for more precise measurements and to identify any ecological and geographic characteristics that would hamper such a development. This tool assists, however, in collaborative decision-making for project analysis and allows planners to develop various alternatives without a great deal of expense in terms of time and funding. Also, if better resolution input data becomes available these processes can be updated simply by changing the model inputs.

Wilderness Monitoring Modeling

From the beginning, those lands designated as wilderness were intended to remain in a natural state and considered a place of unconfined recreation for visitors of all future generations. Activities such as hiking and camping, which initially appear to have little impact to the environment, often leave lasting ecological and social effects. In this case, inventory, monitoring, and analysis will help ensure management and mitigations are appropriate and successful.

Administrators are challenged when it comes to attempting to inventory and monitor large wilderness areas with limited budgets and a seasonal workforce. To increase efficiency managers decided to employ techniques, wherever practical, that would allow them to better focus resources before beginning the inventory process. The use of GIS models to determine probability across landscapes as a first-level sieve is indicated because it is a commonly-used, cost effective industry standard tool for such circumstances.

This 2008-2010 study incorporated GIS along with two predictive models to help wilderness managers map and predict probably campsite distributions throughout wilderness areas in Colorado. The first model developed was a Recreation Habitat Suitability Index (RHSI) using expert knowledge of the area and deductive reasoning about campsite preferences. The second model was a Maximum Entropy model using current inventoried campsite locations and environmental preconditions with statistics to determine probable campsite locations (Cross et al, 2012).

In preparation for the analysis the study area was defined and field data was captured. All 36 federally-designated wilderness areas in Colorado where incorporated into the study which covered approximately 3.2 million acres. Field data was collected as part of an ongoing 2004-2010 campsite inventory. Some 2,600 points were captured by field-going crews using GPS receivers.

Building on previous Habitat Suitability Indices constructed by ecologists and wildlife biologists to project areas of potential organism environments, the team constructed a RHSI that was derived from expert resource knowledge. A focus group was assembled that was composed of wilderness program managers, lead wilderness rangers, and recreation ecologists from the area. The result of this focus group was a RHSI algorithm that scores areas of land based on their distance from certain geographic features such as streams, lakes, trails, roads, and areas with a low slope. Each of these features had various coefficients which were predetermined by the focus group. The final outputs were displayed as a map using GIS to show a range of likeliness a campsite will exist (Cross et al, 2012).

The second Maxtent model uses known locations to create a statistical model that can be used to predict areas where new campsite locations are likely to be found. This tool is freely available through Princeton University website and uses the idea of maximum entropy to interpolate occurrence points. The output of the model presents probability values between 0 and 1, where 1 is the highest likelihood of the campsite existing. This model was trained using a random selection of 70% of the inventoried campsites. The remaining 30% of known sites were retained separately for later evaluation of the model (Cross et al, 2012). This model incorporated the same environmental variables at the RHSI to provide consistency during model evaluation. As with the RHSI model, the Maxtent outputs were incorporated into GIS to be depicted on a map.

For quality assurance each model passed through two statistical evaluations to determine if they were operating accurately. The first test was an Area Under the Curve test. This test finds the probably that a random positive point would fall outside of the predicted range and the probably that a negative point would fall inside the predicted range. The second test incorporated was the Cohen's Kappa statistic which measures the probability of agreement between the model and the data. The results of these tests showed each model had a near perfect discrimination Area Under the Curve score, and an adequate Kappa statistic score. The raw results for each model were also highly similar. The RHSI model predicted a probable area of potential campsites at 979,000 acres while the Maxtent model predicted 982,000 acres (Cross et al, 2012).

The results of both models indicate that each is an effective tool for predicting areas within wilderness that should receive focused monitoring efforts. The models' integration with GIS provides the key to displaying visible representations of this conceptual information for wilderness managers to assimilate creating an overall planning tool for implementing efficient planning efforts for wilderness monitoring. Once managers can visualize priority survey areas, they can create logistical strategies for wilderness teams, and track inventory progression. Additionally these tools can be re-evaluated and revised as issues become obvious, in the end creating a useful product which may be used as a standard protocol across administrative units, and agencies.

These studies have discussed issues the USFS in Region 6 is experiencing with confidence in the ability of administrative units to produce defensible environmental documents. Instead of the results of the analysis determining the type of document to be produced (CE, EA or EIS); project managers are electing to prepare EISs with a mistaken impression that the result will better withstand appeals and litigation. Grasping at straws and hoping for the best is not an optimal or realistic strategy to employ when trying to implement a project on the ground. I believe that this lack of confidence is fueled by an absence of analysis tools that are standardized across districts and forests in the region. GIS models will provide the mechanism for a more uniform, yet appropriately adaptable, analysis execution within the agency which will, in turn, bolster the fortitude of the environmental documents the USFS produces.

Multi-criteria and predictive models are a great way to do project scale analysis efficiently and inform the IDT well enough for them to construct their recommendations for their reports. These models are founded on consistent corporate datasets which are generally available to those within the agency and to the interested members of the public. Not only are results a replicable product that can be shared and repeated from project to project, but use of the model in GIS creates additional process documentation which, as part of the project record, builds in inherit defensibility for any possible legal scrutiny the project may have to endure.

Design and Implementation

The subject of this project is a model that was created in ArcGIS 10 ModelBuilder software. The completed model was stored within a geoprocessing toolbox and can be accessed by the GIS Specialist assigned to support the IDT throughout the NEPA project analysis. This model will reference USFS standard corporate datasets and identify PWAs within and near the NEPA project boundary.

Conceptual Framework

The USFS Handbook defines the parameters for identifying PWAs. In order to qualify, any identified areas must fall within specific land ownership and transportation system criteria. According to the handbook, parameters that define potential wilderness include:

71.01.01: Areas contain 5,000 acres or more.

71.01.02: Areas contain less than 5,000 acres, but can meet one or more of the following criteria:

a. Areas can be preserved due to physical terrain and natural conditions.

b. Areas are self-contained ecosystems, such as an island, that can be effectively managed as a separate unit of the National Wilderness Preservation System.

c. Areas are contiguous to existing wilderness, primitive areas, Administration-endorsed wilderness, or potential wilderness in other Federal ownership, regardless of their size.

71.11.0: Federal ownership of less than 70 percent if it is realistic to manage the Federal lands as wilderness, independent of the private land.

71.01.03: Areas do not contain forest roads (36 CFR 212.1) or other permanently authorized roads...

The model must be built to incorporate these criteria in order to create an accurate representation of a PWA.

The initial step was to consult the, now former, FWNF Environmental Coordinator Glen Westlund. In this position Glen acted as the environmental policy subject matter expert, and provided program managers along with natural resource specialists' technical guidance with respect to interpretation and implementation of environmental laws.

Working with Glen a draft outline of what the forest desired for products was developed. Primary and secondary objectives were identified consisting of model outputs which would be required, and model outputs which would be nice to have if possible.

Primary outputs were to consist of:

- Polygons of 5000 acres or greater which are within or near the project boundary
- Polygons of any size which are within or near the project boundary that is coincident with an existing wilderness, inventoried roadless area, or a Bureau of Land Management wilderness study area.

- Any identified polygons would need to be identified with a unique name and stored within the project file structure in some logical manner

Once primary parameters are met, secondary outputs are created and would consist of:

- Polygons representing historical forest activities within any identified potential wilderness areas
- Acreage numbers for historical forest activities polygons within any identified potential wilderness area.
- Any identified polygons would need to be uniquely named and stored within the project file structure in some logical manner.

These secondary products would not be crucial to the immediate potential wilderness identification process, but they would be important to give contextual information for LRMP revision. The activities history within these polygons will provide an essential overlay and inform the revision team for the qualitative phase of the wilderness characteristic evaluation of any identified potential wilderness polygons.

The next step was to determine the type of interface the model will have. At its simplest the model is stored within a stand-alone toolbox. A toolbox can be added to any map document allowing the model it contains to be run within the MXD or it can simply be activated from ArcCatalog, as needed. Since the specialists who will be using this tool are accustomed to the ArcMap interface, the decision was made to use a standardized map document as the interface. This also gives the user the opportunity to inspect the process visually, and verify the outputs.

Environment

The USFS has two distinct installations of ArcGIS for users. The first is the typical local ArcInfo suite installation on the user's laptop or workstation. The software that is running on the hard drive is validated by a license captured from a license server through a network connection. All analysis and data manipulation is done locally. When completed, data is copied across the network to the project space in the corporate file structure on the T:drive at the national U.S. Department of Agriculture data center in Missouri.

The second ArcGIS environment available to users is a remote service at the national data center. Using a Citrix brand client the user can access GIS software and data over the network. Using a remote instance allows people to operate within common project space on the T:drive without having to transfer data back and forth from the local hard drive.

The model this project represents is intended to be used on the T drive through the Citrix environment. Part of the purpose of this product is to increase replicability between projects and improve process documentation for future reference. Encouraging people to use project analysis models like these that reside on users' personal computers runs contrary to corporate objectives for standardization, accessibility and appropriate redundancy (backup).

Data Requirements

At this point it was it was time to determine which spatial datasets would be required for this project. To meet Handbook requirements and to produce the desired primary outputs, the following datasets will be required:

- Land Ownership- USFS and other agency lands.
- Transportation- All roads in and around the project area.
- Wilderness- Existing wilderness areas that are currently part of the NWPS.
- Inventoried Roadless Areas- This data represents areas of USFS land which have met past roadless area criteria.
- Wilderness Study Areas- BLM land which has been identified as a Wilderness Study Area (WSA).
- Project Boundary- NEPA project or analysis area boundary and will describe the area of a given analysis.

All of these datasets are available for the Fremont-Winema National Forest within the Region 6 spatial data library and will be available for use in this project.

Additional data will be required as prerequisites for the secondary outputs. The USFS has a national tabular database, named FACTS, where information for all past, current, and proposed NEPA project information is stored. Any ground disturbing activity that has occurred on the forest will be present in the dataset. In order to translate this tabular database into a spatial layer, the USFS has developed a data management tool called the Geospatial Interface (GI). This application creates a link between FACTS and corresponding spatial polygons stored in the spatial data library based on key fields. The result is a temporary visualization within the ArcMap document that can be saved as a normal ArcGIS feature class and used as an input to this model. Although the GI must be used to produce this dataset with for use in the model, the polygon and tabular data representing the FWNF are readily available.

File Structure

The USFS corporate file structure includes a directory on the network named the "T" drive. This drive has been designated as the location in which to house all project-specific geospatial information and workspaces where employees can conduct their GIS analyses.

The national standard file structure convention continues on from "T" and organizes project folders based on their administrative unit, National Forest, and Region. Figure 1 shows an example of the GIS project file structure for the Red

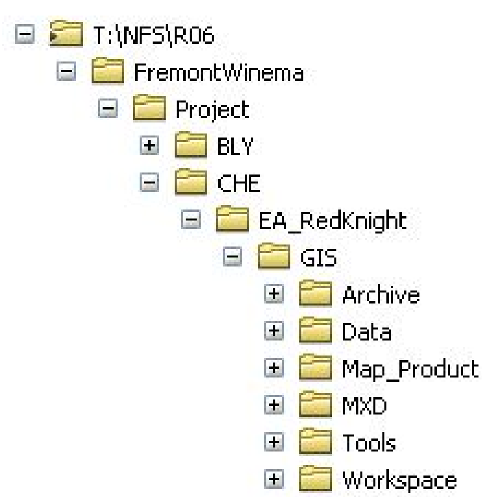


Figure 1. T: Drive Project File Structure

Knight EA. The folders under each project are predefined and have a specific purpose.

- Archive- Versions of project data, maps, etc. are stored here.
- Data- This folder contains all of the geospatial data used for analysis in this project. This is populated from the spatial data library at the beginning of the project.
- Map Product- This folder contains PDFs and images created for the project from ArcMap documents.
- MXD- All interim and final ArcMap documents for the project are stored here.
- Tools- Any specific models, scripts, or unique tools used in the project are stored here.
- Workspace- Within this folder are subfolders for each resource specialist on the project's IDT. Here they can store their specific analysis used for the project document.

The potential wilderness model would need to be able to operate from within the tools folder, but independently under any project name within the project file structure.

Understanding the infrastructure within which the model must operate helped determine the file structure that will be used in the design of the model.

In order to be transferrable from one project folder to another project folder, the model would need to be stored within a single "Potential Wilderness Analysis" folder. Figure 2 shows the

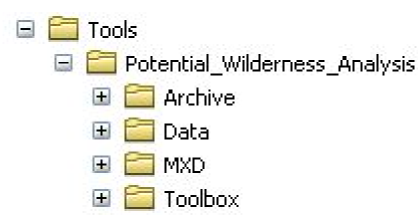


Figure 2. Analysis Tool File Structure

resulting file structure for this project.

- Archive- If the analysis model needs to be run more than once, versions of the data can be stored here.
- Data- This folder will contain a copy of the model input data and all of the model outputs.
- MXD- This folder contains the map document used to interface with the model.
- Toolbox- This folder contains the analysis models and scripts used for identifying potential wilderness.

Within the Data folder there are several subfolders, each representing portion of the model output. Figure 3 also illustrates how these folders are arranged. Any identified polygons greater than 5000 acres will be stored separately from those which do not meet the minimum size criteria. Areas smaller than 5000 acres but identified as contiguous to an existing special management area are broken out by the type. Each output has a corresponding "Activities" folder which contains feature classes representing any activities that have occurred within the identified polygon.

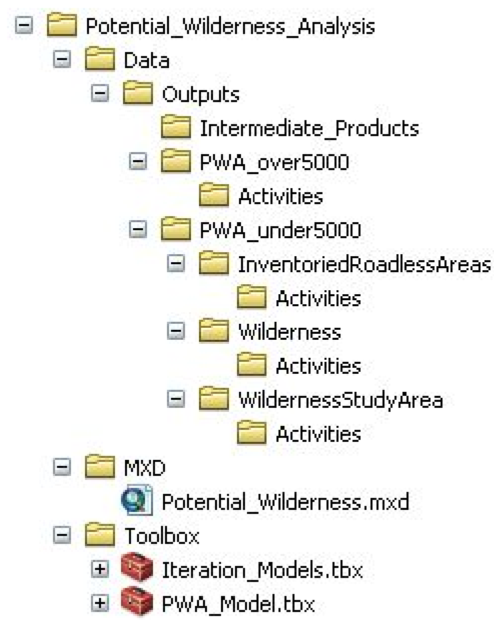


Figure 3. Analysis Tool File Structure Detail

The PWA folder will be stored within a tool development section of the T drive until the model is needed. At that time it can be copied into the Tools folder of the specific project and run from there. The model and its various inputs and outputs will be stored within the project file structure as part of the project record. Spatial and tabular results can be used by the IDT for analysis and then later evaluated during LRMP revision.

The Model

The model as designed has been capable of fulfilling the primary and secondary goals laid out by the Forest environmental coordinator. Figure 4 shows the model as it is now with the main modules underlined. The model incorporated many geospatial tools available within ArcToolbox along with sub-models containing iterators and an additional custom Python script.

The model consists of three main sections or modules, each serving a specific function as part of the process to answer the overall questions presented in identifying PWAs.

Module 1

The primary module within this tool is responsible for the primary goals of the project, identifying PWAs over 5000 acres. The inputs for this module are:

- The project or analysis area boundary layer
- The forest ownership layer
- The forest road layer
- The forest activities layer

To begin this process the project boundary is buffered 5 miles. This ensures that not only the project area is analyzed to highlight potential PWAs, but the surrounding area is also incorporated.

The next step is to clip both the forest ownership and forest roads layer to this expanded project area to reduce extraneous data to the analysis area. The resulting road layer is then buffered 150 feet, a number provided by Glen Westlund. The buffer creates corridors along roads which represent boundaries to any PWAs. To create polygons that will be evaluated based on the size criteria; the expanded project area is then dissected by the buffered roads using the Erase tool and the Multipart to Single part tools. A field is added to the polygon layer table where the area within each feature is calculated in acres. The Make Feature Layer tool is used to create a selection of polygons calculated to be a minimum of 5000, and then the Copy Features tool is used to turn the selected set into a shapefile. A "Poly_ID" field added to this PW_Areas shapefile and it is populated with a unique identifier for each feature (record) in the shapefile. At this point Module 1 splits.

The PW_Areas shapefile is first directed to the PWA_Over5000 sub-model. Within this sub-model an Iterate Field Values iterator is used to cycle through the unique values of the "Poly_ID" field and produce a new individual shapefile for each value.

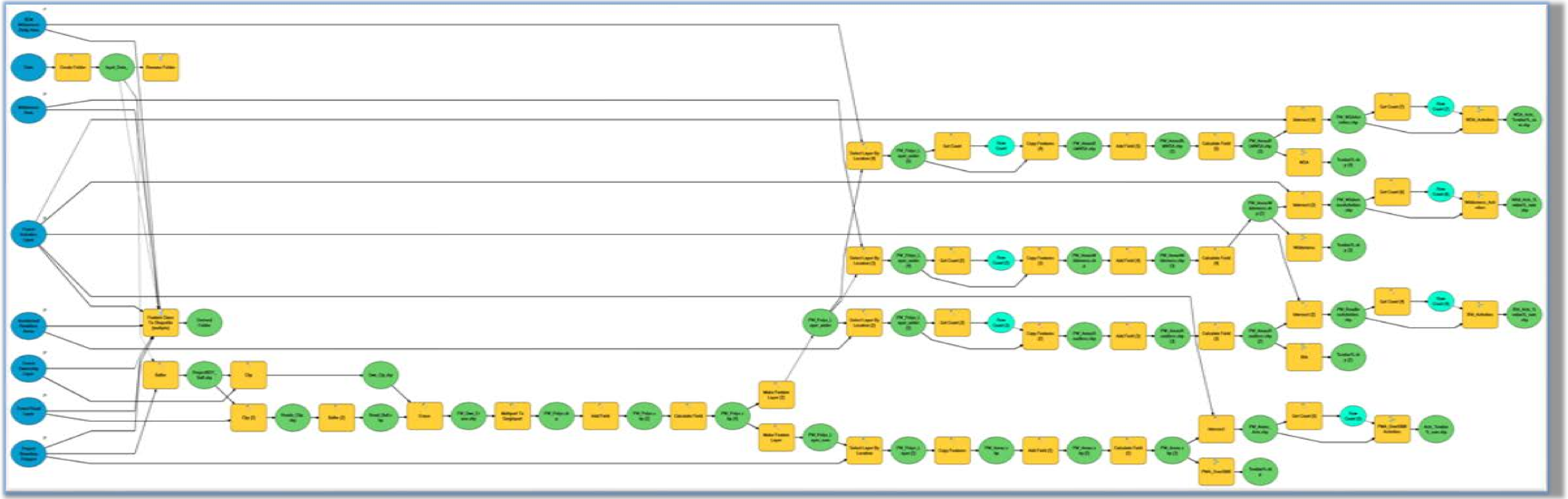


Figure 4. Potential Wilderness Area Analysis Model Diagram

The second course for the PW_Areas shapefile is through an Intersect with the forest Activities layer. This will create specific polygon features if there are any activity records that occur within the PW_Areas polygon. To check to see if there are any records that are the result of this intersect operation, the Get Count tool is used. This tool checks the output of the intersection to validate whether or not records are present. If there are no records present the model defaults to the next module.

If there are records present, Module 1 continues to run by calling another sub-model. The PWA_Over5000Activities operates in much the same way as the PWA_Over5000 sub-model. The Iterate Field Values iterator goes through the activities polygon creating individual new shapefiles for each record. As this iterator runs additional tools are triggered. Upon creating a new shapefile based on unique values in the Poly_ID field, the features within the new shapefile are dissolved and then the Calculate Field tool is used to populate the Acres field with updated values. The results for Module 1 are that any polygons greater than 5000 acres are stored as individual shapefiles with unique names, and their associated activity polygons are also stored as individual shapefiles with unique names. All of the resulting data includes updated acreage calculations which will be useful for future analysis.

Module 2

The purpose of Module 2 is to identify any PWAs within or near the project area which are smaller than 5000 acres in size but may be contiguous to an existing special management area. Module 2 builds off of much of the initial processing of Module 1. It is initiated after the preliminary acreage calculation. Here the Make Feature Layer tool is again used to create a subset layer of PW_Polys for features less than 5000 acres. At this time the secondary different input layes are introduced.

- Inventoried Roadless Areas Layer
- Wilderness Layer
- BLM Wilderness Study Area Layer

Module 2 consists of the same processes run three times, once for each of these layers. The first step is an overlay operation using the Select Layer by Location tool. Here the model checks to see if any of the PW_Polys intersect with a SMA. Once again the Get Count tool is used to see if the selection set does indeed contain records, If it does not the model defaults to the next SMA. If the Get Count query is true those those features are used to create a new shapefile via the Copy Features tool. The new shapefile PW_Areas**X**, where **X** is a SMA, then has a field added and the acreage for each feature introduced into that field. At this point the Module 2 runs through a similar final process as Module 1. PW_Areas**X** is then run through two paths. The first is again a sub-model iterator which creates new individual shapefiles based on their unique value in the Poly_ID field. Similarly the second path involves intersecting any possible activities polygons and then if they do running through a sub-model which creates individual polygon shapefiles for corresponding forest activity features. This process will run for each of the new SMA input layers. Any outputs will be stored within the PWA_Under5000 folder within their respective SMA subfolder for both PWAs under 5000 acres and their corresponding activities polygons.

Module 3

Module 3 was added to the original design in an effort to introduce some context and aid in replicability of the outputs of the model. Although most of the input layers are somewhat static in the library, and the reference layers in the project Data folder should be completely static, both human and digital errors have been known to happen. The most highly favored strategy was to determine a way to capture the input datasets and store them within the model data folder to ensure the static base data used for the analysis was frozen for reference and replicability.

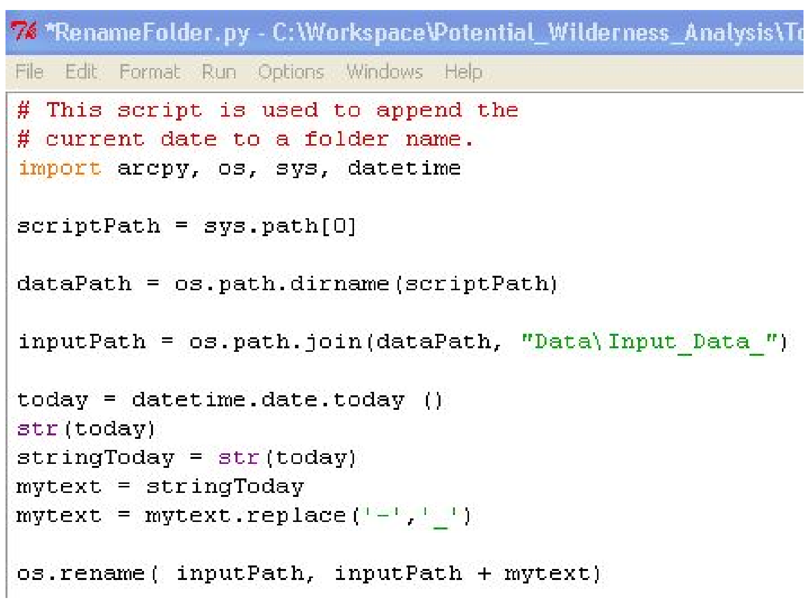


Figure 5. Module 3 Python Code Used to Rename Data Input Folder

After Modules 1 & 2 have completed running, Module 3 begins by creating a folder under the model data folder called "Input_Data_". This is where a copy of all of the input layers will be stored. At some point in the future, possibly during LRMP revision, there may be a question about what data was used and when it was evaluated for this project. In addition to creating a new folder, a custom Python script was written to add the current date to the input data folder name. Figure 5 shows the script that is used.

One hurdle to overcome with Python scripting is it's limitation in the form of an inability to recognize and process relative path names. Since this model is intended to be portable, and be copied around numerous file locations, the script integrates a function that will allow it to deal with relative paths. The directory path must be captured from the system path object. At that point the input path can be defined and, as long as the Data folder stays at the same level in the Potential Wilderness Analysis folder this script, will be able to locate the input data folder. The remainder of the script is used for capturing the day's date from the datetime object and appending it to the input data folder. One note about this is that the native date comes in as YYYY-MM-DD which is not optimal for use within GIS. The script turns the captured date into a text string and then replaces the hyphens with underscores before adding the date to the file name. This will ensure there are no issues with ArcGIS software referencing that path.

Interface

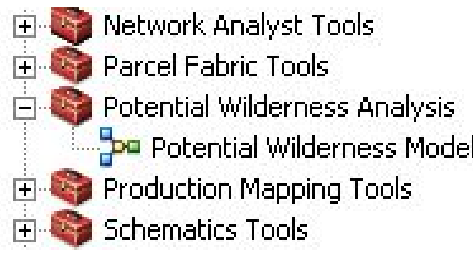


Figure 6. Potential Wilderness Area Analysis Toolbox

The model is to be used through the PWA map document stored within the tools file structure. This interface allows the user to navigate to the essential feature classes and add them to the map document. Here, the user can review the layers visually to better understand the spatial relationships between them. The PWA toolbox containing the PWA model will be preloaded within this map document's ArcToolbox window as seen in Figure 6. Users can then double-click on the PWA model to open the tools analysis dialog box. The user will add the seven required layers for the model to analyze with the PWA interface dialog (Figure 7). The dialog behaves as a normal ArcMap interface, allowing the user to drag inputs in

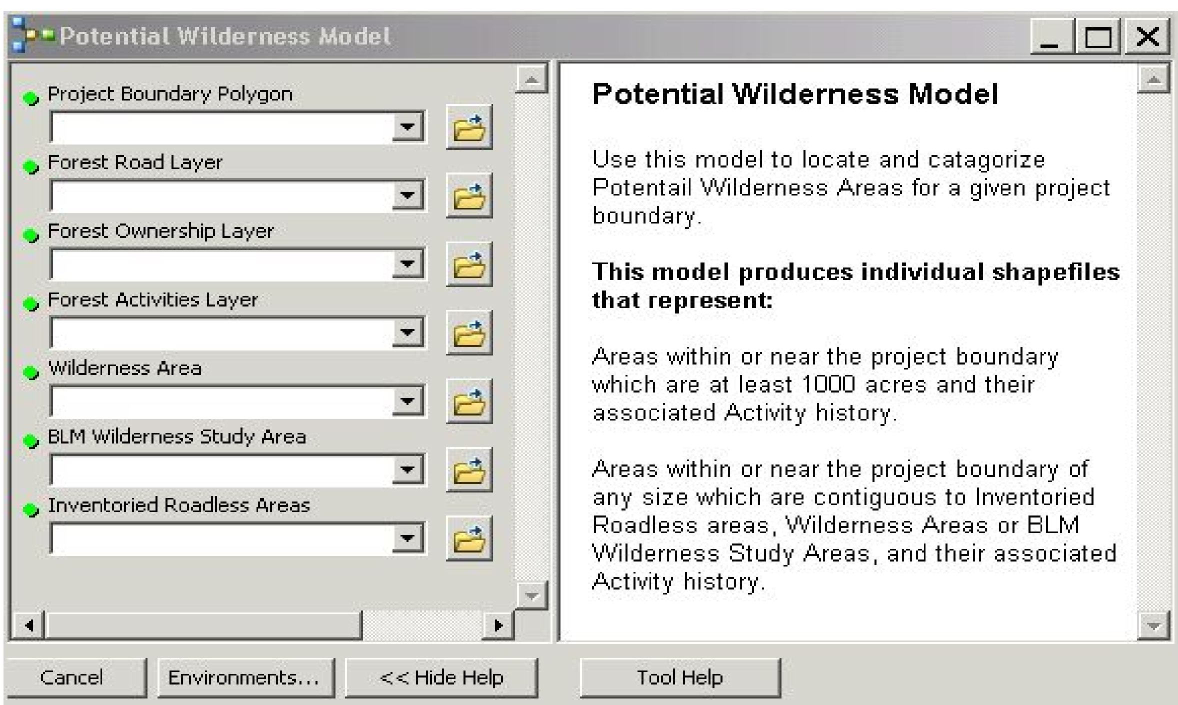


Figure 7. Potential Wilderness Area Analysis Model Input Dialog

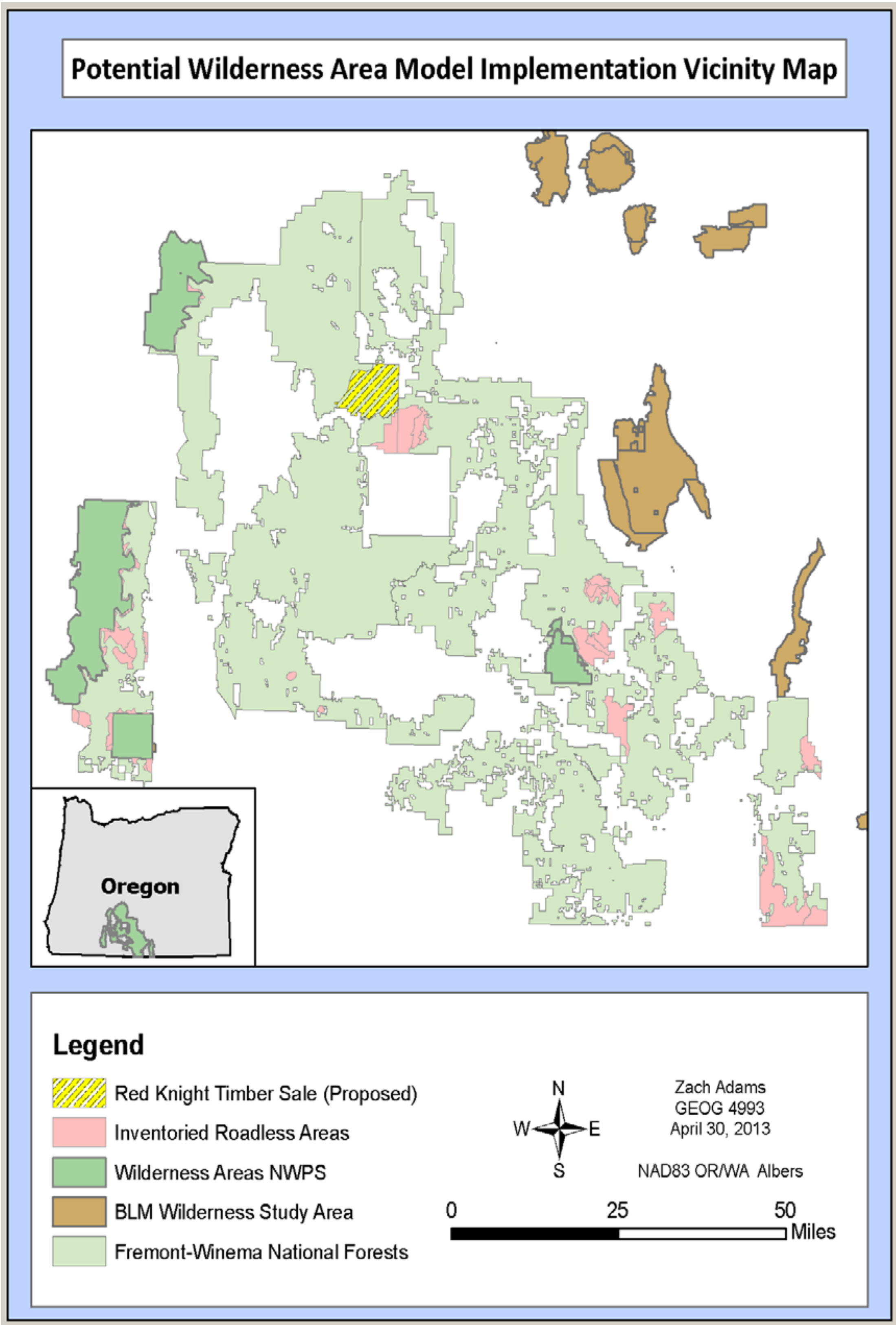
from the Table of Contents, choose from individual drop-down menus, or navigate through the file structure to the layer. Additionally, a brief description of the tool and tool use is listed within the expandable help pane.

Implementation

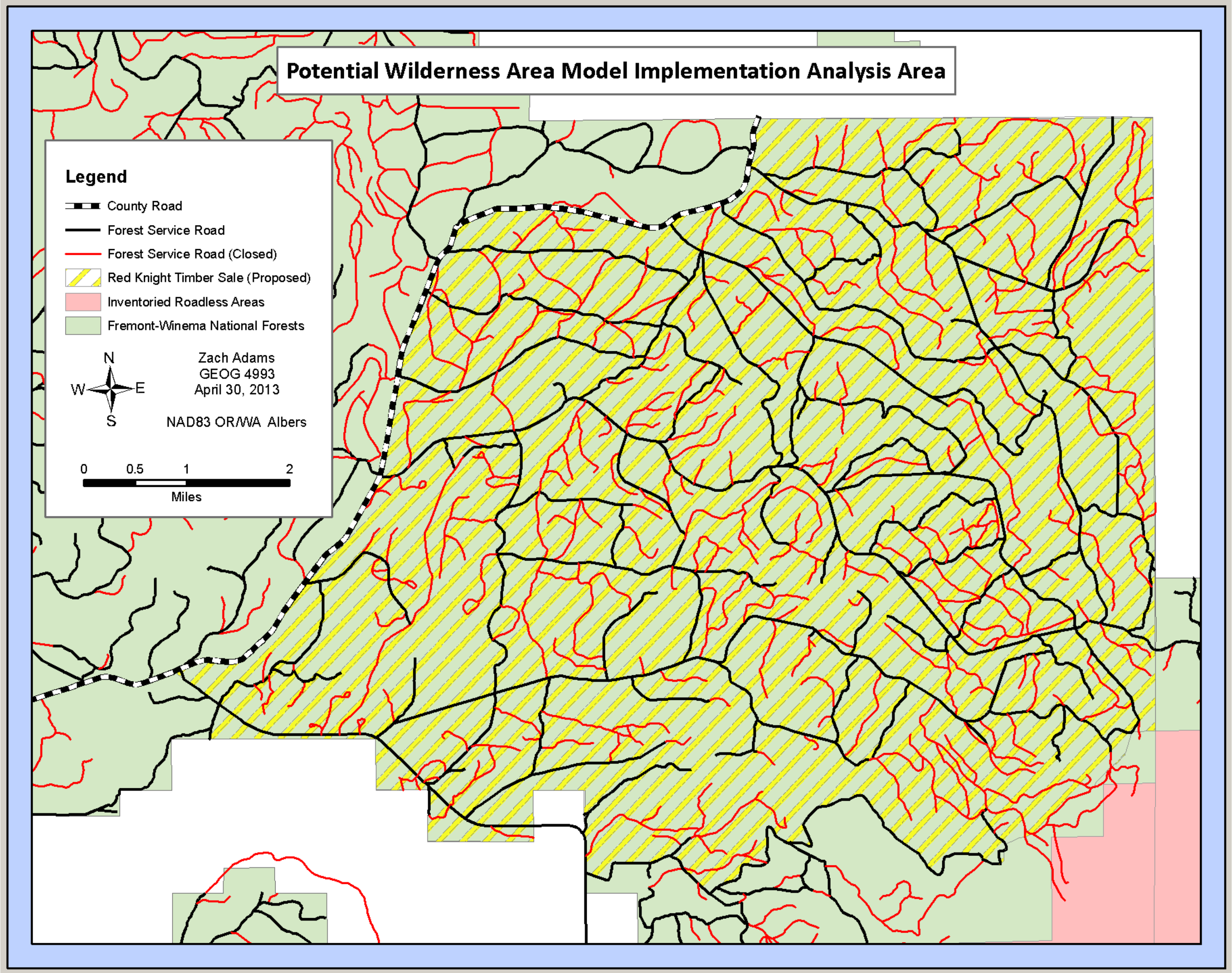
The first step towards implementation was testing in a real-world scenario on an ongoing project. On the FWNF the Red Knight timber sale analysis is underway for the associated EA document. Map 1 is a vicinity map of the FWNF and the approximately 32,000-acre Red Knight planning area. Map 2 shows the Red Knight project area to be considered for PWAs. The Potential Wilderness Analysis folder was copied into the tools directory of the Red Knight project folder and the model was executed from its associated map document.

High road density in the project area created numerous overlapping polygon boundaries. A quick analysis showed that there were no polygons in this project area that would reach the 5000 acre threshold. For model testing purposes this polygon size limit was reduced to 1000 acres to ensure that both Module 1 and 2 of the model would be active.

Layers representing the project boundary, USFS ownership, road system, and the Inventoried Roadless Areas (IRA) were sourced from the Red Knight project data folder. Layers for wilderness, and BLM wilderness study areas were sourced from the USFS spatial data library. The GI was used to create an updated visualization between the FACTS database, and the spatial activity polygons.



Map 1. Project Vicinity



Map 2. Project Analysis Area

A new feature class was created from this visualization and, again, for testing purposes, was stored within my personal workspace on the T drive where it stood as reference for this model exercise. As shown in the Map 1, the vicinity map, there are no wilderness areas or BLM wilderness study areas near the Red Knight project boundary. However these layers were included to verify that the model would operate correctly if empty products were produced.

Results

The initial implementation of the model showed promise. The model was able to create all of the desired primary and secondary products for the Red Knight planning area. This planning area was a good place to test the model due to its proximity to an existing SMA in the Yamsay Mountain and Buck Creek IRAs. Additionally, lowering the acreage threshold allowed the model to identify areas both above and below the 1000-acre limit, thereby testing both modules.

A review of the information in the model's data folder (Figure 8,) demonstrated that all modules of the model executed as planned. The input data folder was present with the day's date appended to its name. Shapefiles representing copies of all of the input data that was used to run the model was noted as current within this folder. These datasets are now stored with their respective outputs allowing any user to return and rerun the same analysis and obtain the same results. If for some reason the model needs to be re-run during its parent project analysis, this folder and the data it contains will be overwritten. If the original data needs to be retained, the input folder must be copied manually to the Potential Wilderness Analysis Archive folder.

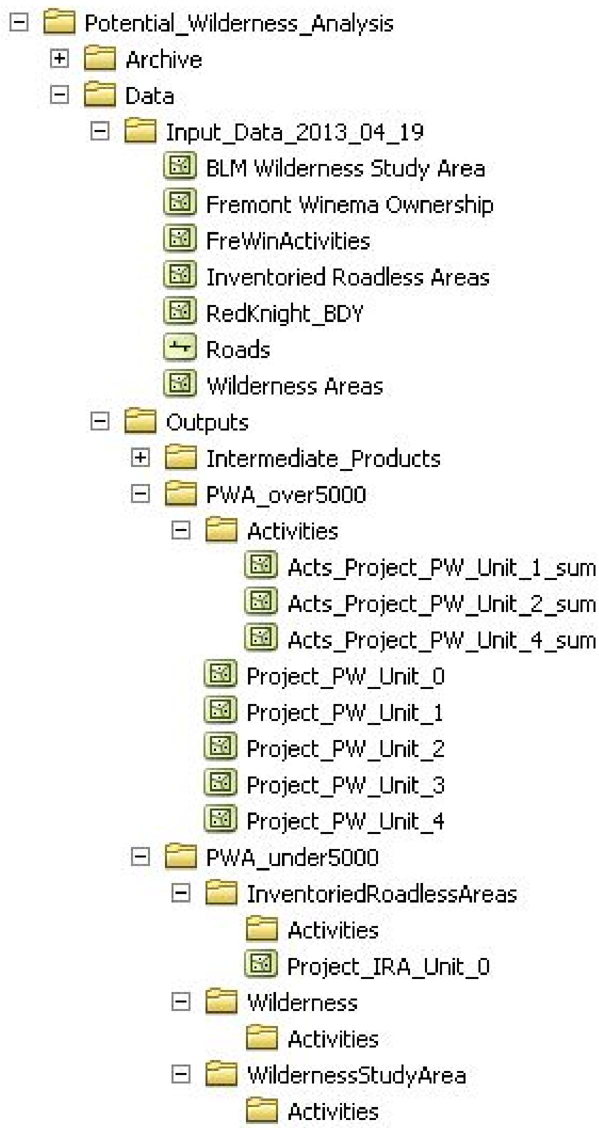


Figure 7. Potential Wilderness Analysis Tool Products

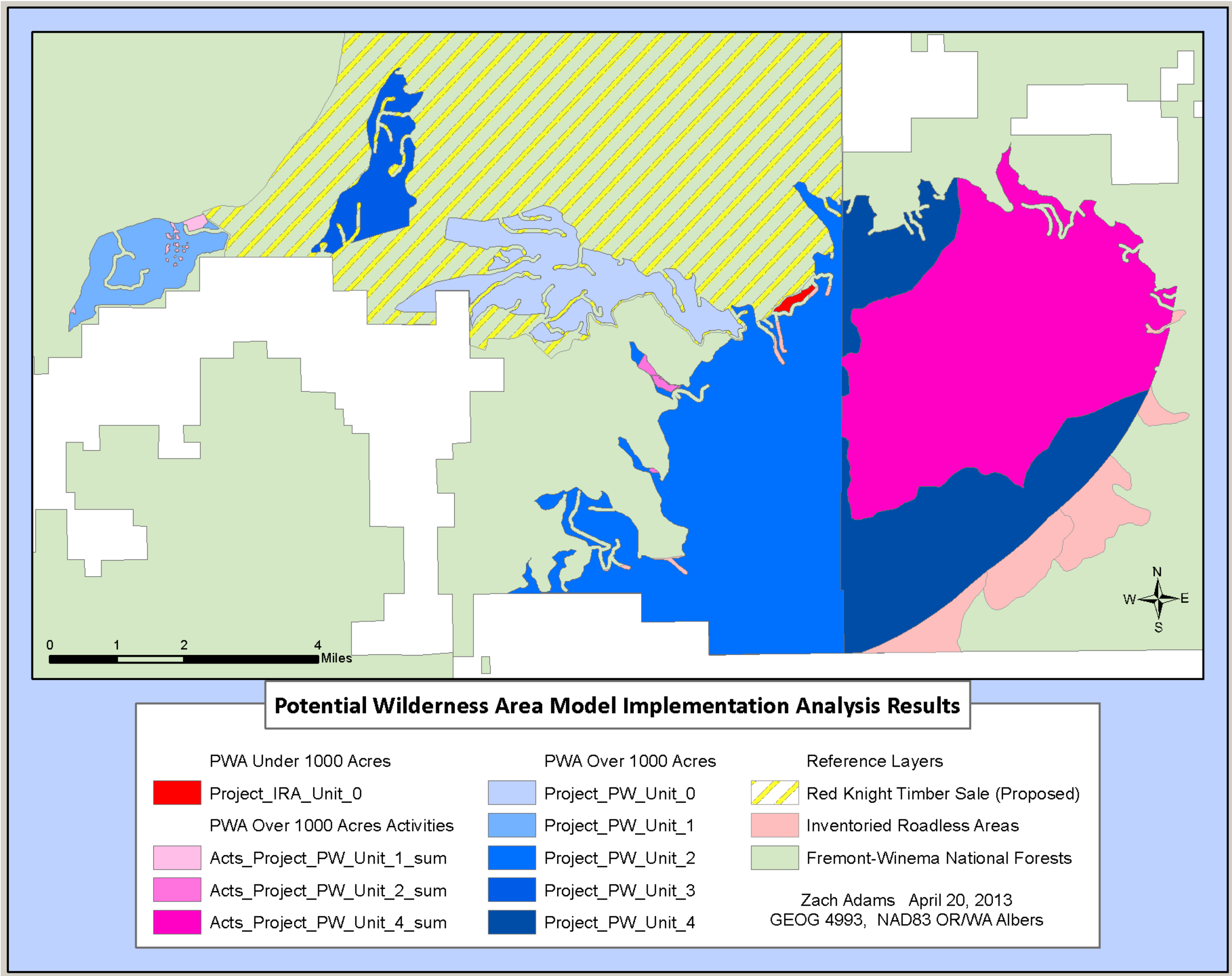
In the Outputs folder, it is substantiated that polygons over the test threshold were found and processed correctly. A total of five polygons were identified, given a unique name, and split into individual shapefiles. The model also produced three activities polygons for the areas within PWAs where records of ground-disturbing activities existed. These activities polygons were also split into individual shapefiles and given unique names corresponding to their parent PWA polygons.

One PWA polygon was identified below the size threshold as well. As expected, no polygons were found near a wilderness or a BLM WSA because there were none within five miles of the project boundary. The polygon identified was found to be contiguous with the neighboring IRA. The model added a unique identifier and SMA type to the output name. No activity polygon was present within this feature, so no corresponding activity was produced.

The model file structure also has an intermediate products folder in the outputs. ModelBuilder allows the user to delete intermediate layers as the model runs in an effort to economize on file space and reduce clutter. For this project it was decided to create a dedicated folder in which these intermediate products are retained as process documentation. These layers would prove to be useful if the model does not run completely or correctly and could assist in troubleshooting should a problem occur within the model sometime in the future.

A visual representation of model outputs is depicted in Map 3. The five identified polygons over 1000 acres are visible in various shades of blue. The activities polygons associated with the polygons over 1000 acres are displayed in various shades of pink. The lone identified polygon under 1000 acres is shown in red. As expected, this polygon is adjacent to the IRA, satisfying USFS Handbook direction for detecting these smaller areas.

Within the PWA activity feature classes attribute tables the model has dissolved the outputs based on the Activity and Activity Code fields. These two fields describe the type of treatment or action that was accomplished on



Map 3. Potential Wilderness Analysis Tool Products

the ground within these polygons. Additionally, the acres field has been recalculated making valid numbers available for any future analysis.

Discussion

Based on initial testing the model was able to produce the desired products required by Handbook direction. The model identified areas which meet the PWA criteria and organized them with a unique identifier. The proposed PWAs are stored within a standardized file structure on a project-by-project basis. The model was also successful in capturing the datasets used for input and storing them within the model's file structure organized by a logical standard. Having these datasets stored along with the model and the outputs allow the model to be re-run at any time, and the original results to be replicated if any questions arise about processes used in the identification process or with the identified areas at a later date.

Analyzing Map 3 a majority of the large polygons are in fact external to the actual project boundary. This is a result of buffering the project boundary by five miles in an effort to get a more inclusive look at the landscape in the project vicinity. The application of this buffer was suggested by the forest environmental coordinator. The thought process behind broadening the project boundary for the PWA analysis was to attempt to create a more expansive view when identifying PWAs during site specific project analysis. Looking a little beyond the project boundary ensures that PWAs are identified even if they are external to the primary analysis area.

Not every acre of forest is covered by a current site-specific NEPA analysis. The additional margin around the project area boundary not only attempts a more holistic view of the analysis, but also provides incremental progress toward a comprehensive inventory of PWAs for the forest before forest plan revision commences. The sweeping external edge of the buffer is visible on the southeast corner of Map 3 where it overlaps with the existing SMA. As IRAs these areas are likely to have been previously identified as PWAs. The fact the model returned them as selections that met PWA parameters in this initial analysis validates appropriate performance by the model. This also shows that the model may not be able to capture an entire polygon if it extends beyond the buffered project boundary. By identifying at least part of an area that meets PWA definitions, it will become obvious to the model user that additional follow-up is necessary. At this point more investigation can be done to determine how best to evaluate that overall area. If it is decided that entire area should be included as a PWA polygon, the GIS specialist will be able to manually create that feature and include it in the model's outputs. Descriptions of the rationale behind these decisions and the geoprocessing that results because of it should be included in the analysis process documentation for the project.

The next step to verify the analysis is a visual inspection of the products to see if the areas that were identified make sense. Part of this process will be accomplished by presenting the results to members of the

IDT. For the most part, the natural resource specialists who are members of the IDT are not only subject matter experts, but they usually have a lot of time and experience in the field. This familiarity in and around the project area will be used to ground truth the model's output. The IDT will be able to verify the PWAs produced by the model. If the model did not recognize a PWA or they lay just beyond the geographic scope of the model's analysis area, members of the IDT can bring them to the attention of the GIS specialist and environmental coordinator assigned to the team. Missed areas, if any, can be manually captured by the GIS specialist or model thresholds can be adapted to capture these regions for that project.

As a pilot project this model shows great promise as an effective tool for standardizing geoprocessing with respect to this aspect of NEPA project analysis. Natural resource specialists frequently need to run the same or similar resource specific analyses for each NEPA project. Process documentation for these analyses should be present within each specialist report; however many times the details of the actual GIS manipulation are overshadowed or left out in favor of the results.

Within Region 6 much of the GIS work is sourced to a regional data management group within the USFS. The GIS specialists and analysts within this group provide support to projects, as requested, but may not be active members of the IDT unless they are specifically assigned to a given project. Those who provide GIS support are rarely required to provide a specialist's report of their analysis to the IDT for incorporation into the final NEPA document and project record. This lack of written procedures and protocols leaves a potential gap in process documentation which extends to a possible vulnerability in the area of replicability. If, at some point in the future, the project is appealed or undergoes litigation, or if someone is interested in reproducing analysis results, it may be difficult to accomplish for those who are interested in doing so.

Incorporating geospatial models during project analysis will substantially help fill these gaps. The models would be stored on the T drive along with all of the project data, much like the PWA model. For those processes that need to be run for nearly every project, incorporating a model will not only be more efficient, but would result in an output that would be highly replicable, and certainly consistently derived. Anyone within the agency who is familiar with GIS would be able to navigate through the network to the project space, and reproduce the analysis. Additionally, models will provide documentation to those interest groups outside the agency who want to evaluate the analysis that contributes to and informs environmental document decisions.

The PWA model itself could possibly be incorporated to every site-specific project analysis once it is thoroughly proven through more trials. The FWNF is overdue for land management plan revision. If time and budgets allow, plan revision will begin sometime within the next five years and incorporate qualitative analysis of any previously-identified PWAs. At that time questions may arise as to how polygons were identified and what went into determining their selection. If the PWA model is incorporated into current and future NEPA analysis, these plan revision questions will be much simpler to answer. The evaluators will be able to review and assess the input data used at the time, process documentation and results. Additionally, the evaluators will have summarized forest activity data for those same units. Any ground-disturbing activities identified may likely have an effect on the overall evaluation of the PWA. The documentation provided by models allows for these questions to be answered much more simply and in a much more timely fashion than the current practice of tracking down the specialist who did the analysis years before to determine whether or not they remember exactly how and why the results came to be.

Areas for Further Research

Beyond this initial testing there is much more that needs to be done to verify the model's viability. There are several NEPA projects that are currently in analysis on the forest, all of which could be used to put the model through its paces and ensure it is generating accurate output. Glen Westlund, who has provided most of the local forest direction and context for this project, retired earlier this year. The forest does not yet have a permanent replacement to fill his position therefore official testing may have to wait until that gap is filled. Testing can continue, however, as a personal project development can continue outside of NEPA analysis with little chance of being misconstrued as either an agency-sanctioned policy or being adopted as part of a project's official record.

Documentation

An additional resource which needs to be developed for this project is an accompanying document to provide direction, context, and explanation for whoever may use the model. This user guide would need to contain step-by-step directions for moving the PWA folder from its repository to a specific projects folder. The guide would also need to describe which datasets to use and where to obtain them including a brief explanation of the GI and how to use it to generate the most up-to-date forest activities information. The model-specific map document would need to be introduced, as well has how to access the model itself and assign inputs. Instructions would include where to look for outputs and what exactly they represent. Some detail on the model itself would provide necessary context in case any adaptations or adjustments were needed for atypical situations. Much of the guidance could be derived from portions of this report, but I believe more detail and structure for the use of less proficient GIS users would be required.

Further Implementation

If the model proves to be a success overall it could then be implemented as direction for all current and future NEPA projects across the forest. For projects that have already been completed, their manually identified PWAs could be verified against the PWA model's outputs in preparation for forest plan revision. Since there is regional direction for the forests to identify PWAs there is potential applicability beyond local use. Most of the forests in region 6 have similar SMAs and land bases, therefore if the model is successful on the FWNF, it may be possible to expand its application to other forests within the region. The model may need to be adapted to accommodate specific or unusual situations, but it could still give planning teams a leg up toward establishing the use of a model to better existing documentation and increase replicability.

Public Disclosure

In an effort to make corporate and project data more available to the public, many of the forests in Region 6 are teaming with the Region 6 Data Resources Management group in investigating an application to disseminate spatial data. The focus of the study is development of a web interface which will make agency data available through ArcGIS Server. PWAs are a distinctive subject of interest among interest groups and the public in general. Having these features available for viewing on national forest websites would be a simple way to show the public where and how PWAs are identified and could contribute to the scope of process transparency in the agency. There are many developmental hurdles for this project to overcome if the region decides to pursue it, however it could provide a reasonable venue to make the agency's data more widely available to the public.

Wilderness Character

The next logical extension of incorporating GIS models in identifying PWAs, is extending the process to evaluating the Wilderness Character of any PWA during plan revision. At this time the LRMP revision team will assess unique character of previously identified PWAs and decide whether or not these areas should be managed as proposed wilderness areas. At this time the planning group will compare what is known about identified PWAs with guidelines from the USFS Handbook. This type of analysis could be more difficult for GIS to analyze.

Looking at Section 2c of the Wilderness Act the criteria for an area of land having Wilderness Character are hard to measure:

> *(1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;*
>
> *(2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation;*
>
> *(3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition;*
>
> *(4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.*

Aside from the explicit acreage parameters there is little in this direction which can be quantified using GIS as an objective tool. There are many datasets which are available that could be used to help evaluate effects to those criteria. For example, forest activities history within a proposed area could help with an assessment of greater or lesser effect on the "natural" aspects of a unit. The topography and vegetation of an area could potentially heavily influence the feeling of solitude and opportunity for unconfined recreation. Other possible datasets could represent unique natural or historical features and could help shape the team's opinion. If there are consistently datasets identified that may provide some measure of influence on any of these criteria, a GIS model could be created to and summarize the data within each PWA boundary. These evaluations could become referential information used to inform the plan revision team, and the figures could act as a quantitative foundation for justifying team decisions. This would add a systematic framework to analysis which in large part relies on the feelings and interpretations woven together by individual team members. Integrating a GIS model during the evaluation process would, again, add process documentation and increased potential for successful replication of the assessments.

Conclusion

Using a model created with ArcGIS ModelBuilder and Python scripting has shown to be an effective way to standardize analysis processes for USFS NEPA projects. Using corporate datasets the model was able to identify PWAs in and around a chosen project area. The model outputs are named and organized in a logical manner and stored for reference within the project file structure. Additional testing will be completed with the model to ensure it is identifying the appropriate areas. Once it is verified that the model process and output satisfies all quality assurance validation, it will be incorporated into the NEPA project analysis process on the Fremont-Winema National Forest.

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