Fort Stewart Timber Salvage and Recovery Study, and Modeling of Potential Windthrow and Storm Surges Associated with Hurricanes

Final Report

Prepared for:

the Directorate of Public Works
Environmental and Natural Resources Division
Forestry Branch
Fort Stewart / Hunter Army Airfield

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September 30, 2010

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This project was funded the Department of Defense's Forestry Reserve Account, a program overseen by DoD's Natural Resources Conservation Program. For more information, visit http://dodnaturalresources.net/

Summary

This Final Report provides a synopsis and summary of the work that has been developed for the Fort Stewart military installation regarding hurricane risk assessment and modeling efforts. This work was conducted in three phases by personnel from the School of Forestry and Natural Resources at the University of Georgia.

Phase I of this project involved the following:

- A review of the biological responses of forests to hurricanes
- A review of management responses following a hurricane
- A survey of natural resource managers associated with past hurricanes
- Projected hurricane activity along the southern Atlantic and Gulf of Mexico coasts
- A process for assessing forest risk to windthrow and breakage associated with hurricanes

This work was reported previously in the Phase I Final Report (Bettinger et al. 2009a).

Phase II involved working with various departments of the Fort Stewart military installation to develop a Timber Salvage Response Plan. The plan that was developed is included as Appendix A of this report.

Phase III involved modeling potential storm surges, the location of potential wind-related forest damage from user-defined storms, and the optimal paths for clearing debris from the road system. A user's guide for the GIS tool that was developed to locate potential wind-related forest damage from user-defined storms is included in this report. An atlas of potential storm surges (Bettinger et al. 2010b) was provided previously to the Forestry Branch of Fort Stewart. Although the methods for the shortest path determination are too complex for the type of discussion provided here, a summary of the shortest path algorithm is provided in this report.

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1. INTRODUCTION

The location and timing of landfalling hurricanes (Powell and Aberson 2001) is of great interest to the public, yet the frequency, timing, location, and impact of hurricanes are all difficult to predict. The immediate priorities of emergency managers and the general public after a hurricane strike involve human health and safety, the free movement of emergency vehicles, the cleaning up of debris from rights-of-way and major thoroughfares, and the restoration of power (Reinhart and McCreanor 1999). Secondary priorities include an assessment of damage, the salvage of downed or damaged timber, the storage of the salvaged timber, and the impacts of severe wind events on environmentally and socially important resources.

The managers of the forests found on Fort Stewart (located near Savannah, Georgia) are concerned about the potential impacts of hurricanes, given the installation's proximity to the Atlantic Ocean, the resources contained within the installation, and the length of time that has passed since the last direct strike of a major hurricane (over 150 years). In collaboration with the Fort Stewart Forestry Branch, researchers associated with the School of Forestry and Natural Resources at the University of Georgia developed a comprehensive assessment of the following issues:

- Biological responses of forests to hurricanes
- Management responses following a hurricane
- Perceptions of natural resource managers regarding forest damage factors
- Projected hurricane activity along the Georgia coast
- Potential forest damage on Fort Stewart (a risk assessment)

The assessment was provided in what was termed the "Phase I Final Report" of the hurricane projects conducted by the University of Georgia for the Fort Stewart Forestry Branch (Bettinger et al. 2009a). The primary goal of the current report is to provide a synopsis of the work that has been developed for Fort Stewart since then. This work includes the development of a Timber Salvage Response Plan and the acquisition and development of tools for modeling the potential impacts and identifying areas of concern with regard to storm surges, windthrow, or tree breakage.

This report is divided into four main sections, including this brief Introduction, and two appendices.

Section 2 of this report provides an overview of the Timber Salvage Response Plan that was developed as Phase II of the Fort Stewart hurricane projects. This section includes a brief description of the methods that were used to develop the plan and a discussion of future actions that may be necessary to keep the plan current.

Section 3 provides a summary of the modeling effort associated with Phase III of the Fort Stewart hurricane projects. Here, there were two main goals: (a) to acquire the SLOSH storm surge model, assess a wide range of alternatives, and make the model available to the Forestry Branch; and (b) develop tools that will allow one to model the potential wind-related forest damage from user-defined storms, and to model the paths one might take in clearing debris from the road system.

Section 4 summarizes the publications and reports that were generated as a result of all three phases of our work on this project.

Appendix A presents the entire Timber Salvage Response Plan that was developed through this work. This plan should evolve over time as personnel and work processes change within the installation.

Appendix B presents a user's guide for the Hurricane Damage Estimation Tool that was developed within the ArcGIS environment using Python programming code. This tool is actually a set of three tools (scripts) for performing a risk assessment, for modeling winds given a storm track, and for estimating the location of debris that might be deposited on roads or powerlines given the storm track.

2. DEVELOPMENT OF TIMBER SALVAGE RESPONSE PLAN

The potential for hurricanes to cause damage to Fort Stewart and Hunter Army Airfield is relatively high, given the long time period that has passed since the last direct strike of a major hurricane. The main emphasis of the Timber Salvage Response Plan concerns the immediate responses and subsequent implementation of timber salvage operations on the installation. In developing the plan, the *Disaster Response Handbook for State Forestry Agencies* (Southern Group of State Foresters, 2007) was reviewed, as were other internally-developed documents, such as the *Fort Stewart Hurricane Plan*, the *Disaster Emergency Operation Plan* (FS REG 500-3), the *Hurricane Alert and Evaluation Plan* (FS REG 500-3-2), and the *Severe Weather Plan* (FS REG 500-3-3). A number of the closely associated issues contained in these documents are repeated in the Timber Salvage Response Plan that was developed (Appendix A).

The main objectives of this area of work included the following:

- Develop a comprehensive list of timber buyers and loggers, as well as timber mills, within the "emergency" hauling distance of the installation.
- Coordinate with the Cultural Resources Management officials at FS / HAAF to identify restricted areas ("no-go" areas), and to identify areas that can be "pre-cleared" for emergency purposes to allow timber salvage efforts to proceed unimpeded after a storm.
- Coordinate with the Emergency Management Operations officials to develop an exhaustive prioritized list of streets, highways, and roads outside the two main cantonment areas (FS / HAAF) where downed trees need to be removed immediately after a storm.
- Coordinate with the Range Control / Emergency Management Operations officials to develop an exhaustive list of ranges and training areas (including tank trails, primary, and secondary roads) where downed trees will likely need to be removed immediately after a storm.
- Develop a list of Emergency Management Operations field commander Point of Contacts (POCs) and their chain of substitutes.
- Assimilate into a salvage plan the information gained from the above objectives, as well as the hurricane damage study report from Phase I of this study, the *Fort Stewart Hurricane Plan*, (prepared by the Emergency Management Operations office), and the standard operating procedures used by the Forestry Branch for hurricane preparation and recovery.

In the effort to meet these goals, we began the process by meeting with a number of key personnel who work at Fort Stewart, including those inside the Forestry Branch and those associated with DPTMS and other departments on the installation. The contacts outside of the Forestry Branch included:

Fred Cavedo, Chief, Operations and Maintenance Division, DPW.......................912-767-5499
Hank Cochran, Army Corps of Engineers 912-767-7522
Mike Flatt, Chief, Voice Communications Branch, NEC 912-767-0266
Tony Fleeger, Emergency & Contingency Planning Officer, DPTMS 912-767-2583
Amber Franks, Environmental Division (NEPA manager), DPW 912-767-2400
Brian Greer, Environmental Division (Cultural resources), DPW 912-767-0992
Roy Griggs, Range Control, DPTMS..912-435-8164
Keith Janowski, Emergency Management Specialist, DES 912-767-0813
Jessica Leek, Range Control, DPTMS 912-435-8046
Robert Lloyd, Environmental Division (Wetlands), DPW 912-767-9443
Tracy McKinney, LMR Technician, NEC 912-767-6443
Jeff Poulin, Engineering Technician, Safety Officer, DPW....................................912-767-4585
Terri Sungur, Industrial Property Manager, DPW..912-767-5713
George Thomas, Range Control, DPTMS...912-315-6480

The Timber Salvage Response Plan (Appendix A) contains the following sections:

Incident Pre-Planning Emergency Contact Information
1. Local emergency manager (lead contact) and Forestry Branch switch number
2. Trunking radio system coordination
3. Forestry Branch tactical radios
4. Other means of communication
5. Pre-positioning of equipment for debris removal
6. Fuel resources
7. Police and fire coordination during immediate responses to emergencies

Incident Response and Recovery Considerations
1. Debris removal
2. Forest damage assessments
3. Timber salvage
4. Wet decks and ponds designated to store salvaged timber
5. Other permitting or permission issues

Information regarding the location of mills, timber buyers, and loggers within 100 miles of the installation was compiled for timber salvage planning purposes. This data was obtained from information provided by the Georgia Forestry Commission, South Carolina Forestry Commission, Florida Division of Forestry, and the U.S. Army Corps of Engineers. The information was also supplemented with searches of Yellow Pages, TimberMart South databases, and other publications regarding pulp mills in the southeastern United States. Mill locations were verified with a review of 2007 digital orthophotographs (aerial photographs). Other quality control and verification processes were used to ensure that the appropriate spatial location of each feature was identified, that the attributes of the data were complete to the best of our knowledge, and that there were no duplicated features within the databases. Two geographic information systems (GIS) shapefiles (Mills, and Timber buyers / loggers) were developed, and each contains point data representing the location of the mill, or the address of the timber buyer or logger. In cases where addresses were Post Office boxes, the center of the city or town noted in the address was used as the point location. The information in these databases should be considered current as of March 2010.

A draft Memorandum of Agreement for post-hurricane operations in culturally-sensitive areas was developed and provided to Arte Rahn (Forestry Branch). This document is included in the Timber Salvage Response Plan as well (Appendix A).

In order to keep the information contained within the response plan current, these future actions may need to be performed every year or two:

- Contact the key personnel who work at Fort Stewart (noted above) and determine whether responsibilities, priorities, or work processes may have changed that will affect the response actions following a hurricane.
- Assess current status of wood-using mills within the region and develop an updated database.
- Assess current status of loggers and timber buyers within the region and develop an updated database.

The latter two of these three actions may require a significant amount of time (1+ months), since (a) numerous data sources were used in their initial development, (b) the data were georeferenced and placed in a GIS database, and (c) some GIS editing is necessary to verify locations, remove duplicate records, and handle addresses that only are represented by Post Office boxes.

3. MODELING POTENTIAL STORM SURGES AND DEBRIS PROBLEM AREAS

Hurricanes will inevitably affect the forests along the southeastern coastline of the United States, yet as we have suggested, the impact of these storms on forest resources is difficult to predict. To attempt to do so would require an understanding of several factors, including a forest's proximity to the eye of the storm, the local topographic exposure, and other site-specific forest conditions (Merry et al. 2010a). The emphasis of the modeling portion of the Fort Stewart hurricane studies was to enable one to visualize potential hurricane damage to forests, and to assess scenarios based on varying characteristics of a hurricane. At the onset of these projects, there were two main objectives:

- Acquire the SLOSH storm surge model, acquire bathymetry necessary for storm surge modeling, test the SLOSH model under a number of different scenarios, develop a user's guide to the SLOSH model, install the SLOSH model at Fort Stewart, and provide training.
- Develop an ArcGIS extension for hurricane windthrow modeling using Python scripting, develop relationships from the literature (from Phase I of the study) to estimate windthrow potential from storms of varying windspeeds, test the ArcGIS extension against some reasonable scenarios, develop and test a method for optimizing the clean-up path using a shortest path optimization algorithm, develop a user's guide to the ArcGIS extension, install the ArcGIS extension at Fort Stewart, and provide training.

3.1. Storm Surge Modeling

The SLOSH (Sea, Lake and Overland Surges from Hurricanes) model (Taylor 2008) was developed by the National Hurricane Center to enable one to estimate storm surge heights resulting from hurricanes by taking into account atmospheric pressure, storm size, rate of forward speed, maximum wind speeds, and the storm track. In developing estimates of storm surge heights, it is suggested that SLOSH is accurate to within ±20% (e.g., if SLOSH suggests a 10 foot storm surge, it may range from 8 to 12 feet). The National Hurricane Center suggests that SLOSH is best used for understanding the potential maximum storm surges for locations along the coastlines of the United States. As a result, we employed SLOSH to help develop scenarios of storm surge potential for the following:

- Storms of different forward wind speed
- Storms of different intensity (as described by the Saffir-Simpson hurricane wind scale system)
- Storms of different forward direction in relation to Savannah, Georgia

The SLOSH model enables one to estimate maximum storm surge values for specific basins along the coastlines of the United States. Savannah, Georgia was chosen as the point of emphasis for this analysis. In relation to the objectives of this portion of the study, the SLOSH model was obtained, installed at the University of Georgia, and used to develop storm surge maps. Contrary to the original objective, acquiring the bathymetry necessary for storm surge modeling was not necessary. Further, a user's guide for the model was provided by the Federal Emergency Management Agency (2003), thus the development of a new user's guide seemed unnecessary. Due to unforeseen Department of Defense technology policies, we were unable to install the SLOSH model at Fort Stewart. However, we provided the installation code and databases necessary for installation should information technology policies change. A short overview of the modeling system was provided to help the Forestry Branch understand the capabilities of SLOSH. However, there is no need for the Forestry Branch to explore storm surge scenarios, as we have provided a report of all possible scenarios that could be generated from SLOSH (Bettinger et al. 2010b). This report contains maps illustrating the areas potentially vulnerable to inundation from surges of sea water associated with hurricanes arising from the Atlantic Ocean and striking or skirting the Georgia coast near Savannah.

All of the available storm surge outputs appropriate to Fort Stewart and Hunter Army Airfield arising from the SLOSH model have been obtained. SLOSH output is presented as a radiating grid of cells of varying sizes that emanate from the point of emphasis (Savannah, Georgia). An example of this data covering the eastern edge of Fort Stewart is shown in Figure 3.1. SLOSH provides water depths for large grid cells (nearly 1 mile^2 in the Fort Stewart area) after taking into account the topography, bathymetry, and parameters of a potential storm. The water depth provided by a SLOSH simulation is calculated based on the average ground elevation within each grid cell, and the amount of storm surge water estimated to be able to flow into each cell. Therefore, the value (water surface) provided for each grid cell is a combination of the ground elevation and the depth of the water from the surge, and can be viewed as the surface of water above sea level. As noted earlier, SLOSH projections have generally been accurate within ± 20% of peak storm surge values for known hurricanes, based on parameters (intensity, speed) associated with these prior hurricanes.

Ultimately, we used the SLOSH model to assess 130 scenarios (Table 3.1). We developed maps of storm surge vulnerability on Fort Stewart and Hunter Army Airfield by first developing SLOSH estimates for storms striking the Savannah area. Estimates of the water surface from the most westerly SLOSH cells that overlapped the Fort Stewart or Hunter Army Airfield boundaries were determined. Since SLOSH grid cells are quite large, and since the radiating grid does not extend far enough inland to represent all areas inundated, we combined SLOSH estimates with a Digital Elevation Model (DEM) to suggest which areas of Fort Stewart and Hunter Army Airfield might be vulnerable to flooding from storm surges associated with hurricanes, given the subtle topography of the area. Grid cells of an elevation equal to or lower than the average water surface value for a particular storm condition were selected from the DEM, combined, and buffered slightly (to remove problems related to inconsistencies in the DEM elevations). The resulting maps illustrate the areas potentially vulnerable to storm surge flooding (Figure 3.2).

Table 3.1. An overview of the storm surge scenarios developed for Fort Stewart and Hunter Army Airfield (Bettinger et al. 2010b).

Storm direction in relation to Savannah	Saffir-Simpson storm categories	Forward wind speed ranges	Total scenarios
North	5	4	20
Northeast	5	4	20
North-Northeast	5	4	20
North-Northwest	5	4	20
Northwest	5	4	20
West	5	3	15
West-Northwest	5	3	15

3.2. Identification of Debris Problem Areas

A literature review was conducted on the modeling approaches for assessing wind-related impacts on forests (Merry et al. 2010a). Following the completion of the review, we obtained the ForestGALES model (Gardiner et al. 2006) from the U.K. Forestry Commission, as it was the most frequently cited in the literature as a hurricane model focusing on stand data. The ForestGALES model estimates the probability of breakage and windthrow based on tree species. Also, it models the probability of average quality trees being damaged. This model may have served as the basis for the development of a new model appropriate for Fort Stewart but was not suitable for the region. ForestGALES uses species-specific tree-pull data as input into the modeling process that we were not able to obtain for species common to Fort Stewart. Therefore, we developed our model independently of the ForestGALES methodology.

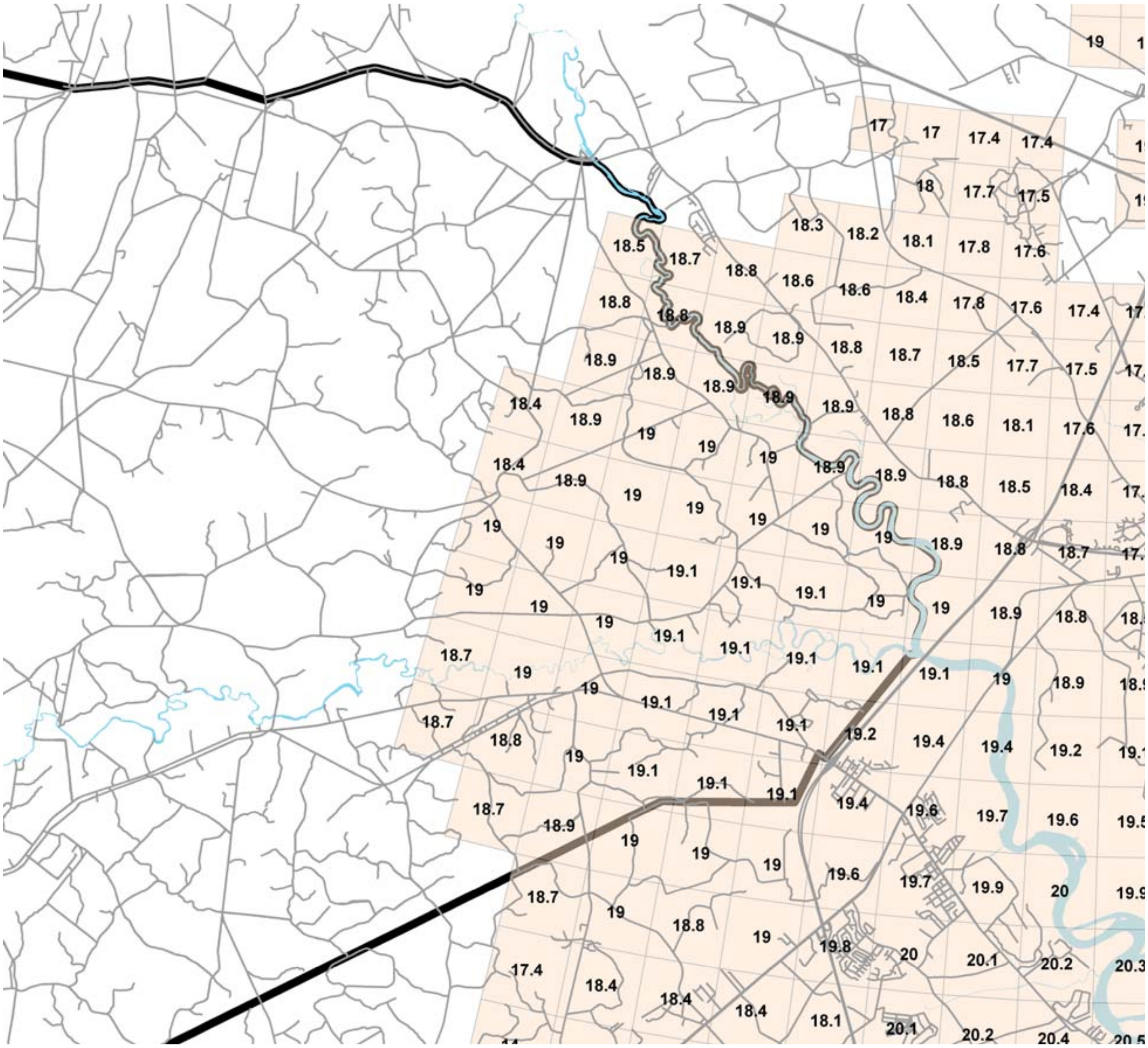

Figure 3.1. Storm surge (water surface, feet) estimates for the eastern portion of Fort Stewart from one SLOSH analysis.

The model we developed for identifying debris problem areas along roads and powerlines was programmed using the Python programming code, and developed for use in ArcGIS. Data inputs for the model are similar to those used in the initial risk assessment (Bettinger et al. 2009a), which has since been automated in ArcGIS. They include raster data sets describing stand characteristics, and climate data such as wind speed, radius of maximum wind speed, and storm forward direction. Following the completion of the programming of the model, we debugged the model using various hypothetical storm tracks. The debugging process included running multiple hypothetical hurricane damage simulations on various computers. We have automated the risk assessment process, the user-defined storm track with wind climate data, and identified areas of potential debris problems into a toolbox within ArcGIS. The tool allows the user to choose a shapefile (GIS database) containing attributes that describe the characteristics of the forest, including stand heights, average diameters, taper, dominant tree species, and soil characteristics. Once the user identifies all of the required databases, a risk assessment is

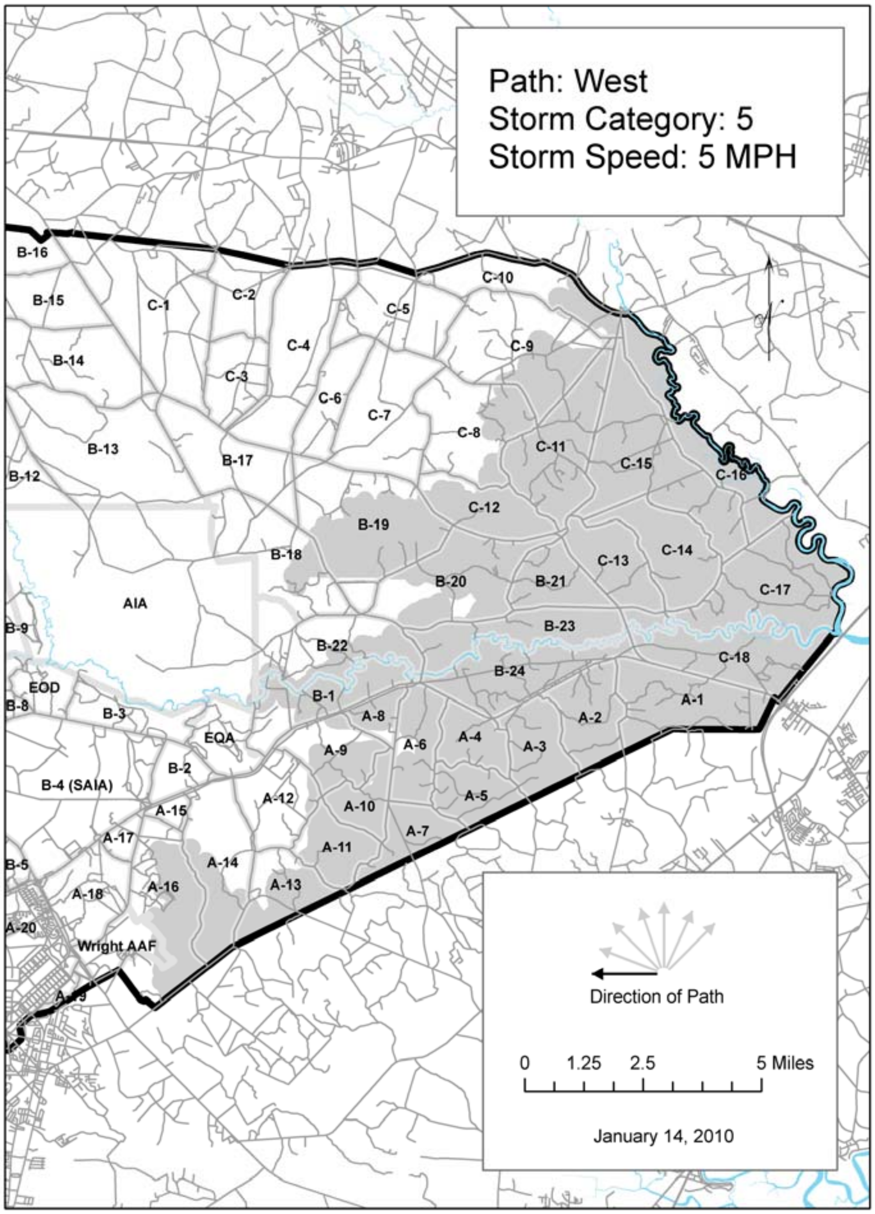

Figure 3.2. Storm surge area of concern on Fort Stewart for a Category 5 hurricane traveling west at 5 miles per hour.

performed which illustrates each stand's potential susceptibility to windthrow or breakage during a hurricane. A brief description of the Hurricane Damage Estimation Toolbox is provided here with a more thorough discussion of its functionality provided in Appendix B.

The Hurricane Damage Estimation Tool has three stages:

Stage 1. An automated risk assessment process. The methodology for developing the necessary input files for input into the risk assessment tool can be found in Bettinger et al. (2009a).

Stage 2. Operation of the StormTrack script. This script incorporates a user-drawn storm track that is then populated with information on hurricane characteristics, including wind speed, radius of maximum winds, and Saffir-Simpson storm category. The “StormTrack” portion of the tool incorporates tree heights from the risk assessment in combination with hurricane attributes, roads, and powerlines to identify areas that could potentially be considered debris problem areas. The model calculates the azimuth of the storm track and adds this field (and value) to the storm track shapefile. The radius of maximum winds (Figure 3.3) is used to derive the area within some proximity to the storm track that will result in tree damage from all wind directions. This assumption was derived from the literature, which suggested that trees within this radius of maximum winds will be subjected to the highest windspeeds from all directions. The average distance from the eye of the storm to where 50 knot (kt) winds will occur is then determined, since beyond the radius of maximum winds, trees may still be damaged in areas where winds are greater than 50 kt. The 50 kt radius winds were selected as a cut-off for tree damage because 50 kt winds are the most comparable (in the historical data) to the lowest windspeed necessary for tree damage to occur (67 mph). The relationship between the radius of maximum winds and the radius of damaging winds was developed for each storm category using linear regression analyses of historical data. This extra distance (beyond the radius of maximum winds) is used to set the extent of where damage will occur to forests, yet in a directional mode based on the prevailing winds.

Stage 3. A determination of the distance from the storm track to each "open area" grid cell and decide whether debris will fall in this cell. The Euclidean distance and direction out from the storm track is derived for each area of land (grid cell). This is necessary to make assumptions about the wind direction in relationship to the storm as well as the direction of blowdown of forested stands. Within ArcGIS, Euclidean direction is assessed using the derived direction toward the storm track. Following the processing of the Euclidean distance and direction, the model uses the user-defined roads, powerlines, and tree height GIS databases to determine where open areas exist.

In processing these shapefiles, they are converted from vector to raster databases. These three raster datasets are then combined into one "open area" database containing both the tree heights of forested stands and the open areas. Changes in tree height are then assessed within a pre-defined distance of each grid cell. Using the storm track azimuth, the information in the open area database, and the prevailing wind direction, the model determines which open areas are susceptible to having debris deposited on them from windthrown or broken trees (Figure 3.4). This is an important assessment that will aid in identifying roads, powerlines, and training areas that will require debris removal following a severe storm.

Although the ArcGIS tool can add value to a risk assessment process, there are areas for improvement and opportunities for future research endeavors. For example, an accuracy assessment could be performed with the resulting information from the risk assessment in order to improve (perhaps) the tool's performance in identifying areas that are more likely to be damaged from a severe storm. Additionally, output from the Hurricane Damage Estimation Toolbox is only an estimation of areas (roads and powerlines) likely to contain tree-related debris after a severe storm. An accuracy assessment using historical information from a specific storm, and the location of debris it produced seems possible. One developmental limitation to the model is that it is site-specific and developed only to assess risks within a 100 mile radius of Fort Stewart. Any storm tracks that are drawn within this 100-mile extent can be processed using the Hurricane Damage Estimation Tool. However, if a storm track falls entirely outside

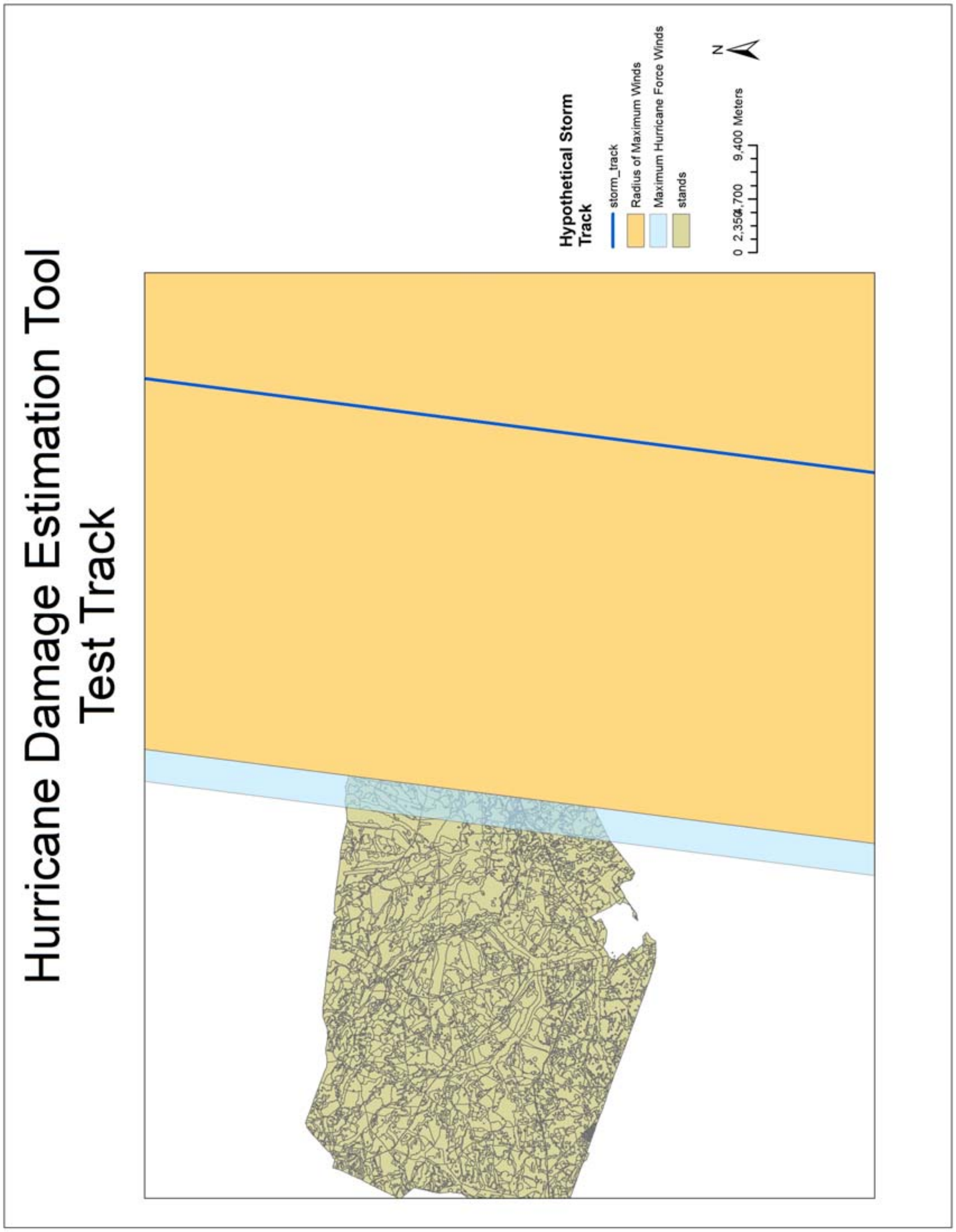

Figure 3.3. Storm track, radius of maximum winds, and other areas where winds may damage trees, for a storm that runs north, on the eastern edge of Fort Stewart.

the 100 mile radius, the model will report that an error has occurred. Further, with newer versions of ArcGIS, the Hurricane Damage Estimation Toolbox may need to be updated if the new software is incapable of supporting the tool. Finally, making the Hurricane Damage Estimation Tool a stand-alone model that can work outside of the ArcGIS environment would make it more easily transferable to other areas as well as more easily disseminated to other forestry management agencies.

As with the storm surge analysis goal, due to unforeseen Department of Defense technology policies, we were unable to install the ArcGIS tool at Fort Stewart. However, we provided the installation code and databases necessary for installation should Fort Stewart staff wish to install the tool at some future date. A short overview of the modeling system was provided to help the Forestry Branch understand the capabilities of ArcGIS storm debris modeling tool.

3.3. Shortest Path Analysis of Debris Clean-up Options

The need for efficient disaster recovery through emergency logistics is a challenging area of interest to academics and land managers. In the hours and days after the occurrence of a natural disaster, communication systems will be taxed and relief demand information will be uncertain and difficult to predict ahead of time. In informal discussions with forest land managers, the likelihood of arbitrary resource allocation decisions is high due to the unpredictable nature of the recovery problem, however coordination of logistics by way of an optimization system may provide guidance to critical recovery processes. The goal of this part of the project was to find a way to minimize the time required to clear all of the storm-affected roads. This needs to be accomplished by clearing (opening up) roads based on their priority, with main arteries first and the remaining roads later.

Node routing problems are those where vehicles (or people) need to visit a set of sites (nodes) within a network with the objective of minimizing the total cost or total time required to do so. Arc routing problems are different, in that vehicles need to service the demand that occurs along the arcs (roads) within a network. The Capacitated Chinese Postman Problem (CCPP) is one example where the demands on arcs of a network need to be serviced by fixed capacity vehicles with the objective of minimizing the total cost. CCPP problems are known to be NP-hard (Assad et al. 1987). If the capacity restriction on the vehicles does not play a role in the problem (i.e., when the constraint is not recognized) the problem reduces to the Chinese Postman Problem (CPP). In cases where only a subset of the arcs (roads) require service, thus where some arc loads are zero (no debris on roads, in our case), these problems become a Capacitated Arc Routing Problem (CARP). Special cases of CARP include the traveling salesman problem and the vehicle routing problem (Assad et al. 1987).

In real-life natural disaster cases, it is doubtful that the resulting network is a directed graph. For example, some roads will only be traversed once, since it is assumed that it only takes one pass of a crew to clear a road of tree-related debris. Some roads (dead ends) will be traversed twice, with different demands placed on each pass. Some roads may be traversed more than twice, if a crew needs to move across cleared roads (i.e., deadhead) to access higher-priority uncleared roads in other areas. In addition, the shortest path from the last road cleared to the starting point (the equipment staging area) is not important; clearing all of the roads quickly, and in order of priority is the most important task. Ultimately, the network is not a completed circuit, and thus not a Euler circuit of the original network because we likely will fail to find a one-to-one correspondence between edges (roads) in the original tree graph and the edges (roads) in the final pseudotree model (e.g., there may be deadheading and other issues previously mentioned in the response plan).

The storm-related debris cleaning problem is difficult to solve for other reasons, such as the presence of dead-end roads, which are common occurrences in forested settings. Scheduling the clearing of a path to the end of a road can be accomplished. An understanding that a crew is at the end of a road can also be obtained, as can an understanding that a crew needs to return back from the dead-end. Some logic needed to be incorporated into the model to prevent the return of crews down dead-end roads once they have been cleared.

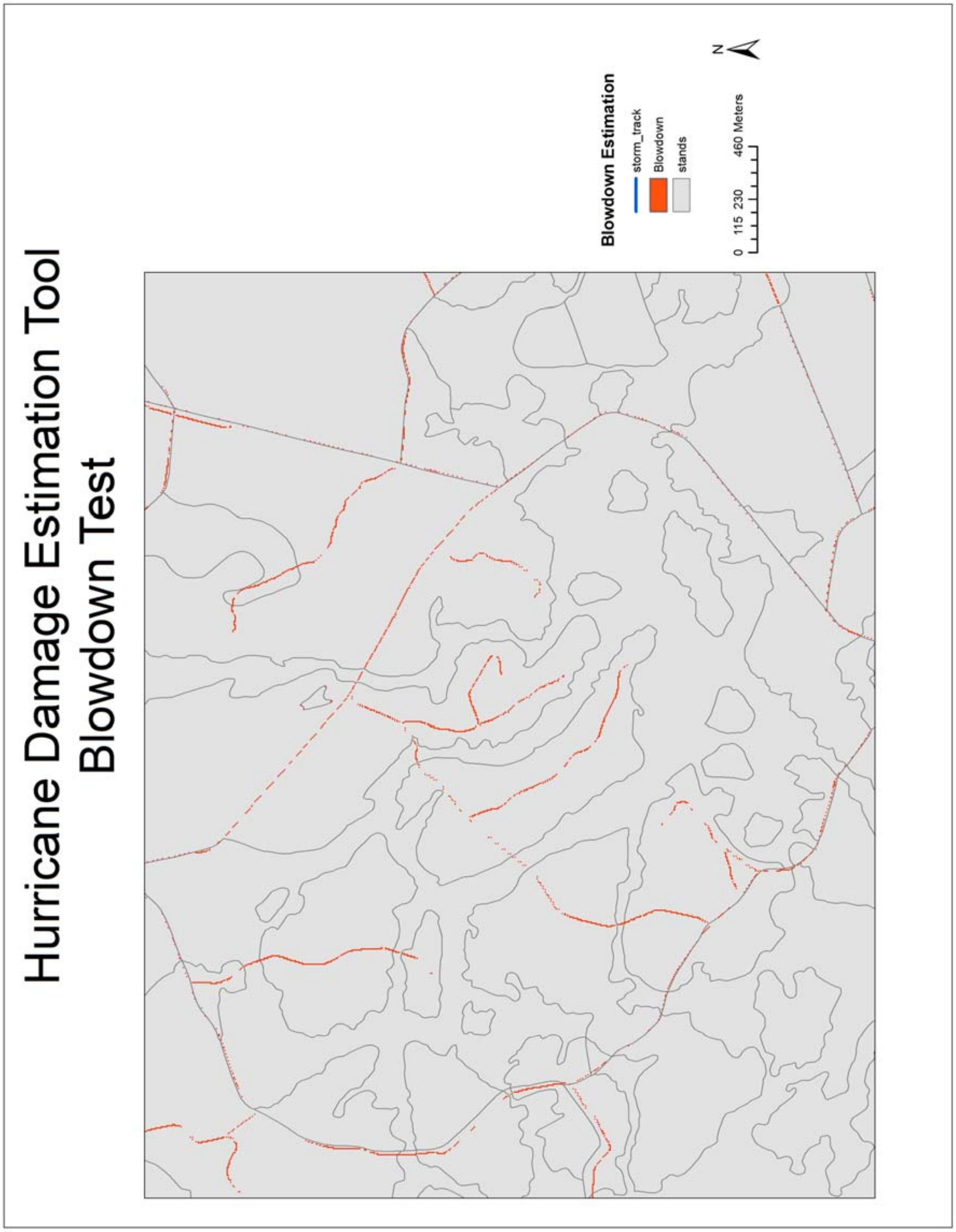

Figure 3.4. Areas (roads or powerlines) where storm-related debris might be located after a severe wind storm (red grid cells).

This model was developed and delivered to the Forestry Branch on September 26, 2010. The model was developed using Visual Basic 6.0, and the uncompiled version can be edited and enhanced by the Department of Defense, should they choose to do so.

Some broad assumptions of the current, completed modeling effort include the following:

- All roads need to be cleared of windthrow or tree breakage. The storm was indiscriminant in determining which roads received debris. Future work might involve transforming the solution process into a CARP problem, where some roads need to be cleared, while others might not.
- A priority list of roads needs to be developed prior to the arrival of the storm. Assigning them all the same priority will work within the model, but does not seem realistic. In conjunction with this issue, the shortest, cleared path to the next highest priority roads needs to be determined as the route to travel to begin the next job of road clearing.
- All roads will be cleared using the same type of equipment and processes. At this time, the ability to define different rates of productivity for different types of equipment and crews has not been built into the model.
- The crews will leave from a pre-designated staging area. The node within the road network that defines the starting point needs to be defined. An examination of the GIS data will therefore be required to determine this location.
- There is no need to track the movement of crews back to the pre-designated staging area. They simply need to clear all of the roads of tree debris. The goal is to clear the roads as soon as possible.
- The crews will neither break down nor get stuck. Processes for accounting for delays or unforeseen problems are not recognized, nor incorporated into, in the model.
- Other than the road clearing equipment, there is no other traffic on the road system to impede progress.
- The amount of debris falling onto roads is constant, although in reality it will be based on the characteristics of the neighboring forests. A closer association with the roads identified as needing to be cleared (from the output from the model in Section 3.2) may be helpful to emergency managers. However, if through a rapid assessment of damage, the actual roads to be cleared are identified, the problem becomes a CARP problem (where some roads need to be cleared and others do not), which is not currently facilitated by the model.

The following three areas of enhancement will be made to the model:

1. In the preparation stages for an imminent hurricane strike, equipment for clearing roads and powerlines will likely be pre-positioned within an organization. This presents a situation where multiple crews will originate from perhaps a central location, and therefore the chance that multiple crews will be working on the same road at the same time is high (at least in the beginning stages of recovery), and thus needs to be tracked in a modeling effort. Since crews are unable to advance beyond others working on the same road, it seems logical that both the day, and the time of day in which they are scheduled to be working or travelling on a particular road segment needs to be assessed. Further, the number of crews who are allowed to work on the same road at the same time may be limited, causing the progress of some crews to be delayed until un-cleared paths are available for them to work.

2. Since roads need to be cleared based on their priority, further investigation into the distinction between levels of priority seems necessary. For example, assume a crew completes work on a priority 1 road system that led to the boundary of an ownership or jurisdiction. A priority-based rule would suggest that they be directed to the next set of high-priority roads (priority 2 roads, for example) which may only be available many miles away. However, lower-priority roads (priority 3 roads, for example) that are closer to where their work was recently completed might be available for clearance.

3. Multiple crews working on the same road need to be tracked, and the optimal path re-adjusted to reflect coordinated work efforts. Because of the intricacies of the hurricane damage response

problem, heuristic methods would seem to be a logical choice for obtaining near-optimal solutions in this case. Bodin and Kursh (1978) described two general heuristic approaches. A "route-first, cluster second" approach would be used to find the most efficient route for the entire network (a CPP problem), then subdivide the network into *N* routes, one for each of the *N* crews involved in the hurricane response effort. A "cluster-first, route-second" approach would be used to define a subset of arcs to assign to each crew, and then to find the most efficient of the non-intersecting subsets. A number of approaches to the multiple-crew snow plow problem divide the road network *a priori* and solve for each subgraph independently of the other(s) (e.g. Robinson et al. 1990, Atkins et al. 1990).

The current version of the shortest path algorithm (ClearPath) was provided to the Fort Stewart Forestry Branch in September 2010. The model requires a user to develop a comma-delimited text file containing the following items (as input) in the following order, with one road segment per line:

Arc number (unique road numbers in sequential order with no skipped numbers)
Road name (text containing road names, all within quotes)
Road length
From-node (some skipped node numbers are permissible, since not all nodes are used as from-nodes)
To-node (some skipped node numbers are permissible, since not all nodes are used as from-nodes)
Road priority (1 is the highest priority)

The model has the following qualities:

- It uses the length of roads as the path value.
- It understands the "lost" condition. When no more nearby roads are available to clear, it finds a path from the "lost" condition to the nearest uncleared, next priority road.
- It backtracks from dead-end roads.
- It ignores missing node numbers.
- It schedules roads based on road priority.

The current version of the model has the following caveats:

- The starting node needs to be a road that has priority equal to 1 (highest priority).
- There is a minor problem with roads within a loop. The algorithm may bypass these roads and schedule others first.

While the larger project has ended, future work with the shortest path modeling effort will continue, and a paper describing the algorithm will be developed and submitted for publication in a peer-reviewed journal.

4. CONCLUSIONS

After the passage of a severe wind storm, and after the immediate priorities have been attended to (those related to health and human safety, power, and access), a forestry organization should assess the damage to their resources, determine how to salvage downed or damaged timber, determine whether to storage the salvaged timber in ponds or wet decks, and examine the impacts on environmentally and socially important resources. The Fort Stewart Forestry Branch is concerned about these issues, and through the three phases of this project we hope we have met the needs of the Forestry Branch as they consider potential impacts of severe wind storms on the forest resources of the installation. From the three phases of the Fort Stewart hurricane projects we generated a number of products that were made available to the Forestry Stewart Forestry Branch. These included:

- A risk assessment based on forest characteristics (contained in the Phase I final report).
- An annotated bibliography of the current research on wind damage to forests.
- GIS shapefiles depicting the locations of mills, timber buyers, and loggers within 100 miles of the installation.
- Maps showing potential storm surges of concern to Fort Stewart and Hunter Army Airfield (either contained in the Bettinger et al. (2010b) publication, or available through an HTML document to allow access to individual PDFs).
- An ArcGIS tool for assessing the roads and powerlines on which trees will likely fall given a user-defined wind storm.
- A Visual Basic shortest path algorithm for debris removal along roads.

4.1 Deliverables Specific to Each of the Project Objectives

During Phase I there were five main project objectives. Phase II had two main project objectives, and Phase III had three main project objectives. The objectives and deliverables (noted as bulleted items) associated with each phase of the project are listed below.

<u>Phase I, Objective 1: A review of biological responses of forests to hurricanes.</u>

- Phase I Final Report (Bettinger et al 2009a).
- Merry, K., P. Bettinger, and J. Hepinstall. 2009a. Physical and biological responses of forests to tropical cyclones affecting the United States Atlantic Ocean and Gulf of Mexico coasts. American Journal of Environmental Sciences. 5(1): 16-32.
- Merry, K.L., P. Bettinger, and J. Hepinstall. 2009b. Annotated bibliography of hurricane-related publications of interest to land managers of forests of the southern United States. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 63 p.

<u>Phase I, Objective 2: A review of management responses following a hurricane.</u>

- Phase I Final Report (Bettinger et al 2009a).
- Bettinger, P., K.L. Merry, and J. Hepinstall. 2009b. Post-hurricane forest management responses in the southern United States. Journal of Emergency Management. 7(6): 35-50.

<u>Phase I, Objective 3: Surveys of natural resource managers associated with past hurricanes.</u>

- Phase I Final Report (Bettinger et al 2009a).
- Bettinger, P., K.L. Merry, and D.L. Grebner. 2010a. Two views of the impact of strong wind events on forests of the southern United States. Southeastern Geographer. 50(3): 291-304.
- Merry, K.L., P. Bettinger, D.L. Grebner, and J. Hepinstall-Cymerman. 2010b. Perceptions of foresters of wind damage in Mississippi forests. Southern Journal of Applied Forestry. 34(3): 124-130.

<u>Phase I, Objective 4: Projected hurricane activity along the southern Atlantic and Gulf of Mexico coasts.</u>

- Phase I Final Report (Bettinger et al 2009a).

- Bettinger, P., K.L. Merry, and J. Hepinstall. 2009c. Average tropical cyclone intensity along the Georgia, Alabama, Mississippi, and north Florida coasts. Southeastern Geographer. 49(1): 49-66.
- Bettinger, P. 2010a. Intensity of tropical cyclones along portions of the southeastern U.S. coasts. In Merry, K., P. Bettinger, J. Hepinstall-Cymerman, J. Fan, J. Siry, J. Kushla, T. Litts, and B. Song (eds.), Proceedings of the 7th Southern Forestry and Natural Resources GIS Conference. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. pp. 54-57.

Phase I, Objective 5: A process for assessing forest risk to windthrow and breakage associated with hurricanes.

- Phase I Final Report (Bettinger et al 2009a).

Phase II, Objective 1: Develop GIS databases of mills, loggers, and timber buyers.

- *Mills.shp* (current as of March 2010).
- *Timber_buyers.shp* (current as of March 2010).

Phase II, Objective 2: Assist in the development of a timber salvage response plan.

- Timber Salvage Response Plan (Bettinger 2010b).
- Section 2 and Appendix A of the Phase II/III Final Report (Bettinger et al. 2010c - this report).

Phase III, Objective 1: Modeling potential storm surges.

- Bettinger, P., K.L. Merry, and J. Hepinstall-Cymerman. 2010b. Potential storm surges of concern to Fort Stewart and Hunter Army Airfield. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 260 p.
- Section 3.1 of the Phase II/III Final Report (Bettinger et al. 2010c - this report).

Phase III, Objective 2: Development of a model to determine the location of potential wind-related forest damage from user-defined storms.

- *Hurricane Damage Estimation Tool* (computer program for use in ArcGIS).
- Section 3.2 and Appendix B of the Phase II/III Final Report (Bettinger et al. 2010c - this report).
- Merry, K., P. Bettinger, and J. Hepinstall-Cymerman. 2010a. Modeling forest damage from hurricanes. In Merry, K., P. Bettinger, J. Hepinstall-Cymerman, J. Fan, J. Siry, J. Kushla, T. Litts, and B. Song (eds.), Proceedings of the 7th Southern Forestry and Natural Resources GIS Conference. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. pp. 58-73.

Phase III, Objective 3: Development of a model for locating optimal paths for clearing debris from the road system.

- *ClearPath* model (a Visual Basic 6.0 program).
- Section 3.3 of the Phase II/III Final Report (Bettinger et al. 2010c - this report).

4.2 Deliverables Categorized

The following categorized list represents the peer-reviewed research from the three phases of the project, other publications that were generated, presentations we made highlighting various aspects of the work, software and databases developed, and a continuing education course that was developed based on the entire body of work.

Peer-reviewed journal articles

Bettinger, P., K.L. Merry, and D.L. Grebner. 2010a. Two views of the impact of strong wind events on forests of the southern United States. Southeastern Geographer. 50(3): 291-304.

Bettinger, P., K.L. Merry, and J. Hepinstall. 2009b. Post-hurricane forest management responses in the southern United States. Journal of Emergency Management. 7(6): 35-50.

Bettinger, P., K.L. Merry, and J. Hepinstall. 2009c. Average tropical cyclone intensity along the Georgia, Alabama, Mississippi, and north Florida coasts. Southeastern Geographer. 49(1): 49-66.
Merry, K., P. Bettinger, and J. Hepinstall. 2009a. Physical and biological responses of forests to tropical cyclones affecting the United States Atlantic Ocean and Gulf of Mexico coasts. American Journal of Environmental Sciences. 5(1): 16-32.
Merry, K.L., P. Bettinger, D.L. Grebner, and J. Hepinstall-Cymerman. 2010b. Perceptions of foresters of wind damage in Mississippi forests. Southern Journal of Applied Forestry. 34(3): 124-130.

Other publications

Bettinger, P. 2010a. Intensity of tropical cyclones along portions of the southeastern U.S. coasts. In Merry, K., P. Bettinger, J. Hepinstall-Cymerman, J. Fan, J. Siry, J. Kushla, T. Litts, and B. Song (eds.), Proceedings of the 7th Southern Forestry and Natural Resources GIS Conference. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. pp. 54-57.
Bettinger, P. 2010b. Timber salvage response plan (Prepared for the Fort Stewart military installation). Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 26 p.
Bettinger, P., J. Hepinstall-Cymerman, and K. Merry. 2009a. Hurricane damage to forests at Fort Stewart, Georgia, Final Report. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 126 p.
Bettinger, P., K.L. Merry, and J. Hepinstall-Cymerman. 2010b. Potential storm surges of concern to Fort Stewart and Hunter Army Airfield. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 260 p.
Bettinger, P., K.L. Merry, and J. Hepinstall-Cymerman. 2010c. Fort Stewart timber salvage and recovery study, and modeling of potential windthrow and storm surges associated with hurricanes. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 57 p.
Merry, K.L., P. Bettinger, and J. Hepinstall. 2009b. Annotated bibliography of hurricane-related publications of interest to land managers of forests of the southern United States. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 63 p.
Merry, K., P. Bettinger, and J. Hepinstall-Cymerman. 2010a. Modeling forest damage from hurricanes. In Merry, K., P. Bettinger, J. Hepinstall-Cymerman, J. Fan, J. Siry, J. Kushla, T. Litts, and B. Song (eds.), Proceedings of the 7th Southern Forestry and Natural Resources GIS Conference. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. pp. 58-73.

Presentations at conferences

Bettinger, P. Average tropical cyclone intensity along the Georgia, Alabama, Mississippi, and north Florida coasts. 7th Southern Forestry and Natural Resources GIS Conference. Athens, GA. December 8, 2009.
Bettinger, P. Disaster planning: Preparing for known and unknown risks. Fast Forestry for Slow Markets: A Commercial Forestry Seminar. Forsyth, GA. November 18, 2009.
Merry, K. Modeling forest damage from hurricanes. 7th Southern Forestry and Natural Resources GIS Conference. Athens, GA. December 8, 2009.

Software

ClearPath (A Visual Basic 6.0 computer program for locating shortest paths for debris removal).
Hurricane Damage Estimation Tool (An ArcGIS tool for hurricane risk assessment, storm track wind assessment, and identification of potential debris locations)

GIS Databases

Mills.shp (A shapefile noting the locations of wood-using mills within 100 miles of Fort Stewart).
Timber_buyers.shp (A shapefile noting the locations of loggers and timber buyers within 100 miles of Fort Stewart).

Continuing education courses

Bettinger, P. 2010. Forests and Hurricanes: Impacts and Planning Considerations. University of Georgia, Athens, GA. July 22, 2010. (4.0 Category 1 Society of American Foresters continuing forestry education (CFE) credits).

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Bettinger, P. 2010b. Timber salvage response plan (Prepared for the Fort Stewart military installation). Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 26 p.

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Bettinger, P., K.L. Merry, and J. Hepinstall. 2009b. Post-hurricane forest management responses in the southern United States. Journal of Emergency Management. 7(6): 35-50.

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Bettinger, P., K.L. Merry, and J. Hepinstall-Cymerman. 2010b. Potential storm surges of concern to Fort Stewart and Hunter Army Airfield. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 260 p.

Bettinger, P., K.L. Merry, and J. Hepinstall-Cymerman. 2010c. Fort Stewart timber salvage and recovery study, and modeling of potential windthrow and storm surges associated with hurricanes. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 57 p.

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Merry, K.L., P. Bettinger, D.L. Grebner, and J. Hepinstall-Cymerman. 2010b. Perceptions of foresters of wind damage in Mississippi forests. Southern Journal of Applied Forestry. 34(3): 124-130.

Merry, K.L., P. Bettinger, and J. Hepinstall. 2009b. Annotated bibliography of hurricane-related publications of interest to land managers of forests of the southern United States. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. 63 p.

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APPENDIX A: TIMBER SALVAGE RESPONSE PLAN

This appendix pages contains the main body of the Timber Salvage Response Plan. The appendices of the Timber Salvage Response Plan have been removed to save space, however the full document has been provided to the Fort Stewart Forestry Branch in September 2010.

Timber Salvage Response Plan

Preface

The potential for severe wind events, such as hurricanes, to cause damage to Fort Stewart and Hunter Army Airfield is relatively high. The intent of this Timber Salvage Response Plan (hereafter called the "Plan") is to provide the Fort Stewart Forestry Branch direction in preparing for, and responding to, severe wind events.

The main emphasis of this Plan relates to immediate responses to severe wind event (e.g., hurricane) damage, and subsequent implementation of timber salvage operations within the Fort Stewart / Hunter Army Airfield installation.

The Forestry Branch should keep in mind that planning for responses to severe wind events is a continual process, and that this Plan should be adjusted and updated as time passes.

Communication within a group and among cooperating groups is critical for planning and response activities. Therefore, this Plan should contain a list of relevant communication channels among emergency management personnel.

Much of the information contained within this Plan is modeled after the *Disaster Response Handbook for State Forestry Agencies* (Southern Group of State Foresters, 2007).

This Plan is consistent with the *Fort Stewart Hurricane Plan*, which outlines the Standard Operating Procedures for preparation and response to hurricanes. However, this Plan provides more detail than the *Fort Stewart Hurricane Plan* where the implementation of timber salvage, wet storage of timber, and debris removal activities are concerned.

In addition, this plan is consistent with:

FS REG 500-3	Disaster Emergency Operation Plan
FS REG 500-3-2	Hurricane Alert and Evaluation Plan
FS REG 500-3-3	Severe Weather Plan

Some of the closely associated issues contained in these policies are repeated in this Plan.

We are hopeful that this Plan is applicable to the needs of the Fort Stewart Forestry Branch, and that effective communication can be achieved to avoid any misunderstandings, delays, or duplications of effort.

Timber Salvage Response Plan

I. SITUATION. This Plan is in accordance with DPW requirements and subservient to FS Regulation 500-2. FS Regulation 500-2 can be downloaded from the Fort Stewart Intranet at:

http://www.stewart.army.mil/IMA/sites/directorates/DMWR/acs/Files%20For%20Download/FS%20Reg%20500-2r,%20Hurricane%20Evacuation.doc

This Plan has been developed to assist the Forestry Branch with preparing for timber salvage issues in response to severe wind events, and describes how to respond in the days, weeks, and months following a destructive storm.

II. MISSION. Efficient and effective response to debris clearing activities after a severe wind event, and to the utilization of damaged timber in order to minimize lost revenues, the threat of fire, and other threats to safety.

III. EXECUTION.

A. Concept of the Operation

FS Hurricane Emergency Contact: Garrison Commander
Phone: 912-767-8606

After a severe wind event, when the "All Clear" is given, co-directors of recovery / clean-up operations are the Fire Chief and the DPW Recovery/Clean-up Director as assigned during or after each storm. All recovery and clean-up efforts will be coordinated via telephone and FS trunking radio system. Some trunking channels may be temporarily reassigned by NEC during the emergency situation.

Forestry personnel may be released or evacuated as conditions and requirements progress through each storm according to FS 500-2. The Chief Forester will notify Forestry Branch personnel of support work needs, releases, and evacuations.

The Forestry Branch will utilize the ICS to coordinate its efforts with regard to hurricane preparedness and response.

Standard Operating Procedures for the Forestry Branch (the "Forestry Branch Hurricane Plan") have been previously developed. This Plan relates to issues specific to timber salvage and debris removal as they pertain to the need for immediately clearing roads and powerlines, and the need for a longer-term timber salvage effort. Therefore, this Plan addresses the need of Section III, Part B, Sub-part 2 (e) of the Forestry Branch Hurricane Plan.

B. Incident Pre-Planning Emergency Contact Information

1) Local emergency manager (lead contact) and Forestry Branch switch number

<u>Local emergency manager</u>

Points of contact can change over time. The main contact for the command structure for responding to a severe storm event is:

FS Contact: Engineering Technician, Safety Officer, DPW (2010: Jeff Poulin)
Phone: 912-767-4585

<u>Main switch number for the Forestry Branch</u>

Phone: 912-435-8030
Fax: 912-435-8025

2) Trunking radio system coordination

In accordance with Appendix G-4 of the Fort Stewart Disaster Emergency Operation Plan (500-3), trunked radios have the following characteristics:

a. All radios will be programmed with Army Common (A Channel 16). This talk-group is to be used when groups or organizations have a requirement to talk and do not have access to each other's talk-groups.

b. All radios will be programmed with an Announcement talk-group that can be keyed by the Dispatch Center and will override all conversations. This was designed to announce tornadoes, disasters, etc.

c. Emergency Service trunked radios will be programmed with Channel 6, TAC4. When called to a scene, all emergency services should use this channel.

d. Point-to-point frequencies will be programmed for unit / organization use. This will be a back-up communication for the unit / organization.

- Point-to-point frequencies have been developed and programmed into most of the Motorola XTS 3000 radios. These frequencies have a range of up to 2 miles, depending on weather conditions and terrain. The frequencies are located on B Channel 1 and 2, and in some cases also Channels 3 and 4.
- Specific frequencies have been designated for use at Fort Stewart and separate frequencies have been designated for use at Hunter Army Airfield. Personnel that work at both locations will have all four channels available.
- Model II and III radios, which have an LED screen, will allow users to identify the frequencies. In general, they are named Disaster 1 and 2.
- The point-to-point frequencies should be used as much as possible when communicating internally and within the 2 mile range. This allows communications outside of the trunking system and will help alleviate radio traffic problems.

For current information on the frequencies for trunking operating channels, the programming of radios, and troubleshooting issues, contact the "Trunk Radio Site Operator", or:

FS Contact: Chief, Voice Communications Branch, NEC (2010: Mike Flatt)
Phone: 912-767-0266

FS Contact: LMR Technician, NEC (2010: Tracy McKinney)
Phone: 912-767-6443

The DPW determines the radios and channels provided to the Forestry Branch.

FS Contact: Chief, Operations and Maintenance Division, DPW (2010: Fred Cavedo)
Phone: 912-767-5499

3) Forestry Branch tactical radios

Radios that do not use the Fort Stewart trunking frequencies are available in the Forestry Branch office. The person with overall responsibility for these radios is:

FS Contact:	Charles Gordon
Phone:	912-435-8049
Home Phone:	912-368-0852
Cell:	912-228-7157

Various other people may have temporary responsibility for these, as they have been distributed to a number of people within the Forestry Branch.

4) Other means of communication

In the event that other means of communication are not available, the contact person for direct contact numbers and information related to Blackberry devices, satellite phones (DPTMS), and ham radios (last resort) is:

FS Contact:	Emergency & Contingency Planning Officer, DPTMS (2010: Tony Fleeger)
Phone:	912-767-2583
Cell:	912-210-1176
DSN:	870-2583
Blackberry PTT	150*35489*17
E-mail:	William.Fleeger@us.army.mil

5) Pre-positioning of equipment for debris removal

Forestry equipment at Fort Stewart are to be pre-positioned at Wright Army Airfield.

Fort Stewart has an MOU with the City of Savannah for positioning equipment at Hunter Army Airfield.

Staging areas for public safety, road clearing, and utility company personnel, vehicles, and equipment are noted in Annex Q (Post Hurricane Operations) to the Fort Stewart Disaster Emergency Operation Plan (500-3). They are:

Location	Address
DPW	Adj. Building 1152
Wright Army Airfield	Adj. Airfield
Canoochee Electric	Building 1099
Hunter Army Airfield	DAACG
Newman Fitness Center	Building 439
Fort Stewart Fire Station	Building 457

FS Contact:	Team Lead, Action Officers, DPW (2010: Fred Cavedo)
Phone:	912-767-5499

FS Contact:	Engineering Technician, Safety Officer, DPW (2010: Jeff Poulin)
Phone:	912-767-4585

FS Contact:	Industrial Property Manager, DPW (2010: Terri Sungur)
Phone:	912-767-5713

6) Fuel resources

Diesel Fuel

A truck containing diesel fuel will be located at Wright Army Airfield, in the general area where the forestry equipment will be staged.

Regular fuel

The Forestry Branch has their own tank and pumps for this resource, but a large tanker containing regular fuel (gasoline) will be moving around the installation during the recovery process to provide regular fuel where it may be needed.

FS Contact: Industrial Property Manager, DPW (2010: Terri Sungur)
Phone: 912-767-5713

7) Police and fire coordinator during immediate responses to emergencies

For the entire installation, police and fire responses are coordinated through one office.

FS Contact: Emergency Management Specialist, DES (2010: Keith Janowski)
Phone: 912-767-0813
Cell: 912-320-0139
DSN: 870-0813
E-mail: Keith.Janowski@conus.army.mil

C. Incident Response and Recovery Considerations

1) Debris removal

The clearing of debris is a high priority after a severe wind event, to allow movement of emergency units into the affected area and to restore services for transportation, utilities, and communications. Debris removal will also be necessary for maintaining property access, for maintaining access to utility lines and rights of way, for keeping waterways clear of fallen trees, for reducing fire hazards, and for re-establishing damaged forests.

a. According to Annex Q (Post Hurricane Operations) of the Forest Stewart Disaster Emergency Operation Plan (500-3), Hunter Army Airfield and Wright Army Airfield will receive priority clearance to facilitate the arrival of disaster relief personnel or equipment in case the need should arise, along with facilities vital to public safety, medical care, and recovery operations. Progress updates / reports will be reported to the IOC at 0500, 1100, 1700, and 2300 hours to assist in damage / needs assessment and recovery planning via working communications.

Primary telephone: 767-8666
Other means of communication: Motorola Channel 10-C or messenger

b. Debris clearing along State re-entry routes will be the primary responsibility of the Georgia Department of Transportation.

c. Other debris clearing within the installation will be the responsibility of DPW.

d. All support requests will be coordinated through the IOC.

e. The Georgia Department of Transportation has primary responsibility for the repair and restoration of State and Federal highways and bridges. Highways and bridges that are not State or Federally maintained are the responsibility of the installation with assistance from the DPW as required and requested through the IOC. Although the Georgia Department of Transportation is the primary for State and Federal highways, DPW must be ready to repair and restore these roadways until the Georgia Department of Transportation is available to do so.

f. State forestry agencies may assist in opening roads and utility rights-of-way. Only trained arborists should work around live wires, and the work should conform to ANSI standards Z133.1 and A300. OSHA 1910.269 and other safety standards may also be relevant (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9868).

g. Temporary debris collection sites have been identified (Appendix F-1 of the Fort Stewart Disaster Emergency Operation Plan).

- Fort Stewart: The weigh station "pit"
- Hunter Army Airfield: The shooting area next to the landfill

FS Contact: Team Lead, Action Officers, DPW (2010: Fred Cavedo)
Phone: 912-767-5499

FS Contact: Engineering Technician, Safety Officer, DPW (2010: Jeff Poulin)
Phone: 912-767-4585

FS Contact: Industrial Property Manager, DPW (2010: Terri Sungur)
Phone: 912-767-5713

h. Since priorities may change, some coordination with Range Control (DPTMS) and Emergency Management Operations (DES) officials to develop an exhaustive prioritized list of streets, highways, roads, grounds, facilities or other areas in and around the two main cantonment areas (FS / HAAF) where debris needs to be removed immediately after a storm. As of June, 2010, the prioritized list of streets, highways, roads, and grounds in and around Fort Stewart and Hunter Army Airfield are noted below.

<u>On Fort Stewart, these are:</u>

Highway 119
Highway 144
FS 47
East Main Arteries (FS 43, FS 47, FS 67, FS 68, and old 144)
West Main Arteries (FS 5, FS 6, FS 17, and FS 129)
Commercial powerlines (above ground)
Towers
Features in the aviation hazard maps
Area above the cantonment
Training areas D-10, D-11 and areas east towards the cantonment

Two maps are provided: prioritized roads (Figure 1), and locations of powerlines and vertical obstructions (Figure 2).

Contact: Range Control, DPTMS (2010: Roy Griggs)
Phone: 912-435-8164
E-mail: Roy.Brinson.Griggs@us.army.mil

<u>On Hunter Army Airfield, these are:</u>

North Perimeter Road
South Perimeter Road
Rio Road

Contact: Range Control, DPTMS (2010: George Thomas)
Phone: 912-315-6480

Official maps of these areas can be obtained from:

FS Contact: Range Control, DPTMS (2010: Jessica Leek)
Phone: 912-435-8046
E-mail: Jessica.A.Leek@us.army.mil

i. In addition, there is a need to know where the current training areas and the "gun line" are located, and which facilities that require commercial power. These areas may become high-level priorities.

Contact: Range Control, DPTMS (2010: Roy Griggs)
Phone: 912-435-8164
E-mail: Roy.Brinson.Griggs@us.army.mil

2) Forest damage assessments

When a natural disaster occurs it is important to start an initial assessment of the resource (timber) damage as soon as possible after the event has passed to facilitate salvage activities, however this has to be conducted in such a manner that does not conflict with restoring infrastructure to the surrounding urban and rural private citizen interface.

a. Initial assessment

Immediately after a severe wind event, an initial (quick) assessment of resources damaged is needed (as noted in the Fort Stewart Forestry Branch Hurricane Plan, Section III, Part C, Sub-parts 7(b), 7(f), and 7(g)). Using aerial survey techniques, damaged areas may be photographed or drawn on pre-existing maps or photographs (Barry et al. 1993). Most initial assessments are conducted primarily with aerial inspections and supported with relatively coarse ground inspections (if access is possible). Aerial and ground assessments are generally not independent of one another, and thus may be conducted simultaneously.

The Georgia Forestry Commission might be able to assist, therefore contacting the Forest Management Department may be advisable:

Georgia Forestry Commission
Phone: 478-751-3500
Phone: 1-800-428-7337
Fax: 478-751-3465

Ciesla et al. (2001), which is included in its entirety in Appendix A, describe the general initial assessment process. They propose standards for two, three, and four levels of damage, although historically different systems have been used in response to each hurricane. The four-level class system proposed by Ciesla et al. (2001) includes:

(1) undamaged areas
(2) lightly damaged areas (10-33% of the trees windthrown, bent, or broken)
(3) moderately damaged areas (34-67% of the trees windthrown, bent, or broken)
(4) heavily damaged areas (> 67% of the trees windthrown, bent, or broken).

Some other examples of initial forest damage assessments include:

1. Hurricane Hugo (1989): Using a four-passenger aircraft, a pilot and two observers flew north-south flight lines across each county at eight-mile intervals and documented the damage on 1" = 1 mile scale maps (unclear how, except that maps were used). For softwood areas, three damage classes were used: light damage (5%), moderate damage (25%), and heavy damage (60%). For hardwood areas, three different classes were used: light damage (10%), moderate damage (35%), and heavy damage (70%) (Freeman 1996).

2. Hurricane Andrew (1992): Using an aerial videography system, a damage assessment was made for timber stands based on timber volume, and four classes were delineated: no visible damage, light damage (1-33% volume windthrown or broken), moderate damage (34-67% volume windthrown or broken), and severe damage (> 67% volume windthrown or broken) (Jacobs and Eggen-McIntosh 1993).

3. Hurricane Ivan (2004): A damage assessment was developed using an aerial survey of nearly 3 million acres of forests (Alabama Forestry Commission 2004). The assessment categorized damage into four classes: very low damage (< 4% of forest damaged), low damage (< 20%), moderate damage (20-50%), and severe damage (> 50%).

4. Hurricane Rita (2005): An aerial survey was used to define the boundaries of the damaged area, and a map was developed indicating four levels of damage: scattered light (approximately 3% of the forest damaged - windthrown, broken, or leaning trees), light damage (approximately 15% of the forest damaged), moderate damage (approximately 50% of the forest damaged), and heavy damage (approximately 60% of the forest damaged) (Texas Forest Service 2005).

Ground-based assessments can add value to the amount of timber damage present in an area, and can provide information on access impediments. Ground-based assessments can be used to prioritize timber salvage activities by providing an estimate of timber volume damaged. Ultimately, the initial assessment must be credible and undertaken in an efficient manner, and needs to result in basic information necessary to develop the necessary requests for assistance.

<u>Checklist for conducting an initial storm damage assessment</u>

☐ Gather equipment necessary for ground-based assessment
☐ Request aerial assessment equipment (fixed-wing aircraft and helicopters)
☐ Assemble personnel for ground-based and aerial surveys
☐ Assign a project leader
☐ Assign personnel to ground-based and aerial teams
☐ Prepare the necessary maps
☐ Prepare timber damage documentation worksheets
☐ Divide affected area into workable units
☐ Assign workable units to ground-based and aerial teams
☐ Coordinate ground-based and aerial survey activities
☐ Provide detailed instructions on estimating timber damage levels
  Perhaps use a rating system such as this:
    Low (< 30% overall stand or tree damage)
    Moderate (> 30% to 60% overall stand or tree damage)
    Heavy (> 60% to 100% overall stand or tree damage)
  And, require teams to delineate damage levels on the maps provided
☐ Acquire information from ground-based and aerial teams
☐ Incorporate aerial and ground-based data into GIS databases
☐ Produce detailed timber damage location maps

- Provide information to timber salvage managers

b. Longer-term assessment

A systematic method to determine areas that can be salvaged over time and space is necessary. Some factors to consider include:
(a) ease of access
(b) amount of salvageable timber
(c) the time of year (logs will degrade quicker in hot, humid weather)
(d) the tree species damaged
(e) the size and quality of damaged timber
(f) the available markets
(g) the availability of loggers and timber buyers

3) Timber salvage

According to the Integrated Cultural Resources Management Plan for Fort Stewart (2001), prior to initiating timber salvage projects, the Fort Stewart DPW needs to notify the State Historic Preservation Officer (SHPO) by telephone or e-mail of its intent to salvage damaged timber. Through previous cultural resource surveys, some culturally-significant site locations will already have been identified and may be salvaged using non-intrusive methods. Sites not previously surveyed will be surveyed ahead of salvage operations using standard pedestrian field techniques. Due to the extent to which storm-damaged timber can restrict movement, it is possible that it will become necessary to fell and remove timber prior to a cultural resource survey. In order to ensure that the most sensitive areas are surveyed first, Cultural Resources personnel and Forestry Branch personnel will identify those areas that either contain or are most likely to contain cultural resources. These areas will be identified as Priority 1 and will undergo immediate field surveys. Areas that are less likely to contain cultural resources will be identified and timber may be salvaged using non-intrusive methods, if possible. Cultural resource surveys of Priority 2 areas will be performed when Cultural Resource personnel become available. If damaged timber cannot be removed non-intrusively, it will be felled and left in place until a cultural resource survey can be completed. Clearing of existing roads and the repair of down power lines and other public health utilities will not be restricted by cultural resources management concerns.

Therefore, coordination with the Cultural Resources Management officials at Fort Stewart / Hunter Army Airfield to identify restricted areas ("no-go" timber salvage areas) is necessary, to identify areas (a) where coordination with the Cultural Resources group is required, (b) where an assessment or call is needed, and (c) that have not been surveyed. The goal is to identify areas that can be "pre-cleared" for emergency purposes to allow timber salvage efforts to proceed unimpeded after a storm. These areas on Fort Stewart are continuously being reviewed and updated.

A map or GIS database of these areas can be obtained from:

FS Contact:	Environmental Division, DPW (2010: Brian Greer)
Phone:	912-767-0992
E-mail:	brian.greer@us.army.mil

Any sites that are eligible for the National Register of Historic Places will be temporarily marked for protection using signs and flagging tape. These will be harvested using non-intrusive methods, or alternatively, the timber will be felled and left on site. In areas where sites are threatened by high military traffic volume, Fort Stewart and Hunter Army Airfield will mark sites more substantially using signs, Fort Stewart stakes, and boundary paint. There will be no adverse effect by timber salvage operations on Eligible or Potentially Eligible sites.

Fort Stewart will provide the State Historic Preservation Officer (SHPO) a report on survey / assessment findings every six months until storm damage control is completed. This report will include, but is not limited to: area surveyed / not surveyed, descriptions of Potentially Eligible or Eligible sites that were discovered during the survey project and were mitigated by avoidance or were cleared by non-intrusive means. Fort Stewart personnel will monitor the activities of timber harvest contractors to ensure that timber harvest regulations are followed.

In the event that a historic property becomes contaminated with a hazardous material (e.g., fuel spill), the Environmental Engineer in charge of hazardous waste will determine the most efficient way to comply with the Resource Conservation and Recovery Act while minimizing damage to the historic property.

A draft Memorandum of Agreement between the cultural resources group and the Forestry Branch has been designed (Appendix C).

FS Contact:	Forestry Branch, DPW (2010: Arte Rahn)
Phone:	912-435-8024
E-mail:	Willard.Rahn@us.army.mil

Timber sales are administered by the Army Corps of Engineers:

USACE Contact:	Army Corps of Engineers forester (2010: Hank Cochran)
Phone:	912-767-7522
E-mail:	Henry.G.Cochran@usace.army.mil

Notification of areas of operation and gates to be opened when timber salvage occurs. The initial contact is:

FS Contact:	Emergency Management Specialist, DES (2010: Keith Janowski)
Phone:	912-767-0813
Cell:	912-320-0139
DSN:	870-0813
E-mail:	Keith.Janowski@conus.army.mil

Other contacts:

FS Contact:	Physical Security
Phone:	912-210-3246
FS Contact:	Conservation Law Enforcement
Phone:	912-210-0988

To obtain daily, 3-5 day, and 5-10 day windows for accessing timber, contact:

Contact:	Range Control, DPTMS (2010: Roy Griggs)
Phone:	912-435-8164
E-mail:	Roy.Brinson.Griggs@us.army.mil

A database of mills, loggers, and timber buyers within the emergency hauling area surrounding Fort Stewart has been developed as of March 2010 (Figures 3 and 4). The scope of coverage includes about a 100-mile zone around the installation, which includes the Jacksonville area to the south, areas just east of Tifton and Macon, areas just south of Augusta, and the Charleston area to the northeast. These lists were developed from (1) databases stored at TimberMart South, (2) information maintained by the Georgia Forestry

Association, the Georgia Forestry Commission, the South Carolina Forestry Commission, resident foresters at Fort Stewart, and other publications, (3) phone and Internet searches of businesses in the areas of concern, and (4) discussions with points of contact made throughout the study time period, and leads generated from these efforts.

The compilation of mills, timber buyers, and loggers is stored in two GIS databases (maps and lists are also available in Appendix B):

- Mills.shp (mills within the emergency hauling distance)
- Timber_buyers.shp (timber buyers and loggers within the emergency hauling distance)

FS Contact:	Forestry Branch, DPW (2010: Arte Rahn)
Phone:	912-435-8024
E-mail:	Willard.Rahn@us.army.mil

4) Wet decks and ponds designated to store salvaged timber

Logs that are stored under water or under a water spray can be held much longer before processing than similar logs that are stored under dry conditions. With a continuous coating of water over logs, insects will drown or be driven from the logs, and fungi will become inactive due to the lack of oxygen. Water on the logs will also mask the natural attractants that might lure insects (Syme and Saucier 1996). Therefore, in order to prevent degradation of salvaged timber prior to sale or processing, wet decks and ponds may be needed.

Many large-scale lumber product facilities already use ponds or sprinkler systems to store logs, but when a forest-based catastrophe occurs, these types of facilities will quickly fill up. This problem can be addressed by constructing and maintaining temporary wet deck sprinkler yards or log storage ponds on the installation. Developing these temporary facilities can increase the amount of timber salvaged. Examples of water storage programs that were developed in response to Hurricane Hugo (1989) include the following:

1. Logs were stored in rows or piles 10-25 feet high, and standard irrigation sprinklers applied a continuous spray. Storage in this manner lasted from one month to about a year. Insect and fungal attack was mitigated if moisture levels were maintained. Permitting procedures were allowed to be temporarily bypassed by the South Carolina Department of Health and Human Control (Marsinko et al. 1996).

2. A closed-loop system utilizing recirculated runoff water and standard irrigation sprinklers with a pressure of 40 psi at the sprinkler head was developed at one sawmill. A continuous, heavy application of water provided the best protection. This meant using a 3/16 inch diameter nozzle orifice that was rated at 6.4 gallons per minute (Syme and Saucier 1996).

<u>Checklist for wet storage facilities:</u>

☐ Scales
☐ Equipment for unloading trucks and stacking timber for storage
☐ One or more water sources
☐ Manpower
- Caulked boots may be required for walking on log decks.

☐ Support equipment (power, water, generators, system infrastructure, tools, etc.).
- Loaders for unloading logs.

<u>For pond systems</u>
- A way to retrieve stored logs from ponds.

For sprinkler systems

- A site with adequate drainage and appropriate soil conditions should be selected.
- One 40 hp pump may provide 80 psi of water pressure (50 psi at the sprinkler heads), and provide coverage for about 5 million board feet of logs. Each pump may require 750,000 gallons per day, and require a pump strainer.
- Three-phase electrical power is needed.
- For closed-loop systems, about 2-3% "make-up" water (for water lost due to evaporation or other issues) from other water sources may be needed each day.
- Water percolation in the recirculation pond should be minimized.
- About two feet of freeboard (the distance between the normal water level and the top of the structure that impounds the water) should be maintained in the recirculation pond.
- Sprinkler heads should be spaced about 60 feet apart on top of the decks, and located at both ends of a log deck to provide considerable overlap and uniform coverage.
- Sprinklers should be placed between decks to keep the ends of logs wet.
- Continuous monitoring of spray flow rate and coverage is necessary.
- A back-up system, in case of pump failure, should be ready for use.

☐ Available space to store the salvaged timber

For sprinkler systems

- About 1 acre for every 2 million board feet of timber is needed.
- Decks should be built directly on the ground.
- Decks should be designed so that the ends of logs are as close together as possible.
- Maximum deck heights should be about 20 feet.

☐ A yard design to catch water runoff, perhaps for recycling the sprinkled water

For sprinkler systems

- A settling pond in front of the pump pond should be developed.

☐ Permits

State-level permitting procedures for the use of biomass or timber concentration yards and storage ponds should be reviewed. Entities operating these facilities must have current permits. For a large-scale disaster emergency event, a relaxation or waiver of specific rules and guidelines for these permits may be available from water regulatory agencies.

The Georgia Environmental Protection Division (GA EPD) may need to be contacted to obtain a permit. The use of reclaimed wastewater from a system permitted by the GA EPD may be exempt from the rules for outdoor water use (391-3-30-.05 "Exemptions").

The GA EPD Administrative contact (Atlanta) information is:

Phone: 404-656-4713
Fax: 404-651-5778

The GA EPD Coastal District contact (Savannah) information is:

Phone: 912-353-3225
Fax: 912-353-3234

In addition, the Army Corps of Engineers may have jurisdiction over some ponds on the installation, and they will need to analyze water bodies and their connection to other water bodies to determine the impact that wet storage of logs may have. Some concerns include the methods for placing logs into ponds, the methods for retrieving logs from ponds, and the clean-up processes that may be necessary once the need for wet storage of logs has passed.

The local-level contact is:

FS Contact: Environmental Division, DPW (2010: Robert Lloyd)
Phone: 912-767-9443 (office)
Phone: 912-213-8486 (field)
Fax: 912-767-9779
Nextel ID: 150*2470*83
E-mail: robert.lloyd9@us.army.mil

Higher-level Army Corps of Engineers contacts are:

USACE Contact: Commander, Savannah District
Phone: 912-652-5226

USACE Contact: Deputy Commander, Savannah District
Phone: 912-652-5224

USACE Contact: Chief Emergency Management Division, Savannah District
Phone: 912-652-5431

USACE Contact: Civil Engineer Technician, Savannah District
Phone: 912-652-5431

Two problems may arise from water storage of logs:

1. Foul odors emanating from log decks. Chlorine tablets introduced into the system will not alleviate this problem (Syme and Saucier 1996).

2. Mosquitoes breeding in the circulation ponds of sprinkler systems.

   The first point of contact should be the appropriate county public works or environmental health department. A limited number of insecticides have proven effective for mosquito control, therefore it is important that applications be made correctly by licensed officials with knowledge of the local problems and the necessary training.

   Liberty County Mosquito Control Department
   Phone: 912-884-2065
   Fax: 912-884-2364

   Bryan County Public Works
   Phone: 912-653-4511

   Richmond Hill Public Works Department
   Phone: 912-756-3803

   Evans County Health Department
   Phone: 912-739-1712

   Tattnall County Health Department
   Phone: 912-557-7850

   Long County - contracts with Liberty County

Another mosquito control contact in the area is:

Ray Dent, Operations Management International (contractor)
Phone: 912-876-8216

Chatham County Mosquito Control uses aircraft for mosquito control. In this program, for larvae control, an environmentally friendly pesticide is mixed with sand and applied during the day. These pesticides include:

Altosid®, an insect growth regulator
Golden Bear® mosquito larvicide
Agnique®, a monomolecular film

All of these products are classified as unrestricted pesticides by the U.S. Environmental Protection Agency (EPA), and are registered for application in environmentally sensitive areas.

For adult mosquito control, Chatham County Mosquito Control uses chemicals registered by the Georgia Department of Agriculture (GDOA) and labeled by the EPA. These applications are not made in the absence of mosquitoes, except in a limited number of known breeding sites.

Chemical products currently being used in Chatham County include:

Aqua Reslin®, a permethrin / piperonlyl butoxide blend is used in aerial applications and is applied at a rate of .0035 - .007 pounds of active ingredient per acre.
Scourge®, a resmethrin / piperonlyl butoxide blend is used in ground applications and is applied at a rate of .0035 - .007 pounds of active ingredient per acre.
Trumpet®, a water-based naled formulation is used in aerial applications and is applied at a rate of .05 - .1 pounds of active ingredient per acre.

These chemicals are slightly toxic, yet break down rapidly and have no residual effect. Ground applications are performed using ultra low volume (ULV) spray equipment mounted on trucks. Treatment is usually limited to dusk, dawn, and nighttime hours. Aerial applications, also using ULV technology, are usually limited to dusk or dawn hours. Local police departments are contacted prior to making aerial pesticide applications.

For biological control, mosquito eating fish are also used wherever possible. They reproduce easily and maintain their numbers where water depth provides protection from birds and other predators. Residents may obtain mosquito fish at no cost through the Mosquito control office.

Gambusia affinis may be seen as an alternative solution for mosquito control in man-made bodies of water that will dry up later, and that will not eventually overflow into permanently flowing streams and lakes (where they will affect native populations of fish). As a result, the fish will be valuable for mosquito control, yet will be controlled itself, since it is considered an invasive species. There is one native species in south Florida, *Gambusia holbrooki*. Fifty fish are sufficient for stocking in spring, in a pond the size of a typical swimming pool. By summer, a *Gambusia* population will quickly increase to hundreds of fish. For operational use, one suggestion is to stock them at a rate of 2,500 per acre of water surface (Duryea et al. 1996), however, stormwater facilities, sewage lagoons, and farm ponds may only require 1,000 per acre, and ditches may only require 1 fish per yard of ditch (Maryland Department of Agriculture 2008).

In the event of a hurricane, Chatham County Mosquito Control will transform into the Georgia ASOC (Aviation Support Operations Center). The ASOC coordinates with the Chatham Emergency Management Agency, and becomes the a center for dispatching all aviation assets that will participate in post-storm recovery efforts.

Contact: Director, Mosquito Control
Phone: 912-790-2540
Fax: 912-790-2550

5) Other permitting or permission issues

a. NEPA planning process. While dealing with the aftermath of an emergency situation, it is important for the installation to contain the environmental impacts. Once normal operations have resumed, a NEPA analysis should be performed to gain approval from the wetlands, cultural resources, and wildlife groups. The important points are:

- The NEPA process cannot be avoided, and should be addressed after the immediate priorities have been addressed.

FS Contact:	Environmental Division, DPW, NEPA manager (2010: Amber Franks)
Phone:	912-767-2400

- A specific plan for salvaging timber should be developed after the severe wind event.
- AEC might need to be involved.
- Clearance or permission from the Wildlife Resources group may be necessary for timber salvage operations within what is (or was) red-cockaded woodpecker habitat.
- The Army Corps of Engineers does not currently have protocols in place related to equipment traffic through wetlands, as it relates to timber salvage efforts after severe wind events. In addition, the Army Corps of Engineers is not able to issue a Memorandum of Agreement concerning this issue without very specific scenarios and response plans outlined. However, the Army Corps of Engineers might not respond negatively to reasonable hurricane response actions as long as the Forestry Branch and their operatives are acting within the appropriate Best Management Practices. Therefore, timber salvage operations may be covered by allowances in the Clean Water Act for silviculture. However after a severe wind event that creates broken or windthrown trees, guidance from the wetlands managers seems necessary.

The local-level contact is:

FS Contact:	Environmental Division, DPW (2010: Robert Lloyd)
Phone:	912-767-9443 (office)
Phone:	912-213-8486 (field)
Fax:	912-767-9779
Nextel ID:	150*2470*83
E-mail:	robert.lloyd9@us.army.mil

Higher-level Army Corps of Engineers contacts are:

USACE Contact:	Commander, Savannah District
Phone:	912-652-5226

USACE Contact:	Deputy Commander, Savannah District
Phone:	912-652-5224
USACE Contact:	Chief, Emergency Management Division
Phone:	912-652-5431
USACE Contact:	Civil Engineer Technician, Savannah District
Phone:	912-652-5431

b. Fuels management Memorandum of Agreement

A draft fuels management Memorandum of Agreement was developed (Appendix C) that is similar in scope to the Southern Pine Beetle-Damaged Timber Salvage Memorandum of Agreement (August 11, 1997) between the 3rd Infantry Division (Mechanized) / Fort Stewart and the Georgia State Historic Preservation Officer (SHPO). Negotiations between the Forestry Branch and the SHPO are necessary to finalize this mutual agreement.

FS Contact:	Forestry Branch, DPW (2010: Arte Rahn)
Phone:	912-435-8024
E-mail:	Willard.Rahn@us.army.mil

c. Wood Transportation Issues

Consideration should be given to an application for a temporary waiver of weight limits on log trucks. Any suspension of weight restrictions should only be for an affected area, and only for emergency response movement of damaged timber resources.

Georgia Department of Transportation contacts:

Commissioner	404-656-5206
Deputy Commissioner	404-656-5212
Director of Operations	404-656-5214
State Maintenance Engineer	404-635-8734
District Five Maintenance Engineer	912-427-5711
District Five Engineer	912-427-5700
District Five Traffic Engineer	912-427-5700

As an example, after Hurricane Katrina (2005) temporary authority was granted by the Mississippi Department of Transportation to exempt the permit requirements for the movement of overweight and over-dimensional storm debris, including timber. The specifications of the temporary authority were:

A. The maximum Gross Vehicle Weight for vehicles equipped with 5 weight-bearing axles with outer bridge spans of not less than 40 feet, but less than 51 feet, shall not exceed 90,000 pounds.

B. The maximum Gross Vehicle Weight for vehicles equipped with 5 weight-bearing axles with outer bridge spans of not less than 51 feet shall not exceed 95,000 pounds.

C. The maximum Gross Vehicle Weight for vehicles equipped with 4 weight-bearing axles with outer bridge spans of not less than 43 feet shall not exceed 80,000 pounds.

D. The total length of any vehicle identified above shall not exceed 80 feet. Rear overhang shall not exceed 28 feet during daylight hours. Any movement after sunset will be limited to a 4 foot rear overhang.

E. The maximum width and / or height of any vehicle shall not exceed 14 feet. If a vehicle exceeds this width and / or height, the MDOT, Permits Division must be contacted for route information.

F. Transporters are responsible for ensuring that they have proper oversize signs, markings, flags, and escorts as defined in the State of Mississippi's rules and regulations. Insurance and safety requirements shall not be waived.

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APPENDIX B: HURRICANE DAMAGE ESTIMATION TOOL USER'S GUIDE

The following discussion and direction provides users with the ability to install and use the Hurricane Damage Estimation Tool developed for Fort Stewart. The tool is actually a set of three tools, was developed for use within ArcGIS, and the data and extent of use are specific to the Fort Stewart area. Some Python programming is necessary to enable one to use the tool in other areas of the world, but these limitations can be overcome with additional time and effort.

Getting Started

1. Copy the data and tools to the hard drive of your computer.

→ From the compact disc provided, copy the entire "Hurricane Damage Estimation" subdirectory to your C:\ drive.

You now have all of the toolbox scripts provided to the Fort Stewart Forestry Branch as of September 2010. Also located in the subdirectory are these GIS database (shapefiles):

- hurricane damage estimation model extent (extent)
- roads (ftstew_rds17)
- powerlines (powerlines)
- soils (soils)
- timber stands (stands)

While these GIS databases are available for your use, and needed for the hurricane damage estimation process, they are not hard-coded into the model. Therefore, users can specify a different roads database, for example, in developing model simulations. This is true for any of the input files into the model. However, the GIS databases need to contain fields (attributes) that the hurricane damage estimation tool can identify. For example, the soils GIS database provided here has been reclassified for use in the risk assessment. The polygons within the soils database have been attributed with susceptibility to damage classifications. More information along these lines will be provided shortly.

2. Open ArcMap and add the toolbox to the map document.

→ Open ArcToolbox.
→ Right Click on the word "ArcToolbox."
→ Select *Add Toolbox* (Figure B1).
→ Navigate to the Hurricane Damage Estimation subdirectory on the C:\ drive, and select the toolbox named "Hurricane Damage Estimation Tool".

The "Hurricane Damage Estimation Tool" should now be displayed in the ArcToolbox of ArcMap (Figure B2).

This tool calls other standard ArcGIS tools, therefore one limitation of the current version of the model is that the path to the subdirectory containing your ArcGIS Toolbox tools will need to be defined, since many of these tools are used in the damage estimation model.

3. Change the location of the ArcGIS Tools in the Python Scripts.

This does not refer to the "Hurricane Damage Estimation" subdirectory to your C:\ drive, but rather it refers to the place where all of the other ArcGIS tools are stored on your computer.

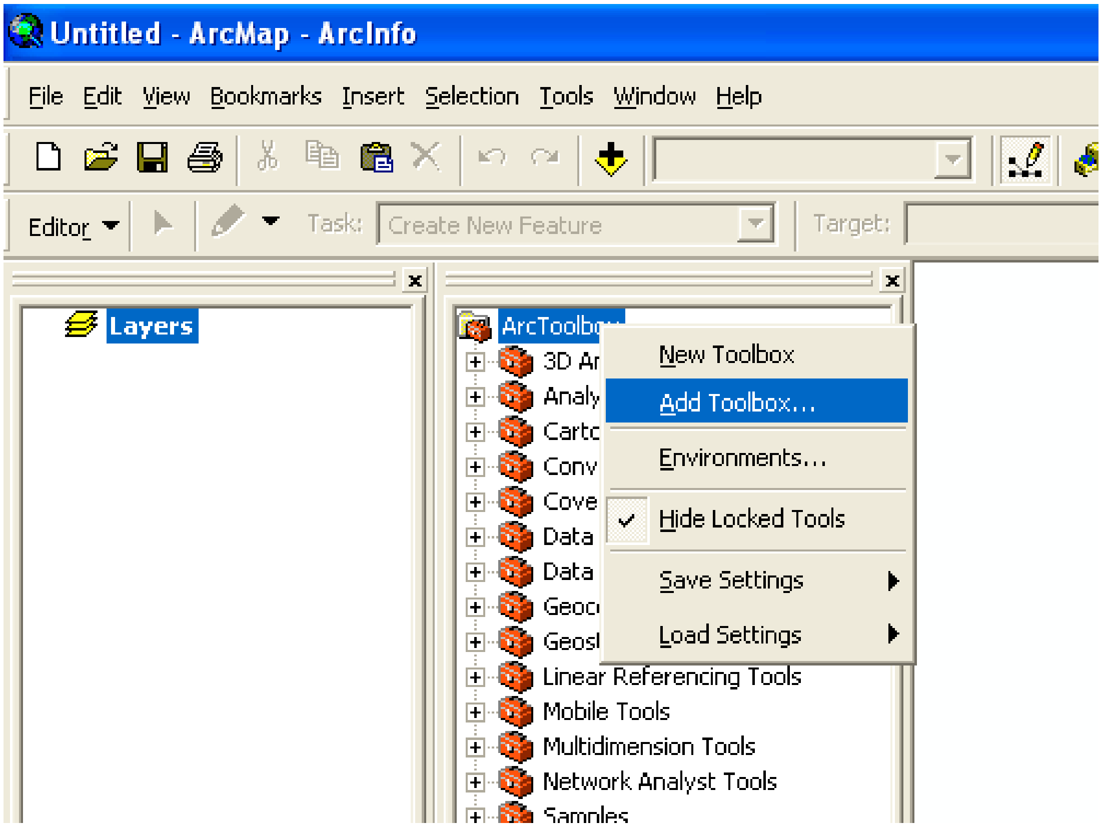

Figure B1. Adding a new Toolbox to ArcGIS.

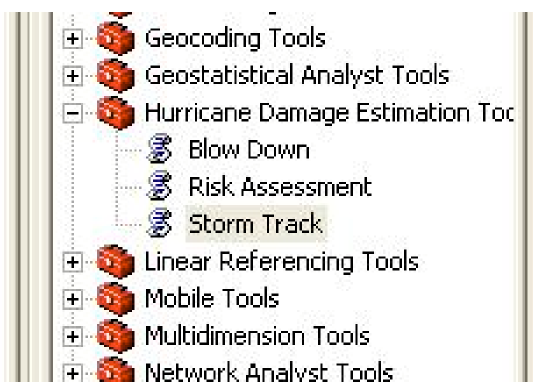

Figure B2. Hurricane Damage Estimation Toolbox.

By expanding the “Hurricane Damage Estimation Tool” in the ArcToolbox, you will notice that three scripts (tools) are included in the overall model:

- Blow down
- Risk assessment
- Storm track

→ Right click on each script, and select Edit.

This will open up a Python Shell window, and a Window containing Python programming language code (the script) (Figure B3).

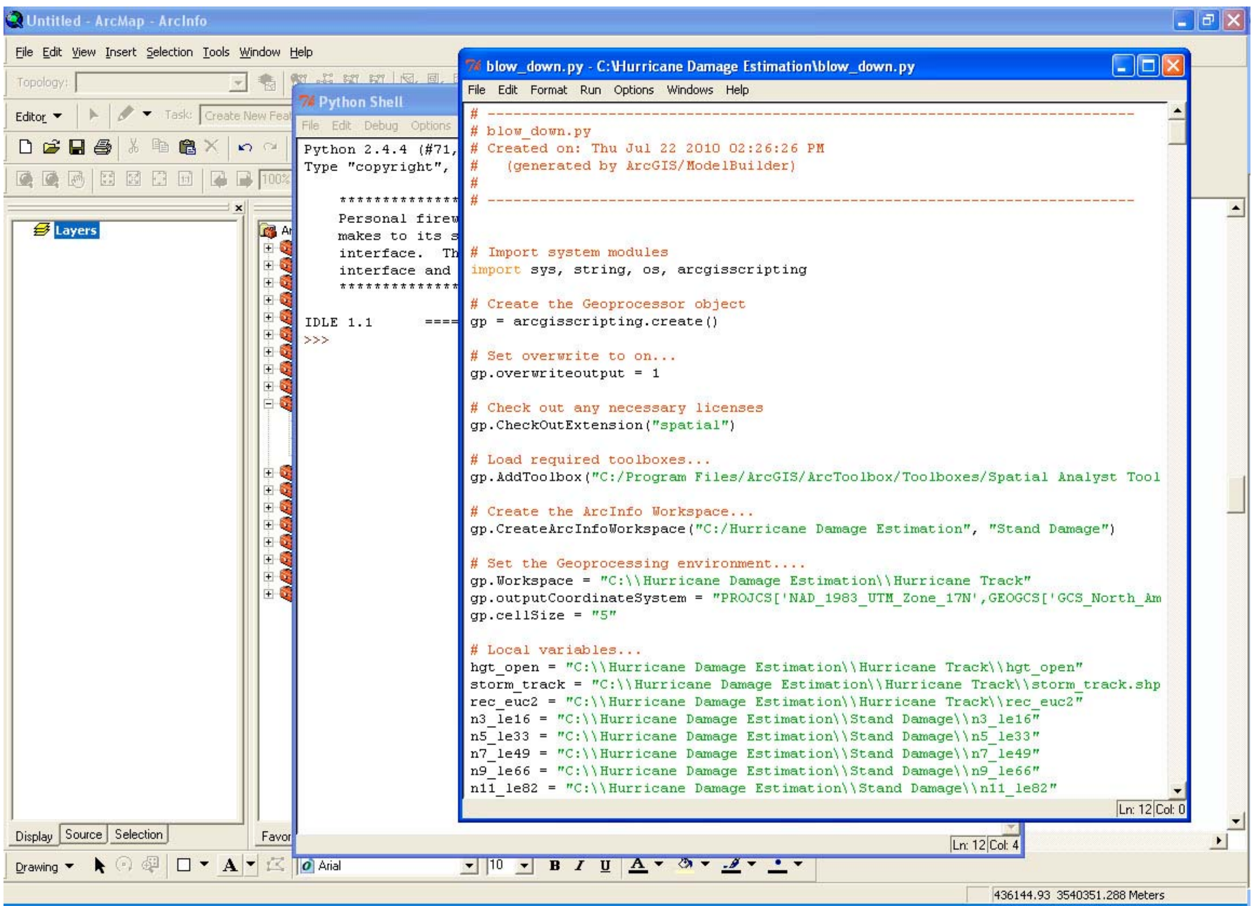

Figure B3. The result of choosing to "edit" the Python scripts.

→ Within the Python code window, move down to the section labeled “# Load required toolboxes….” (this text will be in red) (Figure B4).
→ Here you will have to change the location of the subdirectory that contains the noted tools (the green text). If you do not map to the proper subdirectory containing these items, the damage estimation model will not run.
→ Save the script.

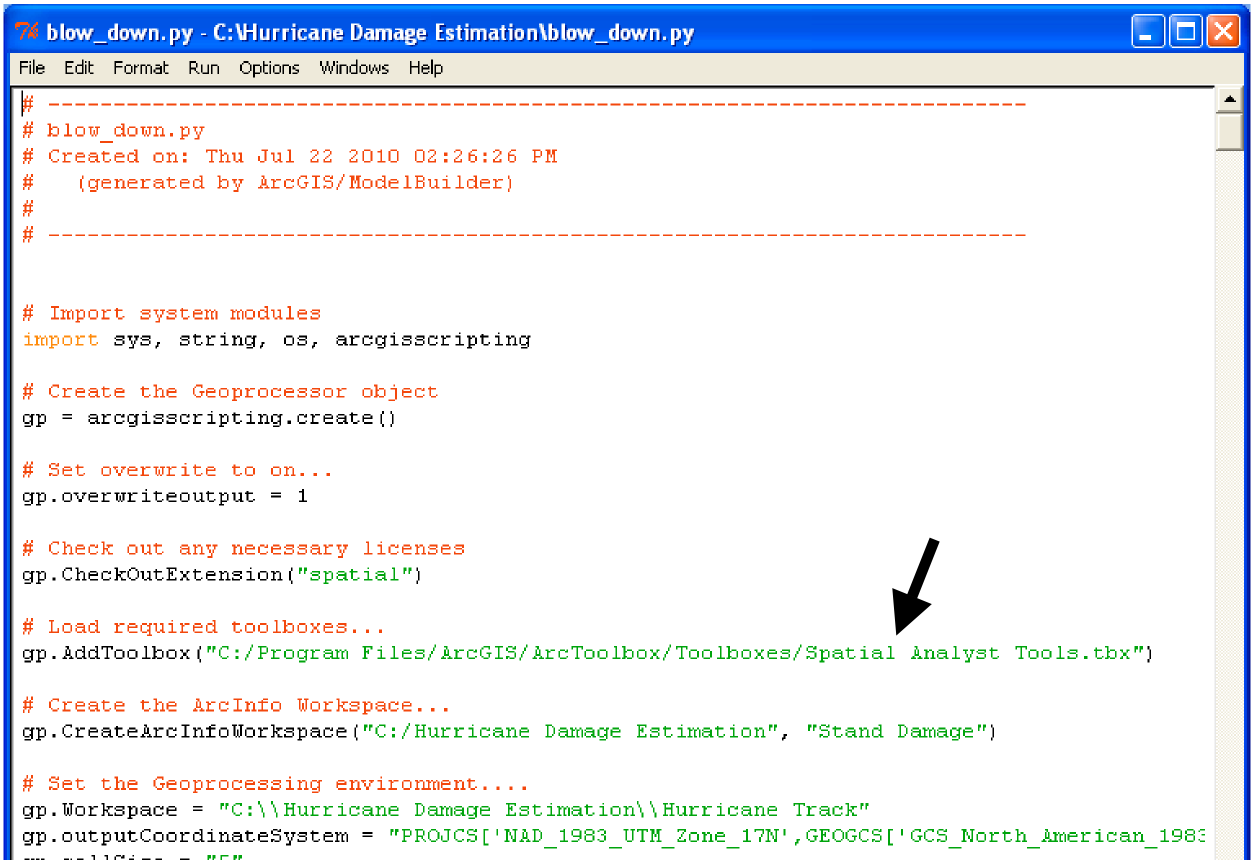

Figure B4. The place in the Python script where the location of the tools is defined.

This editing process will have to be performed on each of the three scripts (and for each of the tools noted in each script) before they are used for the first time, or in rare cases where the location of the ArcGIS ArcToolbox subdirectory has been moved.

- One standard tool is required for the Blow Down script (Spatial Analyst Tools).
- Two standard tools are required for the Risk Assessment script (Spatial Analyst Tools, Conversion Tools). However, the Spatial Analyst Tool is loaded in two different places in this script, so this needs to be adjusted in both of these two places in the code.
- Four standard tools are required for the Storm Track script (Spatial Analyst Tools, Conversion Tools, Data Management Tools, Analysis Tools).

Now that the location of the Toolboxes has been checked, edited, and saved, and now that the Hurricane Damage Estimation Tool has been added to ArcMap, it is time to run the model.

<u>Two important caveats to keep in mind:</u>

- The processes within the Hurricane Damage Estimation Tool have been designed to use the UTM NAD 83, ZONE 17N projected coordinate system.
- The output of various processing steps will be raster GIS databases with a spatial resolution of 5 m. This resolution can be changed by editing of the scripts, but the option to change is not readily available to the user. Using larger grid cells will result in faster processing times, yet with some loss of spatial resolution.

Stage 1: Performing a Hurricane Damage Risk Assessment

A hurricane damage risk assessment is a precursor to the hurricane damage estimation process. The risk assessment needs to be performed once. While multiple damage estimation scenarios may be modeled, the risk assessment will not change from one scenario to the next, unless the underlying data (stands data, for example) changes.

→ To open the Risk Assessment tool, double-click "Risk Assessment" in the ArcToolbox.

The Risk Assessment dialog box (Figure B5) will then open.

The Risk Assessment tool requires the user to identify the stands GIS database.

→ Click the "file open" button to the right of the "Stands File" textbox, navigate to the location of the stands GIS database (a shapefile), and select it.

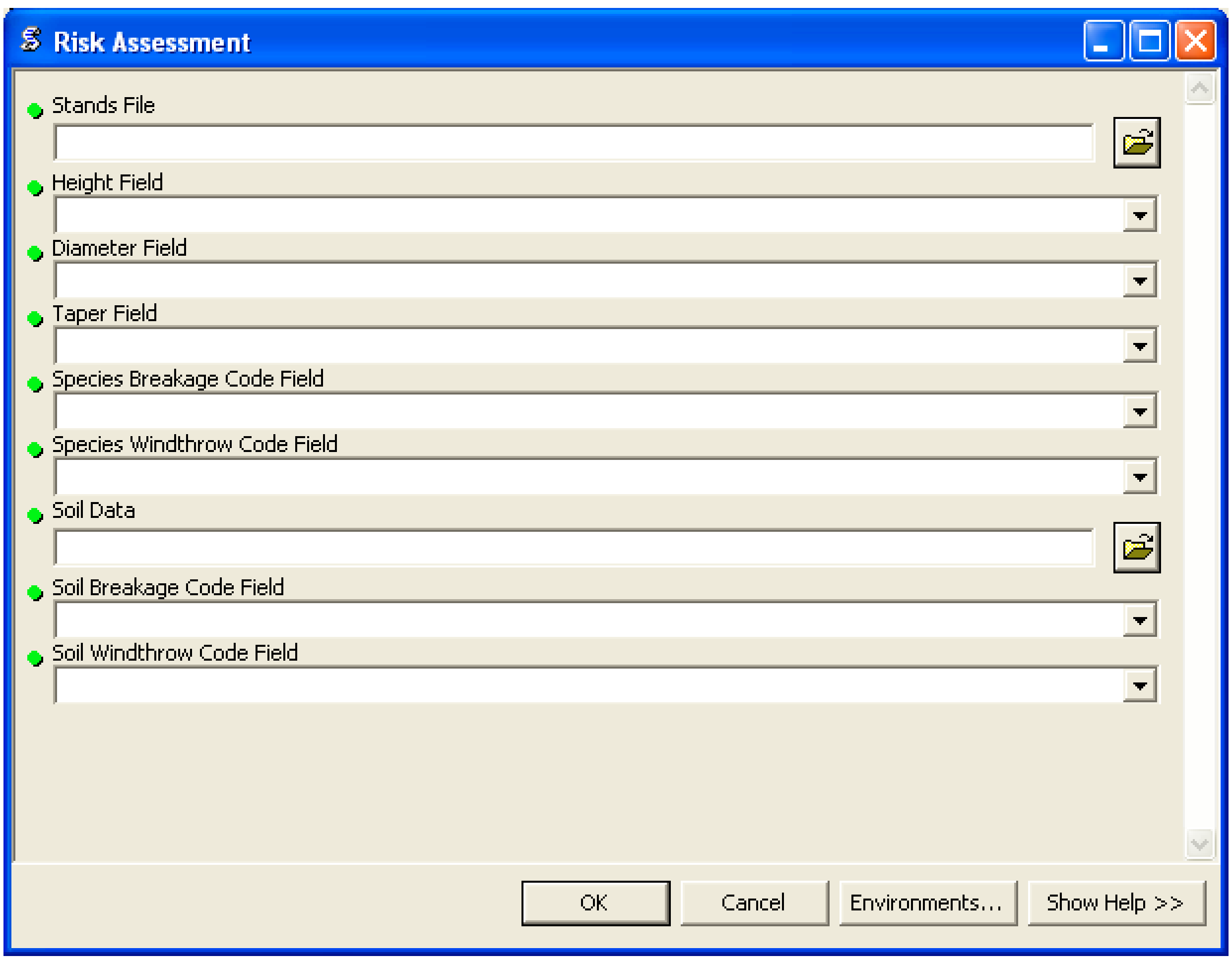

Figure B5. "Risk Assessment" tool dialog box.

Once the stands GIS database has been identified, the fields (attributes) within the shapefile that contain a number of stand characteristics should be identified.

→ Press the down arrow to the right of the "Height Field" textbox and select the field containing average tree heights for each stand (in the stands GIS database provided in September 2010, this field is the AVG_HT_WT).
→ Press the down arrow to the right of the "Diameter Field" textbox and select the field containing average tree diameter for each stand (in the stands GIS database provided in September 2010, this field is the QMD).
→ Press the down arrow to the right of the "Taper Field" textbox and select the field containing average tree taper for each stand (in the stands GIS database provided in September 2010, this field is the TAPER).
→ Press the down arrow to the right of the "Species Breakage Code Field" textbox and select the field containing values representing tree species susceptibility to breakage for each stand (in the stands GIS database provided in September 2010, this field is the SPEC_BRK).
→ Press the down arrow to the right of the "Species Windthrow Code Field" textbox and select the field containing values representing tree species susceptibility to windthrow for each stand (in the stands GIS database provided in September 2010, this field is the SPEC_WIN).

Users will also need to identify the location of the soils GIS database (a shapefile).

→ Click the "file open" button to the right of the "Soil Data" textbox, navigate to the location of the soils GIS database (a shapefile), and select it.

Once the soils GIS database has been identified, the fields (attributes) within the shapefile that contain two soil characteristics should be identified.

→ Press the down arrow to the right of the "Soil Breakage Code Field" textbox and select the field containing values representing soil conditions that make trees more (or less) susceptible to breakage (in the soils GIS database provided in September 2010, this field is the CODE_BREAK). Ranges of acceptable values were noted in the Phase I Final Report (Bettinger et al. 2009a).
→ Press the down arrow to the right of the "Soil Windthrow Code Field" textbox and select the field containing values representing soil conditions that make trees more (or less) susceptible to windthrow (in the soils GIS database provided in September 2010, this field is the CODE_WIND).

Once all of the files, along with the appropriate fields within those files, have been identified (Figure B6), the risk assessment process can begin.

→ Press OK to begin the risk assessment process.

The risk assessment process automates the steps suggested in the Phase I Final Report for the Fort Stewart hurricane projects (Bettinger et al. 2009a), and performs a number of processes in ArcGIS. The information one should receive in the status box after successful completion of the risk assessment should look like the following:

```
Executing: RiskAssessment "C:\Hurricane Damage Estimation\stands.shp" AVG_HT_WT #
QMD # TAPER # SPEC_BRK # SPEC_WIN # "C:\Hurricane Damage Estimation\soils.shp"
CODE_BREAK # CODE_WIND #
Start Time: Thu Sep 23 14:35:52 2010
Running script RiskAssessment...
Converting Stands File to Height Raster
Reclassifying Height Raster
Converting Stands File to Diameter Raster
Reclassifying Diameter Raster
Converting Stands File to Taper Raster
```

```
Reclassifying Taper Raster
Converting Stands File to Species Breakage Code Raster
Converting Soils File to Soil Breakage Code Raster
Converting Stands File to Species Windthrow Code Raster
Converting Soils File to Soil Windthrow Code Raster
Running Raster Calculator
Running ConAsNull
Running Raster Calculator
Running ConAsNull
Risk Assessment Complete
Completed script RiskAssessment...
Executed (RiskAssessment) successfully.
```

To illustrate the time required to perform these processes, the risk assessment was performed on a Dell Latitude laptop with a 1.6 Ghz processor and 500 Mb of RAM in 7.5 minutes. The time required for a Dell Precision 670 personal computer (3.6 GHz processor, 2 Gb RAM) was 6.5 minutes.

Two raster GIS databases, representing susceptibility to both tree breakage and tree windthrow, are developed during the process. These raster GIS databases (“wind_risk” and “break_risk”) can be found in the “C:\Hurricane Damage Estimation\risk assessment” subdirectory. The “risk assessment” subdirectory is created when the risk assessment stage of the toolbox is run for the first time. Both the “wind_risk” and “break_risk” values range from 1 to 50, with values closer to 50 representing areas with a

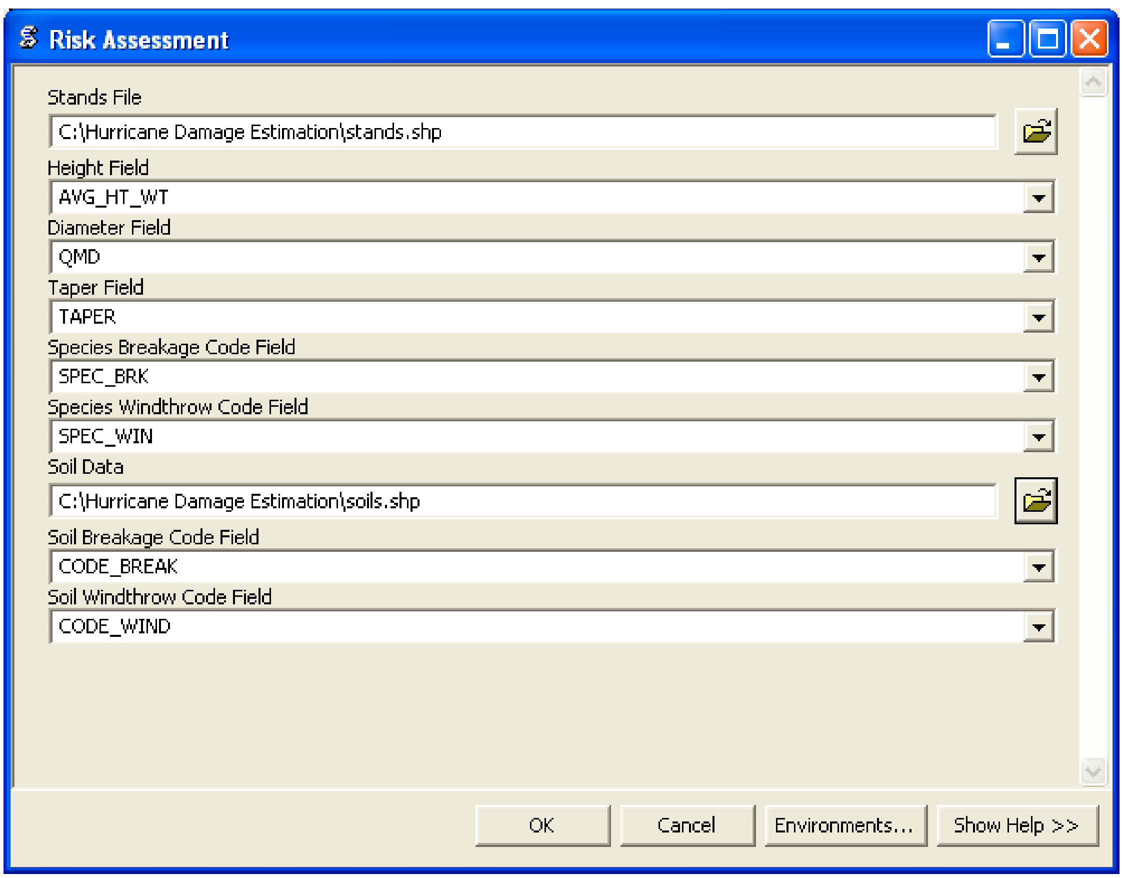

Figure B6. “Risk Assessment” dialog box with files and attributes identified.

higher susceptibility to either breakage (Figure B7) or windthrow (Figure B8). A complete description of the creation of these data inputs and outputs is available in the Phase I Final Report provided to the Fort Stewart Forestry Branch in June 2009 (Bettinger et al. 2009a). In general, the susceptibility rankings might be broken down to representative the impact the various hurricane intensities following a direct hit.

a) Ranking 40+: might represent areas damaged during a Category 1 storm
b) Ranking 30+: might represent areas damaged during a Category 2 storm
c) Ranking 20+: might represent areas damaged during a Category 3 storm
d) Ranking 10+: might represent areas damaged during a Category 4 storm
e) All stands would likely be damaged during a Category 5 storm.

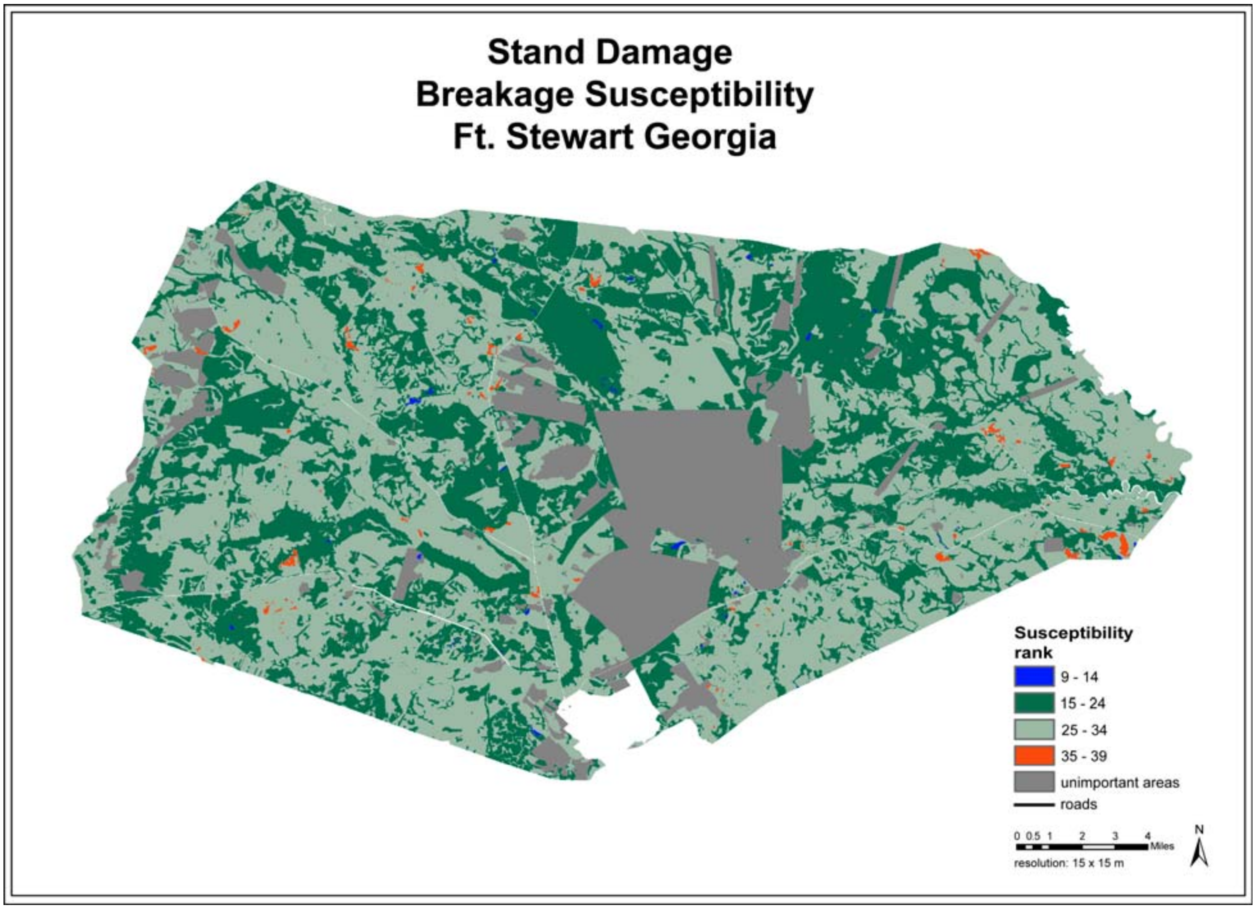

Figure B7. Breakage risk assessment for the forests of Fort Stewart.

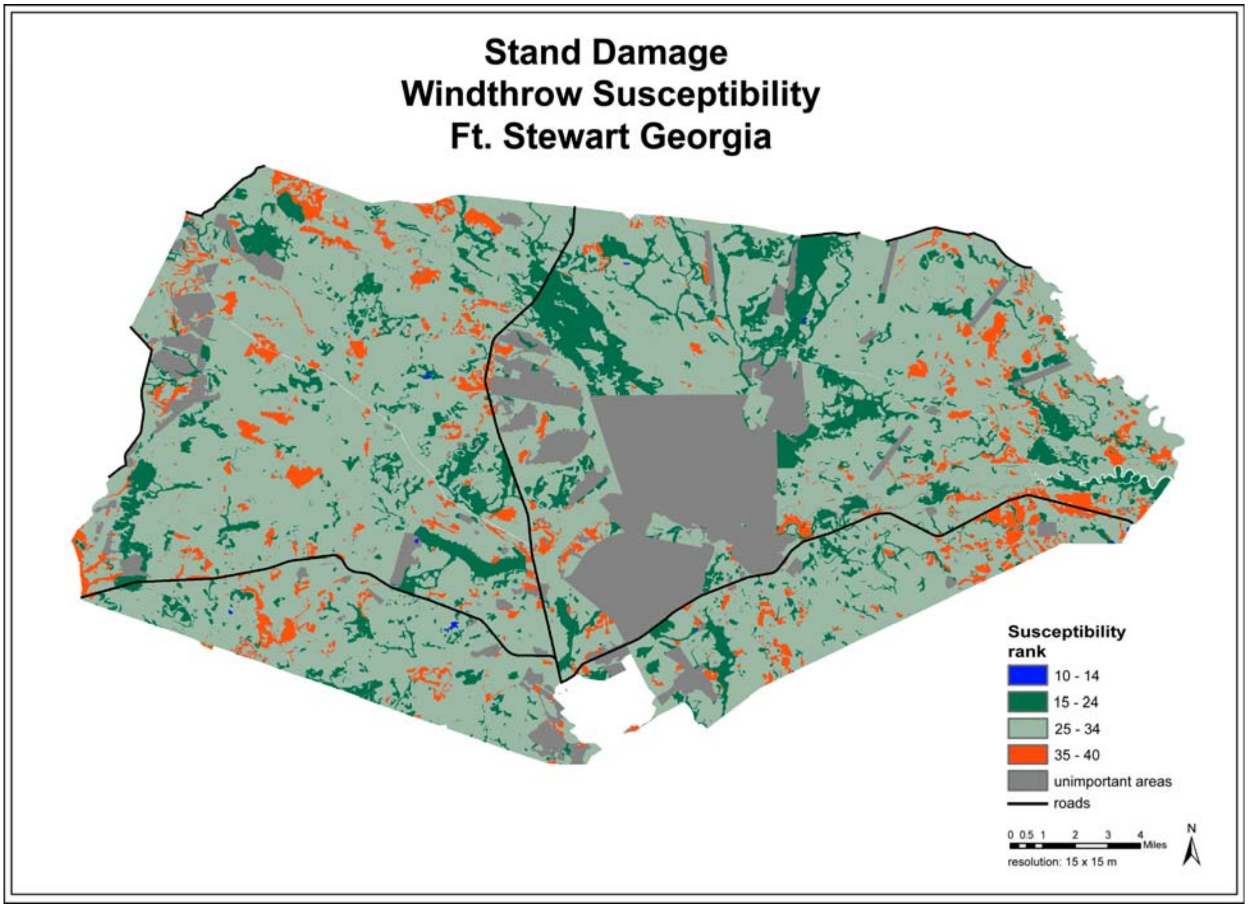

Figure B8. Windthrow risk assessment for the forests of Fort Stewart.

Stage 2: Developing an Estimate of Prevailing Wind Direction and Open Areas

The second stage of the model involves the use of the “Storm Track” script.

When using this tool, a user draws the potential hurricane storm track. In order to do this, they need to create a hurricane storm track GIS database that will contain a single line feature.

→ Open ArcCatalog.
→ In the Table of Contents of ArcCatalog, right-click the “Hurricane Damage Estimation Tool” subdirectory.
→ Select *New*, then *Shapefile*. Within the “Create New Shapefile” dialog box, name this new shapefile. The hurricane storm track GIS database can be named anything with the exception of “storm_track.shp”. When the Storm Tract tool is activated, it will copy this file and rename it “storm_track” so you must name your GIS database something else. Select *polyline* as the type of feature. The Stork Track tool was developed to operate using the UTM, NAD 1983, Zone 17N projection. When creating the new shapefile, this will need to be identified as well, or the Storm Track tool will produce an error.
→ Press OK.

We are about ready to draw the storm track of interest. Before doing so, you should add the stands GIS database (representing the installation) and the extent GIS database (representing the area in which a portion of the storm must pass. Any other GIS database, such as state or county boundaries, may be added to the Display View to help you draw the potential storm path.

→ Add the newly created storm track GIS database to the ArcMap Display View.
→ Click on the Editor Toolbar and select Start Editing.
→ The task should be "Create new feature."
→ The target should be the newly created storm track GIS database (from above).
→ Draw the storm track of interest (one track only) using the sketch tool from the Editor Toolbox.

- When drawing the hurricane track, the user must draw the track in the direction of the storm's potential travel path. For example, the hurricane in Figure B9 was meant to travel from the southwest to the northeast. The line was drawn by beginning in the southern portion of the Data View and ending in the northern portion of the Data View, resulting in a storm track azimuth of 7º. If drawn in reverse (north to south, in this example), the azimuth calculation will be incorrect.
- Be mindful of the model extent when drawing the hurricane track. The storm path simply has to intersect the model extent. The storm path does not have to fall completely within the model extent.

→ Save the edits and stop editing.

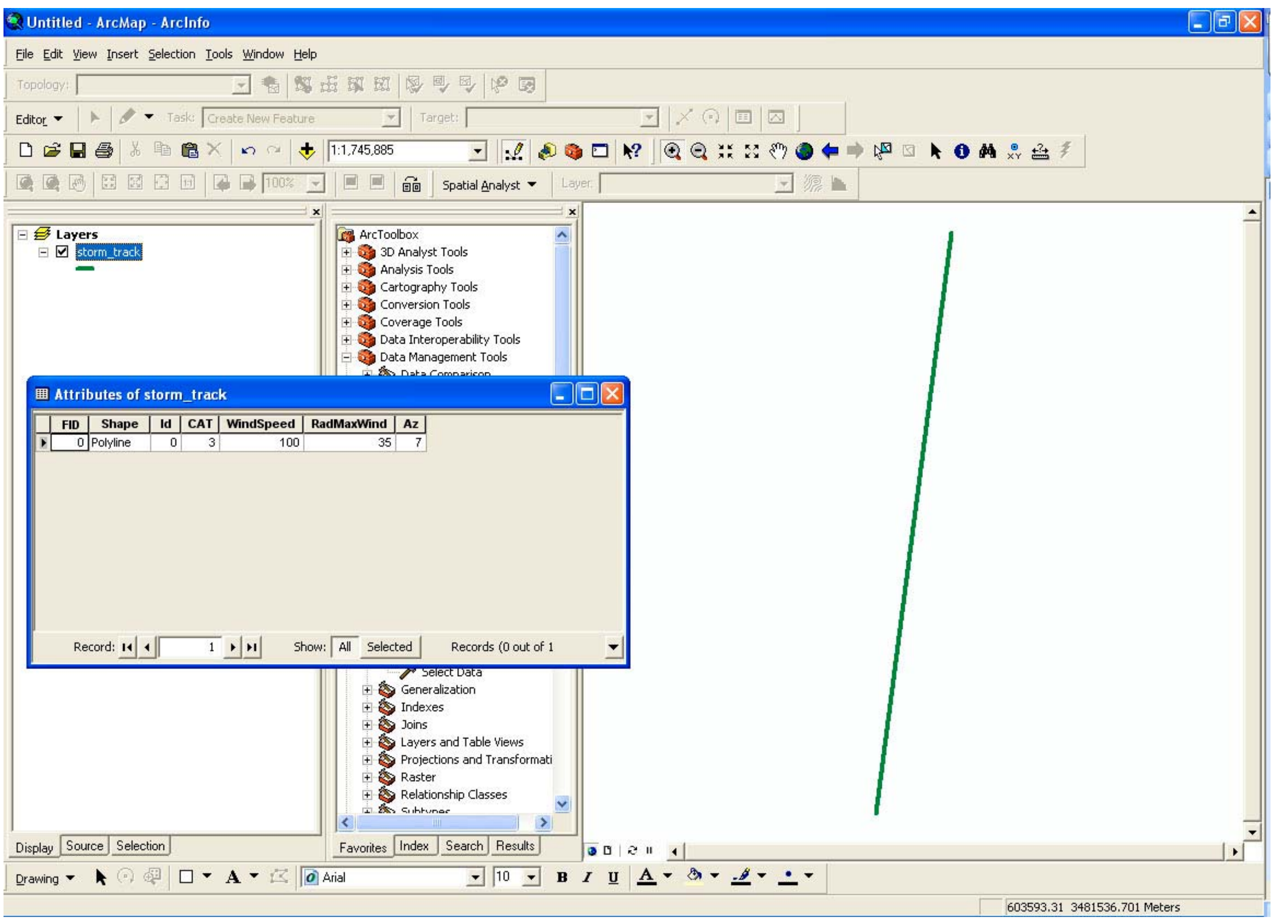

Figure B9. Storm track traveling from the south to the north.

Now that the hurricane track has been drawn, double-click on the “Storm Track” tool from ArcToolbox to open up the dialog box (Figure B10). With this interface a user will identify the storm track GIS database, the roads GIS database, and the powerline GIS database (all shapefiles), as well as specify the storm category, windspeed (MPH), and radius of maximum winds (miles).

→ Click the "file open" button to the right of the "Storm Track" textbox, navigate to the location of the storm track GIS database (a shapefile), and select it.
→ Type a storm category (1-5) into the "Storm Category" text box.
→ Type a wind speed into the "Wind Speed" text box.
→ Type a radius of maximum winds into the "Radius of Maximum Winds" text box.

→ Click the "file open" button to the right of the "Roads File" textbox, navigate to the location of the roads GIS database (a shapefile), and select it.
→ Click the "file open" button to the right of the "Powerlines File" textbox, navigate to the location of the powerlines GIS database (a shapefile), and select it.

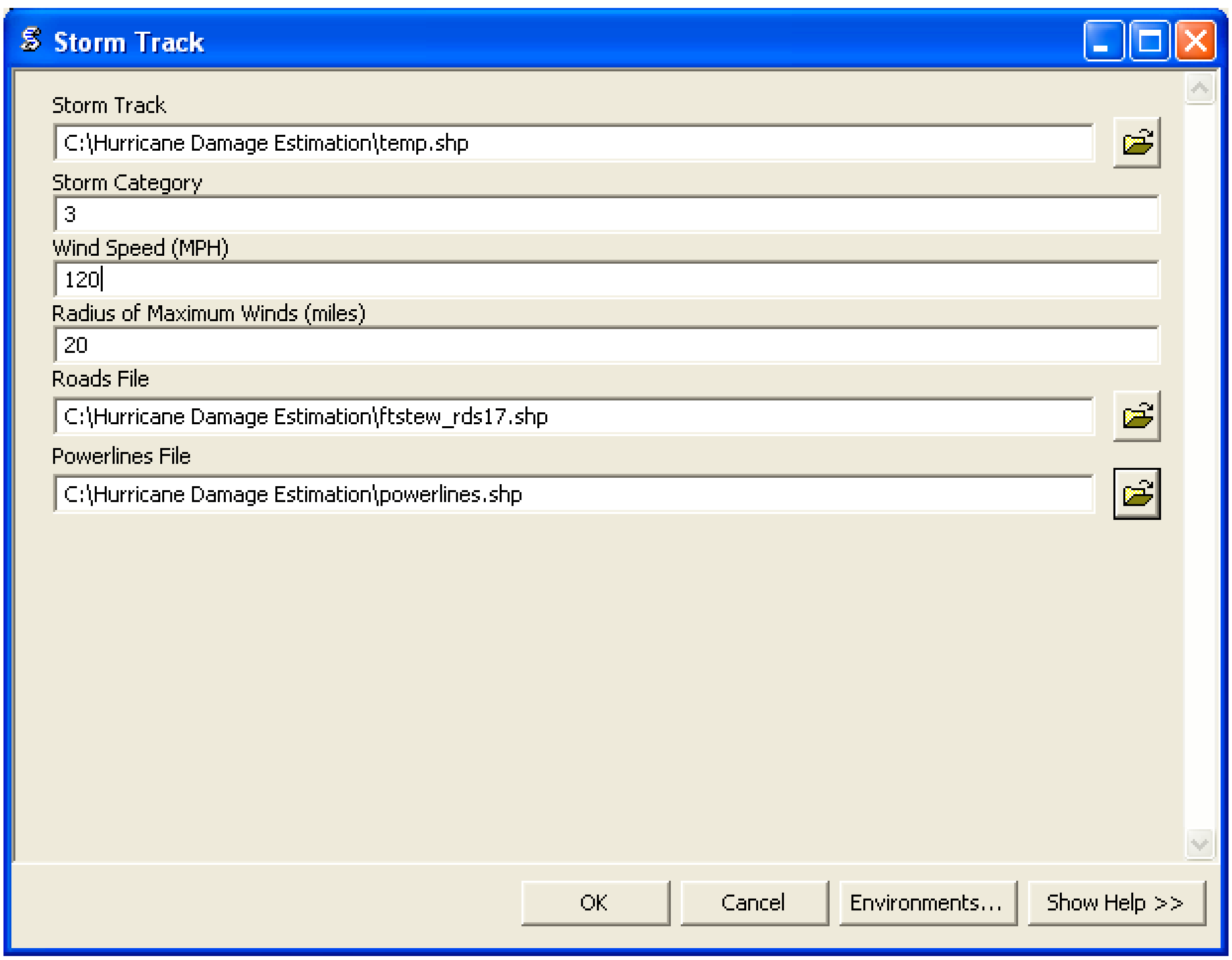

Figure B10. The “Storm Track” tool dialog box.

The necessary information for populating the windspeed and radius of maximum winds fields can be obtained from the National Hurricane Center (http://www.nhc.noaa.gov/nhc_storms.shtml). When this information is unavailable, the historic average conditions for storms might be used (Table B1).

Table B1. Average storm conditions for Category 1-5 hurricanes.

Storm category	Avg. wind speed (MPH)	Avg. radius of maximum winds (miles)
1	82	33
2	103	29
3	120	24
4	139	22
5	166	17

→ Once all of the fields in the Storm Track dialog box have been populated, click OK, and the begin the processing of the model.

During this processing step, open areas are identified, the prevailing wind direction is derived, and the azimuth of the storm track is calculated. Open areas consist of roads, powerlines, clearcuts, and training areas. The open areas, combined with average tree heights, are used in the forthcoming “Blow Down” portion of the model to determine whether trees will fall on them.

The amount of time needed to process this stage of the model will vary between computers. It is the most computationally intensive portion of the model. To illustrate the time required to perform these processes, the storm track processing was run on a Dell Precision 670 personal computer with a 3.6 Ghz processor and 2 Gb of RAM, and required 56 minutes.

Outputs from the Storm Track tool include three GIS databases:

- rec_euc2 (A raster GIS database containing the prevailing wind directions for the potential hurricane. A code of -1 represents areas within the radius of maximum winds. Any other code represents the prevailing wind direction.) (Figure B11).
- hgt_open (A raster GIS database containing the combined open areas and average stand heights. A value of 0 represents areas classified as open, whereas any other number represents the average stand height in feet.) (Figure B12).
- storm_track (A vector GIS database containing information provided by the user through the Storm Track dialog box, as well as the azimuth calculation. The attributes in this GIS database along with their definitions can be found in Table B2.).

Table B2. Storm track attributes and definitions contained in the storm_track.shp vector GIS database.

Attribute	Definition
CAT	The hurricane category defined by the user
WindSpeed	The average wind speed (MPH) defined by the user
RadMaxWind	The radius of maximum winds (miles) defined by the user
Az	The azimuth of the storm track (degrees)

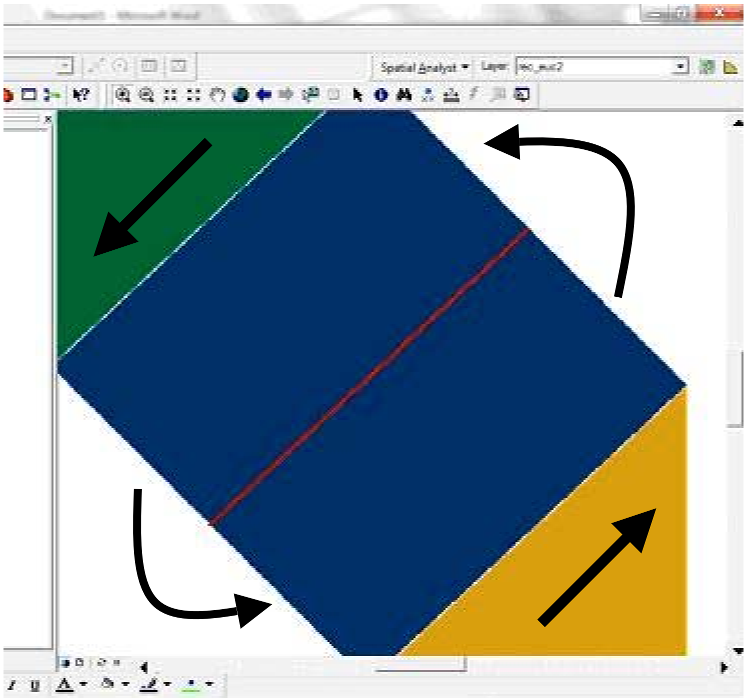

Figure B11. An example of the "rec_euc2" output database from running the Storm Track tool. Maximum wind speeds will affect trees from all directions within the radius of maximum winds. To the right of the storm path (lower right portion of the figure), wind directions are mainly headed towards the northeast in this case. To the left of the storm path (upper left portion of the figure), wind directions are mainly headed towards the southwest in this case.

All three of these GIS databases are stored in the "hurricane track" subdirectory under C:\Hurricane Damage Estimation.

The extent of the output is restricted by the maximum distance of damaging winds for each hurricane. There are two basic zones: (a) within the area defined by the radius of maximum winds, and (b) outside the area of the radius of maximum, yet out to the location where winds are 50 knots (kt) or greater. The 50 kt radius winds were selected as a cut-off for tree damage because 50 kt winds are the most comparable (from a set of available historical data) to the lowest windspeed necessary for tree damage to occur (67 mph). The relationship between the radius of maximum winds and the radius of damaging winds was developed for each storm category using linear regression analyses of historical data. This extra distance (beyond the radius of maximum winds) is used to set the extent of where damage will occur to forests, yet in a directional mode based on the prevailing winds. In the example above, trees to the right of the track will fall in a northerly direction while trees on the left side of the track will fall in a southerly direction.

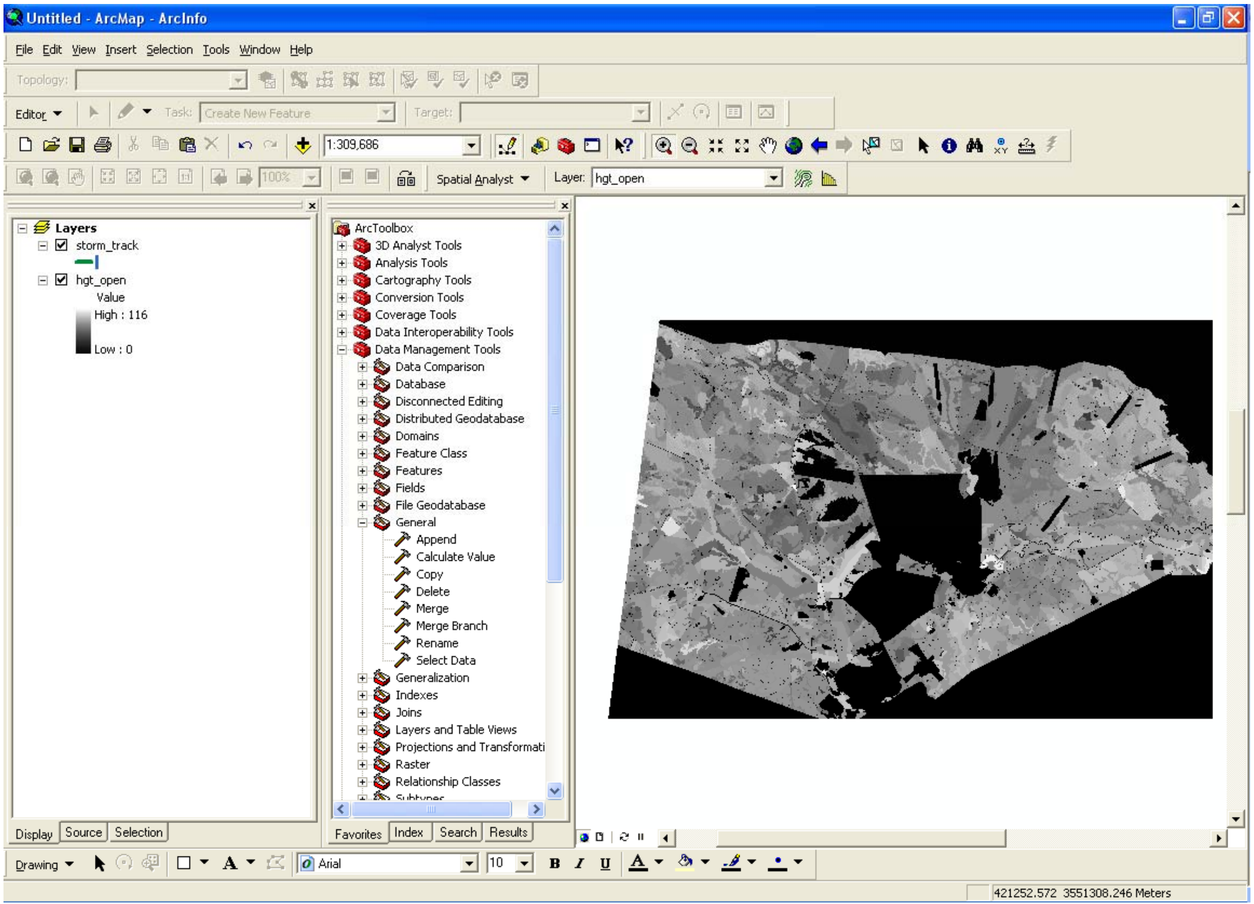

Figure B12. An example of the “hgt_open” output database from running the Storm Track tool.

Stage 3: Developing an Estimate of Areas where Debris will be Deposited on Roads or Powerlines

The *rec_euc2* and *hgt_open* raster GIS databases are required as input to the "Blow Down" stage of the hurricane damage estimation model. In addition, attributes from the vector GIS database *storm_track.shp* are used in this stage of the model. This portion of the model requires only about 2 minutes on a Dell Precision 670 personal computer (3.6 GHz processor, 2 Gb of RAM).

→ To initiate the Blow Down tool, double-click the Blow Down script from the Hurricane Damage Estimation Tool in ArcToolbox.

- You may notice that the dialog box for this tool is basically blank (Figure B13). This condition is not a mistake. All of the processing stages of this portion of the model are hard-coded and rely on files created in previous stages of the model along with pre-derived raster GIS databases. Therefore, a user does not have to provide any information for the Blow Down tool to work, yet needed to have completed prior processing steps (described above).

→ Click “OK” and the tool will begin to run.

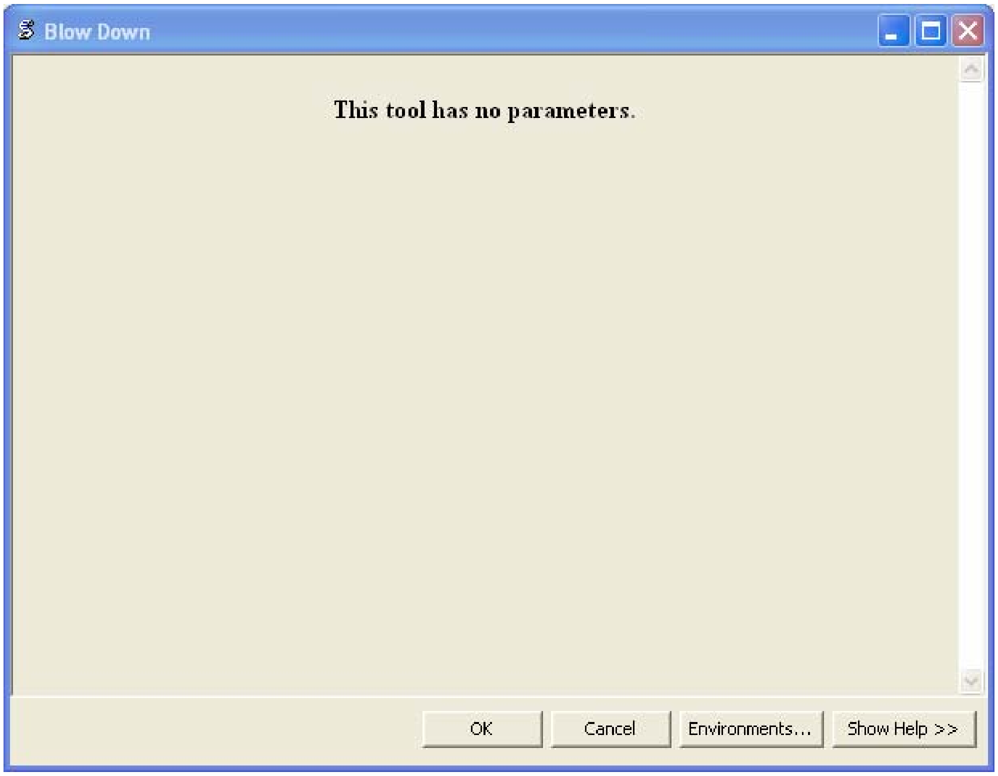

Figure B13. The "Blow Down" tool dialog box.

Using the storm track azimuth, the information in the open area database, and the prevailing wind direction, the Blow Down tool determines which open areas are susceptible to having debris deposited on them from windthrown or broken trees. As a result of using this tool:

- The final output will be a raster GIS database labeled by the storm track direction of origination followed by "_down". As an example, the final output is a raster GIS database might be named "s_down" indicating the hurricane came from the south.
- This raster GIS database can be found at "C:\Hurricane Damage Estimation\stand damage". The output file will have two classes, "0" and "1000".
- Cells with a value of "1000" are cells that are likely to have tree damage that have fallen into them (Figure B14).

This output can then be overlayed on top of the stands, roads, and powerlines databases for determination of areas of immediate concern for post-storm clean-up efforts (Figure B15).

<u>One Important Caveat of the Hurricane Damage Estimation Tool</u>

- The tool was designed to overwrite any output from prior model runs contained in the "risk assessment", "hurricane track", and "stand damage" subdirectories. If the databases in these subdirectories need to be retained, they will have to be copied and stored in a new location prior to running the model again.

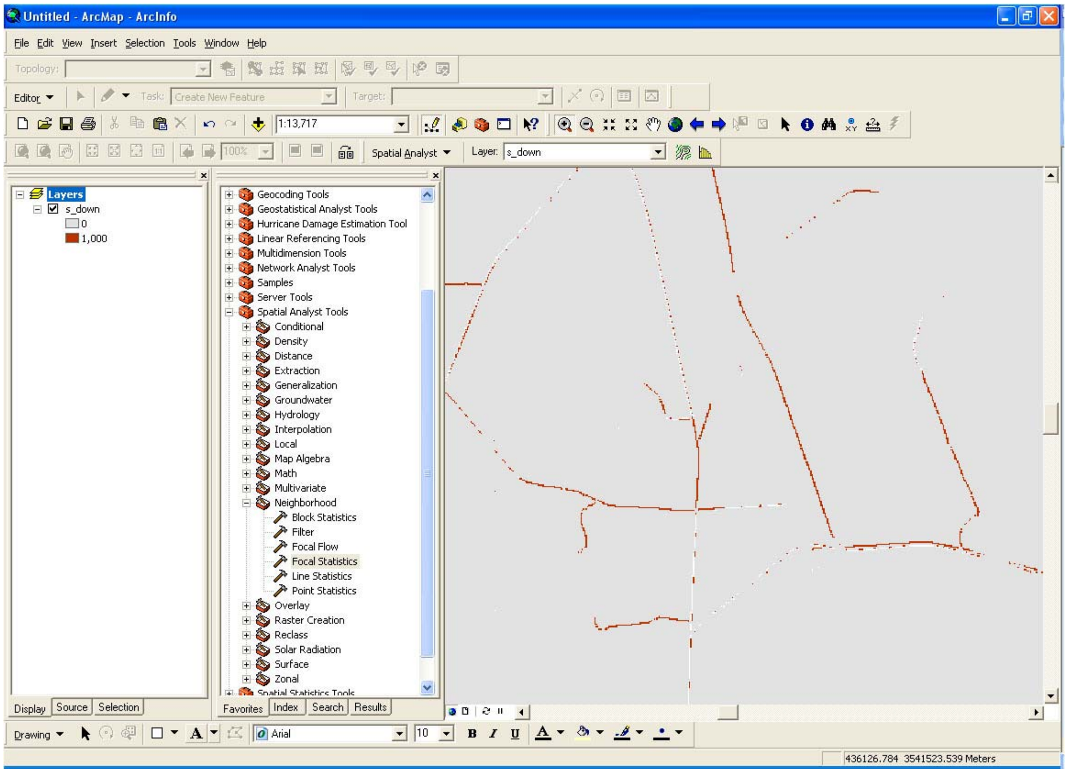

Figure B14. Potential areas of windthrow or breakage damage.

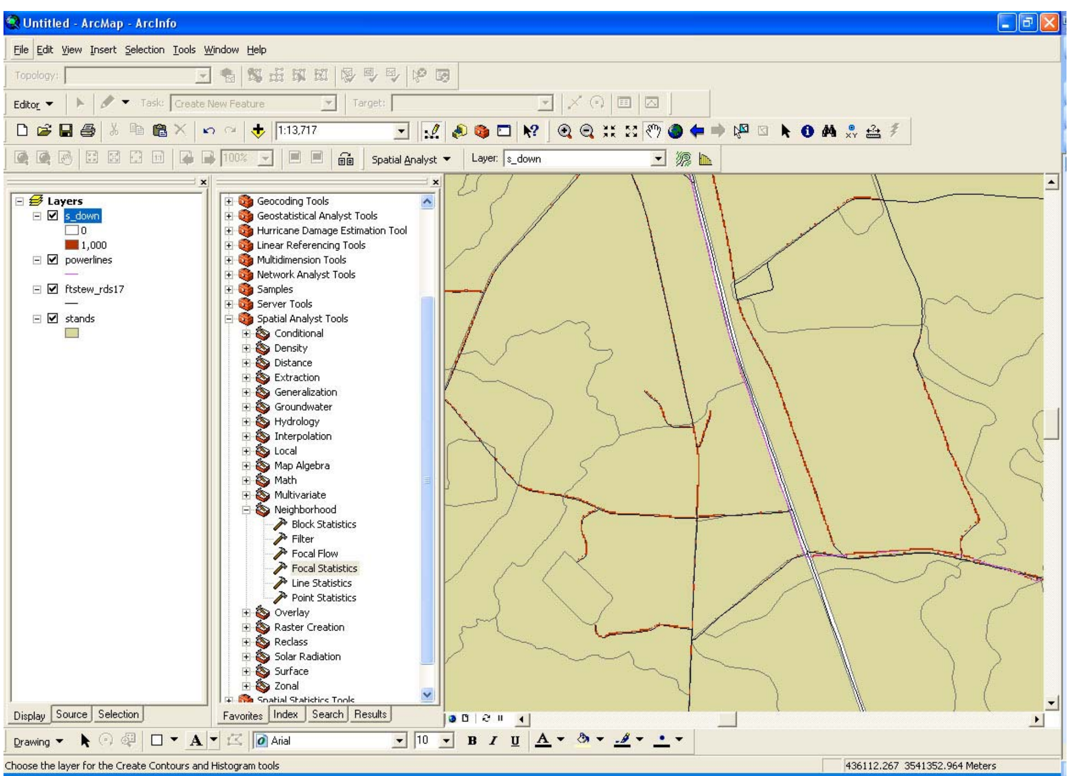

Figure B15. Overlay of potential damage in open areas with stands, roads, and powerlines.

Final Thought #1: Kernel Files

In perusing the subdirectories that were initially created in association with the use of the Hurricane Damage Estimation, you may have noticed that there was a subdirectory called “Kernel Files.” This subdirectory contains both raster GIS database and text files. These are pre-derived files used to identify open areas that have a likelihood to be impacted by falling trees from adjacent stands, given the prevailing wind direction. This subdirectory and the files it contains should never be deleted. If the subdirectory has been deleted, the Blow Down tool will not process data.

Final Thought #2: Using an Updated Stands GIS Database

If a user ever needs to run the Hurricane Damage Estimation tool with a new stands GIS database, new raster GIS databases contained in the subdirectories under the "Kernel" subdirectory will need to be developed. In sum:

- The text files provided directly in the Kernel subdirectory do not need to be changed.
- The raster GIS databases associated with stand heights in the subdirectories under the Kernel subdirectory need to be updated.

Creating the new raster GIS databases can be accomplished through the following steps:

→ Create a raster GIS database of the stand heights from the new stands GIS database.
→ Open the “Spatial Analyst Tools / Neighborhood” toolbox in the ArcToolbox column of ArcMap.
→ Select “Focal Statistics” (Figure B16).

- Focal statistics needs to be run fifty-six (56) times for the following combination of window (grid cell) sizes

  3 x 3, 5 x 5, 7 x 7, 9 x 9, 11 x 11, 13 x 13, and 15 x 15

  and storm directions:

  north, northeast, east, southeast, south, southwest, west, and northwest

→ Choose the input raster GIS database from the first step.
→ Name the output raster GIS database based on the direction of origination of the storm track and the size of the kernel window. For our example, the output raster GIS database for a storm direction of South and a 3 x 3 grid cell window should be called “s_3”. For the 5 x 5 grid cell window “s_5”, and so on. These raster GIS databases have to follow this specific nomenclature in order for them to be recognized by the model. The kernel files are customized moving windows of varying sizes that scan the stands file looking for places where there are dramatic changes in stand height. By doing this, it finds grid cells that are adjacent to open areas and determines if there is a likelihood for trees to fall into these open areas based on the direction of travel of the storm and the stand heights. There are kernel files (.txt) for each cardinal direction (north, northeast, east, southeast, south, southwest, west, and northwest) and window size. For example, “3_S.txt.” This is the kernel file for a 3 x 3 window of a storm traveling from the south.
→ Choose “Irregular” for the Neighborhood.
→ Select the appropriate Kernel file. This will be one of the provided text files.
→ For statistics type select “Maximum” (Figure B17).

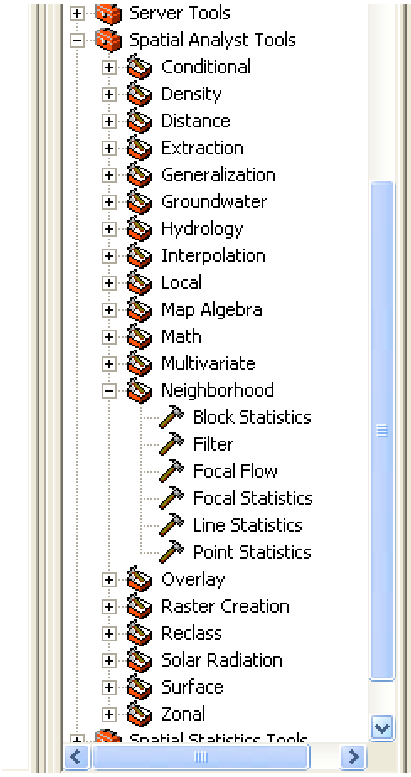

Figure B16. Locating the Focal Statistics tool in the ArcToolbox.

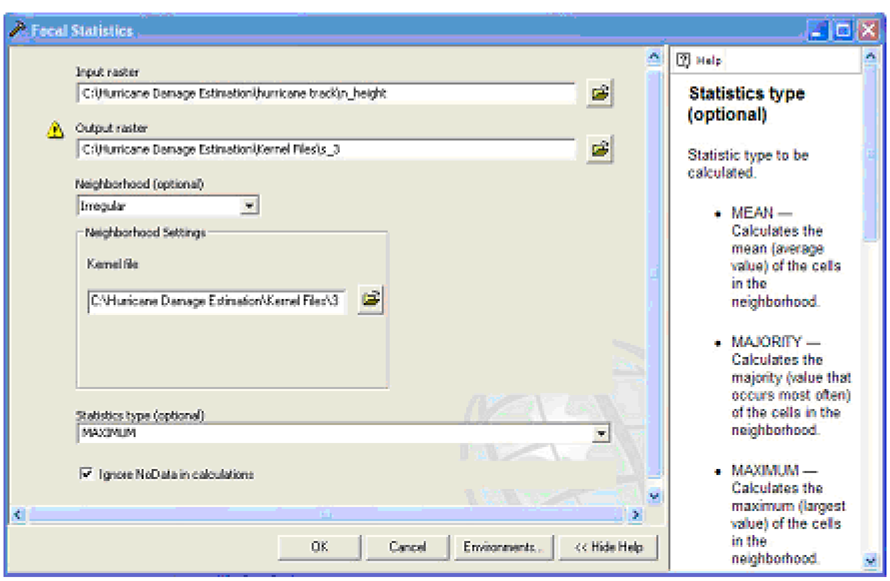

Figure B17. The "Focal Statistics" tool dialog box.