Comparing Existing Fire Records with Historical Fire Regimes for Fuel Mitigation Recommendations in the Wildland Urban Interface: A 10 year Case Study of the North Carolina Sandhills

by

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INTRODUCTION

Throughout the course of the last century, the United States Forest Service and its partner agencies have consistently addressed the issue of fire management with aggressive suppression while failing to implement an equally aggressive fuel management program. The increasing spread of the Wildland Urban Interface (WUI) into overcrowded, fire prone forests has put a considerable burden on our nation's fire management infrastructure by significantly increasing costs and decreasing firefighter and public safety. While progress is being made to address high fuel loads in fire dependent ecosystems, the majority of these efforts take place on state and federal public lands away from the WUI areas that are associated with our costliest wildfires. To bridge this gap and efficiently use the already stretched resources of our land management agencies, fire managers must specifically target the WUI areas at highest risk by addressing the deficiency in management objectives such as prescribed burning and mechanical thinning, as well as the equally important social objectives of public outreach and education.

The North Carolina Division of Forest Resources (NCDFR) and the North Carolina Prescribed Fire Council (NCPFC) have identified the Sandhills Region as a high priority area for fuel mitigation efforts in North Carolina. Over past three summers, NCDFR has utilized Student Conservation Association crews under the NC FIREWISE program to assess WUI communities in the North Carolina Sandhills and other parts of the state by performing fire hazard assessments and completing Community Wildfire Preparedness Plans (CWPP). To facilitate these and future mitigation efforts, my master's project will compile a comprehensive burn history of the North Carolina Sandhills by combining past wildfire and prescribed fire data from multiple agencies and organizations. These data will then be leveraged against other key data sources in a GIS database, including recognized WUI areas and historical fire regimes, to pinpoint those areas in greatest need of fuel mitigation efforts. The overall goal of this project is to integrate existing fire data with remote sensing data in a GIS environment to provide North Carolina fire

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managers with the tools to make informed decisions. This process will include elements under the

broader umbrella of digital forestry, an emerging field that Zhao et al. (2005) define as "the science,

technology, and art of systematically acquiring, integrating, analyzing, and applying digital information to

support sustainable forests…[and] is a framework that links all faces of forestry information at local,

national, and global levels through an organized digital network" (p. 47). The final output will allow

North Carolina fire managers to more effectively use their limited resources in the most fire active region

of the state.

GOALS & OBJECTIVES

Goal 1: Compile a comprehensive 10-year burn history of the North Carolina Sandhills study area, as shown in Figure 1, and integrate it into a GIS database with existing WUI and Historical Fire Regime data.

> Objective 1.1: Acquire burn history data from the North Carolina Division of Forest Resources, Registered Certified Burners, The Nature Conservancy, Fort Bragg, Sandhills Game Land and the Weymouth Woods Sandhills Nature Preserve
>
> Objective 1.2: Acquire other relevant data sources including LANDFIRE Fire Regime Condition Class (FRCC) and Radeloff et al.'s (2005) National WUI map.

Goal 2: Develop a GIS model that determines areas in greatest need of fuel mitigation in the North Carolina Sandhills.

> Objective 2.1: Organize all data sources into a format suitable for analyzing fire risk in WUI communities
>
> Objective 2.2: Create a WUI Risk Model and present the results to Advisory Committee (Toddi Steelman, Chris Moorman and Heather Cheshire).
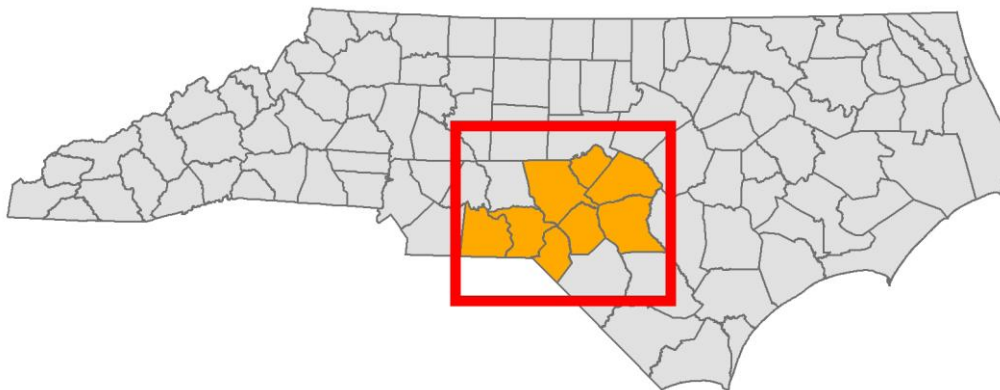

Figure 1

LITERATURE REVIEW

Past and Present Wildfire Management Policy

To fully understand the current state of forested lands in the Sandhills and other areas across the country, it is helpful to be familiar with the policy origins of wildfire management in the United States. At the turn of the 20th century, the passage of the Forest Transfer Act in 1905 brought about the creation of the United States Forest Service and the ascension of its first Chief, Gifford Pinchot, who was a strong advocate of the growing conservation movement. Under his initial direction, "the Forest Service sought to promote the efficient use of natural resources through coordinated, centrally directed decisions made by forestry professionals" with a strong focus on aggressive wildfire suppression as a means of protecting these natural resources (Busenberg, 2004, p. 149). Only five years later, the Great Fires of 1910 swept through parts of Idaho and Montana and "created the foundation for how federal agencies would relate to wildfire" (Dombeck et al., 2004, p. 884). This event directly led to the passage of the Weeks Act of 1911 that gave the Forest Service jurisdiction over the headwaters of navigable streams and "set a precedent of cooperative fire protection that would give the Forest Service far greater influence over national wildfire policy than was possible through the enlargement of the national forests alone" (Busenberg, 2004, p. 150). The passage of the Clarke-McNary Act in 1924 further nationalized this movement by requiring states to adopt a fire suppression policy in order to receive federal appropriations, although it was met with some criticism and debate in the Southeast due to the culturally accepted practice of light burning. The effects of this strict fire suppression policy went largely unnoticed for the next 70 years as massive amounts of unburned fuel accumulated in fire adapted ecosystems. After a string of major fire years throughout the mid to late 1990's and early 2000's, it is apparent that "the very policy of fire suppression that had been adopted decades earlier was actually producing forests with high fire hazards,...and unless fuels-management techniques are employed in appropriate forest types (those that once experienced frequent, low-to-moderate intensity fire regimes)

at necessary spatial scales and arrangements, many of these forests will continue to be subject to uncharacteristically severe fires" (Stephens & Ruth, 2005, p. 533, 536).

Since 2000, federal land management agencies have mandated new policies in response to the growing threat of severe wildfires on public lands, and by extension, the WUI. The 2000 National Fire Plan (USFS, 2000) called for the distribution of $10 billion over the course of the current decade to be used for the protection of communities and restoration of healthy forests in fire-adapted ecosystems. It further states that "Planning in fire-adapted ecosystems requires an understanding of local forest type, fire history, potential fire behavior, past management actions, land-use changes, watershed needs, species viability, and relative risk to human communities" (as cited in Dombeck et al., 2004, p. 888). The 2001 federal wildland fire-management policy stated that "Fire as a critical natural process, will be integrated into land and to resource management plans and activities on a landscape scale, and across agency boundaries" (NWCG, 2001, p. 23). The language of these recent policy changes are very clear and point to an urgent need to restore our wildlands back to their historical fire regimes.

Historical Fire Regimes

Brown (1995) defines fire regimes as the "nature of fires occurring over an extended period of time" (p. 171). Historically, the Sandhills region was dominated by longleaf pine (*Pinus palustris*) savannah and had a low-intensity, high-frequency fire regime occurring every 1-3 years primarily from lightning ignitions (Frost, 1995). Due to the effects of fire exclusion, logging, and conversion to agriculture, the longleaf pine population has been reduced to approximately 3% of its original range and has been replaced by dense stands of less fire adapted species such as loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), shrubs and various mid-story hardwoods. According to Morgan et al. (2005), "The frequency of fires directly and indirectly affects species life cycles, vegetation structure and composition, and fuel accumulation and is the main theme of much of the research involving the evaluation of fire regimes" (p. 330). Understanding the current condition of the Sandhills ecosystem in terms of the

departure from its historical fire regime is particularly "useful for planning, assessing risk, and evaluating ecological conditions" (Morgan et al., 2005, p. 329). The LANDFIRE project, commissioned in 2003, is an attempt to map the Fire Regime Condition Class (FRCC) of the entire United States at a finer spatial scale than was previously available, which is critical for local applications and will be a key data source in the analysis of fire risk in this project.

The Fuels Problem

The three main variables that dictate fire behavior are fuels, weather, and topography, but fuels are the only component of this triangle that fire managers have any control over, which makes the reduction of fuels the primary means of mitigating wildfire risk in the WUI. Wildland fuels can be broken down into four key groups (ground, surface, ladder, and crown), and "In forests that experienced frequent, low-intensity…fire regimes prior to a long period of fire suppression [as is the case in the NC Sandhills], fuels treatments should focus on surface, ladder, and then crown fuels" (Stephens & Ruth, 2005, p. 535). For WUI areas that are subject to high fuel loads, "projects that thin small trees and remove brush followed by the careful use of prescribed fire should be welcomed by a broad cross-section of interests" (Dombeck et al., 2004, p. 887).

It is important to recognize that mechanical thinning and prescribed fire both have their benefits and limitations and can be used alone or in combination. Mechanical thinning has the advantage over prescribed fire in that it does not produce smoke emissions and can be performed throughout the year, but it also requires a significant amount of manpower and equipment, which means progress can be slow. On the other hand, prescribed fire can treat large areas in a short amount of time, but "multiple constraints (air quality, wildlife, weather, and personnel availability) routinely limit periods for burning operations" (Stephens & Ruth, 2005, p. 537).

Defining the Wildland Urban Interface

To target areas in greatest need and assign priorities, one must first accurately define the WUI.

Stewart et al. (2007) stress the political implications of this task: "Tensions over where best to concentrate decision making authority and funding responsibility are natural outcomes of shared responsibility. In this context, defining and classifying the WUI takes on greater significance" (p. 206).

According to the *Federal Register* (2001), "the WUI community exists where humans and their development meet or intermix with wildland fuels. Interface communities exist where structures directly abut wildland fuels, [and] Intermix communities exist where structures are scattered throughout a wildland area" (p. 752-753). In quantitative terms, it defines the WUI as 1 housing unit per 40 acres. Haight et al. (2004) explain the expansion of this definition to include houses within 1.5 miles of wildland vegetation, because "This is roughly the distance that firebrands can be carried from a wildland fire to the roof of a house" (p. 44).

Scale is an important consideration when defining the WUI. At the national and regional level, course-scale data are suitable for detecting broad patterns, but for local applications, fine-scale data is essential. Census data are frequently used to determine WUI locations because they are easy to manipulate and readily available at multiple scales, the smallest of which is at the block level where each unit has an average size of 200 acres and contains approximately 70 people. Zhang & Wimberly (2007) affirm "…that WUI at the block level has a distinguishing spatial pattern: The WUI has more spatial detail, is more fragmented, and is more intermingled with wildland" (p. 147).

In addition to scale, an appropriate metric should be used to determine WUI density. Within the limitations of census data, the choice is between population density and housing density. Kamp & Sampson's 2003 study opted to use population density at the census block level, but others contend that population density underestimates the extent of the WUI because it does not take secondary and vacation homes into account and undervalues the priority of protecting structures in wildland firefighting (Stewart et al., 2007; Theobald, 2001; Zhang & Wimberly, 2007). Given these considerations, this project's data source will be Radeloff et al.'s 2005 assessment of the WUI in the United States. Their

methods take all of these important factors into account and are outlined below:

Housing density: Housing density information was derived from U.S. Census data. Analysis was conducted at the finest demographic spatial scale possible, Census blocks, from the 2000 Census. All measures of housing density are reported as the number of housing units per square kilometer.

Landcover: They utilized the National Land Cover Dataset, a satellite data classification produced by the USGS with 30m resolution based on 1992/93 imagery and available for the entire U.S. (Vogelmann et al. 2001) to identify 'wildlands'. Our definition of 'wildlands' encompasses a range of management intensities. NLCD classes that we included as 'wildlands' are forests (coniferous, deciduous and mixed), native grasslands, shrubs, wetlands, and transitional lands (mostly clear-cuts). We exclude orchards, arable lands (e.g., row crops) and pasture.

The Wildland-Urban Interface (WUI): WUI is composed of both interface and intermix communities. In both interface and intermix communities, housing must meet or exceed a minimum density of one structure per 40 acres (16 ha). Intermix communities are places where housing and vegetation intermingle. In intermix, wildland vegetation is continuous, more than 50 percent vegetation, in areas with more than 1 house per 16 ha. Interface communities are areas with housing in the vicinity of contiguous vegetation. Interface areas have more than 1 house per 40 acres, have less than 50 percent vegetation, and are within 1.5 mi of an area (made up of one or more contiguous Census blocks) over 1,325 acres (500 ha) that is more than 75 percent vegetated. The minimum size limit ensures that areas surrounding small urban parks are not classified as interface WUI.

Buffer Distance for Interface: The California Fire Alliance (2001) defined "vicinity" as all areas within 1.5 mi (2.4 km) of wildland vegetation, roughly the distance that firebrands can be carried from a wildland fire to the roof of a house. It captures the idea that even those homes not sited within the forest are at risk of being burned in a wildland fire. We adopt this buffer distance to identify interface areas.

Targeting High Risk Wildland Urban Interface Areas

Current wildland fire policy targets the WUI as a top priority for fire prevention and preparedness projects (USDA, 2002 & NWCG, 2009), which is not surprising considering the additional challenges fire managers face when wildfires threaten these areas. In non-WUI areas fire managers typically have the full range of strategies and tactics at their disposal, but due to public safety concerns and the additional values at risk, management options in the WUI are often limited to full suppression and point protection, which can significantly increase costs and drain resources that could otherwise be used for fire prevention and preparedness projects. To end this vicious cycle, local fire managers must be proactive and select those areas within the WUI that are most at risk from high fire danger. Haight et al (2004)

reinforce this point: "With limited resources for fire prevention and preparedness, planners set priorities by choosing the type and location of projects to maximize the expected reduction in damage to people, houses, or natural resources. The process of setting priorities typically includes a risk analysis involving the determination of the probabilities of severe wildfire in WUI areas and the values at risk of damage or loss (p. 41-42)." To that end, the ultimate goal of this project is to provide fire managers in the Sandhills with a valuable tool that will enable them to use their resources most effectively.

WUI Outreach

Once fire managers have to tools to locate high-risk WUI areas, the next logical step is to develop relationships by providing risk assessments, preparing Community Wildfire Preparedness Plans (CWPP's) and educating community members regarding potential fuel treatments. Gaining public support is critical in this process, because without their approval even the best-laid plans can be met with tough resistance. For the past three years, the North Carolina Division of Forest Resources (NCDFR) has been working to achieve these goals by dispatching Student Conservation Association (SCA) crews to WUI areas throughout the state under the NC FIREWISE program. By using SCA crews for support, personal outreach efforts can be made year round since NCDFR staff are routinely unavailable during fire season because of other duties and responsibilities. It is this combination of government and non-government contact that is essential in public education and acceptance of fuel reduction treatments. McCaffrey (2004) discovered in her research that "…personal [non-government] contacts were particularly influential in increasing support for more controversial aspects of prescribed burning, and government contacts were influential in increasing the acceptance of more controversial thinning methods" (p. 18). Outreach efforts can be particularly convincing when community members are taken to nearby areas where fuel treatments have already been successfully applied. In this setting "Fire managers are able to show the applicability of fuel management and prescribed burning in a wide range of circumstances" (Rice, 1995, p. 165). These demonstrations also give fire managers the opportunity to move beyond

generalizations and give more specific information regarding the reasons, plans, effects and advantages

of fuel management (Rice, 1995; Shelby & Speaker 1990). Educational materials such as FIREWISE

pamphlets and brochures are also important, but "to be effective, these materials may need to be placed

directly into people's hands and not delivered impersonally via mailings, display tables or newsstands.

Ultimately, coupling educational materials with more-personalized contact appears to be the most

effective method for providing information on wildfire management and mitigation" (McCaffrey, 2004, p.

18).

The true measure of success will be defined by the extent to which local communities and fire

managers can work together to reduce the ignitability of homes through defensible space and fuel

reduction treatments. While it is impossible to fire proof an entire region such as the NC Sandhills, it is

entirely within our reach to be prepared for the inevitable by creating fire-adapted homes and

communities within a fire-adapted landscape. As Dombeck et al. explain, "The challenge is to put fire

back on the land in a way that minimizes the risk to people and communities while mimicking natural

fire regimes to the extent possible. As important as ecological principles are, however, living with fire

largely remains a social issue that will require greater agency leadership and community responsibility"

(p. 887-888).

Achieving the goal of locating these high risk WUI areas will involve two steps: acquiring and cleaning

the relevant fire history, FRCC, and WUI data, and combining them in a geoprocessing model. All

wildfires and prescribed fires will be treated equally and combined into a single polygon feature called

"Sandhills Burn History," out of which two key attributes will be extracted. The first, "Fire Frequency,"

will count the number of times a given area has burned in the last 10 years, while the second, "Last

Burn," refers to the last year a given area has burned. These two variables are important because they

show how the last 10 years of fire activity corresponds with the historic fire regime in the Sandhills WUI.

Statistics will also be extracted from the Sandhills Burn History to give a better sense of how much

prescribed burning is taking place in the WUI when compared to wildfires.

METHODS: DATA SOURCES & CLEANUP

The first step in this process was the fire history data collection. Each dataset was gathered through in person visits or email correspondence with fire managers and land management agency personnel. The amount of cleanup needed for each dataset ranged from minimal to intensive and all efforts were made to maintain data integrity throughout the entire process. The full procedure log for the data cleanup process is included in Appendix A at the end of this document.

Wildfire & Prescribed Fire Data Descriptions and Primary Cleanup

NC Forest Service Wildfires – NC Division of Forest Resources: Andrew Bailey – GIS Point Feature

These data were collected from the NC Division of Forest Resources Wildfire Database and include any wildfire that occurred under the jurisdiction of the NC Forest Service. Due to improper formatting of latitude/longitude coordinates during the conversion from paper to digital records, decimal points were cut off, which effectively reduced the locational precision for a significant portion of the database. As a result, the plotted points take on a grid-like appearance in ArcMap, since many points have been snapped to the nearest latitude/longitude minute intersection. This also created hundreds of artificially coincident points, which affects the accuracy of fire frequency and last fire occurrence variables extracted from this database.

NC Forest Service Prescribed Fires – NC Division of Forest Resources: Andrew Bailey – GIS Point Feature

These data were collected from the NC Division of Forest Resources 4220 Database, which is also known as the Accomplishment Reporting Program. Any prescribed burning performed by the NC Forest Service for private landowners is recorded in this database including the date of burn, purpose of burn, final fire size, and latitude/longitude coordinates. Individual burn records that were entered into the database multiple times to get credit for several objective accomplishments were discarded.

Fort Bragg Wildfires & Prescribed Fires – Fort Bragg Military Base: Pat Wefel / Paul Hinkle – GIS Polygon Feature

These data were collected from both wildfire and prescribed fire records kept by Fort Bragg Military Base. The base is broken down into smoke management units with a total of approximately 162,000 acres, which are burned on a 2-3 year rotation with 25% of the burning taking place during the dormant season (December – March) and 75% of the burning taking place during the growing season (April – June). Fire Managers Joe Stancar and Paul Hinkle estimate that Fort Bragg Forestry completes 98% of their burning objectives each year, totaling approximately 50,000 to 65,000 acres. Although wildfires that occur within the base are recorded as such, they are treated the same as prescribed fires since they fulfill the same fuel reduction or wildlife habitat objectives. The records are well organized and include date of burn, purpose of burn, and final fire size. Very little data cleanup was necessary aside from some minor formatting changes.

Sandhills Game Lands Prescribed Fires – Sandhills Game Lands: Jacob Marquess / Chris Jordan – GIS Polygon Feature

These data were collected from prescribed fire records kept by Sandhills Game Lands. The Game Lands are broken down into burn blocks and are burned on a somewhat irregular schedule with many not having been burned since before 1999. The records are well organized and include date of burn, purpose of burn, and final fire size. Very little data cleanup was necessary aside from some minor formatting changes.

Sandhills Game Lands Wildfires – Sandhills Game Lands: Jacob Marquess / Chris Jordan – GIS Polygon Feature

These data were collected from wildfire records kept by Sandhills Game Lands. Each fire is represented as an individual polygon that roughly coincides with their prescribed fire burn blocks. The records are well organized and include date of burn and final fire size. Very little data cleanup was necessary aside from some minor formatting changes.

Certified Burner Prescribed Fires – NC Division of Forest Resources: Don Watson / Michael Good – Excel Spreadsheet

These data were collected from Smoke Management Log records kept by District 3 and District 6 of the NC Forest Service. Other sources were considered, including personal records kept by Certified Prescribed Burners as well as Prescribed Burn Plans, also kept by District 3 and District 6. Responses to personal record requests were infrequent and incomplete, making it necessary to obtain them from a centralized and consistent source, and Prescribed Burn Plans were dropped from consideration as a data source since there was no guarantee that the burns actually took place once the plan was submitted. Smoke Management Logs were entered by hand into an excel spreadsheet and include name of burner, date of burn, county, purpose of burn, final fire size, and locational data (Note: Records in District 3 went back to 2001, and records for District 6 went back to 2000). The locational data were recorded as either Quadrant-Block-Square-Point (QBSP) or latitude/longitude format, and the QBSP entries were converted to latitude/longitude decimal degrees. This was accomplished by creating a vector grid using the ET Geowizards extension with the following parameters:

- Quadrant: Each degree of latitude and longitude is used to divide the State into blocks containing approximately 3600 square miles and are numbered 1-29
- Block: Each quadrant is subdivided into 144 areas that are 5 minutes of latitude/longitude per side (approximately 25 square miles)
- Square: Each block is further subdivided into 25 areas that are 1 minute of latitude/longitude per side (approximately 1 square mile)
- Point: Each square is finally subdivided into 25 areas that are 12 seconds of latitude/longitude per side (approximately 2/10 square mile) – The centroid of each area was used as the latitude/longitude location for each point

QBSP data recorded down to the Point level is accurate within .2 miles, and data recorded down to the Square level is accurate within 1 mile. Approximately 10 percent of all records were discarded since they did not fall within the correct county or the latitude/longitude format was ambiguous.

Weymouth Woods Prescribed Fires – Weymouth Woods State Park: Scott Hartley – Excel Spreadsheet

These data were collected from prescribed fire records kept by Weymouth Woods State Park. The locational data was recorded as QBSP, which had to be converted to latitude/longitude decimal degrees

using the same process for converting Certified Prescribed Burner fire data. Other attributes included in this spread sheet include date of burn, purpose of burn, and final fire size.

The Nature Conservancy Prescribed Fires – The Nature Conservancy: John Cannon / Mike Norris – Shapefile

These data were collected from prescribed fire records kept by The Nature Conservancy. Land parcels are broken down into burn blocks and are burned on a somewhat irregular schedule with many not having been burned since before 1999. The records are well organized and include date of burn, burn type, and final fire size. Very little data cleanup was necessary aside from some minor formatting changes.

Wildfire & Prescribed Fire Data Secondary Cleanup

The second stage of fire history data cleanup involves merging all datasets into one polygon feature. This inevitably creates overlapping polygon sections that need to have their attributes merged by calculating the sum of the total number of fires, or calculating the most recent burn year. A simplified example of this process is shown below in Figure 2, with each circle representing a fire boundary. Once these overlapping pieces are combined to form single polygons, the dataset is ready to be converted into raster format for analysis. Each variable is shown independently on the following pages in Figures 3 & 4 to illustrate where, when, and how frequently fires have occurred over the last 10 years.
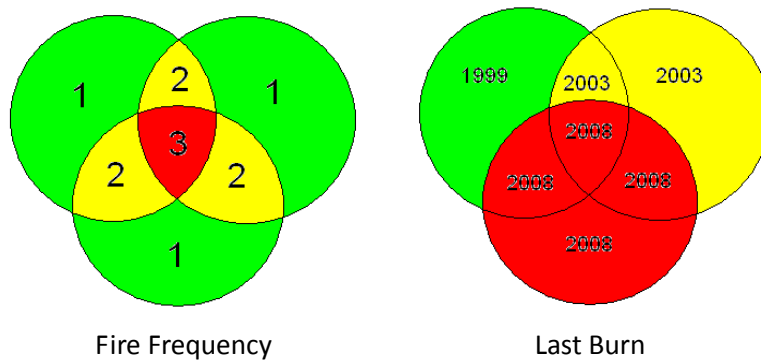

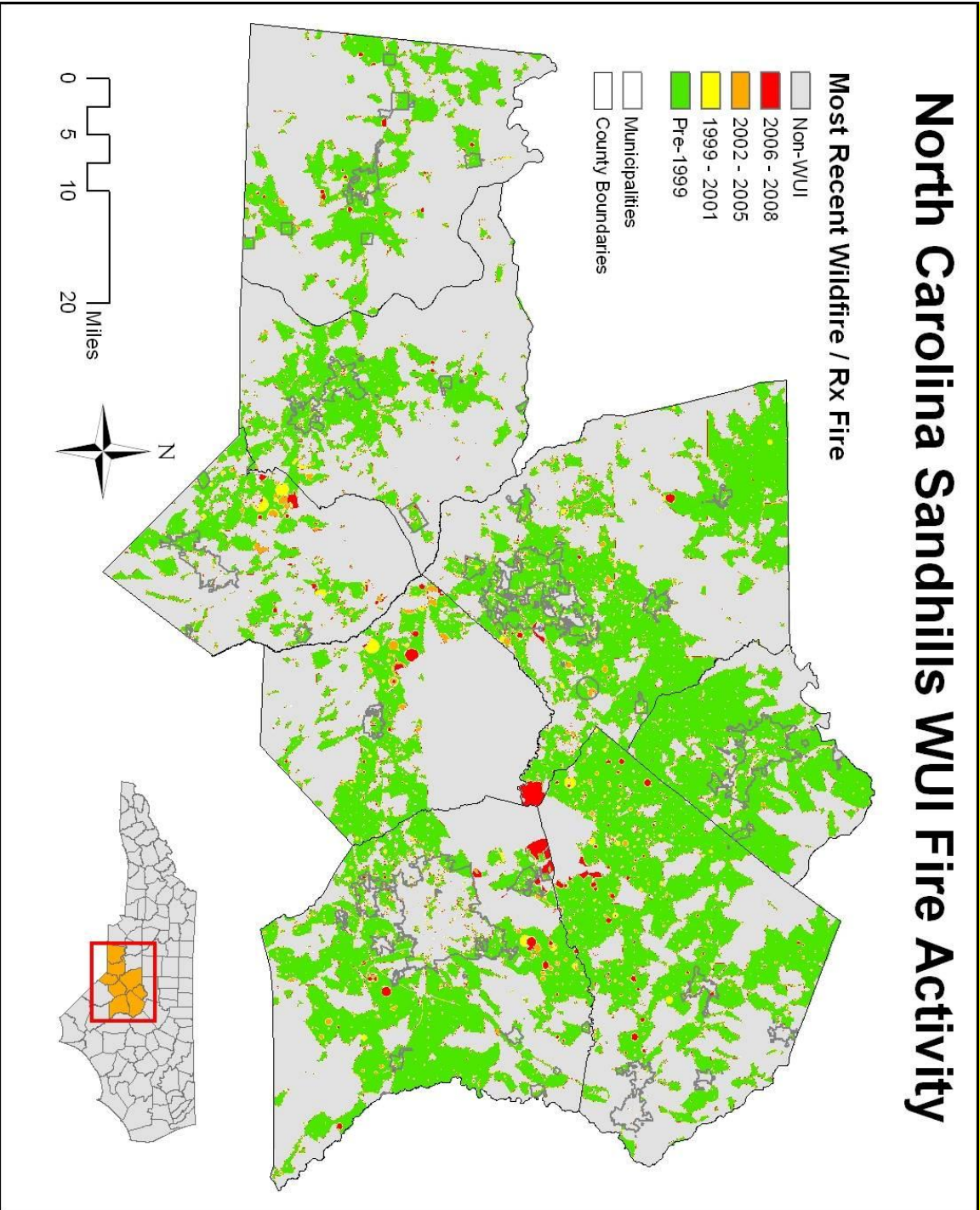Fire Frequency   Last Burn
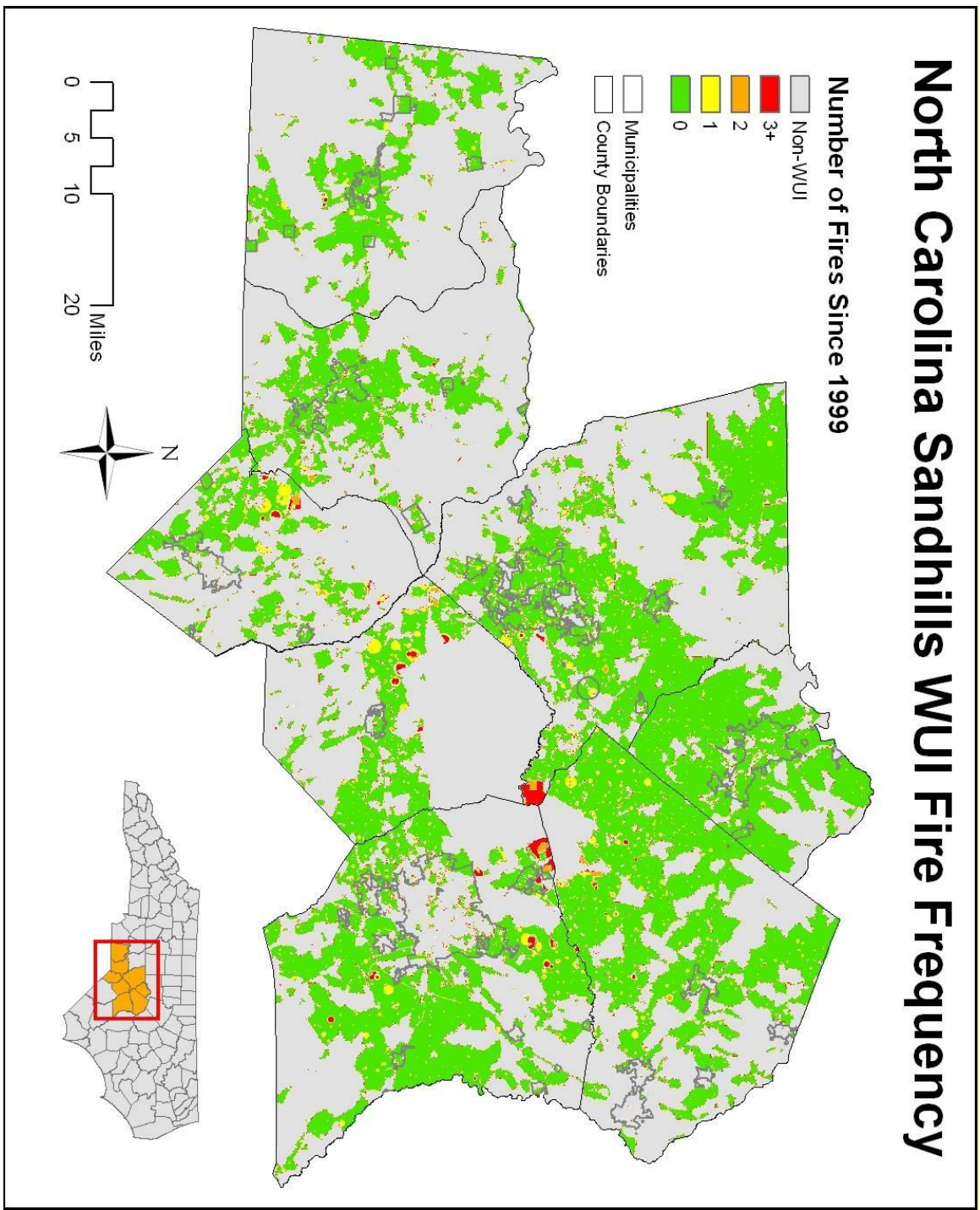
Figure 2

Figure 3

Figure 4

FRCC & WUI Data Descriptions and Cleanup

Once the Sandhills Burn History was compiled, the FRCC and WUI variables were downloaded from

their respective internet servers. Both datasets were very well organized and came with well

documented metadata.

LANDFIRE Fire Regime Condition Class – http://www.landfire.gov – ESRI GRID Raster

This data layer is freely available from the LANDFIRE website and categorizes land into the following

Fire Regime Condition Classes:

- FRCC1: Low (<33 percent) departure from reference conditions
- FRCC2: Moderate (33 to 66 percent) departure from reference conditions
- FRCC3: High (>66 percent) departure from reference conditions

The departure from reference conditions is calculated based on changes to species composition,

structural stage, and canopy closure using 2001 National Land Cover Data (NLCD). The data layer was

already in raster grid format, and very little data cleanup was necessary aside from some minor

formatting changes.

Wildland Urban Interface – http://silvis.forest.wisc.edu/library/WUILibrary.asp – ArcInfo Interchange File

This data layer is freely available from the University of Wisconsin SILVIS Lab website and categorizes

land into the following WUI Density Categories:

- Low Density Interface/Intermix: Areas with housing density >= 6.177635 (housing units/km^2) and < 49.42108 (housing units/km^2), Vegetation <= 50%, within 2.414 km of an area with >= 75% Vegetation
- Medium Density Interface/Intermix: Areas with housing density >= 49.42108 and < 741.3162, Vegetation <= 50%, within 2.414 km of an area with >= 75% Vegetation
- High Density Interface/Intermix: Areas with housing density >= 741.3162, Vegetation <= 50%, within 2.414 km of an area with >= 75% Vegetation

The data layer was converted into a raster dataset, and very little data cleanup was necessary aside

from some minor formatting changes.

METHODS: ANALYSIS

It is important to note that this model did not indicate the probability of a fire occurring in the

Sandhills WUI, since it already ran under the assumption that the Sandhills is the most fire prone area in

North Carolina. Therefore, this model referred to the potential severity and effects of a fire based on Fire

Regime Condition Class (Fuel Loading), WUI Density (Values at Risk), Fire Frequency, and Recent Fire

Activity. All four variables were used as an input in the WUI Risk Model, which was based on the

following assumptions:

  I.   Both wildfires and prescribed fires reduce risk due to the reduction of fuels
       A.   More recent fire activity lowers risk more than less recent fire activity
       B.   More frequent fire activity lowers risk more than less frequent fire activity
  II. Increasing WUI density elevates risk due to a higher concentration of values at risk
  III. Increasing departure from the historical fire regime elevates risk due to a higher buildup of fuels

Based on these assumptions, each variable was reclassified using a scale from 1 - 7 (Table 1) and

given equal weight (25%) using the Weighted Overlay tool. Based on their overall score, the results were

grouped into four risk categories ranging from very low risk to high risk.

Fire Regime Conditon Class		Wildland Urban Interface/Intermix		Fire Frequency		Recent Fire Activity	
Urban / Agriculture	1	Low Density	1	3+	1	2006-2008	1
FRCC 1	3	Medium Density	4	2	3	2002-2005	3
FRCC 2	5	High Density	7	1	5	1999-2001	5
FRCC 3	7	Other	NoData	None	7	Pre-1999	7
Water / Barren	NoData						

Table 1

RESULTS: MAP OUTPUTS

The final output of the WUI Risk Model is illustrated on the following page in Figure 5, which shows all

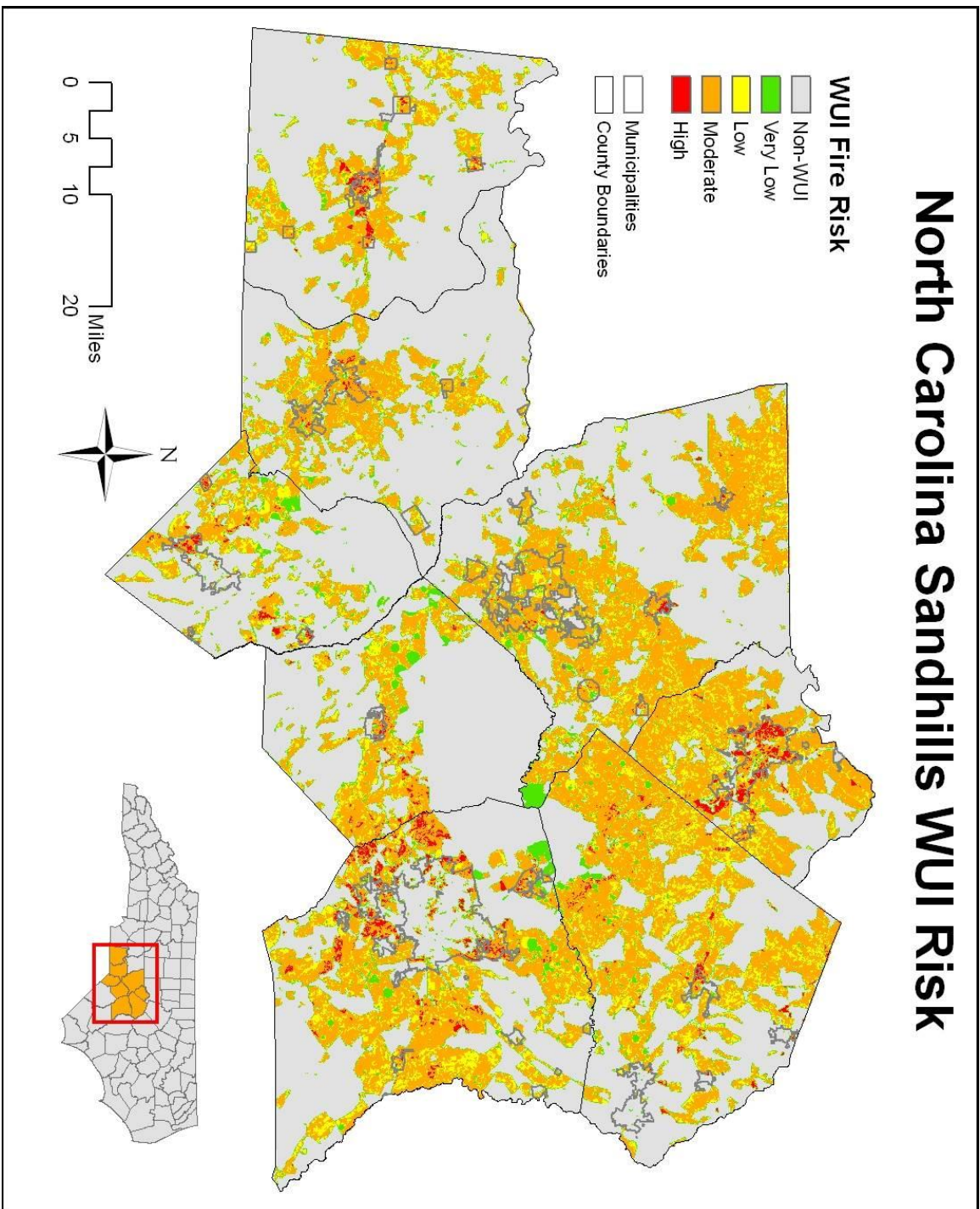WUI areas ranging from Very Low Risk to High Risk throughout the NC Sandhills.

Figure 5

Figure 6 highlights the town of Sanford, an area with minimal fire activity over the last 10 years. Under the assumptions of the WUI Risk model, this area is at higher risk due to the absence of fire to reduce high fuel loads in dense WUI areas.
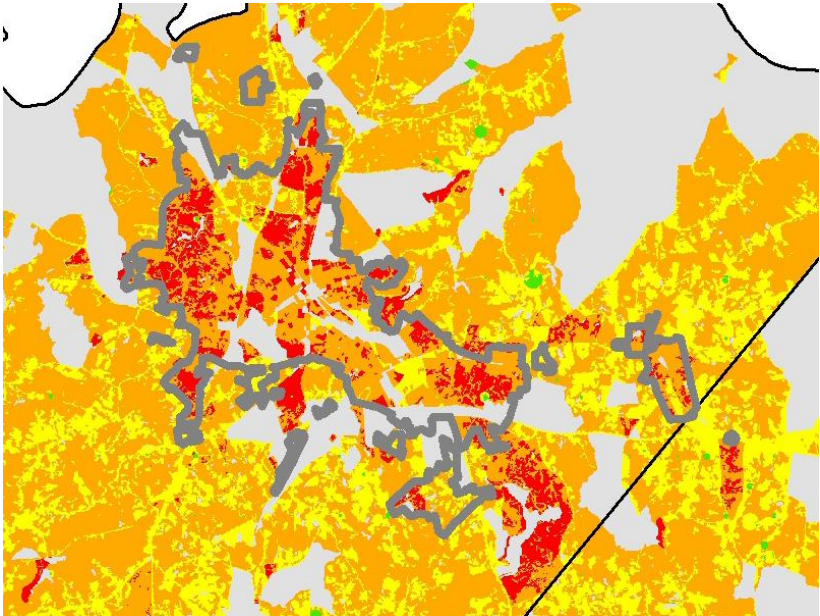

Figure 6

Figure 7 highlights an area just north of Fayetteville, an area with significant fire activity over the last 10 years. Under the assumptions of the WUI Risk model, this area is at lower risk due to the presence of fire to reduce high fuel loads in dense WUI areas.
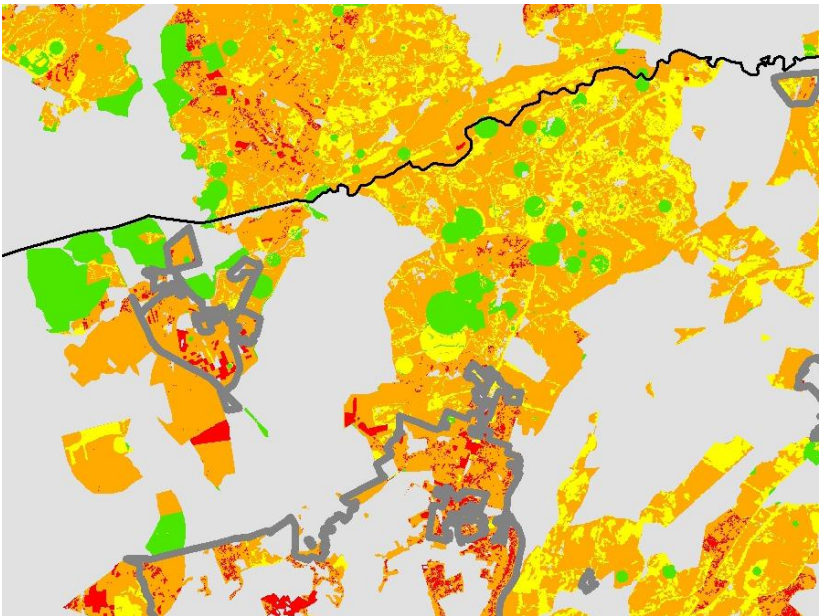

Figure 7

RESULTS: WUI RISK STATISTICS

The following statistics in Table 2 were extracted from the WUI Risk Analysis and show the total percentage of each risk category out of the total Sandhills WUI area.

Wildland Urban Interface Risk Category	Percentage of Wildland Urban Interface
Very Low	3.8 %
Low	26.6 %
Moderate	66.7 %
High	2.9 %

Table 2

RESULTS: PRESCRIBED FIRE & WILDFIRE STATISTICS

The following statistics were extracted based on the Wildland Urban Interface and 10-year burn history data:

43% **of the NC Sandhills Region is classified as Wildland Urban Interface - the NC average is 41% which is the highest concentration of WUI in the US**

35% **of all wildfire acres burned in the NC Sandhills occurred in the Wildland Urban Interface**

24% **of all prescribed fire acres burned in the NC Sandhills occurred in the Wildland Urban Interface**

CONCLUSIONS

Policy Implications & Data Distribution

Aggregate trends show that 1 out of every 3 wildfire acres burned took place in the Sandhills WUI, compared to only 1 out of every 4 prescribed fire acres burned. Although both result in the reduction of fuels, prescribed fire is less risky since it is performed by professionals under controlled conditions, and it typically results in more acres burned. From a policy perspective, we have choices about how to mitigate risk. Since the desired goal is to lower risk in the WUI, the above trends need to be reversed by increasing prescribed fire where it is most needed. To this end, fire managers need to target these high risk WUI areas and educate the public about how prescribed fire and other fuel reduction efforts can

benefit them. The areas of top priority identified by the WUI Risk Analysis include the following

Municipalities and County lands: Sanford, northeast Carthage, Wadesboro, Ansonville, Southwest

Laurinburg, and the areas southwest of Fayetteville in Cumberland County. To keep this process moving

and inform fire managers, prescribed burners, and local decision makers, the entire burn history dataset

and the final WUI Risk Analysis map document will be distributed to the NC Division of Forest Resources,

Prescribed Fire Council of North Carolina, and Sandhills GIS Association.

Community Outreach Applications

Gaining public acceptance of prescribed fire as a management tool will include fire managers

providing community members with focused information about their risk potential during a wildfire.

Quality maps using good data and presented in an easy to understand format will be in important

component in achieving this objective. Any given area from the WUI Risk map in Figure 4 can be zoomed

in, exported as a KML file and viewed in Google Earth to overlay risk with recognizable, real-world

locations. These maps can be used during presentations at community or homeowner's association

meetings, included in FIREWISE handouts and pamphlets, or put on the internet as a free download to

be viewed in Google Earth on a personal computer.

Future Recommendations

As with any remote sensing data, the next important step is taking the results of this model and

"ground-truthing" it in the field with local, experienced land managers. Land cover data has a tendency

to become outdated over time due to rapid development and should be updated when possible as new

data sources become available. Adjustments to this model will also be necessary in areas where fuel type

and historical fire regime differs from the NC Sandhills, which is historically a high-frequency, low-

intensity fire regime in a Longleaf Pine Savannah ecosystem. Areas with longer fire intervals will have

different vegetation types that react differently to fire than vegetation in the Sandhills. After taking into

account the level of detail and scale of most fire data, the ideal application will be for county level sites

with geographically accurate and well maintained fire records that record actual fire boundaries for any activity over ten acres. Data quality and comprehensiveness also weigh heavily on the accuracy of this model for fire frequency, and recent fire activity variables. To a certain extent, the accuracy of this model was compromised due to imperfect data, and it is imperative that fire records are robust enough to take advantage of sophisticated GIS analysis techniques.

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APPENDIX A

Wildfire & Prescribed Fire Data Initial Cleanup Procedure Log

NC Forest Service Wildfires – NC Division of Forest Resources: Andrew Bailey – GIS Point Feature

1) Clip all features to Sandhills boundary
2) Delete records with zero acres final fire size
3) Delete records that fall within Fort Bragg Military Base
4) Add "LastBurn" field to Attribute Table:
   a. Add Field → "LastBurn"
   b. Populate field in Field Calculator with the following SQL Statement: Right([FireDate], 4)
5) Add "FireFrequency" field to Attribute Table:
   a. Add Field → "FireFrequency"
   b. Populate field in Field Calculator with the number "1"
6) Convert point features to polygon features based on fire size attribute:
   a. Add Field → "BufferDistance"
   b. Convert acres to square meters and find the radius:
      Populate "BufferDistance" field using the following SQL statement:
      Sqr((([FinalFireSize]*43560)*.0929030)/3.1415926))
   c. Open Buffer tool to find Acres Burned:
      Input Feature: NCDFR_Wildfires.shp
      Output Feature Class: NCDFR_Wildfires_Buffer.shp
      Distance: Field "BufferDistance"
7) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

NC Forest Service Prescribed Fires – NC Division of Forest Resources: Andrew Bailey – GIS Point Feature

1) Clip all features to Sandhills boundary
2) Delete records with zero acres final fire size
3) Delete records that fall within Fort Bragg Military Base
4) Delete duplicate records:
   a. Add Field → "UniqueID"
   b. Populate "UniqueID" field in Field Calculator with the following SQL Statement: [OBJECTID]+1
   c. Open Summary Statistics Tool:
      Input Table: NCDFR_RxFires
      Output Table: NCDFR_RxFires_Duplicates
      Statistics Fields: UniqueID; Statistics Type: Last
      Case Fields: Date_; Activity_A; LatDD; LonDD
   d. Join Attributes From a Table:
      Input Layer: NCDFR_RxFires
      Input Layer Join Field: UniqueID
      Input Table: NCDFR_RxFires_Duplicates
      Input Table Join Field: Last_UniqueID
      Join Options: Keep only matching records
5) Add "LastBurn" field to Attribute Table:

a. Add Field → "LastBurn"
b. Populate field in Field Calculator with the following SQL Statement: Right([Date_], 4)
6) Add "FireFrequency" field to Attribute Table:
a. Add Field → "FireFrequency"
b. Populate field in Field Calculator with the number "1"
7) Convert point features to polygon features based on average fire size attribute:
a. Add Field → "BufferDistance"
b. Convert acres to square meters and find the radius:
Populate "BufferDistance" field using the following SQL statement:
Sqr(((([Activity_A]*43560)*.0929030)/3.1415926))
c. Open Buffer tool to find Acres Burned:
Input Feature: NCDFR_RxFires.shp
Output Feature Class: NCDFR_RxFires_Buffer.shp
Distance: Field "BufferDistance"
8) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

Fort Bragg Wildfires & Prescribed Fires – Fort Bragg Military Base: Pat Wefel / Paul Hinkle – GIS Polygon Feature

1) Convert projection from WGS_1984_UTM_Zone_17N to NAD_1983_StatePlane_North_Carolina_FIPS_3200 (NC State Plane Meters)
2) Create attribute with most recent burn year for each smoke management unit:
a. In Microsoft Access, create new field named "LastBurn"
b. Populate the new fields using the following SQL statement:
UPDATE fortBraggBurnHistory
SET fortBraggBurnHistory.LastBurn=1999
WHERE (((fortBraggBurnHistory.BURN1999)='DORMANT' Or (fortBraggBurnHistory.BURN1999)='GROWING' Or (fortBraggBurnHistory.BURN1999)='WILDFIRE'));
c. Repeat step [b] for each year through 2008
d. Replace any null values with "1000"
3) Create attribute with fire frequency for each smoke management unit:
a. In ArcMap, create a new field for each burn year from 1999-2008 (ie. "Temp1999")
b. Beginning with "BURN1999", select by attributes using the following SQL statement:
"BURN1999"='DORMANT' OR "BURN1999"='GROWING' OR "BURN1999"='WILDFIRE'
c. In the Attribute Table, show only selected attributes
d. Populate the newly created "Temp1999" field in Field Calculator with "1"
e. Use the Switch Selection command and populate the remaining "Temp1999" fields with "0"
f. Repeat steps [b] through [e] for each burn year through 2008, changing inputs accordingly
g. Create a new field named "FireFrequency" and populate using the following SQL statement:
[Temp1999] + [Temp2000] + [Temp2001] + [Temp2002] + [Temp2003] + [Temp2004] + [Temp2005] + [Temp2006] + [Temp2007] + [Temp2008]
h. Replace any null values with "0"
4) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

Sandhills Game Lands Prescribed Fires – Sandhills Game Lands: Jacob Marquess / Chris Jordan – GIS Polygon Feature

1) Create attribute with most recent burn year for each burn block:
    a. In Microsoft Access, create new field named "LastBurn"
    b. Populate the new fields using the following SQL statement:
       UPDATE SandhillsGameLands_RxFires
       SET SandhillsGameLands_RxFires.LastBurn=1999
       WHERE (((SandhillsGameLands_RxFires.BURN1999)='DORMANT' Or (SandhillsGameLands_RxFires.BURN1999)='GROWING'))
    c. Repeat step [b] for each year through 2008
    d. Replace any null values with "1000"
2) Create attribute with fire frequency for each burn block:
    a. In ArcMap, create a new field for each burn year from 1999-2008 (ie. "Temp1999")
    b. Beginning with "BURN1999", select by attributes using the following SQL statement:
       "BURN1999"='DORMANT' OR "BURN1999"='GROWING'
    c. In the Attribute Table, show only selected attributes
    d. Populate the newly created "Temp1999" field in Field Calculator with "1"
    e. Use the Switch Selection command and populate the remaining "Temp1999" fields with "0"
    f. Repeat steps [b] through [e] for each burn year through 2008, changing inputs accordingly
    g. Create a new field named "FireFrequency" and populate using the following SQL statement:
       [Temp1999] + [Temp2000] + [Temp2001] + [Temp2002] + [Temp2003] + [Temp2004] + [Temp2005] + [Temp2006] + [Temp2007] + [Temp2008]
    h. Replace any null values with "0"
3) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

Sandhills Game Lands Wildfires – Sandhills Game Lands: Jacob Marquess / Chris Jordan – GIS Polygon Feature

1) Rename "Year" Field "LastBurn"
    a. Add Field → "LastBurn"
    b. Populate field in Field Calculator with the following SQL Statement: [Year]
2) Add "FireFrequency" Field
    a. Add Field → "FireFrequency"
    b. Populate the newly created field in Field Calculator with "1"
3) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase
4) Simplify Polygons to eliminate superfluous vertices and lines that double back:
    a. Open Simplify Polygon Tool:
       Input Table: SandhillsGameLands_Wildfires
       Output Table: SandhillsGameLands_Wildfires_Simplify
       Simplification Algorithm: POINT_REMOVE
       Simplification Tolerance: Maximum Allowable Offset = 9 m; Minimum Area = 20 m^2
5) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

Certified Burner Prescribed Fires – NC Division of Forest Resources: Don Watson / Michael Good – Excel Spreadsheet

1) Find the centroid of all Points in the QBSP grid:
   a. Open the attribute table, right-click the field into which you want to calculate the X-coordinate of a polygon centroid (ie. LonDD), and open the Field Calculator.
   b. Check Advanced.
   c. Type the following VBA statement in the first text box:
      Dim dblX As Double
      Dim pPoint As IPoint
      Set pPoint = [Shape]
      dblX = pPoint.X
   d. Type the variable "dblX" in the text box directly under the area field name.
   e. Click OK.
   f. To calculate the Y-coordinate of a polygon centroid, repeat steps 1-5 after replacing all uppercase X's with uppercase Y's in the script.
2) Manually convert all QBSP and latitude/longitude entries into Decimal Degree format, checking for correct county location
3) Import Excel spreadsheet as an INFO Table
4) Convert INFO Table into a point layer using latitude/longitude coordinates:
   a. Open Make XY Event Layer tool:
      XY Table: SmokeManagementLogs
      X Field: Longitude
      Y Field: Latitude
      Layer Name: SmokeManagementLogs_Layer
      Spatial Reference: GCS_WGS_1984
5) Export newly created layer to a new Shapefile called "SmokeManagementLogs"
6) Convert projection from GCS_WGS_1984 to NAD_1983_StatePlane_North_Carolina_FIPS_3200 (NC State Plane Meters)
7) Add "LastBurn" field to Attribute Table:
   a. Add Field → "LastBurn"
   b. Populate field in Field Calculator with the following SQL Statement: [Year]
8) Add "FireFrequency" Field
   a. Add Field → "FireFrequency"
   b. Populate the newly created field in Field Calculator with "1"
9) Convert point features to polygon features based on average fire size attribute:
   a. Add Field → "BufferDistance"
   b. Convert acres to square meters and find the radius:
      Populate "BufferDistance" field using the following SQL statement:
      Sqr((([Acres]*43560)*.0929030)/3.1415926))
   c. Open Buffer tool to find Acres Burned:
      Input Feature: SmokeManagementLogs.shp
      Output Feature Class: SmokeManagementLogs_Buffer.shp
      Distance: Field "BufferDistance"
10) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

Weymouth Woods Prescribed Fires – Weymouth Woods State Park: Scott Hartley – Excel Spreadsheet

1) Manually convert all QBSP entries into Decimal Degree format
2) Import Excel spreadsheet as an INFO Table
3) Convert INFO Table into a point layer using latitude/longitude coordinates:
    a. Open Make XY Event Layer tool:
       XY Table: WeymouthWoodsRxFires
       X Field: Longitude
       Y Field: Latitude
       Layer Name: WeymouthWoodsRxFires_Layer
       Spatial Reference: GCS_WGS_1984
4) Export newly created layer to a new Shapefile called "WeymouthWoodsRxFires"
5) Convert projection from GCS_WGS_1984 to NAD_1983_StatePlane_North_Carolina_FIPS_3200 (NC State Plane Meters)
6) Add "LastBurn" field to Attribute Table:
    a. Add Field → "LastBurn"
    b. Populate field in Field Calculator with the following SQL Statement: Right([Date_], 4)
7) Add "FireFrequency" Field
    a. Add Field → "FireFrequency"
    b. Populate the newly created field in Field Calculator with "1"
8) Convert point features to polygon features based on average fire size attribute:
    a. Add Field → "BufferDistance"
    b. Convert acres to square meters and find the radius:
       Populate "BufferDistance" field using the following SQL statement:
       Sqr((([Acres]*43560)*.0929030)/3.1415926))
    c. Open Buffer tool to find Acres Burned:
       Input Feature: WeymouthWoodsRxFires.shp
       Output Feature Class: WeymouthWoodsRxFires_Buffer.shp
       Distance: Field "BufferDistance"
9) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

The Nature Conservancy Prescribed Fires – The Nature Conservancy: John Cannon / Mike Norris – Shapefile

1) Create attribute with most recent burn year for each burn block:
    a. In Microsoft Access, create new field named "LastBurn"
    b. Populate the new fields using the following SQL statement:
       UPDATE TNCBurnHistory
       SET TNCBurnHistory.LastBurn=1999
       WHERE (((TNCBurnHistory.BURN1999)='Prescribed' Or
       (TNCBurnHistory.BURN1999)='Wildfire'))
    c. Repeat step [b] for each year through 2008
    d. Replace any null values with "1000"
2) Create attribute with fire frequency for each burn block:
    a. In ArcMap, create a new field for each burn year from 1999-2008 (ie. "Temp1999")
    b. Beginning with "BURN1999", select by attributes using the following SQL statement:
       "BURN1999"='Prescribed' OR "BURN1999"='Wildfire'

c. In the Attribute Table, show only selected attributes
d. Populate the newly created "Temp1999" field in Field Calculator with "1"
e. Use the Switch Selection command and populate the remaining "Temp1999" fields with "0"
f. Repeat steps [b] through [e] for each burn year through 2008, changing inputs accordingly
g. Create a new field named "FireFrequency" and populate using the following SQL statement: [Temp1999] + [Temp2000] + [Temp2001] + [Temp2002] + [Temp2003] + [Temp2004] + [Temp2005] + [Temp2006] + [Temp2007] + [Temp2008]
h. Replace any null values with "0"

3) Remove unnecessary fields from attribute table and export cleaned data to Sandhills Burn History Personal Geodatabase

Wildfire & Prescribed Fire Data Secondary Cleanup Procedure Log

1) Merge all Wildfire and Prescribed Fire Datasets into a Single Dataset
   a. Open Merge tool:
      Input Datasets: SmokeManagementLogs; FortBragg; NCDFR_RxFires; NCDFR_Wildfires; SandhillsGameLands_RxFires; SandhillsGameLands_Wildfires; TNC; WeymouthWoods
      Output Dataset: SandhillsAllFires
2) Download Chris Snyder's Super Region Poly (SRP) v1.3 tool from: http://arcscripts.esri.com/details.asp?dbid=16700
3) Combine Overlapping Polygons and Determine Fire Frequency & Last Burn Statistics
   a. Open Super Region Poly (SRP) v1.3 tool:
      Input Polygon Layer: SandhillsAllFires
      Output Planarized Feature Class: SandhillsFireFrequency
      Output Lookup Table: SandhillsFireFrequencyTable
      XY Tolerance: Default Value
      Poly ID Field Name: Default Value
      Overlap Count Field Name: Default Value
      Statistic Field: FireFrequency
      Statistic: SUM
   b. Open Super Region Poly (SRP) v1.3 tool:
      Input Polygon Layer: SandhillsAllFires
      Output Planarized Feature Class: SandhillsLastBurn
      Output Lookup Table: SandhillsLastBurnTable
      XY Tolerance: Default Value
      Poly ID Field Name: Default Value
      Overlap Count Field Name: Default Value
      Statistic Field: LastBurn
      Statistic: MAX
4) Convert FireFreqency & LastBurn Feature Classes to Raster Datasets
   a. Open Polygon to Raster tool:
      Input Features: SandhillsFireFrequency
      Value field: FireFrequency
      Output Raster Dataset: FireFrequency
      Cell assignment type: CELL_CENTER
      Priority field: NONE
      Cell size: 30
   b. Open Polygon to Raster tool:

Input Features: SandhillsLastBurn
Value field: LastBurn
Output Raster Dataset: LastBurn
Cell assignment type: CELL_CENTER
Priority field: NONE
Cell size: 30
5) Export cleaned datasets to WUI Risk Model Personal Geodatabase

FRCC & WUI Data Procedure Log

LANDFIRE Fire Regime Condition Class – http://www.landfire.gov – ESRI GRID Raster

1) Download data from http://www.landfire.gov
2) Convert projection from NAD_1983_Albers to NAD_1983_StatePlane_North_Carolina_FIPS_3200 (NC State Plane Meters)
3) Clip the raster file using the Extract tool with the Sandhills Study Area polygon as the mask
   a. Open Extract by Mask tool:
      Input raster: FRCC
      Input raster or feature mask data: StudyArea
      Output raster: FRCC
4) Export cleaned data to WUI Risk Model Personal Geodatabase

Wildland Urban Interface – http://silvis.forest.wisc.edu/library/WUILibrary.asp – ArcInfo Interchange File

1) Download data from http://silvis.forest.wisc.edu/library/WUILibrary.asp
2) Convert data from ArcInfo Interchange File to Coverage File format:
   a. Open Import From Interchange File tool:
      Feature Type: AUTO
      Input Interchange File: NCwui.e00
      Output Dataset: NCwui
3) Export Coverage File to Feature Class
4) Convert Projection from NAD_1983_Albers to NAD_1983_StatePlane_North_Carolina_FIPS_3200 (NC State Plane Meters)
5) Clip Feature Class to Sandhills Study Area:
   a. Open Clip tool:
      Input Features: NCwui
      Clip Features: StudyArea
      Output Features: NCwui_clip
6) Convert Feature Class to Raster Dataset:
   a. Open Polygon to Raster tool:
      Input Features: NCwui_clip
      Value field: WUIHDEN00
      Output Raster Dataset: WUI
      Cell assignment type: CELL_CENTER
      Priority field: NONE
      Cell size: 30
7) Export cleaned data to WUI Risk Model Personal Geodatabase