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DELINEATING THE WILDLAND URBAN INTERFACE USING PUBLICLY AVAILABLE GEOSPATIAL DATA

A THESIS

Presented to the Department of Geography/Geology

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by

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DELINEATING THE WILDLAND URBAN INTERFACE USING PUBLICLY AVAILABLE GEOSPATIAL DATA

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University of Nebraska, 2012
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The Wildland Urban Interface (WUI), a human-designated area between undeveloped wildlands and urban areas, has been identified using many different kinds of data. The most common data used have been census housing densities to determine urban areas and a vegetation layer from the National Land Cover Database (NLCD) to identify wildlands (Theobald and Romme 2007, Radeloff et al. 2005, Stewart et al. 2003, and Haight et al. 2004). Knowing the location and area of a WUI is important for federal land agencies because federal legislation (Federal Register Notice 2001, 66-3) has provided parameters to identify WUIs and has directed agencies to mitigate the possibility of a catastrophic wildland fire that may reach urban areas.

Many studies have looked at WUIs on large scales (e.g. the entire U.S., or part of a state) but have only used one datum input to determine urban areas and one to delineate wildland areas. The objective of this study was to (1) look at whether publicly available geospatial data could be used to determine WUIs for small tracts of land and (2) compare WUI areas resulting from the combination of different urban and vegetation datasets. Four national parks were studied: Badlands National Park, Wind Cave National Park, Pea Ridge National Military
Urban areas were identified using 2010 U.S. Census Block housing densities or from points identifying individual structures accessed from State web sites. The vegetation layers used were the NLCD, LANDFIRE, and a USGS Vegetation Characterization. In addition, a protocol, “Procedures for Delineating the Wildland Urban Interface at Your Site,” was developed using ArcMap 10. Results showed that either census housing densities or GPS points identifying structures, along with any vegetation classification can be used to determine WUIs for small tracts of land. WUIs varied in size depending on the combination of datasets used but the only factor that appeared to result in larger WUIs was using a detailed vegetation dataset.
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Many thanks go to my family who has tolerated my absence at numerous family functions and their acceptance of my decline of invitations with the ever common, “I can’t, I’ve got to work on my thesis.”

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CHAPTER I

INTRODUCTION

FIRE! This single, small four-letter word has the ability to strike fear in the hearts of many, instinctively triggering a survival reaction. This response is linked to historic catastrophic events culminating in the loss of life and destruction of property. However, land managers, biologists, ranchers, and others, understand that fire can also be an important factor in maintaining ecosystems including grasslands, rangelands, and forests. Fires may originate in many ways; naturally from lightning strikes, accidentally via wind or misfortune, and intentionally as prescribed fires or with malicious intent. Regardless of how fires start, federal land management agencies have been tasked by federal legislation (Federal Register 2001) to reduce hazardous fuels on the lands they manage, thereby reducing the potential for extensive wildfires.

Federal Register Notice No. 66 (2001, 752-3) defines areas to be managed as wildland urban interfaces or WUIs (pronounced woo-ees). Their definition for a WUI is, “the urban wildland interface community exists where humans and their development meet or intermix with wildland fuel.” There are other WUI definitions, but the encompassing thought is that wildlands may contain hazardous fuels that need to be managed so that a catastrophic wildland fire won’t have the undesirable consequences of destroying lives or property. Hazardous fuels may be the fuel load, fuel type, or how the fuel is distributed over the land, thus making the WUI a watch zone. As urban sprawl creeps
closer to wilderness, parks, and natural areas, keeping an eye on the WUI is a more pressing endeavor for land managers who must manage sites to prevent extensive wildland fires and diminish the potential for injuries and destruction of homes.

As pointed out by Ewert (1993), WUIs can offer opportunities for outdoor leisure activities, wildlife viewing, and recreation. Today, “the term wildland-urban interface is now used almost exclusively in the context of wildland fire,” according to Stewart et al. (2007, 202).

The Federal Register (2001, 753) not only provided a definition for WUIs, it also outlined criteria for structure densities to define the urban intermix area. Another component needed to delineate WUIs is determining what constitutes wildland.

NATURE OF PROBLEM

Numerous studies have mapped WUIs on a regional scale (Radeloff et al. 2005, Stewart et al. 2003, Lampin-Maillot et al. 2009, Haight et al. 2004, Theobald and Romme 2007, and Lein and Stumpf 2009); however, I found none that looked at determining WUIs on a smaller, local scale. These studies used one method to determine the urban intermix area and one input to define wildland but no studies were found that combined different urban and vegetation datasets and compared the resulting WUIs.

Federal land managers currently have fire plans for their sites and knowledge of local factors such as stand density, fuel loads, topography, and
terrain aspect. This study adds another layer of data by determining the WUI, to assist land managers in making decisions on where to focus fuel treatment efforts on the lands they manage to most effectively reduce wildland fire risks near populated areas. However, the area of the WUI should not be construed as the catch all for site burn units (areas at a site that have been identified for fire management). Land managers may have identified non-WUI areas within their site boundaries that need to be managed to prevent wildland fires and those areas may not necessarily be located within a WUI. That does not mean that those areas should not be managed, just that those areas don’t fall within the urban intermix buffer area as identified for a WUI.

OBJECTIVES

The objectives of this study were to determine if publicly available geospatial data could be used to delineate WUIs for small tracts of federal land. Would the WUI area change, either in size or location, when different data were used to determine urban intermix areas or wildlands? For this study, urban intermix areas were the urban areas near the study site that met the WUI intermix criteria of at least one structure per 40 acres.

BACKGROUND

Federal agencies have been instructed by the Federal government to manage wildfires as far back as the early 1900s (Stephens & Ruth 2005). The management decision was to suppress all fires without question. It was not until
1968 that the National Park Service deviated from this policy by implementing a prescribed fire protocol at Sequoia and Kings Canyon National Parks in California. Today, federal agencies use prescribed fire as well as thinning and slash burning as common management practices. However, even after acknowledging that fires should be a part of maintaining ecosystems, from grasslands to forests, there is continued public resistance to fire (Cohen 2008). In reality, suppressing fires is still the norm.

After years of fire suppression, not only have the composition of species in an area changed, but so have vegetation fuel structures. Historically, forests might have a fire about every 10 years, depleting fuel buildup resulting in an open forest community like the 1909 Ponderosa Pine forest (Figure 1). After decades of fire suppression, the 1989 photo (Figure 2) illustrates a crowded forest community with plenty of fuel which has changed from Ponderosa Pine to one dominated by
Douglas-fir (Cohen 2008). Along with fire suppression that allows fuels to build up, the popularity of building houses in and near natural areas has resulted in urban sprawl reaching into wildlands, and with it an increased public desire to protect isolated houses from wildland fires.

People like living near natural areas. This trend is being seen throughout the U.S. as outlined in an article in USA Today that points to numerous natural areas near national parks that are in the process of becoming housing developments or are in the planning process for a proposed development (Spillman 2006). As pointed out by Stewart et al. (2007, 201), from 1940 to 2000, suburban and rural areas have had significant housing growth, especially near forests. As land managers watch houses creep nearer to the lands they manage, there is increasing need to manage those lands to reduce the potential for fire as directed by federal legislation.

Some landowners that build far from a city still expect quick fire response times along narrow winding roads in areas without an adequate water supply to fight a fire. Even after devastating fires, landowners have ignored requests to clear shrubs and remove pine needles from their roofs, expecting fire agencies to protect them (Vince 2005, 205). The sad reality is that firefighters may fight a fire, rather than let it burn, in order to protect homes; homes that might survive a fire without intervention if the right construction materials are used and ignitable materials are kept away from buildings.

With houses scattered amidst wildlands there is an increased risk of them being in the path of a wildland fire and in areas that may be difficult for fire
responders to reach. Protecting homes in WUIs becomes even tougher with flammable housing materials, roads that can be challenging for fire trucks to navigate, vast distances between structures, difficult terrain, and responders trained for wildland rather than structural fires.

Federal legislation pertaining to managing WUIs came about in 2000 because more than 6.8 million acres of land burned in the United States, destroying property, damaging natural resources, and interrupting community services. Many of these fires burned in the WUI, exceeding fire suppression capabilities in some areas (Federal Register 2001). Because of the magnitude of the 2000 fire season, President Clinton asked the Secretaries of Interior and Agriculture to prepare a report on how to handle severe fires. The President requested information on reducing the impacts of fire on communities to ensure there would be sufficient fire suppression resources for the future (Federal Register 2001). In response to this request, a report was developed, *Managing the Impacts of Wildfires on Communities and the Environment* (USDA Forest Service 2000), now also known as the National Fire Plan. It called for Federal agencies to increase their investment in reducing the risk of fire by reducing hazardous fuels near homes and communities. Five federal agencies within two departments follow the National Fire Plan (NFP); the United States Forest Service (USFS), an agency within the U.S. Department of Agriculture (DOA), as well as the National Park Service (NPS), the Bureau of Land Management (BLM), the Fish and Wildlife Service (FWS), and the Bureau of Indian Affairs (BIA) within the U.S. Department of Interior (DOI).
In 2003, the Healthy Forests Restoration Act was instituted by President Bush. The intent of the Act was to reduce the threat of wildfires with primary responsibility for defining a Wildland Urban Interface lying with county governments. In the absence of a defined interface, the Act stipulated that federal agencies must use a fixed buffer distance from communities or buildings (Healthy Forests Act 2003). The Federal Register defines three main wildland/urban conditions to identify WUIs: 1) Interface Condition where buildings abut wildland fuels with a development density of about three or more structures per acre; 2) Intermix Condition where structures are scattered throughout a wildland area and the development density in the intermix ranges from structures very close together to one structure per 40 acres; and 3) Occluded Condition, often within a city, where structures abut an island of wildland fuels (e.g. a park or open space). Generally, Federal agencies focus on conditions one and two when working with a WUI (Federal Register 2001, 753).

Many federal agencies (NPS, FWS, BLM, and USFS) use a WUI of 1.5 mi (2.4 km) as defined by the Healthy Forests Restoration Act (H.R. 1904) and recommended by the California Fire Alliance. The California Fire Alliance formed in 1996 as a coalition of representatives from State and Federal Fire Agencies who collaborated to integrate fire management and planning across jurisdictions (California Fire Alliance 2001).

The 1.5 mi (2.4 km) buffer from wildland vegetation is the approximate distance that burning materials can be carried from a wildland fire to the roof of a house. This designation incorporates the idea that even though houses may not
be situated within a wildland area, they can still be at risk of being burned by spotting from a nearby wildland fire (SILVIS Lab). The SILVIS Lab at the University of Wisconsin works in collaboration with the U.S. Forest Service, the Nature Conservancy, and others, to provide students with research oversight for studies in remote sensing, GIS, and statistical modeling.

CURRENT WUI RESEARCH (Literature Review)

Delineating a WUI begins with assessing what data inputs will be used for the study. Although federal legislation provided a definition for a WUI and outlined population and housing densities to delineate urban areas, defining wildland has been left up to each researcher.

With those parameters in place, two basic data inputs have commonly been used to determine WUIs; census data (either housing or population densities) for determination of urban areas, and wildland definitions extrapolated from vegetation data from the National Land Cover Database (NLCD) or data provided by the state where the study occurred. As previous studies covered large areas, NLCD was a logical choice for a vegetation layer as it provided coverage for the entire United States and LANDFIRE data were not available until 2009.

The NLCD is a land classification system taken from the unsupervised classification of Landsat Enhanced Thematic Mapper containing 16 classes. These classifications cover the entire United States at a spatial resolution of 30
meters. The NLCD is offered through a consortium of federal agencies called the Multi-Resolution Land Characterization (NLCD 2006).

LANDFIRE (Landscape Fire and Resource Management Planning Tools) is an interagency mapping program sponsored by the United States Department of Interior and the United States Department of Agriculture, Forest Service, to map vegetation, fire, and fuel characteristics (LANDFIRE). Since 2009, LANDFIRE has made landscape-scale geospatial products available free of charge to the public, facilitating wildland fire management, as well as other applications. Information from LANDFIRE consists of 50 spatial data layers, including maps that are developed from advanced scientific procedures such as satellite-enabled remote sensing, relational databases, gradient analysis, and predictive landscape modeling and are presented as 30-meter pixels (LANDFIRE).

A comprehensive approach to determine WUIs was taken by Lampin-Maillot et al. (2009) who described a reproducible method for mapping WUIs in France using four different building densities, three vegetation classes, and twelve interface types on a regional scale. Urban areas were defined using only occupied dwellings; commercial, public, and industrial buildings were not included. Lampin-Maillot’s study also assessed fire risk using fire ignition points for past fires. The conclusion in this study was that isolated WUIs with low housing densities were at the highest fire risk (Lampin-Maillot et al. 2009). By excluding some buildings this study emulates the essence of U.S. Census housing data used by researchers in the United States to delineate urban areas.
It is not surprising that low housing densities in isolated interfaces had the greatest risk of fire as that trend is being seen in other studies like Haight et al. (2004).

In the U.S., regional-scale studies have used housing densities to define an urban area and vegetation data to define wildlands. For example, two studies encompassing the entire United States (Radeloff et al. 2005 and Stewart et al. 2003) used U.S. Census block data and NLCD for these delineations. Haight and others (2004) used Michigan Department of Natural Resources GAP Analysis data for a vegetation input instead of NLCD and included historic fire regimes and current fuels in a study in the northern half of lower Michigan.

Haight and others’ (2004) comprehensive approach assessed the risk of severe wildfire in WUIs and also developed a database of both historic fire regimes and current fuels to identify areas of high risk for fire. Again, the results showed that a majority (88%) of the WUI with high fire risk also had low housing density. Although Haight and others looked at fire risk in WUIs and expanded data inputs (wildland vegetation flammability and fire history) when compared to other studies that only looked at classifying WUIs, their results were still similar to Lampin-Maillot’s (Haight et al. 2004).

Stewart and others (2003) used U.S. Census housing densities but, unlike Haight et al. (2004), they used the NLCD to define wildland in their assessment of the WUI throughout the United States. Their study stated that census housing densities were used instead of population densities (an alternative offered in the regulations) as they are the more appropriate measure for a WUI because
firefighters must protect homes. Stewart used the same classes as outlined by SILVIS on page seven of this paper to define wildland using the NLCD.

Stewart’s results showed 9.3% of land in the United States was classified as WUI with 37% of homes falling in the WUI (Stewart et al. 2003).

In a 2007 study by Theobald and Romme, WUIs were mapped using 2000 U.S. Census data, a wildfire hazard map based on forest types, and Federal Register WUI definitions. This study provides a more spatially precise WUI because it used refined blocks where public land was removed, variable-width buffering of wildlands, and a narrower definition of housing density. Housing densities outlined in the Federal Register were adjusted for this study, from three houses per acre to one house per five acres and WUIs had to be at least 24.7 acres (10 ha) in size. These criteria were designed to eliminate small WUI islands. Theobald and Romme (2007) combined the U.S. Department of Agriculture’s FUELMAN data with the NLCD to determine vegetation types. FUELMAN provides coarse-scale spatial data for wildland fire and fuel management by offering data layers such as historical natural fire regimes, potential fire characteristics, and fire regime current conditions (FUELMAN).

Several components of Theobald and Romme’s (2007) study, while in depth and detailed, appear to take a vast amount of time to duplicate, such as comparing each cell of the FUELMAN model to the NLCD. It is interesting that their results indicated that 89% of land ownership in WUIs is private, with only 7% federally owned. This is noteworthy since fire prevention measures are aimed at federal wildlands and not at private lands.
The SILVIS Lab determined WUIs for the entire United States based on housing densities from 2000 Census block data with a buffer distance of 1.5 miles (as adopted by the California Fire Alliance (2001)) and vegetation from the National Land Cover Database (NLCD) from the United States Geological Survey to determine wildlands. The NLCD classes used by SILVIS to define wildlands consisted of forests, native grasslands, shrubs, wetlands, and transitional land (mostly clear cuts). SILVIS excluded orchards, cropland, and pasture (SILVIS Lab).

Cohen (2005) offered an alternative approach to reducing fire potential in the WUI; that of reducing a building’s vulnerability to fire, rather than attempting to eliminate the possibility of encroaching wildland fires. FIREWISE, a project of the National Fire Protection Association that encourages wildfire safety by involving homeowners, firefighters, planners, and others to take action locally, promotes this concept (FIREWISE). Cohen (2005, 22) argues, “If homes do not ignite and burn during wildfires then the WUI fire problem largely does not exist.” Point taken: if wildland fires, no matter how intense or extensive, will only burn wildlands, heroic efforts to squelch them might cease. According to Randall and Duryea (2011), two important factors that influence building survival are having fire resistant roofing...
and having little vegetation surrounding the building, which is well illustrated by Cohen (2008) (Figure 3).
CHAPTER II

STUDY OVERVIEW

WUI studies to-date have focused on large areas such as the entire United States, an entire state, or a large region. They have also used population density or housing density to determine urban areas and either NLCD or a state-developed vegetation layer to determine wildlands. None of the studies used different combinations of urban areas and vegetation cover to identify or compare WUIs. This study, however, focused on (1) whether WUIs could be determined for small tracts of land, (2) using housing density OR structure point data to delineate urban areas, (3) using different combinations of urban and vegetation datasets to determine WUIs and comparing WUI acreages and locations, and (4) producing a protocol for conducting such determinations.

Figure 4. Eastern Study Area (Pea Ridge National Memorial Park and Wilson’s Creek National Battlefield).
The WUIs for four national parks were determined for this study: Pea
Ridge National Military Park (Pea Ridge), Wilson’s Creek National Battlefield (Wilson’s Creek) (Figure 4), and Badlands (Badlands) and Wind Cave (Wind Cave) National Parks (Figure 5). In addition, a descriptive protocol was developed that outlines procedures to determine a WUI using ESRI’s ArcMap application. The process includes links to publicly available data where structure and vegetation information may be obtained.

I did not find any WUI studies that determined WUIs for small tracts of land, none that compared WUIs using different data inputs, nor could I find a detailed road map outlining the process that may be passed on to others.

Several studies have used U.S. Census block data to calculate housing densities for WUIs (Haight et al. 2004, Stewart et al. 2003, Theobald and Romme 2007, and Lein and Stumpf 2009). Census blocks are the smallest geographical
area that the U.S. Census Bureau uses to collect decennial census data (U.S. Census Bureau).

Currently, WUIs have not been mapped for many sites; having an easy method to determine a WUI can provide information that may result in altering where wildland fuels are managed. In addition to this study, a protocol, “Procedures for Delineating Wildland Urban Interface at Your Site,” is provided in Appendix D to assist land managers in determining a WUI. Before land managers can manage the WUI, however, it needs to be determined.

STUDY METHODS

This study used publicly available geospatial data to determine Wildland Urban Interfaces for small tracts of land and further considered whether the WUI acreage changed in size and location when using different data inputs. To designate wildlands, both NLCD and LANDFIRE existing vegetation type were used for all four parks; wildlands were delineated by excluding features such as wetlands, barren land or sparse vegetation, and developed areas from the vegetative dataset. USGS NPS Vegetation Mapping Inventories were also used for Badlands and Wind Cave, although these inventories are currently not available for Pea Ridge or Wilson’s Creek. The USGS NPS Vegetation Mapping Inventory (USGS) classifies, describes, and maps vegetation by producing detailed information for more than 270 national park units (USGS NPS).

Urban areas were determined using 2010 U.S. Census block housing densities for all four parks. For Badlands, Wind Cave, and Pea Ridge, building
point data were also used, although these point data were not found for Missouri (Wilson’s Creek). The Federal Register’s (2001) WUI definition for wildland/urban included parameters for urban development density but did not define wildland. The term urban intermix area used in this thesis refers solely to urban areas that were delineated in relation to their proximity to wildlands.

The WUI for each park was ascertained using different combinations of determinations for urban and wildland from the above-outlined data inputs. Examples of combinations of datasets used were census housing densities combined with the NLCD; census housing densities combined with USGS vegetation; building point data combined with LANDFIRE vegetation; building point data combined with the NLCD, etc. The resulting WUIs from each set of data combinations were compared to see how they differed in size and location.

In this study, WUIs were determined for four, national parks: Pea Ridge, covering 4,300 acres near Bentonville, Arkansas; Wilson’s Creek containing 2,369 acres near Springfield, Missouri; Badlands, covering 244,000 acres near Wall, South Dakota; and Wind Cave, containing 28,295 acres near Custer, South Dakota.

National park boundaries (as reported on the National Park Service’s Natural Resources Information Portal (https://nrinfo.nps.gov/Map.mvc /GeospatialSearch) on November 1, 2011, were used to define park boundaries. Park boundaries do change so a shapefile downloaded at a future date may contain different boundary areas than those used in this study.
To identify urban areas via housing densities, population/housing block data from the 2010 U.S. Census ([ftp://ftp2.census.gov/geo/tiger/TIGER2010BLKPOPHU/](ftp://ftp2.census.gov/geo/tiger/TIGER2010BLKPOPHU/)) were used. Only polygons outlining census blocks in and around each park were included in the datasets. A query was run on the census housing density layer to determine the intermix criteria of one house per 40 acres which equates to seven or more houses per square kilometer (the unit for census block data). The housing polygons selected from this query were buffered by 1.5 miles. Any resulting housing polygons or buffered area that occurred within the site boundary showed the urban intermix area.

Another approach to identifying urban areas was the use of point data to identify specific building structures. These data were obtained from the State of South Dakota at [http://arcgis.sd.gov/server/sdGIS/Data.aspx](http://arcgis.sd.gov/server/sdGIS/Data.aspx) for Badlands and Wind Cave, and from the State of Arkansas at [http://www.geostor.arkansas.gov/G6/Home.html](http://www.geostor.arkansas.gov/G6/Home.html) for Pea Ridge. In some cases, point data contained a variety of point classifications. For this study, points inside parks such as overlooks and campgrounds were removed but building points were retained in the dataset. In addition, points outside the boundary such as overlooks, antennas, and historical monuments that were not human occupied were removed. Chicken coops in Arkansas were left in the points database as these may well be large structures or operations and thus, be protected by firefighters. After removing the unnecessary points from the dataset, all remaining points within 1.5 miles of the site boundary were selected and buffered by 1.5 miles. Any points, along with buffered areas that fell within the site boundary, offered a delineation for the
urban intermix area, an alternative to the delineation that resulted from using census housing densities.

Vegetation within the boundary of each site was selected and then vegetation determined to be wildland was extracted by its attributes via the attribute table in ArcMap and retained to use in determining the WUI. Three different datasets were used to define wildlands. One approach used existing vegetation types from LANDFIRE (http://landfire.cr.usgs.gov/viewer/). LANDFIRE offers several vegetation layers; vegetation type was chosen because it represents vegetation currently present at the site compared to vegetation cover, the average percent cover. Vegetation in the LANDFIRE datasets that were excluded in wildland determinations included water, wetlands, developed lands, barren land, roads, and agriculture or cropland.

A second dataset, the NLCD (http://www.mrlc.gov/finddata.php), was used since it has been used in many previous studies and offered a well known vegetative layer for comparison. To determine wildland, several vegetation types were excluded from this dataset including wetlands, pasture or hay, and developed areas. Vegetation types chosen to include in the wildland determinations are shown on each park’s WUI map.

The USGS NPS Vegetation Inventory (http://science.nature.nps.gov/im/inventory/veg/index.cfm) was a third dataset used for Badlands and Wind Cave to ascertain if a detailed on-the-ground vegetation determination would change WUI boundaries. For these wildland determinations, rivers and streams, riparian
and floodplains, agricultural lands, transportation, beaches, urban, cropland, mines, water, and wetlands were removed from this dataset.

The USGS vegetation studies at Badlands and Wind Cave were conducted in 1999 by the USGS Biological Resources Division in conjunction with National Park Service staff. Vegetation classifications were determined through extensive field reconnaissance, as well as data collection and analysis (USGS NPS).
CHAPTER III

RESULTS

The combination of different data inputs for urban and wildland resulted in WUIs covering different acreages and locations at each site. In general, an increase in the size of the WUI tracked with the progression from generalized data inputs to more detailed inputs. This study also provided a protocol by which WUIs in small landscapes can successfully be identified.

At the beginning of this study it was anticipated that using more refined data inputs would increase the area covered by the WUI. These inputs included using more detailed vegetative coverages to establish wildlands and using building point data rather than generalized housing density polygons to determine the urban intermix area. Using finer-grained spatial data was suggested by Theobald and Romme (2007) as the next step to develop more refined WUI estimates.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Number of Vegetation Classes Present in Each Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park</td>
<td>NLCD</td>
</tr>
<tr>
<td>Badlands</td>
<td>14</td>
</tr>
<tr>
<td>Wind Cave</td>
<td>8</td>
</tr>
<tr>
<td>Pea Ridge</td>
<td>9</td>
</tr>
<tr>
<td>Wilson's Creek</td>
<td>11</td>
</tr>
</tbody>
</table>
by WUIs increased when the more refined vegetation data were used, moving from NLCD to USGS (Table II).

Dramatic WUI increases were seen when switching from generalized U.S. Census housing density polygons to individual structure point data in determining the urban intermix area for Wind Cave. However, this increase was not seen for Badlands. A smaller increase was seen when using different vegetative determinations when the vegetative dataset detail increased from the NLCD to either LANDFIRE or USGS (Table II).

Table II.

Total acres covered by the WUI by park using different data inputs.

<table>
<thead>
<tr>
<th>Park</th>
<th>Total Acres</th>
<th>Census Intermix¹ Total Acres</th>
<th>Points Intermix¹ Total Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CENSUS INTERMIX¹ WUI</td>
<td>POINTS INTERMIX¹ WUI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NLCD + 2010 Census</td>
<td>LANDFIRE + 2010 Census</td>
</tr>
<tr>
<td>Badlands</td>
<td>244,000</td>
<td>42,704</td>
<td>36,639</td>
</tr>
<tr>
<td>Wind Cave</td>
<td>28,295</td>
<td>8,537</td>
<td>11,941</td>
</tr>
<tr>
<td>Pea Ridge</td>
<td>4,300</td>
<td>4300*</td>
<td>4300*</td>
</tr>
<tr>
<td>Wilson’s Creek</td>
<td>2,369</td>
<td>2369*</td>
<td>2369*</td>
</tr>
</tbody>
</table>

¹ Intermix = Urban area determination
* Both Pea Ridge and Wilson’s Creek intermix¹ areas contain all lands inside park boundaries.
**USGS vegetation classifications were not available.
***Building point data were not available for Missouri.
The method used in this study that differs from that used in other studies was to compare the WUI areas resulting from combining different urban and wildland determinations. Three vegetation classifications were used; the NLCD, LANDFIRE, and USGS (when available) combined with an urban intermix area determined with either 2010 U.S. Census housing density polygons or points generated from a GPS that identified the location of individual structures. Each combination of the above datasets provided a WUI coverage which was converted to acres and compared to each other (Table II).

Different WUI acreages within a park was a common theme, although not every dataset that offered more detail resulted in increased WUI areas. For example, at Wind Cave, the WUIs decreased in size when using LANDFIRE data which offers more detailed vegetative coverage than the NLCD. This decrease was seen when LANDFIRE data were combined with either census or point data, the two different datasets used to determine urban intermix areas. A reason for this decrease in area may be because LANDFIRE’s more detailed vegetation classification with 28 classes, compared to the NLCD’s eight classes (Table II), contained more areas like wetlands and developed areas that were removed from the wildland determination.

Even with differing numbers of vegetation classifications for each site (Table I), it was common for similar vegetation types to be cited at the same location; a 200-acre woodland may fall into several woodland categories for LANDFIRE or USGS, but the same area would still be classified as a woodland in the NLCD. A good example of this was Badlands, where the interior of the
park is sparsely vegetated which is obvious in the vegetation types shown in Figures 7, 8 and 9. They are similarly categorized: NLCD and LANDFIRE call this barren, while USGS considers this sparse vegetation.

DISCUSSION OF INDIVIDUAL SITES

BADLANDS - Badlands’ WUI coverages (Table II) increase within each intermix category going from NLCD to USGS vegetation. This is the trend that was expected for all sites. The differences between census-generated and point-generated urban intermix areas are outlined in red in Figure 15A. These differences were not surprising as different datasets were used. What is most notable is that the outlined area for census data (the top inset map) does not show up as an urban intermix area in the bottom points map. This illustrates how census block data may define an intermix area even though the actual structures within that block are located more than the 1.5 mile outside the buffer distance.

WIND CAVE – WUI results are consistent for Wind Cave as the most extensive WUIs occurred in the more refined USGS vegetation category. An anomaly for Wind Cave is that the WUI decreases in area for LANDFIRE vegetation when combined with either census or points intermix areas. An explanation for this may be that LANDFIRE contained many detailed classifications and more vegetation categories were removed from the wildland classification resulting in a smaller area being designated as wildland.
PEA RIDGE - Pea Ridge has had a large increase in urban sprawl close to its boundaries over the last 10 years in the form of ranchettes (houses on small acreages). This may be the reason that the entire site was considered an urban intermix area when either census or point datasets were used.

Also, any combination of urban and vegetative datasets resulted in WUIs that differed by only one acre. The LANDFIRE dataset contained only two more WUI vegetative categories than the NLCD. The one acre difference may be attributed to how vegetation was mapped or categorized, or could have resulted from the vegetation categories that were chosen to be removed from LANDFIRE.

As mentioned previously, it was common for similar vegetation types to be found at the same location at a site which is the case at Pea Ridge. So, although there were many more vegetation classifications offered by LANDFIRE for the entire site, when non-wildland areas were removed from both NLCD and LANDFIRE datasets, the remaining wildland areas contained nearly equal acres.

WILSON’S CREEK - Wilson’s Creek feels the pressures of urban sprawl from its location just outside of Springfield, Missouri, which results in the entire site being designated as an urban intermix area. This site’s WUI expands when going from the NLCD with six wildland vegetation categories to LANDFIRE which also contains six wildland vegetation categories. Because the entire park is considered an intermix area, and the number of wildland vegetation classes are the same, the only conclusion for the additional 315 acres of WUI from LANDFIRE vegetation (Table II) can be that the LANDFIRE classes that were chosen as wildland cover a larger area within the park.
The WUI extents shown in Table II reveal mixed results in answering the question of whether more detailed data inputs result in more extensive WUIs. The results for Badlands and Wilson’s Creek fit the model that was expected. As more detailed data were used, the area covered by the WUI increased.

This process guideline and information are offered to assist land managers with locating data and extrapolating vegetation characteristics to develop a WUI for their site.
CHAPTER IV

CONCLUSION

The desire to have homes nestled within the serenity of natural settings has resulted in urban sprawl. As a result of this demographic shift, the extent of the WUI has expanded, increasing the likelihood that wildland fires will threaten people and houses. The expanding WUI has significant implications for resource managers since the WUI indicates the presence of people, structures, and social pressures near the resources they manage.

As shown by this study, different combinations of urban and vegetation datasets offer choices for determining WUIs. Land managers will need to provide some oversight to cull out irrelevant information from datasets, whether it is removing housing areas that don’t meet the housing density criteria, or culling point data like cattle guards. For vegetation classifications, areas identified as roads, utilities, barren areas, or wetlands may be removed from the dataset. Many states are now posting point data for dwellings and buildings. Point data, if up-to-date and complete, may offer the best information for determining the urban intermix area. However, keeping that information current and constantly culling points will need time and attention.

To successfully use GPS points for structures, a basic knowledge of the area is needed. To the casual observer, chicken coops might not be retained as structures in a database. However, knowing the culture and economics of an area, may warrant their retention when the coops refer to an agricultural business.
Fire is a natural process in nearly all ecosystems; living with this phenomenon is the challenge. Successfully managing fuels in a WUI is one key to reducing the risk of a catastrophic wildfire; another key is working with landowners in the WUI to reduce fuels around buildings and to encourage the use of fire-resistant building materials.

The WUI is a constantly changing environment; as new houses and buildings emerge, the interface changes. Documenting this constantly changing landscape is a substantial undertaking that will probably be the greatest challenge in maintaining an accurate WUI map. However, building point data, as it becomes more widely available, will be a great resource in updating WUIs.

There are numerous factors that can contribute to a catastrophic wildfire event; fuel loads, scattered housing, drought, topography, highly flammable buildings, lightning strikes, etc. Defining the WUI is just one step in the process of reducing the hazards associated with wildland fire. Many other factors outside the scope and control of land managers may contribute to a wildland fire that spreads beyond the political boundary of federal lands.
Figure 6. Badlands Census Polygons. Blue shaded areas depict 2010 U.S. Census housing block data polygons containing 7 or more houses per square kilometer (equivalent to 1 house per 40 acres). Polygons and coral buffering that occur within the park boundary indicate the intermix urban area.
Figure 7. Badlands National Land Cover Database (NLCD) vegetation includes 14 land cover categories within the park.
Figure 8. Badlands LANDFIRE Existing Vegetation Types. There are 35 LANDFIRE vegetation types that occur within the park.
Figure 9. The detailed USGS Vegetation Characterization of Badlands defined 34 vegetation classes.
Figure 10. This variation for determining the WUI using NLCD and census block polygons resulted in 21,956 acres of WUI containing 5 vegetation types.
Figure 11. Badlands WUI using LANDFIRE vegetation data and 2010 U.S. Census housing polygons. This WUI contains 13 vegetation types and covers 22,097 acres.
Figure 12. Badlands WUI using USGS vegetation data and 2010 U.S. Census housing polygons. This WUI contains 34 vegetation types and covers 24,972 acres.
Figure 13. Badlands WUI using National Land Cover Database (NLCD) and building point data resulted in 5 vegetation types in 21,221 acres.
Figure 14. Points showing building locations were selected within 1.5 miles of the park boundary; those points were then buffered by 1.5 miles (intermix area). LANDFIRE existing vegetation type within the park was masked with the buffered area; 10 vegetation types define the WUI in these areas and cover 21,354 acres.
Figure 15. There are 21 vegetation types within 22,654 acres of WUI at Badlands when calculated using building points and the USGS vegetation characterization.
Figure 15A. Areas that differ between intermix determinations made with census data (top) and GPS structure points (bottom) are circled in red.
Figure 16. Wind Cave Census Polygons. Blue shaded areas depict 2010 U.S. Census housing block data polygons containing 7 or more houses per square kilometer (equivalent to 1 house per 40 acres). Polygons and coral buffering that occur within the park boundary indicate the intermix urban area.
Figure 17. National Land Cover Database at Wind Cave reveals 8 vegetation categories.
Figure 18. The 28 vegetation categories at Wind Cave when using LANDFIRE existing vegetation types shows a more detailed classification than the 8 shown when using the NLCD.
Figure 19. Using USGS data at Wind Cave results in 33 vegetation classifications.
Figure 20. The WUI at Wind Cave that results from using census housing densities and NLCD vegetation categories covers 8.206 acres.
Figure 21. LANDFIRE vegetation classes and census housing polygons reveal 8,105 acres of WUI.
Figure 22. This WUI at Wind Cave covers 8,408 acres when using census data and USGS vegetation classes as inputs.
Figure 23. The WUI area increases when moving from using census housing densities to building point data to determine the urban intermix area. The WUI at Wind Cave using NLCD and points for individual structures covers 11,514 acres.
Figure 24. The defined WUI when using LANDFIRE vegetation and building points results in 11,300 acres at Wind Cave.
Figure 25. Between the three different vegetation types combined with building point data, the USGS vegetation characterization provides the greatest coverage at 11,734 acres.
Figure 26. 1.5 Mile Buffer on Census Housing Polygons with 7 or More Houses per Square Kilometer. The entire site lies within 1.5 miles of the urban intermix area.
Figure 27. The NLCD contains 8 vegetation categories within Pea Ridge.
Figure 28. There are 18 vegetation classes at Pea Ridge when using LANDFIRE existing vegetation types.
Figure 29. This WUI map contains 3,204 acres using the NLCD and census housing densities.
Figure 30. Using Census housing densities to determine an urban area resulted in the entire park being within the intermix area. The resulting WUI using LANDFIRE vegetation is 3,205 acres.
Figure 31. The 3,204-acre WUI resulting from NLCD and building points is the same as the WUI using NLCD and census housing densities. The Inset map shows all building points located outside the park boundary. Then the points are buffered by 1.5 miles (the intermix area) it results in the entire site being within the buffer.
Figure 32. The 3,205-acre WUI resulting from LANDFIRE vegetation and building points is the same as the WUI using LANDFIRE and census housing densities. The intermix area covers the entire site as shown in the inset.
Figure 33. When 2010 U.S. Census Block Data housing density polygons are buffered by 1.5 miles, the result is that the entire park falls within the intermix area.
Figure 34. The NLCD contains 11 vegetation categories at Wilson’s Creek.
Figure 35. The LANDFIRE existing vegetation classification contains 16 categories at Wilson’s Creek.
Figure 36. The combination of census housing densities and NLCD vegetation results in a 1,303-acre WUI at Wilson's Creek.
Figure 37. The WUI coverage using LANDFIRE and housing densities contains 1,618 acres, 315 more than using NLCD coverage.
REFERENCES


Federal Register. 2001. Urban wildland interface communities within the vicinity of federal lands that are at high risk from wildfire, 66, no. 3 (January).


FUELMAN, http://www.fs.fed.us/fire/fuelman/


NLCD (National Land Cover Database), 2006.  


1432.


SILVIS (Spatial Analysis for Conservation and Sustainability) Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison.  
http://silvis.forest.wisc.edu/old/Projects/WUI_Main.php.


U.S. Census Bureau.  Blocks and Block Data.  

USGS National Park Service Vegetation Mapping Inventory.  
http://science.nature.nps.gov/im/inventory/veg/index.cfm.

APPENDIX A – GLOSSARY

BIA – Bureau of Indian Affairs

BLM – Bureau of Land Management

DOA – Department of Agriculture – includes the United States Forest Service

DOI – Department of Interior – includes the following agencies: Bureau of Indian Affairs, Bureau of Land Management, National Park Service, and U.S. Fish & Wildlife Service

FWS – Fish & Wildlife Service

LANDFIRE – Landscape Fire and Resource Management Planning Tools

NFP – National Fire Plan

NLCD – National Land Cover Database

NPS – National Park Service

SILVIS - Spatial Analysis for Conservation and Sustainability Lab

Urban Intermix Area - the urban areas near the study site that meet the WUI intermix criteria of at least one structure per 40 acres

USFS – United States Forest Service

USDA – United States Department of Agriculture – includes the Forest Service

USGS – United States Geological Survey

WUI – Wildland Urban Interface
APPENDIX B

Data were obtained from these sites:

LANDFIRE  http://landfire.cr.usgs.gov/viewer/

National Land Cover Database (NLCD)  http://www.mrlc.gov/finddata.php

National Park Service’s Natural Resources Information Portal  https://nrinfo.nps.gov/Map.mvc/GeospatialSearch


USGS NPS Vegetation Inventory  http://science.nature.nps.gov/im/inventory/veg/index.cfm

U.S. Census Tiger Files (2010 population and housing shapefiles)  ftp://ftp2.census.gov/geo/tiger/ TIGER2010BLKPOPHU/
APPENDIX C

PROCEDURES FOR DELINEATING
WILDLAND URBAN INTERFACE AT YOUR SITE

Developed by Mary Rozmajzl

As part of a Thesis:
DELINATE THE WILDLAND URBAN INTERFACE
USING PUBLICLY AVAILABLE GEOSPATIAL DATA

The Wildland Urban Interface or WUI (pronounced woo-ee) is the area between undeveloped wildlands and urban areas. Federal land management agencies\(^1\) have been tasked by Federal legislation (Federal Register, 2001, 752-3) to reduce fire hazards on the lands they manage, thereby reducing the potential for extensive wildfires. The following procedures for determining the WUI for a small tract of land were developed to provide another layer of data to assist Land Managers in making informed decisions about the lands they manage.

These procedures were developed using ArcMap 10; if you are using another version of ArcMap, the procedure pathways or windows may differ. These instructions are basic and there are other ways to manage your ArcMap project and data. *If you are an employee of the National Park Service (NPS),*

\(^1\) Federal Land Management Agencies listed in Federal Register 66(3) (2001) are the Forest Service (USDA); Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, and National Park Service (DOI).
instructions specific to NPS, as well as intranet links will be provided in italics and bracketed (e.g. [NPS – ]).

DATA NEEDED
At a minimum, you will need the following data to create a WUI map for your site (hyperlinks provided under appropriate categories below):

1) A shapefile of your site boundary;

2) Census population/housing shapefile; OR a shapefile that identifies structures by points (usually generated from a GPS unit or created in ArcMap)

3) A vegetation coverage file (LANDFIRE existing vegetation type or NLCD (National Land Cover Dataset) are publicly available or another vegetation coverage file. [NPS: USGS vegetation coverage if available.]

4) Basemap (optional); a basemap is available within ArcMap or you can import imagery.

1) SITE BOUNDARY SHAPEFILE

The shapefile of your site’s boundary should be in the form of polygons and it must be projected so that ArcMap can place it appropriately within the project you will be creating. Polygons are needed to identify the area from which to perform clipping functions. Most agencies maintain a boundary shapefile for their sites.

As areas are determined with English measurements, these instructions are for a project projected in NAD 83, State Plane, foot.
[NPS - Data is projected in NAD 83 and posted as polygons. To download your site’s boundary shapefile, go to https://irma.nps.gov/App/Reference/Welcome, hit Search (for Documents and Datasets), Search Type: Advanced, Search Fields: change Display Citation to Title [containing], type in: tract and boundary. Hit the drop down arrow in front of Units – type in the four digit code for your site; select the site name so that it populates the Units box. Hit the search button at the top or bottom of the page. Your search should reveal the site’s current official boundary data [link]. Click on the link under Title. Scroll down to the middle of the page under Holdings, External (the file showing should be ……[your site]_tracts.zip. Click on Open on the far right. In the File Download box, hit Save and save the zip file to your computer. You will need to unzip the .zip file before you can import your site’s .shp boundary into ArcMap.]

2) U.S. CENSUS HOUSING DATA

U.S. Census Tiger files contain population and housing data in census block groups. Census block groups are used because they are the smallest unit of measurement for census data. By using the population and housing (pophu) file you will be importing polygons with housing densities. Housing densities are used to help identify the WUI. Visit the Census.gov Tiger files site to download 2010 files for your site at ftp://ftp2.census.gov/geo/tiger/TIGER2010BLKPOPHU/. To identify the
zip file for your state you will need your state’s code; see the Census Two-Digit State Code Listing in Appendix 1.

3) LANDFIRE DATA

LANDFIRE provides a vegetation land cover raster data set; other sites such as the National Land Cover Database (NLCD) provide similar information (other links are listed below). To download vegetation data from LANDFIRE, visit www.landfire.gov and follow the directions below:

i. On the left, click on Data Distribution Site.

ii. Select your zone from the map (on the next page the map will be zoomed in to your general area).

iii. Select your area from the map by zooming in. To zoom in, choose the compass icon (top left) – zoom in) and draw a box around the area.

iv. Once you are zoomed in to the area you want, click on the world icon (top left) and choose Download Data. In the Download Data box there are layers listed; choose LF 110; Vegetation; us_110_ Existing Vegetation Type.

v. Click on the selection Define Rectangular Download tool at the top of the Download Data window and draw a box around your area (this opens a Request box). Under LF_110, Vegetation, Select us_110_ Existing Vegetation Type and hit the Download button, and then Download again. When the Download window comes up, choose Save and select a location to save the data.

Vegetation data from the NLCD can be obtained at http://www.mrlc.gov/nlcd06_data.php.

[NPS: USGS Vegetation Characterization can be found at http://biology.usgs.gov/npsveg/products/parkname.html. Under Geographic Vegetation Information, choose the ZIP file containing Spatial...
PREPARING YOUR DATA

Unzip the Census and LANDFIRE zip files that you downloaded previously from census.gov and landfire.gov.

Before beginning this project, it is recommended that you create a new File Geodatabase where you can store the layers and feature classes that you will create. To do this, open ArcCatalog (or access it within ArcMap by clicking on the catalog icon on the Standard toolbar) and navigate to the location where you want to store the geodatabase (hit the connect to folder icon if your location is not listed in the Location drop down box); right click within the Catalog window and select New; File Geodatabase; close the Catalog window.

To project a shapefile to State Plane [NPS: perform this conversion], open a new ArcMap project, Import the boundary shapefile (.shp) of your site using the Add Data icon on the Standard toolbar. Open ArcToolbox, select Data Management Tools, Projections and Transformations, Feature, Project. In the Input Dataset box, hit the drop down arrow to the right and choose your boundary file. The current coordinate system will automatically populate the next box. In the Output Dataset box, hit the folder icon to the right and navigate to your File Geodatabase and give the file a name. For the Output Coordinate System, hit the hand icon to the right, hit the Select button, and
choose Projected Coordinate Systems. Select State Plane from the list, choose NAD 83 (US Feet); navigate to your state listings. It is important to choose the correct FIPS listing here. To find the Zone listing for your site, visit
http://home.comcast.net/~rickking04/gis/spc.htm. On this site, find your state with the county for your site. The section listing your county will have the zone you should use (N, S, etc.). Select the same zone for the ArcMap coordinate system, hit the Add button, OK, OK. Close the ArcMap project.

NOTE: When naming files for use in ArcMap, do not use spaces in file names; use capital letters or _ for separations (e.g. BoundaryStatePlane.shp OR boundary_state_plane.shp.)
**IMPORT SITE BOUNDARY**

Start ArcMap and open a new Blank Map. (NOTE: ArcMap sets projections for projects according to the projection of the first file you import.)

Import the state plane boundary shapefile (.shp) of your site using the Add Data icon on the Standard toolbar.

[OPTIONAL] To facilitate ease of use and consistent file projection, you can set up your ArcMap project to automatically populate the file location and indicate the projection you want for all new files. On the Standard Toolbar, select Geoprocessing, Environments. Next, choose Workspace; for both Current and Scratch Workspace entries, hit the folder icon on the right and navigate to your File Geodatabase folder. Choose Output Coordinates in the main Environment Settings window; under Output Coordinate System, hit the drop down arrow and choose Same as layer [choose your state plane boundary layer]. Hit the OK button at the bottom of the window.

**ADDING A BASEMAP (Optional)**

In ArcMap, click on the down arrow next to the Add Data button, choose Add Basemap, and choose the version you want. NOTE: you must always be online for this basemap to be available.

Or, you can import an image of your choice. An option for that is to use orthoimagery from the National Agricultural Imagery Program (NAIP); their
imagery is available for download free at http://datagateway.nrcs.usda.gov, click on the green Get Data button, enter your state and county, scroll to the Ortho Imagery section, and choose 2010 National Ag. Imagery Program Mosaic if it is available. Once it is downloaded, you may have to unzip a folder to access the .sid image; import it using the Add Data button.

**ADD CENSUS DATA**

The Census Tiger files contain population and housing data. You will be accessing the housing information to help determine the WUI. To determine the WUI, Federal regulations provided three conditions where differing building densities abut wildland fuels: 1) building density is three or more buildings per acre; 2) building density ranges from buildings close together to one building per 40 acres; and 3) where structures abut a park or open space. To determine the WUI we will use the second condition outlined above (one building per 40 acres) as this is the least dense scenario. The census data are presented in square meters so a housing density conversion was performed which converts one house per 40 acres to 6.175 houses per square kilometer; we can round up to 7 as the housing data are presented in full numbers.

Hit the Add button in your ArcMap project and navigate to your census files; insert the tabblock2010_XX_pophu_st.shp file. You may want to change the symbol for this layer in your Table of Contents (a clear box with an outline is suggested).
BUFFERING THE SITE BOUNDARY

Many federal agencies use a WUI buffer of 1.5 mi (2.4 km) as defined by the California Fire Alliance (California Fire Alliance) and you will use the same buffer distance. Before you can buffer census housing polygons by 1.5 miles, you need to do a little maintenance. You will be merging (dissolving) census housing polygons with greater than seven houses per square kilometer (which you will choose in the next step). Open the Attribute Table for the pophu layer and add a Field named Dissolve with the Type as Short Integer; hit the OK button (Figure 1). Select the new Dissolve field (it will highlight), right click, and choose
Field Calculator. In the empty box in the bottom half of the Field Calculator page, type in “1”; hit the OK button (Figure 2). The Dissolve field will populate with 1s for each polygon. With the Attribute Table still open, hit the Select by Attributes icon at the top of the Table window. To create your query to select census housing polygons with a value greater than 7, double click on HOUSING10 in the list at the top of the window (you may have to scroll down to see it), click on the >= button, hit Get Unique Values, and choose 7. This selects all census polygons needed to determine the urban area for your WUI. Your query window should look like Figure 3. Hit the Apply button and close the Attribute Table.

Figure 2
With the census polygons selected, right click on the pophu layer and go to Selection, Create Layer from Selected Features; a new layer is created. Rename the new layer Housing_density_grtr_7 (or some other appropriate name); uncheck the original pophu layer so that it does not show in your map.

Now you will combine (dissolve) the Housing_density_grtr_7 layer polygons.

Open ArcToolbox, select Data Management Tools, Generalization, Dissolve.

In the Dissolve box, for Input Features, hit the drop down arrow (your project
layers will show) and choose the Housing_density_grtr_7 layer; the Output
Feature Class will automatically populate (hit the folder next to this to save this
feature class in your File Geodatabase). Select dissolve as the Dissolve Field;
hit the OK button (Figure 4). Dissolve may take a while; watch the progress bar
at the bottom right of the screen; a new _Dissolve layer will automatically be
created and added to the Layers on the left of your ArcMap project.

To create a 1.5 mile buffer on the Census greater than 7 houses polygons,
open ArcToolbox, select Analysis Tools, Proximity, Buffer. In the buffer window
choose the new _Dissolved housing density layer as the Input Feature; the
Output Feature Class will automatically populate. For Distance, leave Linear unit
selected, and type 1.5 in the blank field box; hit the drop down arrow next to Feet
and choose Miles. The Side Type should remain FULL; Dissolve Type is NONE;
click O.K. (Figure 5). Buffering will take a while. Your new boundary-buffer is
added as a layer to your map.
The buffered area, along with any housing polygons that occur within your site boundary, encompass the WUI for your site. To CLIP the buffered area to only show the WUI within your site boundary, open ArcToolbox, choose Analysis Tools, Extract, Clip. Input features will be your buffered census polygons, the clip features will be the site boundary. Name the output feature class (this is the WUI inside your boundary) and choose a folder for the file (you may encounter a 🚨 during this process (ignore it; you will deal with it when importing the new feature class); hit O.K. Clipping may take a while; watch the progress bar at the bottom right of the screen. You may need to add the newly created clipped feature class to your map. If you get a coordinate system warming, hit close and the layer should import.

________________________________________________________________
ADDING A VEGETATION DATASET

Adding vegetation data to your map will allow you to identify areas within your urban delineation that are wildlands. The following instructions are for a LANDFIRE dataset. Both LANDFIRE and NLCD are rasters which will get converted to shapefiles through this process; the USGS Vegetation Characterization is already in shapefile format.

To add a LANDFIRE vegetation layer to your ArcMap project, click the Add button, navigate to your LANDFIRE data folder and select the us_110evt (existing vegetation type) file; click Add. The vegetation dataset will show as white and black or grey. To clip out the LANDFIRE vegetation within your site boundary, open ArcToolbox, select Spatial Analyst Tools, Extraction, Extract by Mask. For the Input Raster, hit the drop down arrow and choose the us_110evt layer. The feature mask data will be your site boundary. If you set up the Environments for your project (p. 7), the Output raster dataset box will be populated with the location of your File Geodatabase and the Output Coordinate System will be populated with the State Plane projection you specified. Hit OK. Uncheck the original us_110evt layer in the Table of Contents.

You need to convert the raster dataset to polygons. Open ArcToolbox, select Conversion Tools, From Raster, Raster to Polygon. The Input Raster will be the masked (extracted) raster within your boundary that you just created; Field Value can remain VALUE; UNCHECK simplify polygons; hit OK. At this point the only checked layers in the Table of Contents should be your site boundary and
the newly created raster_extract layer. If you check the Properties for the new raster_extract layer (right click on the raster_extract layer and choose Properties at the bottom of the window and select the Source tab) the Data Source should show that you have a Shapefile, the Geometry Type is a Polygon, the Projected Coordinate System is the State Plane system you chose earlier, and the Linear Unit is Foot.

To open the Attribute Table for a layer, select the layer in the Table of Contents, right click, and choose Open Attribute Table. If you do this for the raster_extract layer that you just created there will be four columns of information. Open the Attribute Table for the original raster layer you imported and you will see that there are many more columns. What is relevant here is that the original raster layer contains an EVT_NAME and a VALUE column. When you converted your raster to polygon the VALUE information was stored in the new raster_extract layer in the GRIDCODE column. To transfer the EVT_NAME (vegetation names) to the new raster_extract layer you will perform a join.

Before joining the two layers, open the attribute table for the raster_extract layer, add a field (Figure 1), name the field VEGETATION with the Type as Text, and the precision as 200 (you want the field long enough to hold all characters from the EVT_NAME information that you will be bringing in); hit OK. With the attribute table window still open, hit the Table Options drop down button (Figure 6), select Joins and Relates, Join. In the Join Data window, 1 will be GRIDCODE, 2 is the original raster layer, and 3 is VALUE (Figure 7); hit OK.
The join added all of the attribute table information from the original raster dataset to the raster_extract attribute table. Scroll across the joined attribute table and you will see the EVT_NAME field. To enter the EVT_NAME information into the new VEGETATION field, select the VEGETATION field on the top grey bar, right click and choose Field Calculator. From the Fields box, double click on the us_110evt.vat:EVT_NAME so that it populates the formula box below; hit OK (Figure 8). The vegetation information will populate the VEGETATION field. Hit the Table Options drop down arrow, select Joins and Relates, Remove joins, Remove All Joins; close the attribute table.

To clip out the vegetation that is located in the urban area you previously defined and buffered, open ArcToolbox, Analysis Tools, Extract, Clip. Input the
raster_extract1 layer, clip with the buffer_dissolve_clip layer you created previously.

To choose only wildland vegetation from this new layer, you will need to make decisions on which types of vegetation constitutes wildland for your site. Suggestions on vegetation types to NOT CHOOSE in the next step would be developed land, water, cropland, barren, rock outcrops, floodplain, or wetlands. Some sites may want to include wetlands in their wildland classifications.

Open the attribute table for the raster_extract1_clip layer; hit the Select by Attributes icon at the top of the Table window. Double click on the top of the window, click on the = button, hit Get Unique Values, and choose the vegetation types you have decided constitute wild-lands at your site. As you create this list, be sure to hit OR between each vegetation selection. Your query should look something like Figure 9; hit Apply; close the attribute table.

Figure 9
Right click on the raster_extract1_clip layer, select Selection, Create Layer from Selected Features. This action takes all the vegetation values that you selected as wildland vegetation, copies them from the raster_extract1_clip layer, and creates a new layer. Name this new layer wildlands. Clear the selection by hitting the Clear Selected Features on the Tools Toolbar.

To symbolize the different vegetation types with different colors, right click on the wildlands layer and choose Properties. Select the Symbology tab, select Categories on the left, Unique values, and change the Value Field to VEGETATION; hit the Add All Values button (Figure 10); hit OK.

You have just created the WUI for your site. The only two layers selected in the Table of Contents should be your boundary and wildlands. As you worked through this process your buffered area may look like Figure 11 and your final WUI like Figure 12.
ACKNOWLEDGEMENTS

Thanks go to Kathie Hansen, National Park Service Midwest Fire GIS Specialist, who provided the original framework for this study. Hansen also provided an outline of procedures for determining the urban area for a WUI using U.S. Census Housing data, crafted by Katie Dosch.
REFERENCES


Federal Register Notice. 2001. Urban wildland interface communities within the vicinity of federal lands that are at high risk from wildfire. Vol. 66, No. 3.


APPENDIX 1

Two-Digit State FIPS Code Listing (in 2010)

http://www.itl.nist.gov/fipspubs/fip5-2.htm

NOTE: The list does not contain code numbers 03, 07, 14, 43, or 52; this is not an error.

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