The Wildland-Urban Interface in the United States

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Introduction

The purpose of this project is to provide information on "the area where houses and wildland vegetation coincide." Although there are other ways of defining the wildland-urban interface (WUI), this is the definition referenced in the National Fire Plan. Details about the rationale, development, testing, and sensitivity analysis of this definition, as well as the data sources and analytical methods we used, can be found at the end of the article in the methods section.

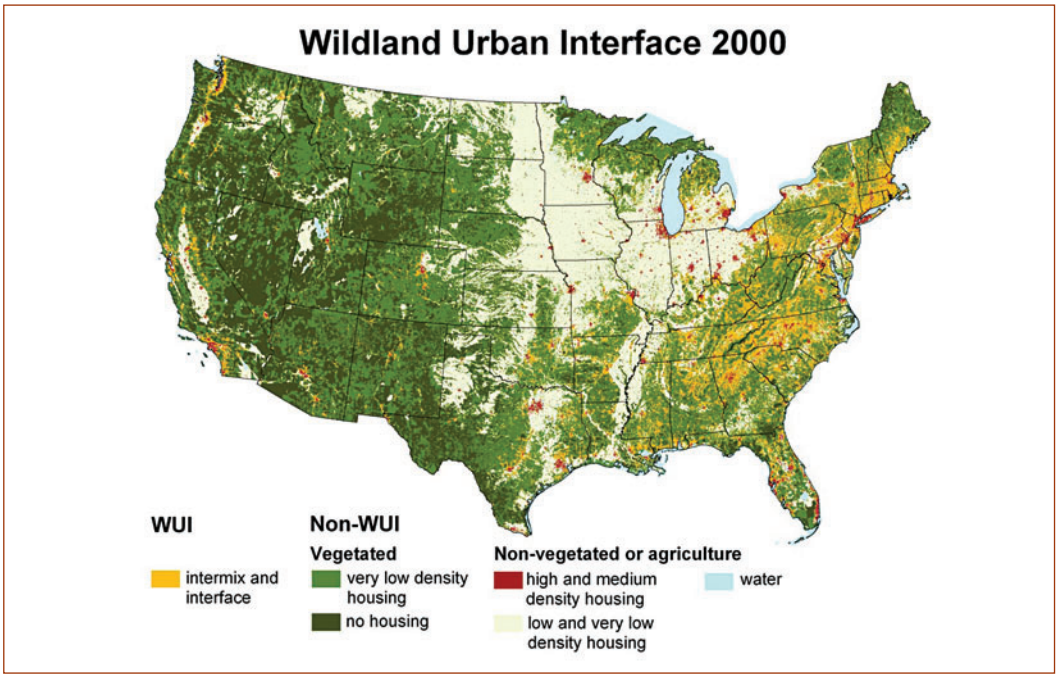
The WUI maps and data were created with the hope they would be useful to planners and managers at the local, state, and national levels. Tools and information regarding the WUI are available on our Web site for public use. Users should note that the resulting WUI map does not indicate the risk of fire; it shows only where houses and wildland vegetation coincide. Some of the areas identified as WUI are prone to fire, and some are not.

Key Findings

The 2000 U.S. WUI map offers insights about the extent and distribution of the interface across the United States (fig. 1).

- All States have at least a small amount of land classified as WUI, and some have almost three-quarters of their land area in the WUI.
- Across the United States, 9.4 percent of all land is classified as WUI.
- WUI is concentrated along the eastern seaboard.
- WUI is also commonly found in amenity areas with extensive recreation and tourism including the northern Great Lakes and the Missouri Ozarks.
- In the Rocky Mountains and the Southwest, virtually every urban area has a large ring of WUI, reflecting the sprawling patterns of recent growth, with extensive medium- and low-density housing near or in low-elevation forested areas.
- Although the WUI is not extensive along the west coast, it encompasses a high percentage of homes, particularly in the fire-prone areas of southern California.

Figure 1.—The 2000 wildland-urban interface



Source: Radeloff *et al.* 2005b

WUI Distribution Across the U.S.

- Large Eastern and Southern States have the most land area in WUI.
- The smaller States, all in the Northeast except for North Carolina, have the highest percentage of land in the WUI.
- California, Florida, and Texas have the largest numbers of homes in areas where wildland vegetation is relatively dense.
- The Western States have the highest proportions of their homes in the WUI.
- Across the country, 38.5 percent of all homes are in the WUI.
- In 19 of the 48 contiguous States, more than 50 percent of all homes are located in the WUI.

State by State, distribution of the WUI varies with the physical and biological settings and the infrastructure an area provides for home building. Several State rankings are shown in table 1 to illustrate how the WUI varies across the country.

Tools for Resource Managers

A complete listing of State-level WUI statistics is available on our Web site, http://silvis.forest.wisc.edu/projects/WUI_Main.asp. The Web site has an interactive mapping feature that allows any user to create custom graphics showing the WUI in a county or a group of counties or in a group of States. A help card available on the Web site provides step-by-step instructions for creating custom WUI graphics. Both WUI and housing density map images, with a black background suitable for slide shows or a white background for publications, can be downloaded for individual States, Forest Service regions, and for the whole United States Statistics also are available at the state, regional, and national level as well, detailing the land area and number of homes in interface and intermix in 1990 and 2000.

Because the WUI data make up one of many layers or sources of information that may be useful in community, regional, or state fire planning, the Web site has been designed so that our maps can be downloaded for use in GIS applications. Alone, our data indicate only where houses and wildland

Table 1.—State rank by area and housing units in interface, intermix, and total WUI

Rank	Interface		Intermix		WUI	
Area (ha)						
1	PA	1,048,577	NC	4,784,695	NC	5,527,830
2	CA	746,021	GA	3,328,527	PA	4,338,705
3	NC	743,134	PA	3,290,128	GA	3,957,293
4	TX	728,196	VA	2,911,236	NY	3,573,641
5	NY	707,604	NY	2,866,037	VA	3,504,168
Area (percent)						
1	DC	19	RI	61	CT	72
2	NJ	15	CT	60	RI	70
3	MA	12	MA	53	MA	65
4	CT	12	NH	38	NJ	46
5	RI	9	NC	38	NC	44
Housing units (number)						
1	CA	3,480,285	CA	1,607,624	CA	5,087,909
2	FL	1,636,248	GA	1,479,368	FL	2,587,074
3	TX	1,426,326	NC	1,451,811	TX	2,568,047
4	PA	1,395,140	PA	1,146,366	PA	2,541,506
5	NY	983,059	TX	1,141,721	NC	2,322,458
Housing units (percent)						
1	WY	62	ME	50	NH	83
2	NM	41	NH	47	WV	82
3	MT	40	GA	45	WY	80
4	UT	40	WV	42	ME	79
5	WV	39	NC	41	NM	79

vegetation coincide, which is just one small part of the information resource planners must assemble in developing fire management plans. GIS technicians can access the WUI Web site and overlay WUI boundaries and characteristics on their own GIS map(s) of local road networks, resource conditions, values at risk, fire hazard, ecological characteristics, and so on. ArcIMS software automates the process of matching locations and accounting for different mapping projections. Using our ftp server, GIS analysts can also download our dataset to modify our analysis and create original maps using their own local or regional datasets, such as a county-level "buildings layer" (i.e., digital record of specific building locations), which would be more complete and precise than census housing density data.

WUI Change Over Time

The key to future trends in the size, extent, and location of the WUI lies in housing growth, a function of many local and state policy decisions and economic conditions. Our analysis of WUI change indicates that growth in WUI housing was rapid during the 1990s. The counter-urbanization trend of the 1970s that brought retirees and many others to rural high amenity areas as well as the growth of suburban and exurban areas have increased the WUI, particularly the number of houses it encompasses. We estimate that 60 percent of the homes constructed between 1990 and 2000 were built in existing WUI areas. Further analysis of change over time in the WUI will provide us with useful insights about WUI dynamics, an essential foundation for projections of future WUI growth.

Methods

Although mapping the WUI might appear to be straightforward, there are actually many different ways to define the WUI that capture the basic concept of human presence in or near wildland vegetation. Our intent was to produce a national map, both to provide information for policymaking and to assist managers whose work is directly impacted by national policy. Because these were our goals, we used the policy-specific criteria for the WUI that were published in the Federal Register, January 4, 2001 (66 FR 751). The Federal Register definition borrows heavily from a consultant's report about fire in the WUI, commissioned by the Council of Western State Foresters (Teie and Weatherford 2000). A national map such as this can be made only with data that are nationally available. For this reason, the map and the data on which it is based are relatively simple, using just two key characteristics, human presence (measured by housing density) and wildland vegetation. We expect that managers with more complete local data will supplement the WUI map with these data to extend the quality and quantity of information conveyed in the map.

We map the WUI using ***housing density*** data, because housing density is a more suitable measure of human presence and influence on the landscape than population density. Housing counts include

seasonal residences, whereas population counts do not, and because national forests, parks, and other natural resources are attractive to seasonal home owners, this is a significant distinction. Housing density information was derived from U.S. Census data. Analysis was conducted at the finest spatial scale possible, census blocks, from the 2000 census. The Federal Register established a minimum density of one structure per 16 ha.

The housing density data are combined with vegetation data that indicate the areas where wildland vegetation is continuous in housing areas, or is within their vicinity. We use the National Land Cover Dataset, a satellite data classification with 30-m resolution based on 1992/93 satellite images, and available for the entire U.S. (Vogelmann *et al*. 2001). Our definition of ***wildland vegetation*** includes land cover classified as forests (coniferous, deciduous and mixed), native grasslands, shrubs, wetlands, and transitional lands (mostly clearcuts). We exclude land cover that is intensively human-dominated, including urban grasslands (often golf courses), orchards, arable lands (such as row crops), and pastures.

Finally, the Federal Register identifies interface communities as those where housing is "within the vicinity" of forests and other wildlands as part of the WUI, but it does not say what distance counts as the "vicinity." In its identification of WUI, the California Fire Alliance (2001) defined ***vicinity*** as all areas within 2.4 km of wildland vegetation, because that is roughly the distance that firebrands can be carried from a wildland fire to the roof of a house. This rationale for defining the vicinity takes into account the idea that even those homes not sited within the forest are at risk of being burned in a wildland fire. We adopt this vicinity measure as the buffer distance used to identify interface areas.

With housing density threshold, wildland vegetation types, and interface buffer distances determined, the operational definition of the WUI is complete: There is more than 1 house per 16 ha and more than 50 percent wildland vegetation; and, neighborhoods with less than 50 percent wildland vegetation are included if they are within 2.4 km of an area (made up of one or more contiguous census blocks) more than 500 ha that is more than 75 percent covered with wildland vegetation.

Users should note that the resulting WUI map does not indicate the risk of fire; it shows only where houses and wildland vegetation coincide. Some of the areas identified as WUI are prone to fire, and some are not.

The WUI data were tested for sensitivity to each aspect of the definition we use. The 2.4-km vicinity distance, the housing density threshold, the vegetation density threshold, the vegetation types treated as "wildland vegetation" were changed, and the analysis was rerun in selected States across the U.S. Combinations of these changes were also made to assess the extent of overlap between them. Sensitivity tests show that the WUI definition is robust. For each change we tested, the responses

(measured as the number of acres characterized as WUI, and as the number of homes located in WUI areas) were minor in comparison to the definition change. The biggest response was to changes in the housing density threshold. Changes to other aspects of the definition had smaller effects. Individual States varied in their sensitivity to the changes. Details and results of the sensitivity analysis can be found in Radeloff *et al*. 2005. Testing WUI definition changes is technically demanding and requires considerable computing time, but anyone interested in assessing the significance of a definition change they wish to make in creating a custom, local WUI map may contact the authors for details about the procedures involved.

References

California Fire Alliance. 2001. Characterizing the fire threat to wildland-urban interface areas in California. Sacramento, CA: California Fire Alliance. 15 p.

Radeloff, V.C.; Hammer, R.B.; Stewart, S.I.; *et al*. 2005. The wildland urban interface in the United States. Ecological Applications. 15(3): 799-805.

Teie, W.C.; Weatherford, B.F. 2000. Fire in the west: the wildland/urban interface fire problem. Report to the Council of Western State Foresters. Rescue, CA: Deer Valley Press.

U.S. Department of Agriculture, U.S. Department of the Interior. 2001. Urban wildland interface communities within the vicinity of Federal lands that are at high risk from wildfire. Federal Register. 66: 751.

Vogelmann, J.E.; Howard, S.E.; Yang, L.; *et al*. 2001. Completion of the 1990s National Land Cover Data set for the conterminous United States from Landsat Thematic Mapper data and ancillary data sources. Photogrammetry Engineering & Remote Sensing. 67: 650-662.