Defining the Wildland–Urban Interface

Susan I. Stewart, Volker C. Radeloff, Roger B. Hammer, and Todd J. Hawbaker

ABSTRACT

Federal wildland fire policy in the United States has been substantially revised over the past 10 years and new emphasis has been given to the wildland–urban interface (WUI), which creates a need for information about the WUI's location and extent. We operationalized a policy definition published in the *Federal Register* (US Department of the Interior [USDI] and US Department of Agriculture [USDA]), 2001, Urban wildland interface communities within vicinity of federal lands that are at high risk from wildfire. *Fed. Regist.* 66(3):751–777) to create national maps and statistics of the WUI to guide strategic planning. Using geographic information system analysis, we evaluate the national WUI by altering the definition's parameters to assess the influence of individual parameters (i.e., housing density, vegetation type and density, and interface buffer distance) and stability of outcomes. The most sensitive parameter was the housing density threshold. Changes in outputs (WUI homes and area) were much smaller than parameter variations suggesting the WUI definition generates stable results on most landscapes. Overall, modifying the WUI definition resulted in a similar amount of WUI area and number of homes and affected the precise location of the WUI.

Keywords: wildland–urban interface; wildland fire; housing growth; GIS sensitivity analysis; wildland fire policy

The wildland–urban interface (WUI) has become the central focus of wildland fire policy in the United States. The tragic 1994 Storm King incident, in which 14 firefighters were killed, initiated intense scrutiny of wildfire policy and management (US Department of the Interior [USDI] and US Department of Agriculture [USDA] 2006). When the Federal Wildland Fire Management Policy and Program Review was issued the following year, it clarified the role of the federal agencies in fighting fires in the WUI (USDI and USDA 1995). A 10-year overhaul of US wildland fire policy followed, spurred on by the extreme fire season of 2000. Each of the reports and initiatives issued in successive years—the Report to the President in September of 2000, the 10-year Comprehensive Strategy of 2001, its implementation plan and the Healthy Forest Initiative in 2002, and the Healthy Forest Restoration Act (HFRA), which became law in 2003—reiterated the need for resource managers to work with communities and homeowners in the WUI to reduce the risks associated with wildfire.

The increasing national fire policy focus on the WUI came in response to recent housing trends in the United States. Homeowners want to be near open space and in close contact with nature. From 1940 to 2000, significant housing growth occurred in suburban and rural areas, especially in and near forests (Radeloff et al. 2005a). Housing growth was strong nationwide, including areas with short fire return intervals and high departure from historic conditions such as the Rocky Mountains and the Sierra Nevada (Hammer et al. in press). The effects of resource management practices, climate changes, and insect and disease infestations, together with continued housing growth in high fire-risk areas thus create an urgent need to understand and manage fire risk in the WUI (Pyne 2001).

Governments at all levels share responsibility for wildland fire management in the WUI. The federal government's role is to provide leadership, coordination, and research across the country, a role that benefits

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from the ability to locate and compare the WUI in different states and regions. To support this aspect of WUI management and strategic planning, we created a map of the WUI across the lower 48 states (Radeloff et al. 2005b). Unlike a community-level WUI map that can be enriched by using detailed local data, this "big picture" national map required nationally consistent data and a single standardized WUI definition. Here, we sought to understand how the national WUI map is influenced by the WUI definition used, the relative effect of each part of the definition, and the overall usefulness of the map in identifying homes likely to be affected by wildfire. We used geographic information system (GIS) analysis to address these questions.

Literature Review

A good WUI map provides a graphic representation that matches the conceptual understanding of what and where the WUI is. This conceptual understanding of the WUI has evolved over time; the area where houses and forests meet has attracted attention for many years. Bradley's book (Bradley 1984) on the resource management issues in the interface is a major early contribution. Even earlier, Henry Vaux characterized the WUI as the "hotseat of forestry" (Vaux 1982) and cautioned foresters not to underestimate its political and policy significance. Both authors discussed a wide range of WUI issues and neither equated the WUI with wildland fire. However, the focus of WUI discussions had narrowed by the end of the 1980s, when Davis (1990) characterized the WUI as a setting where wildland fire is a problem and where conflicts arise over responsibility for protecting homes from wildfire. A 1997 issue of the *Journal of Forestry* featured a cover photo of a wildland fire encroaching on a subdivision and included two articles about the WUI that emphasized fire planning and management (Greenberg and Bradley 1997, Plevel 1997). The term "wildland–urban interface" is now used almost exclusively in the context of wildland fire.

Extensive references to the WUI in US fire policy reflect the fire management community's long familiarity with the concept. Published in the *Federal Register* in conjunction with the National Fire Plan (NFP), the WUI definition states that "The WUI community exists where humans and their development meet or intermix with wildland fuels" (USDA and USDI 2001, p. 752–753). This definition was adapted from a report to the Western Governor's Association (Teie and Weatherford 2000), with only minor changes. The more recent HFRA moves away from this standardized approach to defining the WUI by allowing communities to establish a buffer zone around the town, the civic infrastructure, and evacuation routes, including these areas in the WUI as well. This more flexible definition is consistent with the HFRA's emphasis on empowering local communities to develop Community Wildfire Protection Plans.

Throughout its evolution, the WUI definition always includes three components: human presence, wildland vegetation, and a distance that represents the potential for effects (e.g., wildland fire and human activity) to extend beyond boundaries and impact neighboring lands. Beyond these three components, most WUI discussions are imprecise regarding what is or is not included. For example, human presence has been defined by housing density, population density, number of houses, or configuration of housing developments and neighborhood characteristics. Wildland vegetation is always mentioned, but the density, extent, and type of vegetation that makes some vegetation "wildland vegetation" is not well defined. The distance that the WUI extends into wildlands or into a housing development has been described in many different ways, including the distance a golf ball will fly off the porch or the distance from which flames or firebrands can reach a structure (Summerfelt 2003), but specific distances are rarely given.

Conceptually, these many definitions all refer to the same basic idea, that the WUI is where houses and wildlands meet or overlap. However, operationally, they differ and in previous WUI maps, definitions vary depending on data available at the time and across the extent of the map. For example, Greenburg and Bradley (1997) used remote sensed data to assess vegetative characteristics related to human presence in two cities. In their Eugene, Oregon, WUI map, population and road densities captured human presence; for the Seattle map, distance from the city center was used as a proxy for human presence. Lein introduced fuzzy methods of determining the WUI's location, relying on remote sensed data to detect the presence of both structures and vegetation (Lein 2006). Two earlier maps attempted to represent risk from fire as well as vegetation and housing characteristics. Space Imaging's (2002) Floridawide fire risk tool used Census population data and determined vegetation proximity via detailed fuels mapping, although the Census data's resolution, the rules for determining vegetation and population proximity, and the types of vegetation included were not specified, and the distinction between interface and intermix WUI was made based on population density alone. A coarse-scale map of the wildland fire risk to structures was developed as a tool for strategic planning (Schmidt et al. 2002). Ambient population data (USDE 2005) was used to derive housing densities and combined with extreme fire potential (derived from climate data) and potential fire exposure data (derived from vegetation data) to categorize threat levels at a 1-km resolution.

These examples illustrate that despite all that has been written about the WUI and its significance in fire policy, there is no single operational definition. A review by the Government Accountability Office (GAO) of NFP implementation criticized the federal agencies responsible for wildland fire management on this point (Hill 2001). In a formal response included in the GAO report, Forest Service Chief Bosworth reaffirmed his agency's commitment to maintaining enough flexibility in defining the WUI to accommodate the many different kinds of landscapes it manages.

Flexibility is valuable for both forest- and community-level mapping and management but is counterproductive when comparing WUI across places or over time periods. Our research was intended to assess the WUI across regions and to track its growth and change over time, two purposes that required standardizing the WUI definition. With no previous standard definition of the WUI to draw from, we tested the definition we developed to ensure its consistency with our research aims and with strategic wildland fire planning.

The 2001 *Federal Register* (USDA and USDI 2001)WUI definition describes the characteristics of houses and vegetation and the relationship between them that must occur for an area to be classified as WUI. In this regard, the definition is a model or abstract representation of reality. Sensitivity analysis is a set of methods used in GIS analysis to assess various characteristics of a model (Crosetto et al. 2000). The housing and vegetation characteristics and the buffer distances are the parameters of the WUI definition, and the definition can be assessed by varying the parameters one at a time to isolate the effect of each on the model output, which is the WUI map (Hamby 1994). Sensitivity analysis also indicates how sensitive or stable a model is overall (Store and Kangas 2001).

To fulfill its role as a policy tool, our WUI map needs to be relatively stable as individual parameters are changed. Stability would indicate that the specific levels we chose for housing density, vegetation characteristics, and so on, do not outweigh the importance of the components in combination. Conceptually, the WUI is a conjunction of housing and vegetation characteristics; all are important, so no single parameter should dramatically change the WUI map. However, housing growth is the most volatile factor influencing WUI growth. Hence, sensitivity to the housing density parameter is essential to the model's ability to reflect the real world where the WUI is sensitive to housing growth (Rykiel 1996). This characteristic of the model will ensure its suitability for sensing WUI change over time.

Although explicit consideration of risk from fire is beyond the scope of this project, the policy intent of the WUI definition and map is to identify those homes most likely to be affected by wildland fire. For the states of Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming, where fire perimeter data are relatively good, we assess the extent to which houses close to recent fires were in areas classified as intermix or interface WUI and compare them with houses statewide.

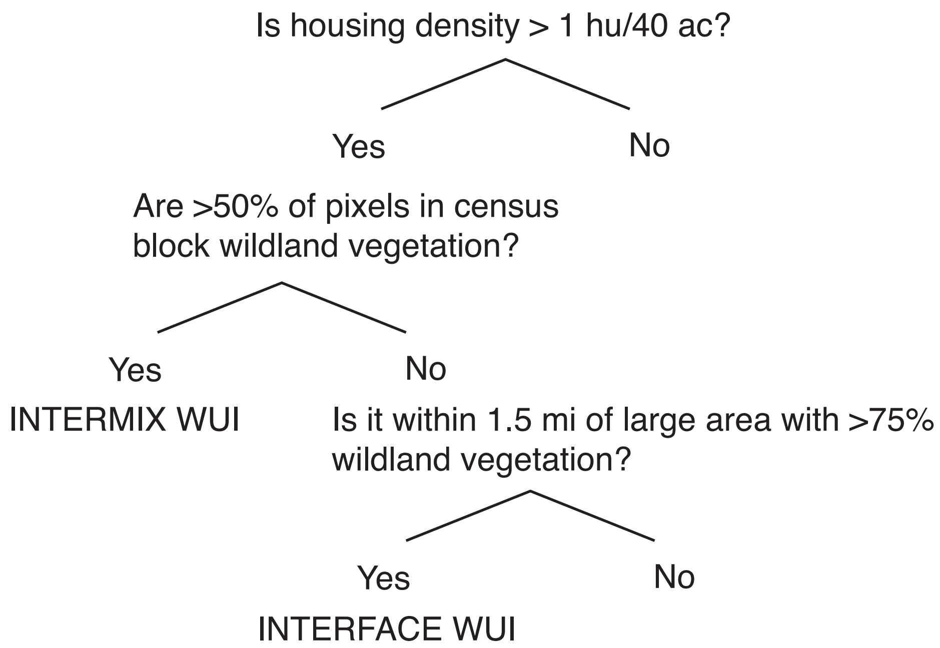

Figure 1. The WUI definition.

Methods

The policy definition on which we base our map was published in the *Federal Register* and notes that "Generally, Federal agencies will focus on [interface and intermix] communities . . . Interface communities exist where structures directly abut wildland fuels. . . . Intermix communities exist where structures are scattered throughout a wildland area" (USDA and USDI 2001, p. 753).

In the extensive text that follows, just one of the three major components of the WUI, human presence, is defined in detail sufficient for analysis. We calibrated parameters for the other two components (wildland vegetation characteristics and buffer size) to develop an operational definition. The calibration of each parameter of the definition is discussed next, and then sensitivity analysis procedures are explained.

Human Presence. Housing density is the most appropriate metric for human presence in this context because of the importance of structure protection in wildland firefighting. Because housing density has grown faster than population density in recent decades, it is the better measure for evaluating WUI change and projecting future WUI location and extent (Liu et al. 2003). Furthermore, nonresidential structures are likely located close to houses; e.g., barns and garages, bars, and restaurants tend to be clustered near homes and are absent from areas without homes. We used 2000 Census housing data to calculate housing density by census blocks. The size of census blocks varies widely with population density but they are the smallest geographic unit for which US Census data are reported (mean = 25 ac; SD = 2,674 ac), and are always subdivisions of counties. Housing density calculations include all housing units as defined by the Census Bureau, such as apartments and houses, vacant and occupied, including seasonal homes (US Census Bureau 2002). The minimum housing density for WUI specified in the *Federal Register* (USDA and USDI 2001) definition is 1 housing unit per 40 ac.

Wildland Vegetation Characteristics. Using land cover data to identify wildland vegetation requires specific direction for including or excluding each type of vegetative cover and for determining how much vegetation must be present for an area to be considered "vegetated." We assessed vegetative cover using the 1992/1993 National Land Cover Data (NLCD) from the US Geological Service, a classification of Landsat Thematic Mapper imagery, at 30-m resolution, to determine vegetative cover type and extent (Vogelmann et al. 2001). We defined "wildland vegetation" as all types of vegetative cover except those that are clearly not wild, such as urban grass, orchards, and agricultural vegetation. After reviewing the WUI mapping efforts of the California Fire Alliance (2001) and analyzing vegetation density in several test areas, we chose a vegetation density threshold of 50% for intermix. Thus, a census block was retained as potential intermix if at least 50% of its area consists of forest, shrubland, native grassland, transitional, or wetland vegetative cover. Census blocks where less than 50% of pixels were classified as wildland vegetation were not included as potential intermix WUI, although portions of these blocks could be classified as interface WUI when they were close enough to wildland vegetation to fall within the interface buffer (see the following section).

Interface Vegetation and Buffer Distance. The interface is the area where housing is in close proximity to wildland vegetation. Locating the interface required first identifying areas with wildland vegetation and then including areas within "close proximity," represented by a buffer some distance from the vegetation. Interface census blocks must meet the same housing density minimum (at least one structure per 40 ac) to be included in the WUI, but do not have to have more than 50% wildland vegetation.

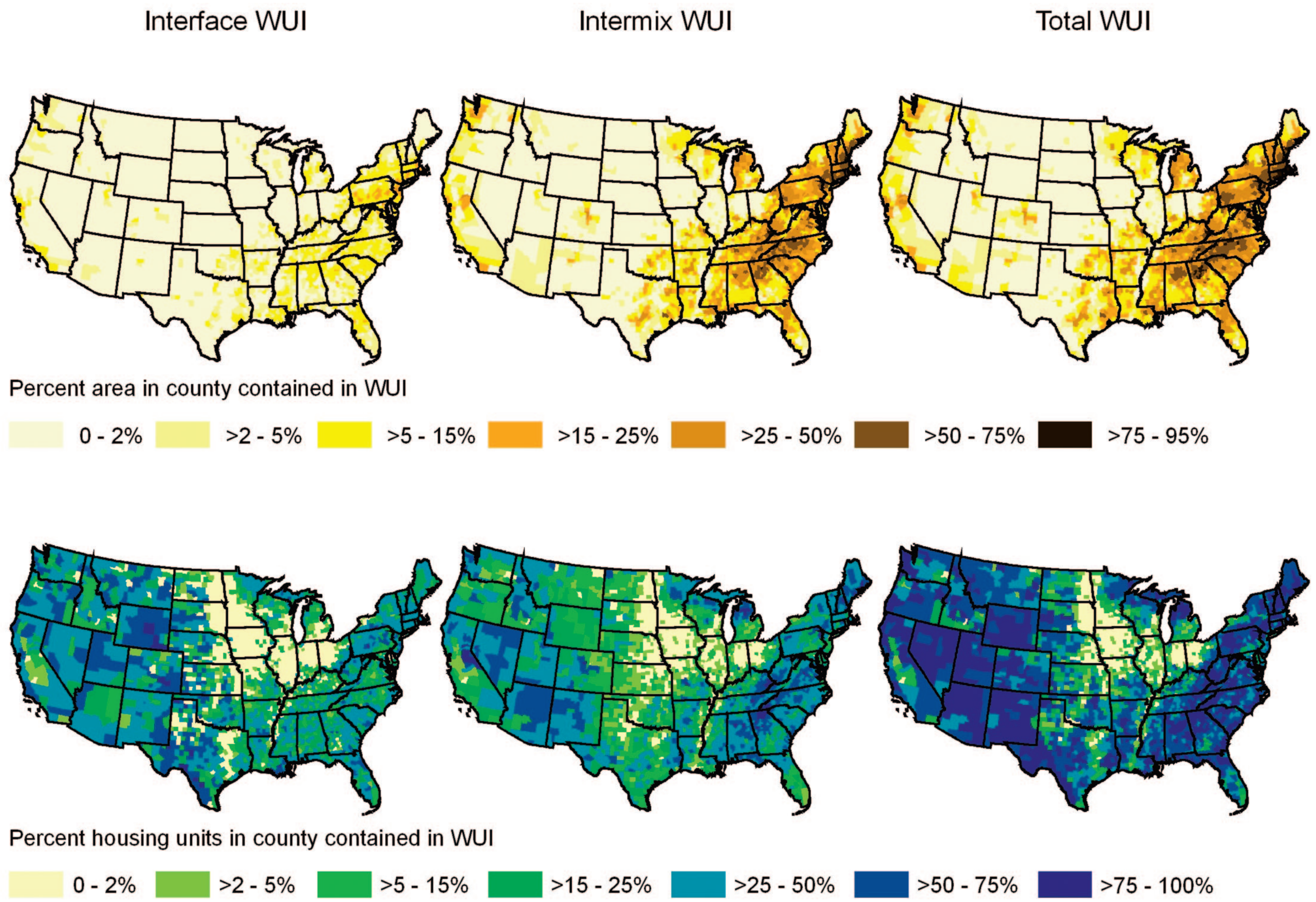

Figure 2. Distribution of WUI area and housing units by US county in 2000.

We chose a 1.5-mi buffer distance based on the precedent of the California Fire Alliance (2001). This distance represents an estimate of how far, on average, a firebrand can fly ahead of a fire front, a rationale clearly related to the fire policy application for which the WUI map was developed. Although winds and topography affect the distance a firebrand will actually travel, the information needed to capture these myriad fine-scale variations in fire brand lofting is not available. A comprehensive search of published WUI mapping work uncovered no alternative rationale for the buffer distance and no evidence against the validity of the 1.5-mi distance we chose. The vegetated block from which the buffer extends was required to meet a higher vegetation density criterion of 75% wildland vegetation. Census blocks that were only partially within the 1.5-mi buffer distance were split and only the portions within 1.5 mi of the vegetated block were defined as interface. The interface buffer was extended only from vegetated areas of at least 1,235 ac (5 km^2) to prevent areas surrounding small urban parks from being classified as interface WUI.

WUI Definition. In summary, the WUI definition as we operationalized it is the area where houses exist at more than 1 housing unit per 40 ac and (1) wildland vegetation covers more than 50% of the land area (*intermix WUI*) or (2) wildland vegetation covers less than 50% of the land area, but a large area (over 1,235 ac) covered with more than 75% wildland vegetation is within 1.5 mi (*interface WUI*). This definition is diagrammed in Figure 1, and the parameters tested in the sensitivity analysis are shown in bold.

GIS Sensitivity Analysis. To test the stability of our operationalization of the WUI definition, we specified that a stable definition is one where the percent change in output (housing units and area classified as WUI) is always smaller than the percent change made to any single parameter. One-at-a-time variations in the definition's parameters were made to determine the influence of each parameter individually (housing density, vegetation type and density, and buffer distance) on WUI housing units and area, with particular attention given to the influence of the housing density parameter. In addition to the individual parameter changes, minimum and maximum WUI scenarios were tested in which all parameters were changed simultaneously to assess the extent of overlap across individual parameter responses.

The size of the national WUI data set (8.9 million census blocks) precluded using the whole data set for sensitivity analyses. Instead, the following states were chosen representing different geographic regions of the country, with different ecotypes and housing patterns: California, Colorado, Florida, Michigan, North Carolina, New Hampshire, and Washington. For each parameter modification, data were reprocessed for all census blocks in each sample state (a total of 1.7 million census blocks, 20% of the national data set), and results were reported for WUI area and number of houses. Because one aim of the WUI mapping

Table 1. Percent change in WUI area and WUI housing units in response to parameter changes, by state.

	California	Colorado	Florida	Michigan	North Carolina	New Hampshire	Washington	Average
Original WUI								
Area (1,000,000 ac)	7.23	1.98	6.97	5.84	13.66	2.38	3.75	—
Housing (100,000 HUs)	*50.9*	*8.4*	*25.9*	*9.7*	*23.2*	*4.5*	*12.0*	—
Percent change in response to parameter changes (percent change in area, *percent change in housing units*)								
Housing density (original, >1 HU/40 ac)								
>1 HU/ 80 ac	40.6	71.7	39.8	62.3	34.0	40.0	36.9	46.5
	1.0	*3.0*	*1.9*	*6.7*	*3.7*	*3.9*	*2.0*	*3.2*
>1 HU/ 20 ac	−29.2	−39.6	−33.7	−45.6	−39.4	−39.0	−29.8	−36.5
	−1.5	*−3.3*	*−3.2*	*−9.7*	*−8.3*	*−7.4*	*−3.3*	*−5.2*
Intermix vegetation density (origina,l >50% of pixel)								
>25% of pixel	4.9	5.4	11.1	47.4	13.7	0.6	6.4	12.8
	14.0	*5.8*	*17.8*	*57.1*	*20.3*	*2.6*	*22.5*	*20.0*
>5% of pixel	−2.3	−2.3	−8.2	−18.5	−14.1	−0.8	−3.8	−7.1
	−3.7	*−1.9*	*−6.2*	*−20.3*	*−11.5*	*−1.4*	*−8.2*	*−7.6*
Interface buffer size (original, 1.5 mi)								
3.0 mi	12.6	10.0	13.7	12.1	7.4	1.2	9.4	9.5
	46.7	*33.3*	*49.0*	*19.9*	*21.7*	*15.7*	*29.3*	*30.8*
0.75 mi	−9.9	−8.5	−9.6	−6.8	−5.3	−1.8	−7.5	−7.1
	−3.7	*−24.1*	*−27.9*	*−13.5*	*−14.7*	*−13.5*	*−20.2*	*−20.7*
Vegetation (original all wildland vegetation)								
Upland only	−0.6	0.2	−12.7	−30.8	−17.9	−1.8	−0.6	−13.9
	−0.8	*0.2*	*−71.5*	*−3.6*	*−18.8*	*−9.9*	*−1.9*	*−20.0*
Forest only	−65.9	−57.6	−20.7	−37.9	−18.8	−1.9	−19.5	−39.3
	−87.8	*−76.2*	*−86.8*	*−4.3*	*−20.3*	*−11.0*	*−31.0*	*−51.0*
WUI scenarios[a] (simultaneous changes)								
Maximum	58.9	91.2	64.3	134.2	50.4	41.3	52.8	70
Extent	*55.5*	*39.3*	*61.4*	*79.0*	*20.9*	*19.8*	*45.4*	*46*
Minimum	−84.3	−80.7	−94.4	−83.1	−50.9	−48.0	−52.9	−71
Extent	*−92.5*	*−83.4*	*−95.5*	*−75.7*	*−22.9*	*−37.9*	*−55.3*	*−66*

[a]Maximum extent: housing density > 1 HU/80 ac, intermix vegetation density >25%, interface buffer 3 mi, vegetation all wildland; minimum extent: housing density > 1 HU/20 ac, intermix vegetation density > 75%, interface buffer 0.75 mi, vegetation forest only.
Note: Figures in italics give percent change in housing units.

project was to support fire policy, we made a series of eight individual parameter changes that represent plausible policy alternatives. Plausible alternatives are those that do not violate the underlying WUI concept in wildland fire management. For example, if we set the housing density threshold too low (e.g., 1 house per 150 ac), the resulting map would no longer match what most land managers envision as "WUI" because vast areas would have no structures. The same logic guided all our test parameter choices; the alternative parameters varied from starting values as far as was plausible, without losing sight of the WUI concept and the map's policy purpose.

Two test values were chosen for each parameter, typically a maximum and minimum. The housing density threshold and interface buffer distance were both doubled and halved; intermix vegetation density was increased and decreased by 50%. Vegetative cover types were eliminated to create two more limited conceptions of "wildland," one with only *uplands* (eliminating all wetland vegetation classes) and the other, just *forests*, excluding wetlands, grasslands, and shrublands. Responses were expressed as percent change in WUI homes and area.

The WUI and Recent Western Fires. Fire perimeters for 2006 available in the GeoMac database (USDI and USDA 2007) representing 169 fires that covered 1.27 million ac were used to assess the amount of WUI near recent western fires. The number and classification of housing units within 1-mi-wide buffers at distances of 1–10 mi from the fire perimeters were analyzed. Within 10 mi from the fire, potential effects will vary; closer homes would be more likely to experience evacuation orders, and homes that are more distant may be affected only by smoke; but homes within this distance seldom would be considered too distant for concern.

Results

WUI in the Lower 48 States. Using the initial values for housing density, vegetation type, vegetation density, and interface buffer size, the NLCD and Census housing data were processed in a GIS and maps were prepared (Figure 2). WUI occurred in all the lower 48 states, with concentrations along the Eastern Seaboard, in amenity-rich regions of the northern Great Lakes and the Missouri Ozarks, and around the metropolitan areas of the Rocky Mountains and the Southwest. In western states, relatively small amounts of the land area, but a high percentage (well over 50% in many states) of the housing units fell into the WUI. Intermix WUI covered more land area (81% of all WUI area) than interface WUI; but because housing density is typically higher in interface areas, intermix WUI contained just over one-half (53%) of all WUI homes nationally.

Varying Individual Parameters. Housing density threshold changes (100% increase and 50% decrease) affected WUI area more than any other single parameter change across all test states (Table 1). In both California and Florida, lowering the housing density threshold increased the WUI extent by over 11 million ac, and raising it reduced the size of the WUI by 8.5 and 9.5 million ac, respectively. Effects on WUI houses are small, averaging a 3.2% increase with a lower threshold and a 5.2% decrease with a higher threshold.

Intermix vegetation density changes (50% increase and 50% decrease) had little impact in most states, averaging a 12.8% increase with a lower vegetation requirement and a 7.1% decrease in area when a higher density of vegetation is required. A lower vegetation density threshold does, however, increase the number of WUI homes on average by 20%, with a wide variation in settings evidenced in the range of responses, from a 57.1% increase in Michigan to a 2.6% increase in New Hampshire. Taken together, the two modifications in intermix vegetation density tested affected the classification of 750,000 Michigan homes.

Interface buffer distance changes (100% increase and 50% decrease) had small effects in terms of area and mixed effects on housing. The impact of using a larger buffer was particularly high in California (46.7%) and Florida (49%) because extensive areas of high density housing occurred within 3 mi of wildlands. However, in percentage terms across the test states, the changes in interface buffer distance generated only a 26% change in the number of WUI homes and an 8% change in WUI area.

Vegetation type definition changes yielded mixed results because the distribution of nonforest vegetation varies across states, and the changes to the vegetation type definition that we tested focused on nonforest vegetation. In areas where the wildland vegetation is mostly shrublands or grassland, such as California, the "forest only" definition eliminated large areas from the WUI. For those where wetlands are extensive such as Florida, the "uplands only" definition had similar effects. New Hampshire was least affected by the changes because its land cover is largely forest.

Overall Map Stability. When changes were made in individual parameters, the magnitude of responses to each change as measured by percent change in the number of homes or WUI area was less than the magnitude of the parameter change (Table 1), satisfying our criterion for stability. The highest average response was a 51% drop in WUI housing units associated with use of the "forest only" vegetation parameter (dropping wetlands, grasslands, and shrublands from the vegetative classes defined as wildlands) and a 46.5% increase in WUI area in response to a 100% increase in the housing density threshold. The states we sampled differed in their sensitivity to changes. Michigan, Florida, and Colorado were more sensitive to changes in the WUI definition. In these three states, there are many housing units, a diverse array of vegetative characteristics, and large land areas. Even with the greater sensitivity in these states to some individual changes, responses never exceeded the magnitude of the parameter change. The WUI scenarios with their suite of simultaneous changes confirm that many responses overlap, so that changing all the parameters simultaneously generates a smaller response than the sum of responses to individual parameter changes.

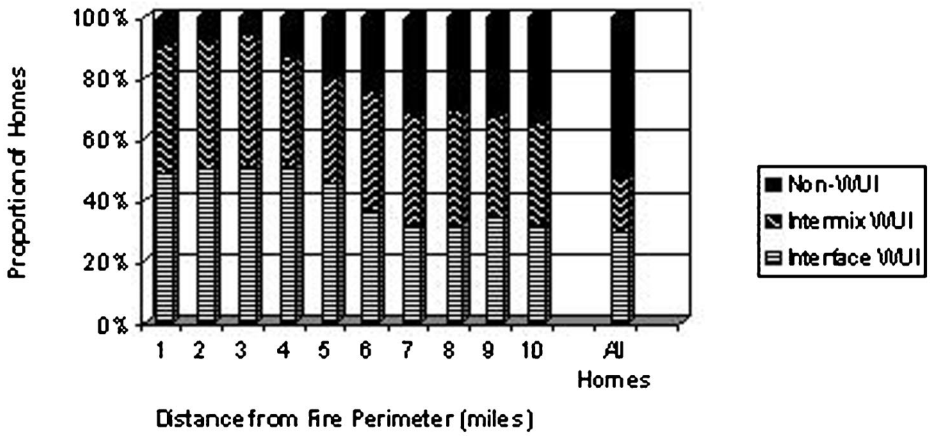

Figure 3. WUI classification of homes near 2006 western wildland fires.

The WUI and Recent Western Fires. GIS analysis of the WUI classification of homes with a 1- to 10-mi distance from 2006 western fires revealed that nearly all housing units within 10 mi of the fires were classified as WUI (73%), but the proportion declined with increasing distance from the fire (Figure 3). Within 1 mi of the fire perimeter, 92% of homes were classified as WUI. Homes 9–10 mi from the perimeter still include a majority of WUI homes (65%), which far exceeded the overall proportion of WUI homes in these western states. The limited number of fire perimeters available made this analysis less comprehensive than our wall-to-wall WUI map, but results suggested that the WUI definition mapped here tends to capture homes close to the areas where wildland fire occurs, supporting the validity of the national map.

Implications and Conclusions

Results of the sensitivity analysis suggested that the operational definition developed for this mapping effort is stable. Changes made across a plausible range of alternatives for the WUI definition's parameters showed that at the national scale for which the map was developed, modifying the settings to use other conceptually similar values did not change the overall pattern or prevalence of WUI areas.

The involvement of governments at local, state, and federal levels testifies to the significance of wildland fire in US society at the present time. Tensions over where best to concentrate decisionmaking authority and funding responsibility are natural outcomes of shared responsibility. In this context, defining and classifying the WUI takes on greater significance. Our purpose here was to provide those who use the WUI data with more information about how a different WUI definition would have affected the national WUI map and statistics.

Although a single national definition such as the one we mapped may be unworkable for day-to-day management of individual national forests in the United States, it serves a valuable purpose for strategic planning by providing consistency and credibility to estimates of the scope of the WUI nationwide. Trends suggest the WUI will continue to grow, which makes a national perspective on the scope of the WUI fire problems even more critical. Furthermore, the USDA's Office of the Inspector General issued a report in November of 2006 (USDA 2006) suggesting WUI growth is pushing firefighting costs higher, adding urgency to our need to understand the WUI.

Beyond its strategic purposes, the national WUI map also provides information for every state and community regardless of the other resources available to local planners. Certainly, communities can go beyond the WUI data in detail (e.g., locating individual structures) and specificity to wildland fire issues (e.g., distinguishing high- from low-hazard WUI areas based on locally available fuels data), but for communities without the resources and technical staff to create a customized local WUI map, this classification is a suitable guide to the location and extent of WUI.

Among the parameters we tested, the change that generated the largest response was housing density, and housing density was the only parameter defined directly in the *Federal Register*. The rest of the WUI definition was less specific. Testing these definition changes showed how the definition interacts with local conditions. We tested just those changes that seemed most plausible in light of the focus on forest policy and the availability of data, but even so, most changes we tested would make the WUI definition less representative of the underlying WUI concept.

The sensitivity of the WUI definition to housing density was reassuring because it indicated that as housing growth occurs, the WUI will grow accordingly. Analysis of change over time interests those concerned with resource impacts, particularly because there is reason to expect that the full effect of housing development on wildland resources will take time to become apparent. The ability of the WUI definition to represent effects of change over a long time period enhances its usefulness for resource management.

When the WUI data are combined with data regarding fire risk, the exclusion of low-risk WUI areas will alter the distribution of WUI across the country. But the temporal and spatial variability in fire hazard and the many diverse factors (e.g., weather, fuels, and topography) that determine it will always limit our ability to make fire risk predictions on the same scale and with the same confidence as we can map the WUI. Wildland vegetation and housing units change only slowly over time relative to the complex, dynamic factors determining fire risk.

Last but not least, although the current perception of the WUI centers on wildland fire, the concept is applicable much more broadly. The WUI is an area where the influence of human development is manifested in many different ways, among them, through impacts on birds, mammals, plants and other ecosystem structures, functions, and services. The WUI also is an area where people come into contact with wildland and its management, and the full range of public responses to management play out. Thus, tracking the growth and change of the WUI is essential to dealing with the consequences of housing growth and, ultimately, to sustaining the wildlands in the face of mounting development pressures.

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