INVITED PAPER

Threatened Wilderness Areas in the National Wilderness Preservation System

Allison Ginn Barnes, Gary T. Green, Nathan P. Nibbelink, and H. Ken Cordell[2]

Continued residential development in the United States threatens the boundaries of most of America's valuable public lands (Radeloff and others 2010, see sidebar). Many Americans are relocating to wilderness areas or retiring to areas high in natural or recreational amenities in a movement referred to as "amenity migration" (Cordell and others, 2012; Price and others 1997). The term "backcountry sprawl" describes housing development increases within and near national forests and parks. Population growth between 1970 and 1988 near Federal public land (23 percent) was more than double the average growth nationwide (11 percent). However, national parks and forests are not the only protected lands at risk from development along their borders. It is also highly likely that housing density will increase significantly in and around Federal Wilderness Areas (Cordell and Overdevest 2001).

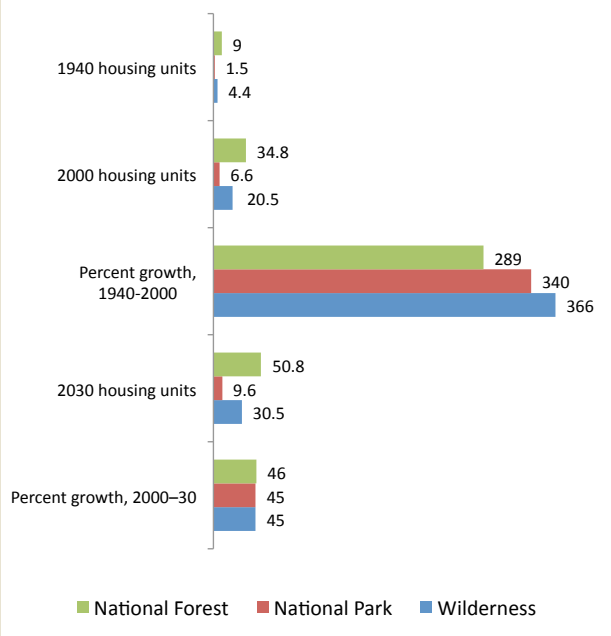
Federal Wilderness Areas are particularly vulnerable to exurban and rural sprawl. The land within areas designated as Wilderness is meant to be protected in its natural state, thus land development is highly inconsistent with this protection designation and with the associated values ascribed by the public (Cordell and others 2005). The pressures of human development and private land ownership around and within protected Wilderness landscapes create challenging issues for managers as they strive to protect natural and cultural assets and maintain access for recreation. Development within and around protected lands can significantly affect their ecological condition by increasing habitat fragmentation and reducing air and water quality. This development can also reduce recreational opportunities through denial of access. Even though most of it is low-density and residential, development nonetheless poses a threat to these sensitive and uniquely valuable wild lands which are defined by law as Wilderness Areas.

Problem statement—Being able to monitor and perhaps predict increases of housing density near Wilderness boundaries is essential if there is to be early detection of threats. Without this capability, land managers cannot effectively plan for and implement appropriate management

[2] Outdoor Recreation Specialist, Bureau of Land Management, U.S. Department of the Interior, Newcastle and Buffalo Field Offices, WY 82834; Associate Professor, University of Georgia, Warnell School of Forestry and Natural Resources, Athens, GA 30602; Associate Professor, University of Georgia, Warnell School of Forestry and Natural Resources, Athens, GA 30602; and Pioneering Scientist, Southern Research Station, U.S. Department of Agriculture, Forest Service, Athens, GA 30602.

In a study of protected Federal lands, Radeloff and others (2010) found that designated wilderness encountered greater growth (366 percent) between 1940 and 2000 in development of housing units in surrounding areas within 50 km of boundaries than either that of national parks or national forests. Growth of housing units was even greater within 1 kilometer of wilderness boundaries (474 percent between 1940 and 2000). As well, housing unit growth within 1 kilometer was projected to be faster near wilderness (64 percent) than near either national parks or forests from 2000 to 2030. This research pointed out that housing units within or near administrative boundaries can greatly influence the condition of protected areas (e.g., habitat disruption, noise and light pollution, and increased pressure on wildlife from pets). From as far away as 50 km, housing development can result in increased recreational pressures from residents, most of whom are within a 1-hour drive of the protected land.

Number and growth in housing units (in millions) within 50 kilometers of U.S. protected areas from 1940 to 2000, with projections to 2030, by type of protected area



Note: Numbers of housing units are not additive because many wilderness areas are embedded in a national forest or national park, and similarly, many national forests are adjacent to each other, which would result in double-counting. Percent growth is based on unrounded numbers of housing units. Source: Radeloff and others (2010).

options. Similarly, overall management of the National Wilderness Preservation System (NWPS) will not be as effective if a general assessment of development pressure is not provided. Though research regarding amenity migration, exurban sprawl, human use impact, and the wildland-urban interface is plentiful, research examining nearby rural and exurban land development is, for the most part, lacking.

Purpose statement—This research assumes a close correlation between the likelihood of nearby development, and the proximity of Wilderness to urban areas, areas of high road density, and private land. By employing this assumption of correlation, this study will attempt to identify how many and which NWPS Areas are most likely to face development pressures nearby and within their boundaries. This research was done to provide the Forest Service with a report on the development pressures facing the National Wilderness Preservation System for inclusion in the 2010 Renewable Resources Planning Act Assessment.

Selecting areas for the study—At the time of this study, the NWPS consisted of nearly 800 Federal designated areas. Of these, our study was limited to screening the 600 that had geographic data (boundary files) in order to identify those meeting development potential criteria (described below). At the time of this study, the only areas that had the necessary boundary data were those that were more than 640 acres in size and were designated prior to 2004. From this pool of 600 designated areas, 71 met the selection criteria of proximity to urban areas, road systems, and private land.

Methodology—In examining the 71 selected areas, several buffer distances were chosen to mimic the approach used in a similar study quantifying development risks surrounding national forests (Stein and others 2005). These buffers were based on the fundamental assumption that impacts to public lands and their natural characteristics vary depending on the distance of existing development and human settlement from those lands. The analysis was focused on the land within individual Wilderness Areas and the development potential within three buffers ranging from zero to one-half, one-half to three, and three to ten miles from the borders of each selected Wilderness Area. These buffers represent straight-line distances perpendicular to the NWPS borders and are analogous to a circular radius if Areas were a perfect circle. NWPS Areas are not circular but irregularly shaped. Thus, the buffers represent an outward expansion of this irregular shape. An additional buffer zone was analyzed consisting of all land within 10 miles of NWPS Area boundaries. As earlier described, Wilderness Areas with the greatest likelihood of development pressures are predicted to be positively related to existing exurban housing densities, the presence of nearby private land, and proximity to roads and metropolitan areas.

Table 3.1 specifies the calculation method for each of six metrics used to compare and rank the selected 71 Wilderness Areas by likelihood or potential for development. This comparison identified which Wilderness Areas were most likely to experience housing density increases along or near their borders. Metrics used included the following:

- Percent of nearby land protected by Wilderness managing agencies
- Percent of land protected by other Federal, tribal, State or local entities
- Housing density
- Distance to the nearest road
- The transformed value of the sum of passengers boarding at airports within 50 miles of the NWPS unit
- Area of water features within each buffer distance.

Each metric in table 3.1 was normalized to a zero-to-one scale, assigning a zero to the minimum value in the range and a one to the maximum value for each metric in each buffer distance zone. Thus, for each metric, a zero indicates the least likelihood of contributing to development, whereas a value of one indicates the highest likelihood of contributing to a housing density increase.

Current literature does not quantify the relative degree to which each of the above comparison metrics contributes to likelihood of development. Thus, an index was created that

Table 3.1—Calculation method for six metrics used to assess likelihood of nearby development

Metric	Unit	Calculation method
Non-Protected Land Tier 1	Percent	((Area of Buffer—Area of Land Protected by BLM, FS, FWS, or NPS)/Area of Buffer)*100
Non-Protected Land Tier 2	Percent	((Area of Buffer—Area of Land Protected by any entity)/Area of Buffer)*100
Housing density	Units/square mile	Housing Units/Total Land Area for Buffer
Mean distance to roads	Mile	Distance to Nearest Road for 30-meter Cell
Enplanements for airports within 50 miles	Persons	Sum of Number of Boarded Passengers for All Airports Intersecting a 50-Mile Buffer of NWPS
Presence of water features	Square mile	Area of all Lakes, Reservoirs, or Oceans Within Each Buffer Zone

assumes that the six metrics affect development equally. The values across metrics were averaged for each Wilderness Area, resulting in a comprehensive index score for comparison across the selected 71 NWPS units for each of the buffer zones. For each Wilderness Area, this comprehensive index score for each of three buffer zones (zero to half, half to three, and three to ten miles) was used to rank order Areas. Rank was then multiplied by the total distance to the outer perimeter of each particular buffer zone, then divided by that result by the number of zones included in the analysis. A lower score indicated a higher propensity for development.

By use of a comprehensive index score (i.e., Composite Potential Development Index = PDIc), Wilderness Areas were rank ordered to show relative risk of development for each buffer zone. This method assigns each Wilderness Area a rank that denotes its risk of exurban development relative to the other 70 units at the same buffer distance. In addition, to test the relative sensitivity of the PDIc to each metric, scores for each metric were doubled, then the composite score was re-calculated and Wilderness Areas were re-ranked.

Results—The weighted mean rank indicated which Wilderness Areas face the highest risk of borderland development (see table 3.2). The sensitivity analysis indicated that at least 8 of the 10 Wilderness Areas remained in the top 10 for risk of borderland development, despite a doubling of each metric (table 3.2). These results indicate that the PDIc is relatively robust, and assuming that the metrics chosen are in fact predicting risk of development, as the literature suggested, the Wilderness Areas remaining at the top of the list are priorities for further investigation into potential development risks.

Discussion and conclusions—This research represents a national analysis of development risk to designated Federal Wilderness. Based on available geographic data, this study identified that 71 of 600 Wilderness Areas are likely to face significant development threats near their borders. Wilderness has usually been thought of as remote lands located within a landscape of other natural lands. This increasingly is not the case. In selecting and ranking Wilderness Areas for this national study, metrics more sensitive at the local or regional levels may have been overlooked. Ultimately, it may be desirable to expand use of the PDIc approach to enable comparison of NWPS units across multiple spatial and temporal scales.

Spatial or temporal patterns may exist for Wilderness Areas experiencing a relatively high risk of development. More than one-third of the top 25 most threatened Wilderness Areas are located in the Pacific Coast region (table 3.2), a region often characterized as the interface of wild lands and urban areas. Future research may shed further light on these patterns and quantify threshold values for each metric that prove useful in refining projections of the risk of future housing density increases. Future research may also lead to differential weighting of metrics for computing the development potential index.

The methods used in this research have provided a solid advancement of methods for identifying areas with relatively high or low risk at various local scales. However, more translation of the data, methodology, and results is needed before using index scores for establishing conservation goals. Inclusion of other disciplines, such as landscape ecology, is encouraged. The ability to link or connect Wilderness Areas with critical fish or wildlife habitat is also needed. Identification of stakeholders in land preservation, such as nongovernment organizations, and State and local governments, as well as programs such as the Conservation Reserve Program will increase the ability to plan for and execute landscape level protection of the NWPS. Nonprofit organizations such as The Nature Conservancy, Sierra Club, and the Campaign for America's Wilderness may find this study of use in prioritizing lands for conservation, or acquisition of buffer lands adjoining Wilderness.

End Invited Paper

Private Land Conservation

Land trusts—Increasingly important to private land conservation throughout the United States are conservation easements. Conservation easements keep land in private ownership, but with development restrictions. The incentive is lower taxes to landowners. Conservation easements are most often administered through a land trust, which is a special type of private, nonprofit organization with a mission to preserve undeveloped land. Land trusts may be national or regional organizations, but they are noted for being active at the local or community level. Land trusts have emerged as one of the more popular and successful of conservation movements in the country.

The Land Trust Census—The Land Trust Alliance conducts a census of land trust organizations at 5-year intervals. As estimated in its 2005 Land Trust Census, the United States loses about 2 million acres of farm, forest, and open space land each year (Land Trust Alliance 2006). Thus, conservation of private land through trusts or other mechanisms is of growing importance.

As noted in the executive summary of the 2005 Land Trust Census, rural landscapes are increasingly being converted to developed uses including shopping malls, subdivisions, and highways. These conversions impact more than 100,000 acres of wetlands each year. Such conversion of wetlands leads to degradation of water quality and unnatural flooding.

Table 3.2—National Wilderness Preservation System units as ranked by the Composite Potential Development Index (PDIc), followed by the ranking of each unit using the PDI for each buffer alone and then the ranking of the PDIc for a doubling of each contributing variable

Name	Agency	State	PDIc Rank	0–0.5 Rank	0.5–3 Rank	3–10 Rank	LO1x2	LO2x2	H2Ox2	MRDx2	ENPx2
Juniper Dunes	BLM	WA	1	9	4	1	1	1	2	1	1
Mingo	FWS	MO	2	15	3	2	4	4	4	3	6
Ishi	BLM/FS	CA	3	6	5	3	2	2	3	2	3
Soldier Creek	FS	NE	4	2	1	6	3	3	5	4	8
Kisatchie Hills	FS	LA	5	5	9	4	5	5	6	5	5
Hells Canyon	BLM	AZ	6	1	8	5	6	6	7	7	2
Table Rock	BLM	OR	7	4	2	7	7	7	9	6	4
Blackbeard Island	FWS	GA	8	3	6	9	24	22	8	40	14
Greenhorn Mountain	FS	CO	9	34	14	8	8	8	10	8	15
Glacier View	FS	WA	10	18	10	12	15	12	17	17	7
Wambaw Creek	FS	SC	11	30	16	11	14	17	13	12	9
Mount Sneffels	FS	CO	12	27	12	13	10	10	12	10	11
Devils Backbone	FS	MO	13	14	17	15	9	9	16	9	43
Swanquarter	FWS	NC	14	10	11	18	19	16	1	26	10
Mountain Lakes	BLM/FS	NV	15	22	18	17	28	25	11	13	17
Sylvania	FS	MI	16	8	7	22	20	14	14	11	18
Badlands	NPS	SD	17	24	23	16	11	15	15	14	12
Menagerie	FS	OR	18	11	21	19	23	20	18	15	16
Jacumba	BLM	CA	19	17	19	21	18	23	25	25	28
Chanchelulla	FS	CA	20	12	15	23	21	18	21	16	20
Mill Creek	FS	OR	21	45	53	10	26	26	23	18	19
Juniper Mesa	FS	AZ	22	13	22	25	17	13	20	20	27
Capitan Mountains	FS	NM	23	55	45	14	12	19	19	19	26
Black Mountain	BLM	CA	24	7	13	31	22	24	24	21	22
Tamarac	FWS	MN	25	16	24	28	13	41	22	23	24
Hell Hole Bay	FS	SC	26	39	34	24	31	29	31	22	21
North Maricopa Mountains	BLM	AZ	27	31	20	30	34	30	29	29	13
Caribou-Speckled Mountain	FS	ME	28	62	42	20	25	21	26	28	38
Yolla Bolly-Middle Eel	BLM/FS	CA	29	58	28	26	29	27	27	24	23
Welcome Creek	FS	MT	30	49	36	29	32	28	32	36	25
Seney	FWS	MI	31	21	35	33	16	11	30	27	54
Sky Lakes	FS	OR	32	54	47	27	39	37	28	30	29
Upper Kiamichi River	FS	OK	33	29	38	32	35	32	34	31	30
Cache La Poudre	FS	CO	34	33	30	37	36	35	39	37	35
East Fork	FS	AR	35	37	39	34	33	31	36	33	41
Trinity Alps	BLM/FS	CA	36	44	32	36	40	40	33	32	31
Rodman Mountains	BLM	CA	37	26	25	40	30	33	35	34	33
Strawberry Crater	FS	AZ	38	32	31	41	37	34	38	35	36
Lizard Head	FS	CO	39	46	26	43	44	39	40	42	34

continued

Table 3.2—(*continued*) National Wilderness Preservation System units as ranked by the Composite Potential Development Index (PDIc), followed by the ranking of each unit using the PDI for each buffer alone and then the ranking of the PDIc for a doubling of each contributing variable

Name	Agency	State	PDIc Rank	0–0.5 Rank	0.5–3 Rank	3–10 Rank	LO1x2	LO2x2	H2Ox2	MRDx2	ENPx2
Laurel Fork South	FS	WV	40	23	27	45	47	42	41	38	42
Uncompahgre	BLM/FS	CO	41	41	33	42	42	36	42	41	32
Big Island Lake	FS	MI	42	38	56	35	48	44	44	39	45
Fish Creek Mountains	BLM	CA	43	20	29	46	27	46	37	45	39
Apache Creek	FS	AZ	44	47	50	38	41	38	43	44	48
San Pedro Parks	FS	NM	45	48	48	44	51	49	46	43	47
Trigo Mountain	BLM	AZ	46	42	37	51	46	50	47	53	44
Coyote Mountains	BLM	CA	47	40	41	50	45	57	54	54	51
Anaconda Pintler	FS	MT	48	68	67	39	43	45	45	48	40
Strawberry Mountain	FS	OR	49	50	46	49	49	43	51	47	67
Cebolla	BLM	NM	50	28	57	48	38	48	50	49	65
Mount Jefferson	FS	OR	51	53	44	52	52	51	48	46	46
Mount Skokomish	FS	WA	52	25	40	56	58	55	56	65	37
Cloud Peak	FS	WY	53	64	62	47	56	54	52	50	52
Goat Rocks	FS	WA	54	51	49	55	54	53	53	52	50
Bosque del Apache	FWS	NM	55	56	55	53	50	47	55	51	66
Imperial Refuge	FWS	AZ/CA	56	35	43	59	53	52	49	56	49
Riverside Mountains	BLM	CA	57	43	51	58	55	59	57	55	58
Picacho Peak	BLM	CA	58	36	54	60	60	60	60	58	53
William O. Douglas	FS	WA	59	59	59	57	59	58	61	59	55
Salmo-Priest	FS	WA	60	66	68	54	57	56	62	57	69
Glacier Peak	FS	WA	61	70	58	61	63	63	59	67	57
Swansea	BLM	AZ	62	19	52	67	61	62	63	61	60
Lake Chelan-Sawtooth	FS	WA	63	52	65	63	62	61	58	62	56
Rice Valley	BLM	CA	64	60	61	64	66	65	66	60	64
Death Valley	NPS	CA/NV	65	65	60	65	65	67	67	66	62
Bob Marshall	FS	MT	66	69	70	62	64	64	68	71	61
Salome	FS	AZ	67	63	66	66	69	69	65	64	68
East Cactus Plain	BLM	AZ	68	61	64	68	67	66	64	63	63
Jennie Lakes	FS	CA	69	57	63	69	68	68	69	69	59
Sierra Ancha	FS	AZ	70	67	71	70	70	70	70	68	70
Tatoosh	FS	WA	71	71	69	71	71	71	71	70	71

LO1 and LO2 = Land Ownership Tiers; H2O = Area of Water Features; MRD = Mean Road Distance; ENP = Enplanements; BLM = Bureau of Land Management; FWS = U.S. Fish and Wildlife Service; FS = U.S. Forest Service; NPS = National Park Service.

As of the 2005 Land Trust Census, there had been a promising wave of growth in land conservation through land trusts. At the time of that Census, there were 1,667 private land conservation trusts across the country. Lands being protected through trusts included, for example, ranches, urban undeveloped lands, wetlands, forests, riparian areas, and mountainous sites. Land trusts rely heavily on volunteer labor and on land owners' participation with their organization. Trusts work with land owners to conserve land through acquisition of conservation easements, and will sometimes manage the conserved land and/or the associated easement.

Results from the 2005 National Land Trust Census report—The 2005 Census (released November 30, 2006) described national trends in private land conservation over the last several decades. Each 5-year interval showed dramatically more land protected than during the preceding interval. The following key findings were highlighted in the report (Land Trust Alliance 2006):

- Total acreage conserved through private means in 2005 was 37 million acres, a 54 percent increase from the previous 24-million-acre level in 2000. This included local, State, and large national land conservation groups such as The Nature Conservancy, Ducks Unlimited, The Conservation Fund, and The Trust for Public Land.
- The pace of private land conservation by local and State land trusts had tripled. From 1995 to 2000, land trusts conserved an average of 337,937 acres per year. That pace rose to 1,166,697 acres on average per year from 2000 to 2005.
- Land trusts moved to enhance their professionalism and their numbers grew from 1,263 in 2000 to 1,667 in 2005.
- Acres conserved by local and State land trusts doubled to 11.9 million acres in 2005—an area twice the size of the State of New Hampshire. This was an increase of 5.8 million acres since 2000.
- The States with the highest total acres conserved through land trusts were California, Maine, Colorado, Montana, Virginia, New York, Vermont, New Mexico, Pennsylvania, and Massachusetts. At that time, only Colorado and Virginia were offering State tax incentives for conservation.
- Local and State land trusts increased the acres under conservation easements by 148 percent. These private, voluntary agreements saved 6,245,969 acres as of 2005, versus 2,514,566 in 2000.
- Easements, on the rise for more than a decade, allow landowners to take advantage of Internal Revenue Service-approved tax incentives. Easements are sometimes the only way family farmers can afford to conserve their working farm, ranch, or timber lands.
- The land type reported as being the primary focus of land trust efforts was protecting natural areas and wildlife habitat (39 percent), followed by open space (38 percent), and water resources (26 percent), especially wetlands. Other protected areas include farms, coastal shores, prairies, deserts, urban gardens, and local parks.
- The West was the fastest growing region in both the number of acres conserved and in the number of land trusts, especially for protection of rangeland in many Western States. The second fastest growing region, by percentage of acres conserved, is the Southeast, an area that historically has had fewer land trusts.
- The highest number of land trusts is found in California (198), followed by Massachusetts, Connecticut, Pennsylvania, New York, and Maine. The large number of land trusts in the Northeast reflects the birth of land trusts there over 100 years ago.
- Land trusts numbers and financial status have grown strongly over the last 5 years. Land trusts grew 32 percent in number and by over $1 billion in endowments for long-term stewardship of protected land.
- Rangeland protection is rising. As of December 31, 2005, the Partnership of Rangeland Trusts held 786 conservation easements on 1,061,969 acres in the States of California, Colorado, Nevada, Oregon, Montana, Kansas, and Wyoming.

In addition to land trusts, which are nonprofit, nongovernmental organizations, another strategy to achieve private land conservation is to pursue ballot measures. Local and State governments may bring conservation issues to their citizens via referendum votes, typically to fund land and water conservation programs or grants to be administered by those governing bodies. The use of this democracy-in-action tactic for conservation purposes is promoted and monitored closely by The Trust for Public Land.

INVITED PAPER

State and Local Government Financing for Land Conservation

Andrew du Moulin and Mary Bruce Alford[3]

Between 1998 and 2005 State governments demonstrated significant commitments to support land conservation. During this period, State governments conserved 8.6 million acres and spent $13 billion to protect land from development. The East outspent other regions of the country.

Over the past two decades voters approved more than 75 percent of conservation ballot measures put before them, with approval rates in some States topping the 80–90 percent

[3] Director, Center for Conservation Finance Research, The Trust for Public Land, Boston, MA 02108; and Senior Research Associate, Conservation Finance Program, The Trust for Public Land, Jackson, MS 39201.