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Threats to At-Risk Species in America's Private Forests

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A Forests on the Edge Report

ABSTRACT

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More than 4,600 native animal and plant species associated with private forests in the United States are at risk of decline or extinction. This report identifies areas across the conterminous United States where at-risk species habitats in rural private forests are most likely to decrease because of increases in housing density from 2000 to 2030. We also identify areas where the future of forested habitats for at-risk species could be compromised by additional pressures from wildfire, insects, and disease. More than 90 percent of the 1,370 watersheds that met our screening criteria support at least one at-risk species. Watersheds where increased housing density in rural private forests is likely to contribute to the decline of the largest numbers of forest-associated at-risk species are located primarily in the East but also in parts of the West and Southwest. Watersheds in which habitats for the greatest variety of at-risk species are likely to be affected by wildfire are found in the Southeast, much of the Southwest, and along California's Sierra Nevada range. Watersheds where private forests providing habitat for the greatest variety of at-risk species are most threatened by insects and disease are located throughout the East and also in the Southwest and in northern California. Conservation actions can reduce impacts on wildlife and plant species already at risk, while supporting compatible development of housing. This report updates methodology and findings of a previous Forests on the Edge study of development impacts on at-risk species habitats.

Key Words: private forests, development, wildfire, insects and diseases, wildlife, threatened, endangered, imperiled

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Gray wolf (*Canis lupus*)

About the Forests on the Edge Project

Sponsored by the Forest Service's State and Private Forestry/Cooperative Forestry staff, in collaboration with Forest Service Research and Development and other partners, the Forests on the Edge project uses data prepared and analyzed by scientists across the country to increase understanding of the many public benefits derived from private forests and the pressures that might affect these benefits. Forests on the Edge researchers have presented findings related to at-risk species in *Frontiers in Ecology and the Environment*, a publication of the Ecological Society of America (Robles et al. 2008); and the *Journal of Forestry*, a publication of the Society for American Foresters (Stein et al. 2010). Key points also were summarized in the Forests on the Edge publication, *Private Forests, Public Benefits: Increased Housing Density and Other Pressures on Private Forest Contributions* (Stein et al. 2009).

INTRODUCTION

America's private forests harbor thousands of species—from butterflies, bears, birds, and bats; to salmon, snails, and salamanders that inhabit streams and wetlands; to flowers, trees, and shrubs that feed and protect wildlife and enrich human lives. Many native animals and plants found in private forests nationwide are at risk of decline or extinction, in part because of impacts from increasing housing development. Plants and animals specifically identified under the Endangered Species Act or by NatureServe[1] as being in jeopardy of extinction are characterized as at-risk species for this study. The effects of development on at-risk species in private forests are intensified by additional impacts from fire, insects, and disease.

Sixty percent of the at-risk species of plants and animals in the conterminous, or "lower 48," United States are associated with private forests (Robles et al. 2008). More than 57 million acres of private forests across rural America are projected to experience substantial increases in housing density in coming decades (Stein et al. 2009). Most of the 100 watersheds predicted to experience the greatest increases in housing density on private forest land between 2000 and 2030 are in southeastern states and contain private forests with high densities of at-risk species (Robles et al. 2008).

This report updates the findings of a previous analysis (Robles et al. 2008) sponsored by the U.S. Department of Agriculture, Forest Service, Forests on the Edge project. That analysis identified areas across the conterminous United States where at-risk species habitats in rural private forests are most likely to decrease because of increases in housing density from 2000 to 2030. This report uses updated data on at-risk species from NatureServe's central databases (NatureServe 2008) and further identifies areas where the future of forested habitats for at-risk species could be compromised by additional pressures from wildfire and insects and diseases. We describe a range of implications, along with conservation actions that could help address the impacts on at-risk plant and animal species.

[1] NatureServe, a nonprofit conservation organization, provides data on at-risk species in the United States through a network of natural heritage conservation programs and data centers.

USFWS

Green pitcherplant (*Sarracenia oreophila*)

Defining "At-Risk"

At-risk species, for purposes of this publication, are those classified under the U.S. Endangered Species Act (ESA) as threatened or endangered, or those with a global status of critically imperiled, imperiled, or vulnerable according to the NatureServe conservation status ranking system (Faber-Langendoen et al. 2009).

The ESA defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range; a threatened species is one that is likely to become endangered in the foreseeable future. Species that are designated as candidates or proposed for listing under the ESA are, for purposes of this study, also considered at-risk. NatureServe coordinates a nationwide network of Natural Heritage programs that maintain databases recording the status and locations of rare and endangered plants and animals in each state. Precise locational records are aggregated to provide integrated national and regional datasets.

Who and Where Are Private Forests Owners?

Seventy-five percent of all forest lands in the East are privately owned, while lower percentages of forests in the West fall under this category: 25 percent in the Rocky Mountain region and 33 percent in the Pacific Coast region. America's private forests are owned by about 11 million land owners, 92 percent of whom are "family forest" owners—families, individuals, trusts, estates, family partnerships, and other unincorporated groups of individuals (Butler 2008). Most of the remaining private forest lands are owned by corporations (Smith et al. 2009). Family forest owners—who hold 62 percent of all private forests (35 percent of all forest land)—value their forests for aesthetic values, family legacy, privacy, and nature protection among other reasons; they use their land for a variety of activities including recreation and wildlife habitat conservation (Butler 2008).

Private Forests Are Key

More than half (423 million acres) of all U.S. forest land is privately owned (Smith et al. 2009) (Fig. 1). Privately owned lands support a disproportionate number of habitats that are critically important to numerous species of wildlife at some point in their life cycles; many rare or declining species require private lands for survival (Maestas 2007, Robles et al. 2008). Private lands are particularly important to wide-ranging animals, whose home ranges can encompass a network of public *and* private lands.

As reported in Robles et al. (2008), private forests support 60 percent of at-risk species found in the conterminous United States. In some watersheds, up to 95 percent of forest-associated at-risk species occur **only** in private forests. These forests are located across the country but particularly in the private forest matrix of the East, as well as along the prairie-forest border in Texas and Oklahoma and within riparian areas or isolated forests in the Midwest, Northeast, and western interior basins.

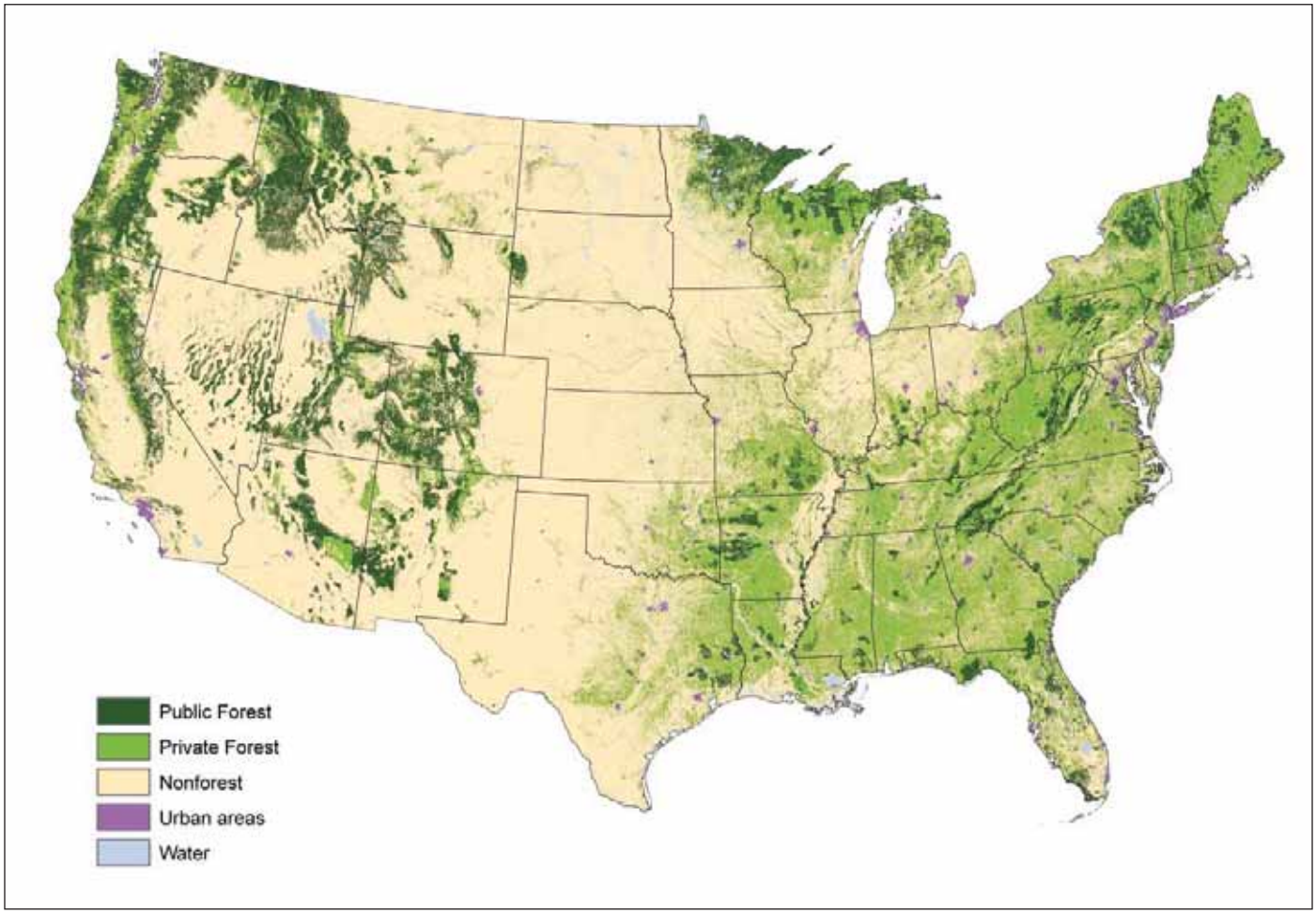

Figure 1—Location of private and public forest, nonforest, and urban areas. About three-quarters of America's private forests are in the East.

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Private lands in Florida account for half the habitat occupied by the endangered Florida panther (*Felis concolor*) (Robles et al. 2008).

ASSESSING THREATS TO PRIVATE FOREST HABITATS FOR AT-RISK SPECIES

Analyses were conducted to answer the following questions concerning private forest habitats for at-risk wildlife species across the conterminous United States:[2]

- In which watersheds do privately owned forests support the greatest number of at-risk species?
- In which watersheds is increased housing density in rural private forests most likely to further jeopardize at-risk species?
- In which watersheds are wildfire and insects and disease most likely to affect at-risk species on private forest lands?

Although the methodology used is the same as that described in an earlier Forests on the Edge study (Robles et al. 2008), updated data on at-risk species, housing density projections, land ownership, and land cover have been used here; therefore, the results may differ somewhat.

We first estimated the number of at-risk species associated with private forests in each watershed. Data came from several sources:

- Fourth-level watershed boundaries as defined by Steeves and Nebert (1994)
- Location of at-risk species recorded since 1970 (NatureServe 2008)
- Land classification obtained from the National Land Cover Dataset (NLCD) of 2001 (Homer et al. 2004, 2007) and the Protected Areas Database (PAD 4.6) (CBI 2007, DellaSala et al. 2001, Theobald 2007).

To understand where, across the conterminous United States, at-risk species are most likely to be affected by future housing density increases in rural forests, we used geographic information system (GIS) techniques to combine (a) data on the number of at-risk species associated with private forests in each watershed with (b) estimates of the percentage of private forests in each watershed expected to experience increased housing density. These methods are reported in more detail in Stein et al. (2010). To be included in this analysis, watersheds had to be at least 10 percent forested and contain at least 10,000 acres of private forest. The size of the watersheds analyzed varied widely (coefficient of variation 0.76), from 53,000 acres to slightly more than 14 million acres.

We also conducted two additional analyses that combined the data on the number of at-risk species on private forestland in each watershed with data on the level of wildland fire potential for private forests in each watershed and with data on the threat (basal area[3] loss) from insects and diseases. Data on fire were obtained from the Wildland Fire Potential Model produced by the Forest Service's Fire Modeling Institute (http://www.fs.fed.us/fmi/). Data on insect and disease threat were obtained from the Forest Service's Forest Health Monitoring Program (Krist et al. 2007) and provide an estimate of the average loss of basal area due to insect pests and disease. Detailed descriptions of these data layers are provided in Stein et al. 2009.

[2] Because of insufficient data, we were not able to undertake a similar analysis for Alaska, Hawaii, or other areas affiliated with the United States, although private forests in these areas also provide important wildlife habitat.

[3] Basal area is the cross-sectional area of a tree in square feet, commonly measured at breast height (4.5 feet in the United States). Stand- or plot-level basal area is the sum of basal areas for all trees growing in a stand or on a plot and is often used as an indicator of stand or plot attributes because it combines the number of trees and their sizes.

Defining Increased Housing Density

As in previous Forests on the Edge studies, the terms *housing development* and *increased housing density* refer to an increase in the number of housing units per unit area on rural lands such that the housing density shifts from either the rural I or rural II categories to a higher density category (Stein et al. 2007, 2009; Theobald 2005), where:

Rural I is 16 or fewer housing units per square mile;

Rural II is 17 to 64 housing units per square mile; and

Exurban-urban is 65 or more housing units per square mile.

Sixteen housing units per square mile is equivalent to 1 unit per 40 acres, while 64 units per square mile is equivalent to 1 unit per 10 acres. A single family household is considered to be a unit, as is a single building with multiple households. Seasonal homes not occupied as primary residences are included in this analysis.

KEY FINDINGS

At-Risk Species Associated With Private Forests

Most private forest land in the conterminous United States provides habitat for at least one of the 4,613 at-risk plants and animals that use these forests for at least part of their life cycle. More than 90 percent of the 1,370 watersheds that met our screening criteria support at least one at-risk species.

Most watersheds with the greatest total number of at-risk species associated with private forests are found in the East (Fig. 2). The highest percentile rankings in the East include a chain of watersheds extending along the Appalachian Mountains, from southern Pennsylvania into northern Georgia, and continuing through much of Mississippi and western Georgia. High-ranking watersheds also are found in Texas, Arkansas, Louisiana, most of Florida, at the southern tip of Lake Michigan, and in parts of New England. Further, high numbers of at-risk species are found in the West, especially in California, eastern Oregon, and parts of the Southwest.

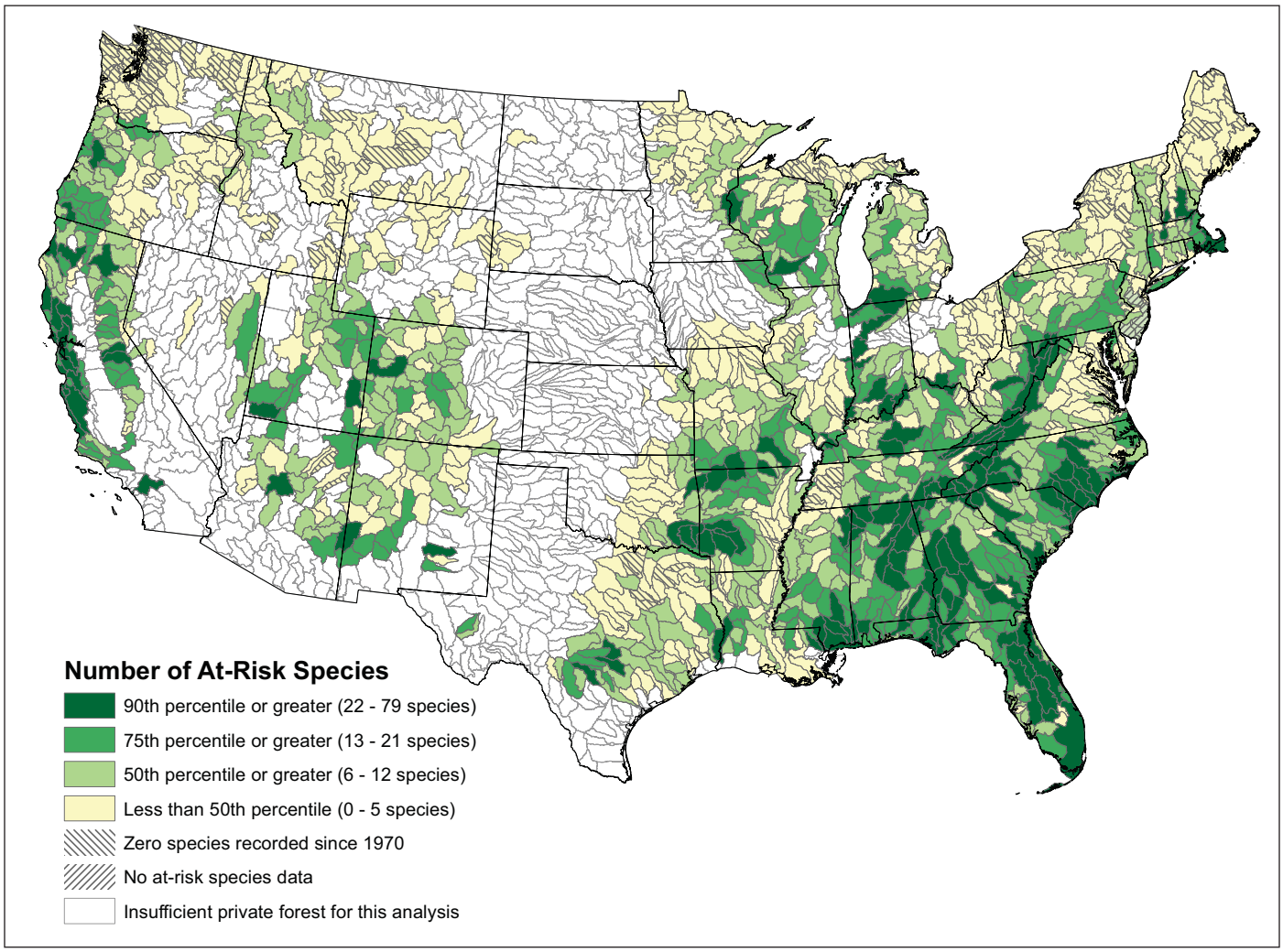


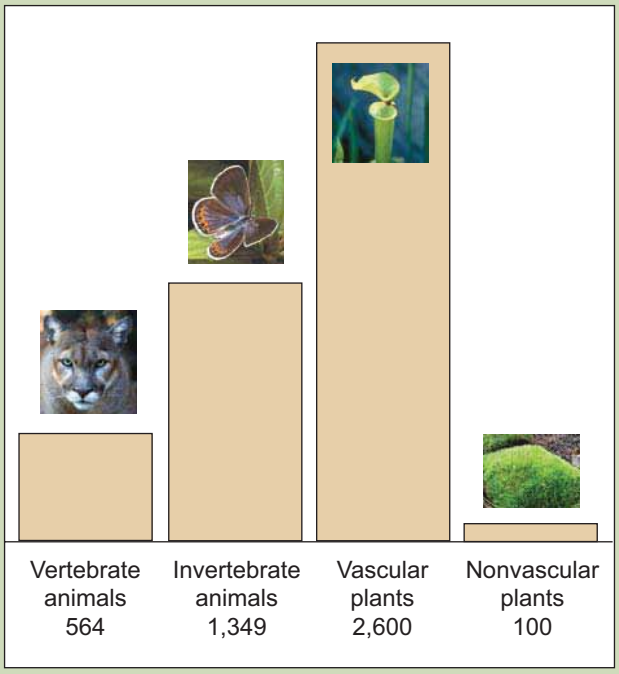
Figure 2—Number of at-risk species associated with private forest, by watershed. Most watersheds with the greatest total number of forest-associated at-risk species are found in the East and in coastal California, but some also are located in the South and West.

Watersheds with a high number of at-risk species in private forests are found in the East and in coastal California.

At-Risk Species and Increased Housing Density in Private Forests

Watersheds in which increased housing density in rural private forests is likely to contribute to the decline of the largest numbers of forest-associated at-risk species are located primarily in the eastern United States—along coastal areas, in and around the southern Appalachians, along the shores of Lake Michigan, and throughout Florida (Fig. 3). Additional watersheds of concern are located in central California, Oregon, and parts of the Southwest.

Numbers of At-risk Species Occurring in or Associated with Private Forests



Additional Pressures from Wildfire and Insect Pests and Diseases

Wildfires, native insects, extreme weather events, and timber harvest are among the ecological and socio-economic forces that keep forests dynamic and constantly changing (Stein et al. 2009). However, the extent and impacts of wildfire and insect pests and disease can be exacerbated by the addition of houses to the landscape (Syphard et al. 2007, Meekins and McCarthy 2001).

As indicated in Figure 4, watersheds in which wildfires on private forests are most likely to affect at-risk species habitats are found in the southeastern United States, the Southwest, and along California's Sierra Nevada range.

In contrast, watersheds in which insects and diseases are most likely to affect at-risk species habitats provided by private forests are found in much of the eastern United States, especially along the Appalachian range, areas just inside the coastal Southeast, and the Great Lakes states (Fig. 5). Western areas of high overlap between private forest at-risk species habitat and insect and disease threats are found in the Southwest and in northern California.

IMPLICATIONS

Impacts from Housing Development

Specific impacts of increased housing density on forest-associated at-risk species are likely to vary depending on the location, species, and level of development. The chief effects of housing development on native plant and animal populations—not only in the immediate vicinity of homes but also on nearby public and private

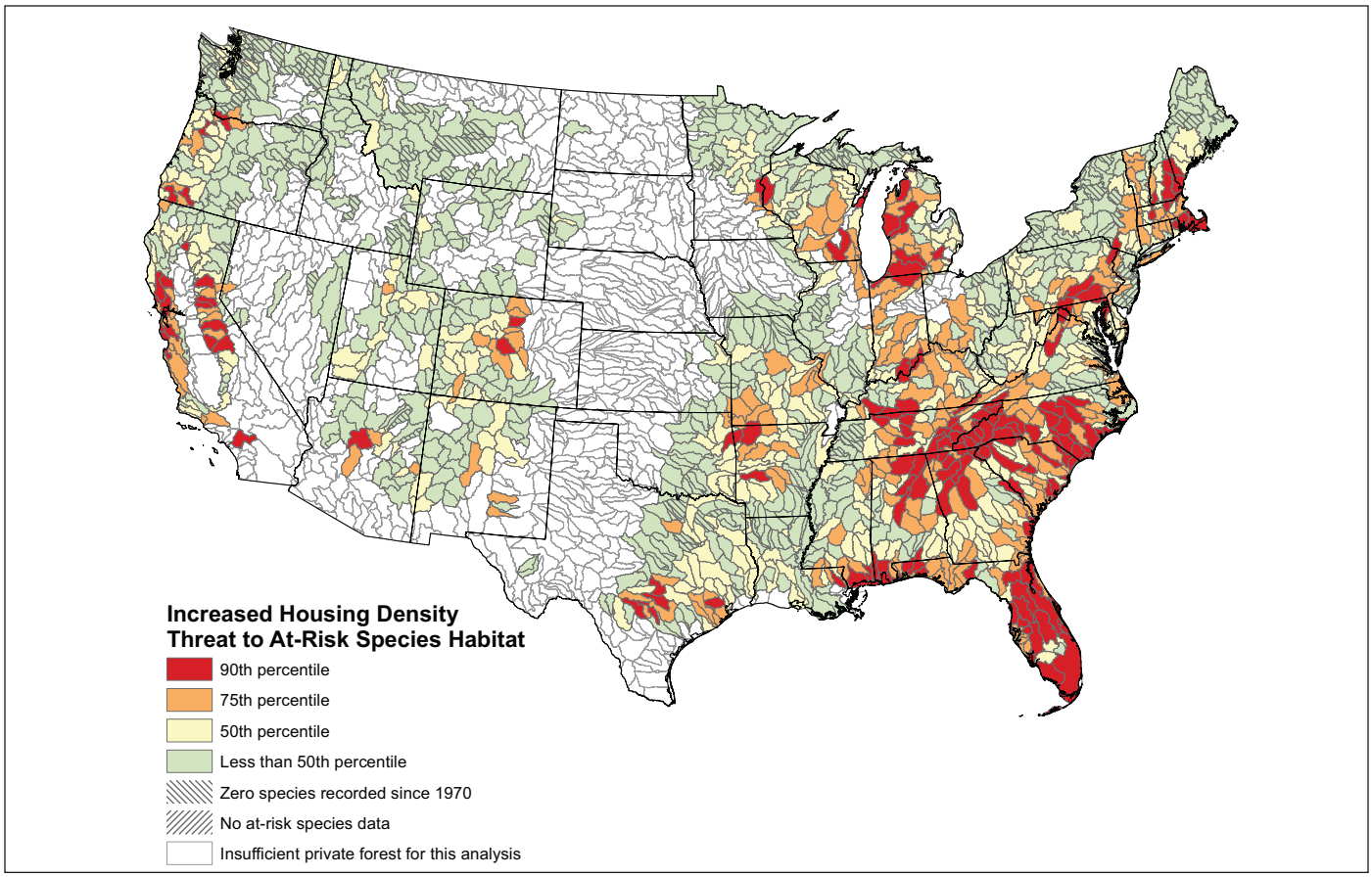


Figure 3—Threat to habitat for at-risk species associated with private forests as a result of increased housing density. Watersheds in the East are particularly at risk of decline in forest-associated at-risk species due to increased housing density.

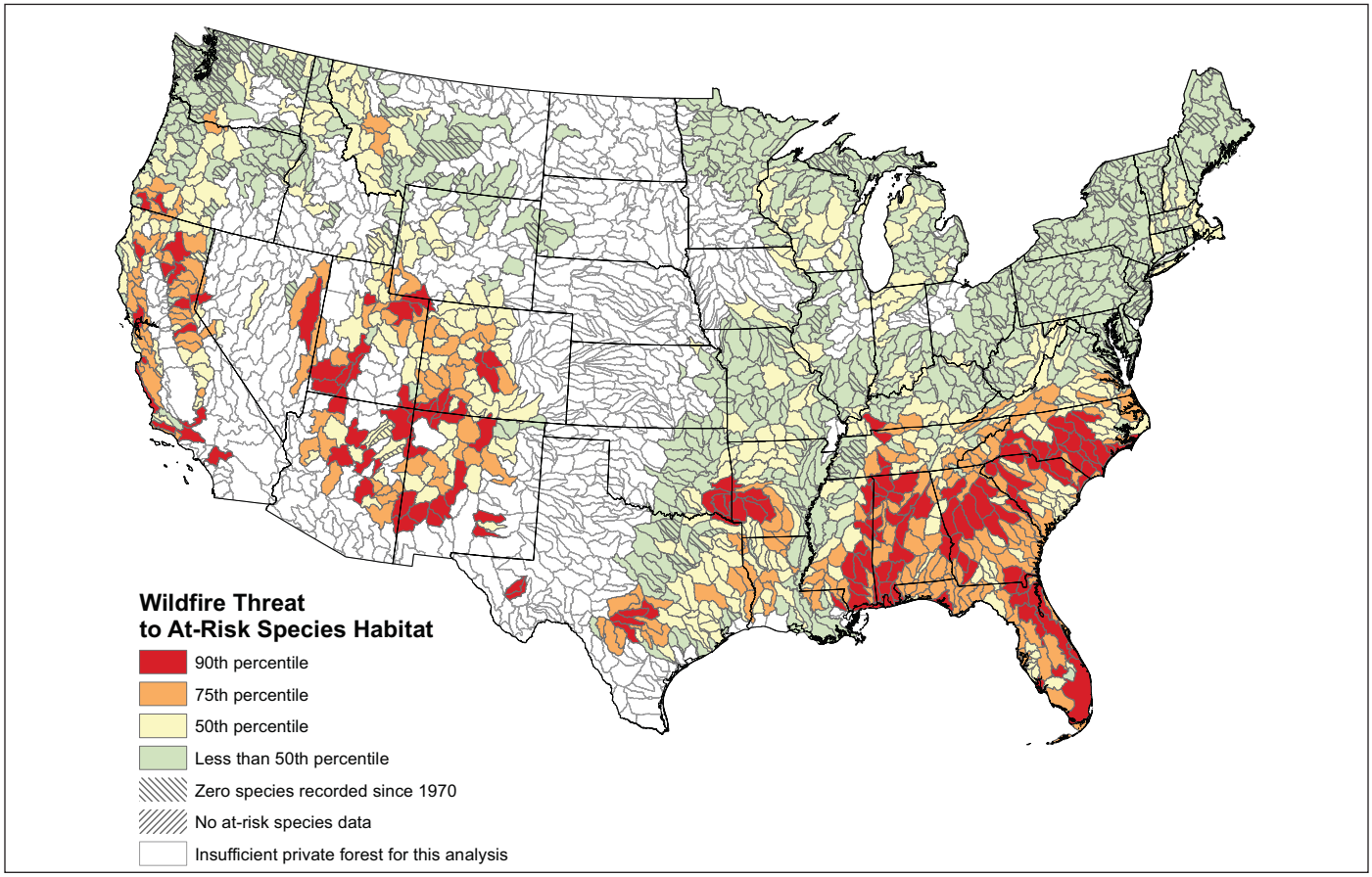


Figure 4—Wildfire threat to at-risk species associated with private forests. Watersheds where at-risk species are most likely to be affected by wildfire are in the Southeast, the Southwest, and in California.

lands (Hansen et al. 2005, Houlahan et al. 2006, Maestas 2007)—relate to a lowering of the quantity and quality of terrestrial and aquatic habitats. Such changes can result in numerous impacts on native species, including:

- Increased predation and parasitism (Coleman and Temple 1993, Engels and Sexton 1994, Lepczyk et al. 2003, Sieving and Willson 1999)
- Increased injuries and mortality from roads, fences, vehicle collisions, power lines, toxic substances, and other factors (Forman and Alexander 1998, Houlahan and Findlay 2003, Janss 2000, Maestas 2007, Mumme et al. 2000, van Langevelde et al. 2009)
- Spread of invasive species (Houlahan et al. 2006, Meekins and McCarthy 2001)
- Loss of pollinators or prey species (Harris and Johnson 2004, Lienert 2004)
- Decreased ability to move and disperse (including plant seeds), find food, and reproduce (Jacobson 2006, Lampila et al. 2005)

Further, some animals will alter their behaviors to avoid humans or to take advantage of human food and shelter, often to the detriment of both the animals and people (Maestas 2007, Miller et al. 2001, Sime 1999, Wisdom et al. 2000). The impacts may last for several decades following development (Hansen et al. 2005).

Even low-density housing development in rural areas can have disproportionate impacts on wildlife, because places that are attractive to people for housing—such as near parks, rivers, and other natural areas—are also the places that are favored by native wildlife, particularly top carnivores and "wilderness" species (Hansen et al. 2005). Although many private forest landowners specifically strive to protect and enhance wildlife habitat through careful and sustainable management (Butler 2008), continuing loss and fragmentation of private forests could cause local populations of some forest-associated species to decline or disappear (Donovan and Flather 2002, Ewing and Kostyack 2005, Fahrig 2003, Lampila et al. 2005).

At-risk species may be particularly vulnerable to these effects (Donavan and Flather 2002, Janss 2000); conversion of forests to developed landscapes has already contributed to the decline of approximately 35 percent of threatened, endangered, or proposed species in the United States (Wilcove et al. 1998, 2000).

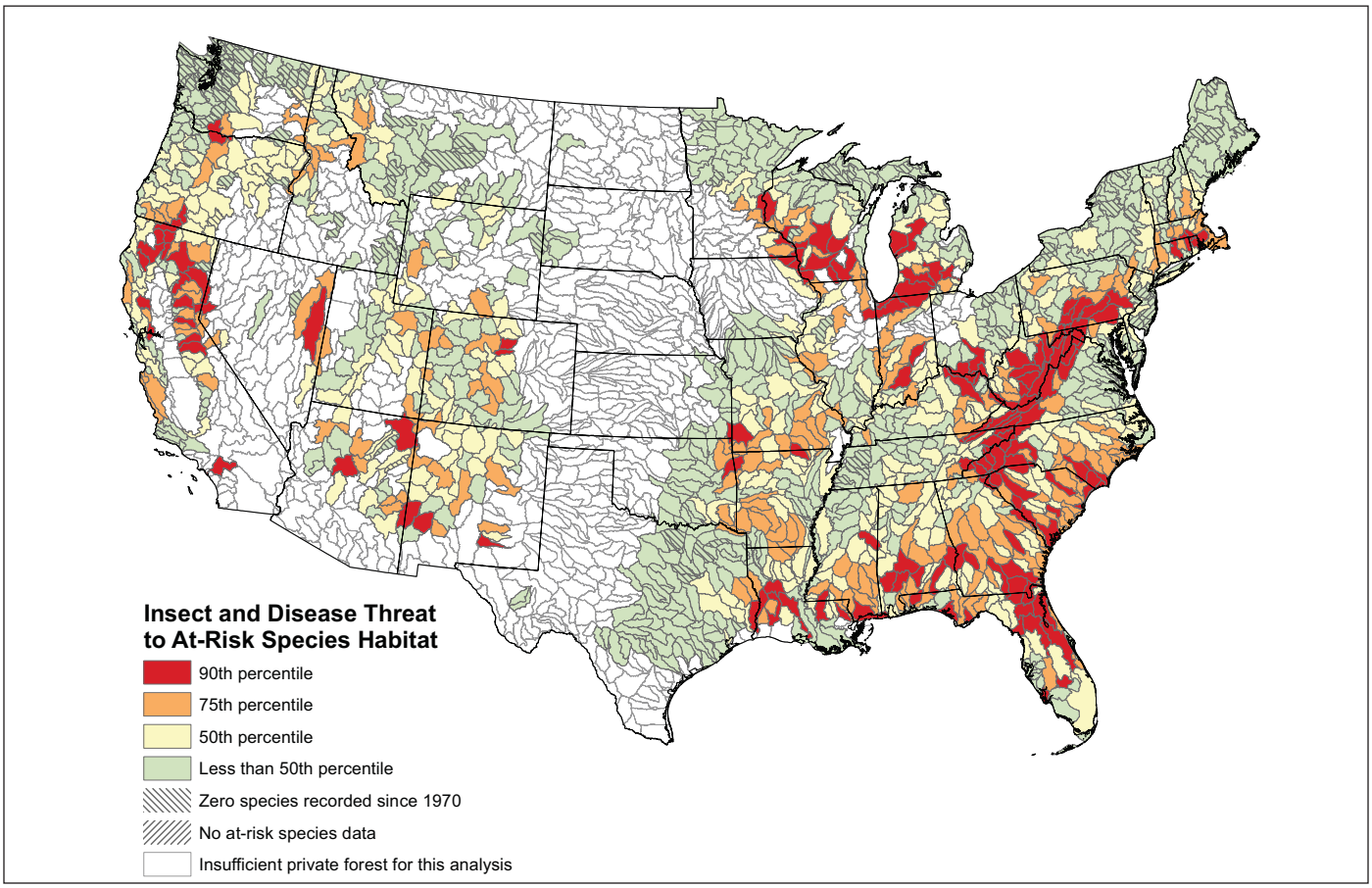


Figure 5—Insect and disease threat to at-risk species associated with private forests. Watersheds where at-risk species are most likely to be affected by insects and disease are in the East, with some vulnerable watersheds in the West and Southwest.

Beyond Habitat: Indirect Impacts Can Be Detrimental

Increased housing development can have a negative impact on certain species even if direct loss or fragmentation of habitat has not occurred. In Texas, populations of endangered golden-cheeked warblers (*Dendroica chrysoparia*) declined when populations of blue jays (*Cyanocitta cristata*) increased in nearby suburban developments. The blue jays preyed on warbler eggs and intimidated adult warblers so they failed to establish territories, echoing a widely observed effect in which human-adapted jays and crows predate on eggs and nestlings of other bird species (Engels and Sexton 1994, Sieving and Willson 1999).

For every kilometer (0.62 mile) of highway construction, an estimated 644 hectares (1,591 acres) of land is converted from its original vegetative cover, resulting in significant loss of habitat for wildlife (Ament et al. 2008).

AP

Some wildlife lose their fear of people, leading to ecological and public safety problems (Kloppers et al. 2005, Wisdom et al. 2000, Yoder 2002) as well as increased costs for landowners from property or crop damage (Yoder 2002).

Ground-nesting species and birds that nest in the open in shrubs or trees are particularly vulnerable to predation from domestic cats (Coleman and Temple 1993, Lampila et al. 2005, Sieving and Willson 1999, Woods et al. 2003). In one study (Lepczyk et al. 2003), 800 to 3,000 outdoor cats in three rural-to-urban landscapes in southeastern Michigan killed between 16,000 and 47,000 birds of 23 species—including two of conservation concern—during one breeding season.

AP

Development and road building often involve removal of large trees, snags, or down logs that are needed by cavity-nesting birds and mammals. In boreal conifer forests, the bird species most sensitive to such forest change are resident cavity nesters that rely on older forests (Schmiegelow and Monkkonen 2002).

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Around 16 percent of the population of endangered key deer are killed on Florida roads every year (Forman and Alexander 1998). Physical contact with vehicles is the leading direct human cause of wildlife mortality on land, including extraordinary numbers of insects as well as frogs, toads, turtles, snakes, and birds that travel across or along roads (Forman and Alexander 1998, Wisdom et al. 2000). Collisions with large animals, such as deer and moose, also present hazards for humans (CDC 2006).

On the Edge

While the amount of habitat is considered to have the greatest impact on species population size, habitat fragmentation can also have a substantial effect in certain situations (Flather and Bevers 2001). “Fragmentation” refers to the conversion of a large expanse of habitat into multiple smaller patches, which become isolated from each other and surrounded by different kinds of habitat (Fahrig 2003, Lampila et al. 2005). Over time the fragments get even smaller and more distant from each other, and their shapes may change.

“Edges” are boundaries between different habitats such as forest and meadow (Kremsater and Bunnell 1999). Increases in edge resulting from forest fragmentation can result in increases in species that find edges and small forest patches favorable—such as black-tailed deer, skunks, and raccoons (Kurki et al. 2000, Lepcyzk et al. 2003, Pedlar et al. 1997)—and declines in species that avoid edges or prefer forest interior habitat (Lienert 2004, Meekins and McCarthy 2001, Wisdom et al. 2000), such as red squirrels (Mahan and Yahner 1999).

—Illustration adapted from Wilcove et al. 1986, cited in Fahrig 2003.

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Some plants can persist in small populations for long periods of time, but many will decline if habitat loss adversely affects the animals needed for pollination or seed-dispersal (Harris and Johnson 2004, Lienert 2004).

IMPACTS OF HOUSING DEVELOPMENT

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Certain birds, such as the meadowlark, fly away from roosting or nesting areas when dogs and pedestrians are present (Maestas 2007, Sime 1999).

AP

Amphibians are among the species that may be particularly vulnerable to declining water quality and increased exposure to toxic substances that often accompany an increase in habitat fragmentation and roads (Houlahan and Findlay 2003).

Susan Stein, USFS

A warning sign for key deer (*Odocoileus virginianus clavium*) in the Florida Keys.

AP

Garlic mustard can invade both disturbed and undisturbed areas (Meekins and McCarthy 2001) and is currently displacing native understory species in the forests of northeastern United States and southern Canada. It is also a threat to species that depend on the native understory habitat, such as the endangered Virginia white butterfly (*Pieris virginiensis*) and the native American butterfly (*Pieris napi aleracea*).

Impacts From Insect Pests and Diseases

Whether native or exotic, insect pests and diseases can have important economic and ecological impacts on forest resources, ecosystems, and endangered species (Liebhold et al. 1995). Pimental et al. (2005) found that 42 percent of federally listed threatened and endangered species were at risk primarily because of a nonnative invasive species.

An example is the balsam woolly adelgid (*Adelges picea*). Introduced from Europe around 1900, this insect pest has caused substantial damage and mortality to true fir species (*Abies* spp.) (Ragenovich and Mitchell 2006). Particularly hard hit is one of its hosts, the Fraser fir (*Abies fraseri*) in the southern Appalachian mountains. The balsam woolly adelgid (coupled with additional threats from increased recreation and pollution) has not only jeopardized the fir trees (NatureServe 2009) but could also result in the extinction of several species closely associated with the Fraser fir (Liebhold et al. 1995). Among those species threatened are the spruce-fir moss spider (*Microhexura montivaga*) (USFWS 2000b) and the rock gnome lichen (*Gymnoderma lineare*) (NatureServe 2009).

Impacts From Fire

Habitat destruction due to disruption of an area's characteristic fire pattern—either by fire suppression or by controlled or uncontrolled fires—constitutes one of the major threats to at-risk species (Wilcove et al. 1998). The season, frequency, extent, complexity, duration, intensity, and severity of a fire will affect different species and their habitats differently (Anderson 2001, Smith 2000). For example, a patchy burn can add to wildlife habitat diversity in the short term by creating more "edge," while a high intensity/high severity fire can extensively alter habitat composition for extended periods of time (Anderson 2001). Some at-risk species such as the federally endangered Karner blue butterfly (*Plebejus melissa samuelis*) depend on fire to maintain their habitat (Mitchell and Carnes 1996), while others might be adversely affected by uncharacteristic fire because of mortality, habitat loss, changes in stream temperature or nutrient loads, and other impacts (Smith 2000, Ice et al. 2004). For plant species, factors such as fuels and moisture conditions can result in varied impacts among fires or within different areas of one fire, where some species may be eliminated or others may appear in areas not seen before the fire (Miller and Findley 2001).

Dr. Fred Coyle, USFWS

Spruce-fir moss spider (*Microhexura montivaga*)

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Karner blue butterfly (*Plebejus melissa samuelis*)

AP

Some species already at risk can be further threatened by uncharacteristic wildfire.

Delmarva Fox Squirrel

One of the largest tree squirrels in the Western Hemisphere—at 30 inches and 3 pounds—the endangered Delmarva fox squirrel (*Sciurus niger cinereus*) is native to the mid-Atlantic region. The squirrel garners its name from the Delmarva Peninsula bordering the Chesapeake Bay; it was found historically throughout the peninsula in mature and mixed acorn-producing hardwoods and mature loblolly pine stands. This fox squirrel's original range was reduced to just 10 percent primarily because of loss and fragmentation of habitat due to timber harvesting, conversion of forests to farmland, housing development, road construction, and commercial property developments (Kulynycz 2003, USFWS 1993). Consequently, the species was listed by the Fish and Wildlife Service as endangered in 1967. After reintroductions in Maryland, Delaware, Virginia, and Pennsylvania, and decades of conservation work by recovery partners, 11 of the 16 reintroduced populations are succeeding. Much of the habitat now occupied by Delmarva fox squirrels is on privately owned land.

—Source: USFWS 2008

California Tiger Salamander

Described as large, stocky, and terrestrial, the California tiger salamander (*Ambystoma californiense*) is known to frequent grassland, oak savanna, and edges of mixed woodland and lower elevation coniferous forests. This salamander is recognized as endangered in two of the six known genetically distinct populations: the Sonoma and Santa Barbara populations of California. The species was listed as threatened range-wide in 2004 because its range and abundance continued to decline, most likely because of habitat loss and degradation. Most populations of this species are found on private land; only an estimated 5 percent of known populations occur on government-managed lands. In Santa Barbara County, the entire known and potential habitat for the California tiger salamander is largely on private land currently unprotected from development.

—Sources: USFWS 2000a, NatureServe 2009

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Etonia Rosemary

Etonia rosemary (*Conradina etonia*) is a member of the mint family, found only in Putnam County in northeastern Florida. Discovered in 1990, the Etonia rosemary is restricted to limited areas of scrub vegetation with scrubby evergreen oaks (*Quercus* spp.) and sand pines (*Pinus clausa*). The only two sites where it is known, near Etonia Creek, are privately owned and were already subdivided for residential development or had been approved for development when the plant was discovered. Fire suppression also threatens the rosemary habitat. With its limited geographic distribution, small population size, and imminent threats to its habitat from residential development, Etonia rosemary was listed in 1994 by the U.S. Fish and Wildlife Service as an endangered species.

—Sources: NatureServe 2009, USFWS 1994

Anthony Mercieca, Photo Researchers Inc.

Black-Capped Vireo

The black-capped vireo (*Vireo atricapilla*) is a small, insect-eating, migratory songbird found in mixed deciduous/evergreen shrublands in the south-central United States (Kansas, Louisiana, Oklahoma, and Texas). Habitat losses are occurring as a result of development, over-browsing, and nest parasitism, as well as suppression and alteration of natural disturbance regimes (fire in particular). The U.S. Fish and Wildlife Service listed the species as endangered in 1987. The overall population of black-capped vireos is unknown because access to private property in Texas has been limited until recently. Of the known population, 25 percent of documented occurrences have been on private lands. Incentive-based programs are now encouraging private landowners to manage their lands for sensitive species such as this rare bird.

—Sources: USFWS 1991, 2007

CASE STUDIES

Hops Azure

A recently described species, the hops azure (*Celastrina humulus*) is a highly range-restricted butterfly that lives in the gulches and steep ravines of canyons on the Front Range of the Colorado Rockies. Extensive habitat alteration due to housing construction, recreation, and water development has placed pressure on this species. Threats to hops azure habitat will likely continue because of the proximity of its entire range to urban environments. NatureServe lists the hops azure as imperiled (global status G2G3).

—Source: NatureServe 2009

Eastern Massasauga Rattlesnake

Several states in the range of the eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*)—including Wisconsin, Michigan, Pennsylvania and New York—consider it a critically imperiled species. This snake makes its home in a variety of habitats, from marshes to dry woodlands, preferring wetlands and the adjacent natural upland habitat. The primary threat to the eastern massasauga is the destruction, loss, or modification of its habitat due to human activities, including residential development. Szymanski (1998) cited articles where populations were isolated or fragmented by development or where a large residential development eliminated already critically degraded habitat.

—Sources: NatureServe 2009, Szymanski 1998

CONCLUSIONS

The alteration of habitat associated with increased housing density and the development of associated infrastructure can have numerous and varied impacts on at-risk species, including their further decline. As the human population continues to increase, more houses will be added to rural landscapes—both forested and nonforested—to the detriment of many rare plant and animal populations. With more attention focused on this issue, a host of conservation actions are being implemented to conserve wildlife and plan for sustainable development.

Like previous Forests on the Edge reports and other national assessments, the findings of this study are based on data available at a national level and may not precisely describe projections for specific locations or watersheds. Nonetheless, our findings can provide a useful tool to individuals, communities, and organizations who wish to consider implications for threatened, endangered, and other imperiled flora and fauna as a critical component of local and regional strategic planning efforts.

Conservation Actions

Numerous actions can be taken to support the development of housing and associated infrastructure on the landscape while reducing impacts on wildlife and plant species already at risk. A few examples include:

- √ Create tunnels across or under highways to help amphibians and other wildlife cross roads safely (Clevenger et al. 2003, Kobylarz 2003, Fahrig et al. 1995, Litvaitis and Tash 2008).
- √ Modify road network configurations, traffic volumes, and vehicle speeds; and use fences to minimize dangers to animals on or near roads (Jaeger et al. 2006, Seiler 2005).
- √ Increase awareness about negative impacts of free-roaming cats and other pets (Lepczyk et al. 2003), and about moose and other large animals to help avoid vehicular collisions (CDC 2006).
- √ Pass zoning and other ordinances to protect nest trees and dens and to prevent picking of or damage to vulnerable plant populations.
- √ Select pesticides, herbicides, and fungicides with a consideration for the sensitivity of pollinators such as bees and butterflies.
- √ Negotiate and implement conservation easements to keep private forest lands intact.
- √ Use federal, state, and local tax incentives to reduce costs of long-term private forest stewardship.
- √ Consider clustered housing developments that incorporate environmental considerations and help maintain open space.
- √ Expand forest certification programs such as Sustainable Forestry Initiative and Forest Stewardship Council.
- √ Encourage locally based comprehensive planning that considers forest benefits such as wildlife and water quality. This may include informing landowners and planning boards of the relative ecological importance of at-risk species' habitats that are, or will be, under consideration for development, and of any legal evaluation/analysis that must be made.

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Metrics Table

When you know:	Multiply by:	To find:
Feet (ft)	0.305	Meters (m)
Acres (ac)	0.405	Hectares (ha)
Square feet (ft^2)	.0929	Square meters (m^2)
Square miles (mi^2)	2.59	Square kilometers (km^2)

AP

Northern monkshood (*Aconitum noveboracense*)

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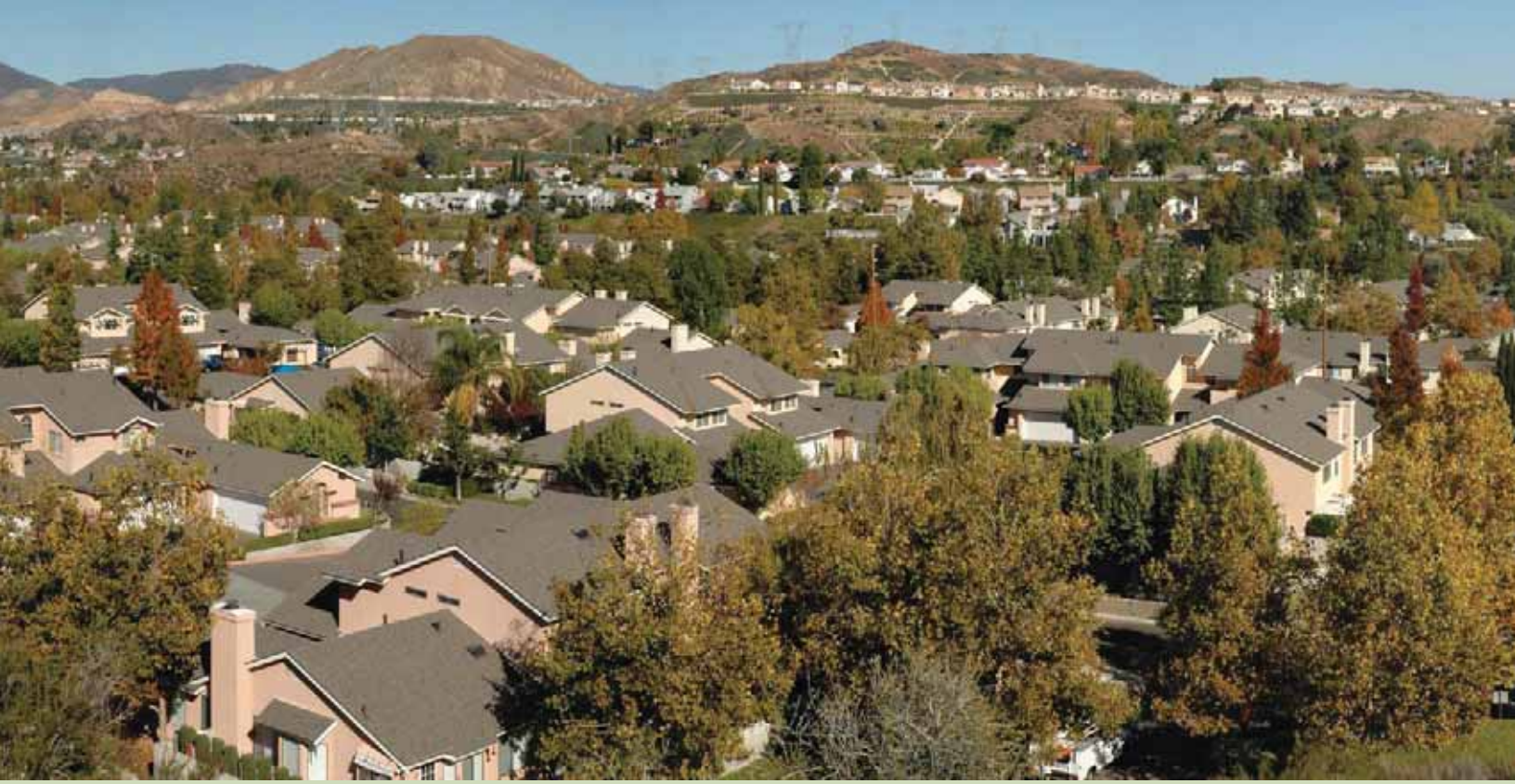

Photo courtesy of Matt Jalbert, mattjalbert.com

FORESTS ON THE EDGE

Forests on the Edge is a project of the U.S. Department of Agriculture, Forest Service, State and Private Forestry, Cooperative Forestry staff, in conjunction with Forest Service Research and Development and other partners. The project aims to increase public understanding of the contributions of and pressures on America's forests, and to create new tools for strategic planning. The first report (Stein et al. 2005) identified watersheds in the conterminous United States where private forests are most likely to experience housing development. Subsequent reports have provided more in-depth discussion and data on the locations and impacts of future housing development in rural areas, and the benefits and threats to urban forests. This report highlights threats to private forest habitats for at-risk species of plants and animals and identifies watersheds nationwide where the future of at-risk species could be further complicated by additional pressures from wildlife, insects, and diseases.

Future Forests on the Edge work will include assessments of additional contributions and risks, and construction of an Internet-based system that permits users to view, combine, and depict results for selected contribution and threat layers.

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