Private Forest Habitat for At-Risk Species: Where Is It and Where Might It Be Changing?

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ABSTRACT

Owned by individuals, families, corporations, and other private groups, private forests account for almost 60% of all forestland in the conterminous United States and provide critical habitat for wildlife, including over 3,700 at-risk plant and animal species. Extensive areas of private forest and other land covers have experienced increased housing development in recent years, with numerous implications for wildlife conservation. Twenty-eight percent of all private forests are under corporate ownership and provide important wildlife habitat. In some areas of the country, large amounts of private forest under corporate ownership are being sold and, in some cases, subdivided, with consequent implications for at-risk species conservation. Sponsored by the US Forest Service, the Forests on the Edge (FOTE) project uses geographic information systems to identify areas across the United States where private forests provide important services that might be detrimentally affected by increased housing and other threats. This article presents the results of FOTE research on the importance of private forests in general, and corporate forests in particular, to at-risk species. It also identifies areas across the country where future housing development on private forests could further reduce wildlife habitat. Results indicate that private forests and private corporate forests in the West Coast states, parts of the Gulf and Atlantic Coasts, as well as interior areas of the Southeast provide habitat for a large number of at-risk species and that these areas are also among those where private forests are most likely to experience increased housing development.

Keywords: private forest, at-risk species, housing development, corporate forest

Private forests account for almost 60% of all forestland in the conterminous United States (Smith et al. 2004) and provide critical habitat for many wildlife species, including 3,704 at-risk plant and animal species [1] (Robles et al. 2008). A wide range of at-risk plants and animals are associated with private forests including the bald eagle (*Haliaeetus leucocephalus*), American ginseng (*Panax quinquefolius*), and the Indiana bat (*Myotis sodalist*). In fact, in most watersheds [2] across the conterminous United States, private forests support at least 1 and as many as 101 at-risk species (Robles et al. 2008). Although higher numbers of at-risk species are found in watersheds in the southeastern United States and the West Coast, private forests in watersheds of the arid Interior West also provide habitat for as many as 21 species.

Extensive areas of land under forest and other land covers have been developed in recent years (Alig et al. 2003). From 1982 to 2003, the area of developed land in the United States increased by more than 48%, and an average of 1.68 million ac of rural land was converted to developed uses annually (USDA 2007). From 1992 to 1997, the average annual rate of conversion of forestland alone was 1 million ac (Alig et al. 2003).

Housing development on private for-

Projected Development (2000 - 2030)

- 🟥 High change
- 🟪 Medium change
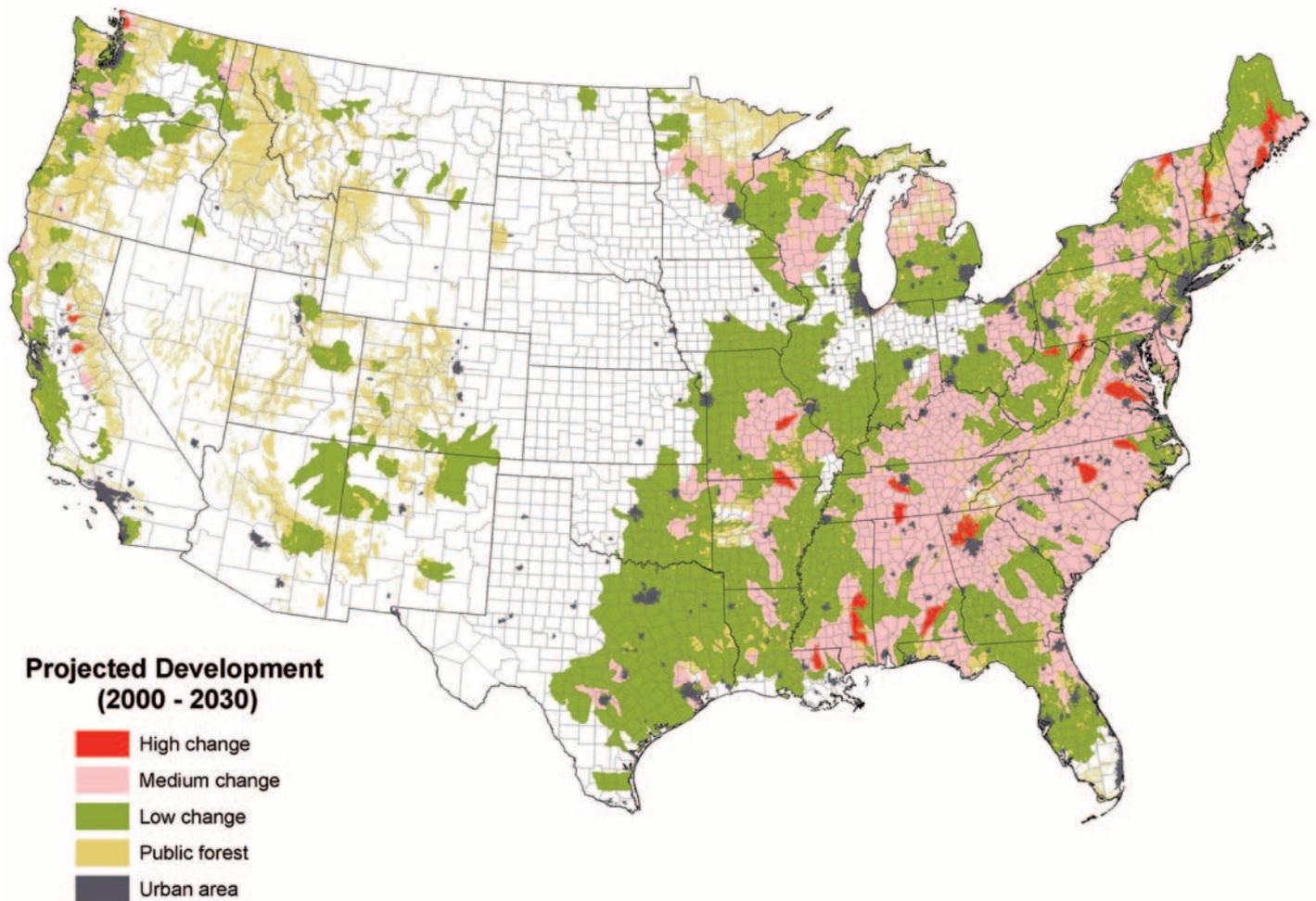- 🟩 Low change
- 🟨 Public forest
- ⬛ Urban area

Figure 1. Watersheds in which housing density is projected to increase on private forests by 2030. Data from Steeves et al. 1994, US Digital Chart of the World 1998, DellaSala et al. 2001, Vogelmann et al. 2001, ESRI Data and Maps 2002, Theobold 2005.

ests and the associated construction of roads, shopping malls, and other infrastructure have numerous implications for plants and animals. The loss or fragmentation of habitat can reduce population numbers and impede wildlife movement; increased numbers of people and their pets can lead to increased predation and mortality of native wildlife (Stein et al. 2005). Increased development can also result in changes to forest structure and function, modifications in water quality and quantity, and increases in fire risk, each of which, in turn, can affect wildlife habitat.

There is a wealth of literature reporting specific impacts of urbanization on wildlife. Impacts reported for birds include increased numbers of generalist species and consequent decreased numbers of specialists, decreased species richness, decreased community completeness, increased nest predation, and reduced numbers of offspring (Cam et al. 2000, Fraterrigo and Wiens 2005, Stratford and Robinson 2005, Lepczyk et al.

2008). Urbanization and loss of habitat have also been associated with declines in species richness and/or reduced abundance of aquatic invertebrates, fish, and amphibians (Houlahan and Findlay 2003, Moore and Palmer 2005, Morgan and Cushman 2005). Impacts observed for riparian forests include an increase in nonnative plant species, weak regeneration of overstory trees, and reduced stem density of native trees (Burton and Samuelson 2007).

Private forests are owned by individuals, families, corporations (including timber industries), and other private groups. A 2007 estimate indicates that about 28% of all private forests are under corporate ownership (Smith et al. 2009) including industrial ownerships (with wood-processing plants such as saw mills), as well as pure investment companies and other companies without wood-processing facilities. In parts of the country, large amounts of private forest under industrial ownership are being sold (Mendell et al.

2005, Gustafson and Loehle 2006). Although many of the lands sold are retained for timber management purposes, some are being subdivided and sold for housing development, with consequent implications for at-risk species conservation. In the Northeast, for instance, new tax structures and escalating land prices are resulting in sales of large areas of forestland from industrial owners to new buyers, some of whom are developing these lands or managing them for purposes other than long-term timber production (Weinberg and Larson 2008).

The Forests on the Edge Project

Sponsored by the US Forest Service, the Forests on the Edge (FOTE) project uses geographic information systems (GIS) to identify areas across the United States where private forests provide important services and where these services might be detrimentally affected by increased housing and other threats. The purpose of this article is to present the re-
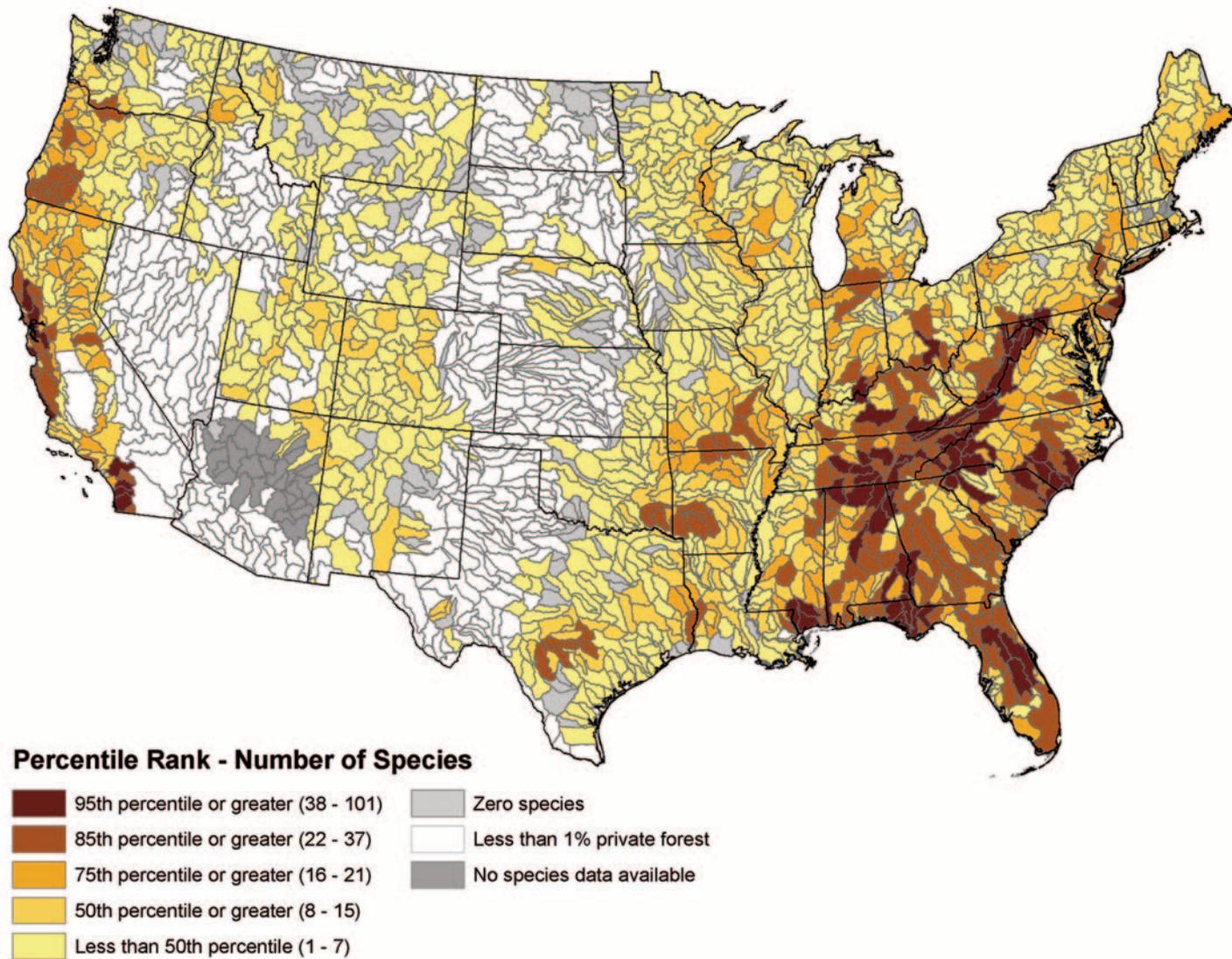
Percentile Rank - Number of Species

- 95th percentile or greater (38 - 101)
- 85th percentile or greater (22 - 37)
- 75th percentile or greater (16 - 21)
- 50th percentile or greater (8 - 15)
- Less than 50th percentile (1 - 7)
- Zero species
- Less than 1% private forest
- No species data available

Figure 2. Number of at-risk species found in private forests. Data from DellaSala et al. 2001, USGS 2001, Vogelmann et al. 2001, NatureServe 2004.

sults of FOTE analyses that can help increase our understanding of where, across the conterminous United States, private forests are important to the conservation of at-risk species and where at-risk species habitat might be most impacted by increased housing density. Results are provided for private forests in general as well as for corporate forests. We start by reviewing three previously published FOTE studies: the first identifies areas across the conterminous United States where private forests might change due to future increases in housing density; the second identifies factors responsible for increased housing development; and the third identifies watersheds where private forests are most important for at-risk species conservation. We then present the results of new FOTE-sponsored analyses aimed at un-

derstanding the potential impacts of increased housing density on habitat for at-risk species. Given current concern with recent timber industry divestitures, we also examine the contribution of corporate forests to at-risk species habitat and discuss the implications of future development of these forests.

Each of the analyses described focuses on private forestlands that are now in one of two "rural" categories and are projected to leave that rural category because of increased housing density. In particular, our focus has been on forestlands where housing density is currently ≤16 units per sq. mi. (Rural 1) and is projected to shift to a higher density category, as well as lands that are now between 16 and 64 units per sq. mi. (Rural II) and projected to shift to a higher-density category of ≥64 units per sq. mi. (exurban/

urban). All FOTE studies to date have summarized results by eight-digit watershed to emphasize the importance of forests to water and the other ecological services provided by private forests. The term "eight-digit watershed" is used in a system devised by the US Geological Survey (USGS) to classify watersheds (USGS 2001). There are 2,108 watersheds of this category in the conterminous United States, with an average size of 1 million ac and ranging in size from about 21,000 to 13 million ac (Stein et al. 2005).

Overview of Three Previous FOTE Studies of Private Forest Development and At-Risk Species Habitat

The objectives of the three previous FOTE studies summarized here were three-

Percentile Rank - Density of Species

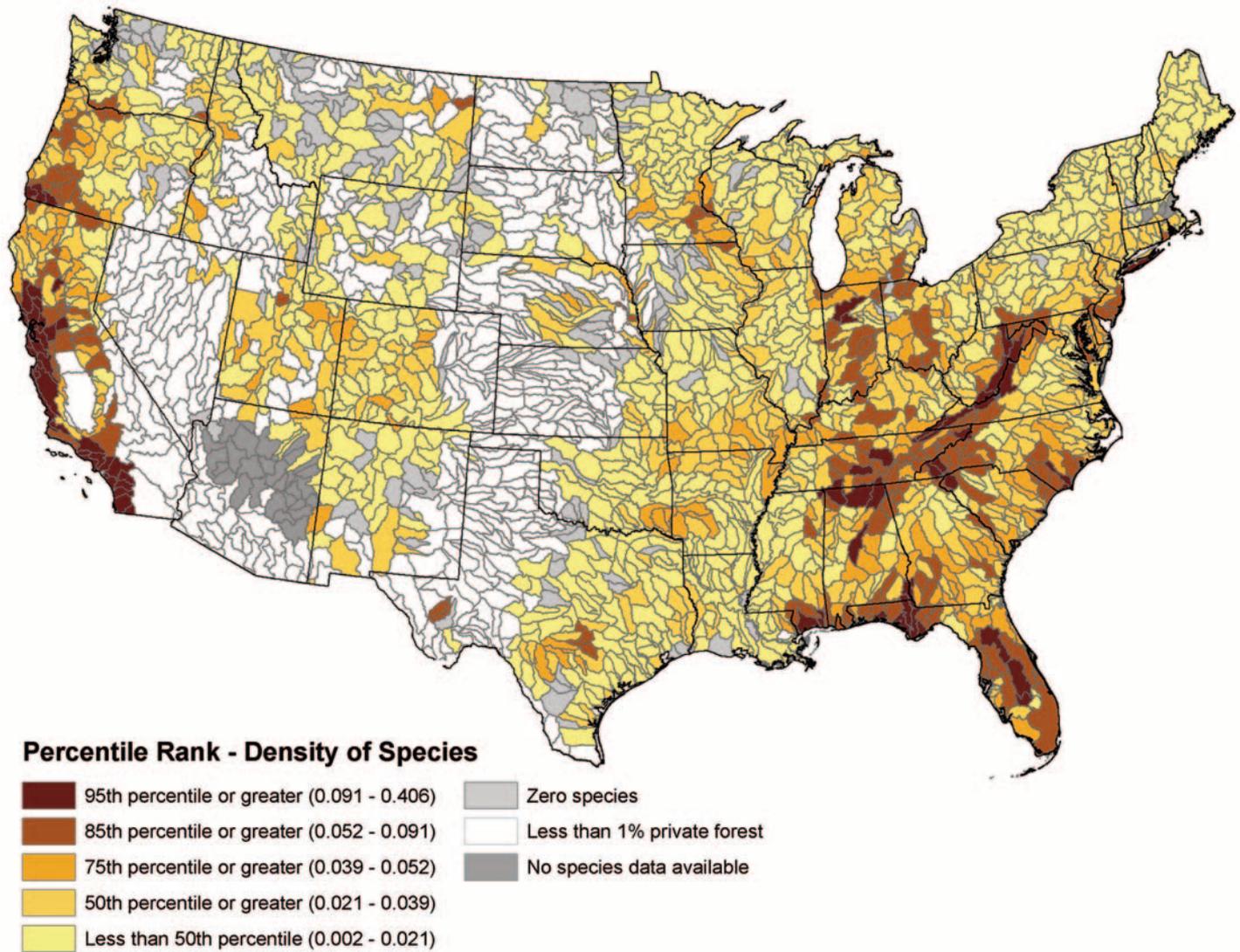|	
95th percentile or greater (0.091 - 0.406)	Zero species
85th percentile or greater (0.052 - 0.091)	Less than 1% private forest
75th percentile or greater (0.039 - 0.052)	No species data available
50th percentile or greater (0.021 - 0.039)	
Less than 50th percentile (0.002 - 0.021)	

Figure 3. Adjusted density of at-risk species found in private forests. Data from DellaSala et al. 2001, USGS 2001, Volgelmann et al. 2001, NatureServe 2004.

fold: (1) identify watersheds across the conterminous United States where ecological conditions are most likely to change due to future increases in housing density on private forests; (2) understand the economic drivers of housing development in watersheds where high increases in housing density are projected; and (3) identify watersheds making the greatest contribution to at-risk species habitat.

Housing Development on America's Private Forests

The purpose of our first report "Forests on the Edge: Housing Development on America's Private Forests" (Stein et al. 2005), was to present estimates of the amount of private forest projected to experience future housing density increases and to identify watersheds across the conterminous

United States that would be most affected by increased housing density on private forest. Data on forest cover (Vogelmann et al. 2001), landownership (DellaSala et al. 2001), watershed boundaries (Steeves and Nebert 1994), and housing density projections (Theobald 2005, Stein et al. 2006) were used in this analysis.

Based on our analysis, we estimated that more than 44 million ac of private forest would experience substantial increases in housing density between 2000 and 2030 (Stein et al. 2005), an estimate consistent with other studies (e.g., Alig et al. 2002, 2003). Watersheds were ranked with respect to the percentage of each watershed containing private forest projected to experience an increase in housing density (i.e., projected to shift from one housing density category to a

higher-density category; Figure 1). Most of the highest ranking watersheds are located in the East.

Socioeconomic Drivers of Development

In a follow-up study, White and Mazza (2008) analyzed socioeconomic drivers of increased housing density in watersheds in Maine, Georgia, and Washington that ranked high in the first report. Studies of top-ranked watersheds in these three states revealed a complex interaction of multiple factors responsible for projected increases in housing density including population growth from migration, changes in ownership of forestland, trends in land values and stumpage prices, and land-use planning and policies (White and Mazza 2008). The relative importance of each factor varied considerably among the three study areas.

Percentile Rank - Proportion of Species

- 85th percentile or greater (0.96 - 1.00)
- 75th percentile or greater (0.83 - 0.96)
- 50th percentile or greater (0.57 - 0.83)
- Less than 50th percentile (0.00 - 0.57)
- Less than 4 species
- Zero species
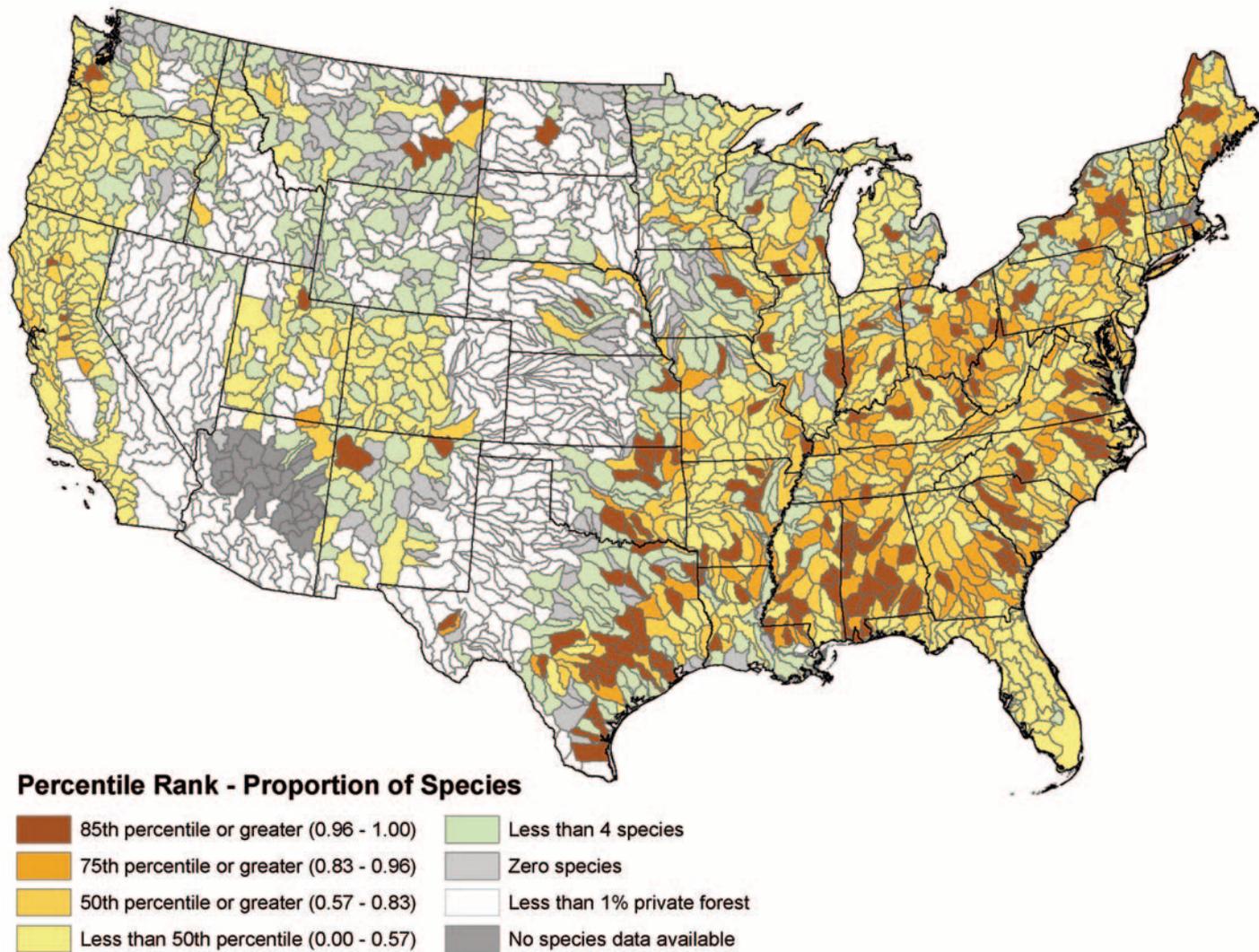- Less than 1% private forest
- No species data available

Figure 4. Proportion of at-risk species found only in private forests. Data from DellaSala et al. 2001, USGS 2001, Vogelmann et al. 2001, NatureServe 2004.

Private Forests as Habitat for At-Risk Plant and Animal Species

A recent FOTE study (Robles et al. 2008) focused on exploring methods for ranking watersheds relative to the contributions of private forests to habitat for at-risk plant and animal species. The study used data on forest ownership from the first FOTE report and data on known locations of at-risk plant and animal species within eight-digit watersheds from NatureServe (2004). At-risk species were defined as species, subspecies, or varieties that were either (1) federally designated under the Endangered Species Act as endangered, threatened, candidate, proposed, special concern, or similarity of appearance; or (2) designated in NatureServe's conservation status ranks (NatureServe 2004) as critically imperiled, imperiled, or vulnerable. All at-risk species location records that intersected a watershed

and had been observed by an authoritative source within the past 50 years were used to generate the species list for each watershed. A watershed had to contain at least 1% private forest to be included in this analysis.

The results showed that private forests provide habitat for 60% of all 6,175 at-risk species. In addition, private forests in more than two-thirds of all watersheds across the conterminous United States support at least one at-risk species. Watersheds with the most at-risk species associated with private forests are clustered along the central and southern Appalachians, the southeastern Gulf Coast, and parts of the Midwest and West Coast (Figure 2).

Because watersheds vary in size and because species counts are known to be affected by area, Robles et al. (2008) estimated an adjusted at-risk species density in a way that accounted for the nonlinear species area

relationship (National Research Council [NRC] 2000, Flather et al. 2008). The adjusted density of at-risk species (D_i) in watershed i is given by

$$D_i = S_i/A_i^z$$

where S is the count of at-risk species and A is watershed area. The exponent z indicates the rate species are added as watershed area increases and was estimated to be 0.481 for the Robles et al. (2008) analysis. When the data are adjusted to account for density of at-risk species associated with private forest, large, high-ranking watersheds in the southeast Coastal Plain (Figure 3) were supplanted by a set of smaller watersheds along the Pacific Coast (Figure 4). Robles et al. (2008) also quantified the relative importance of private forests (compared with public forests) in providing habitat for at-risk species. Those water-
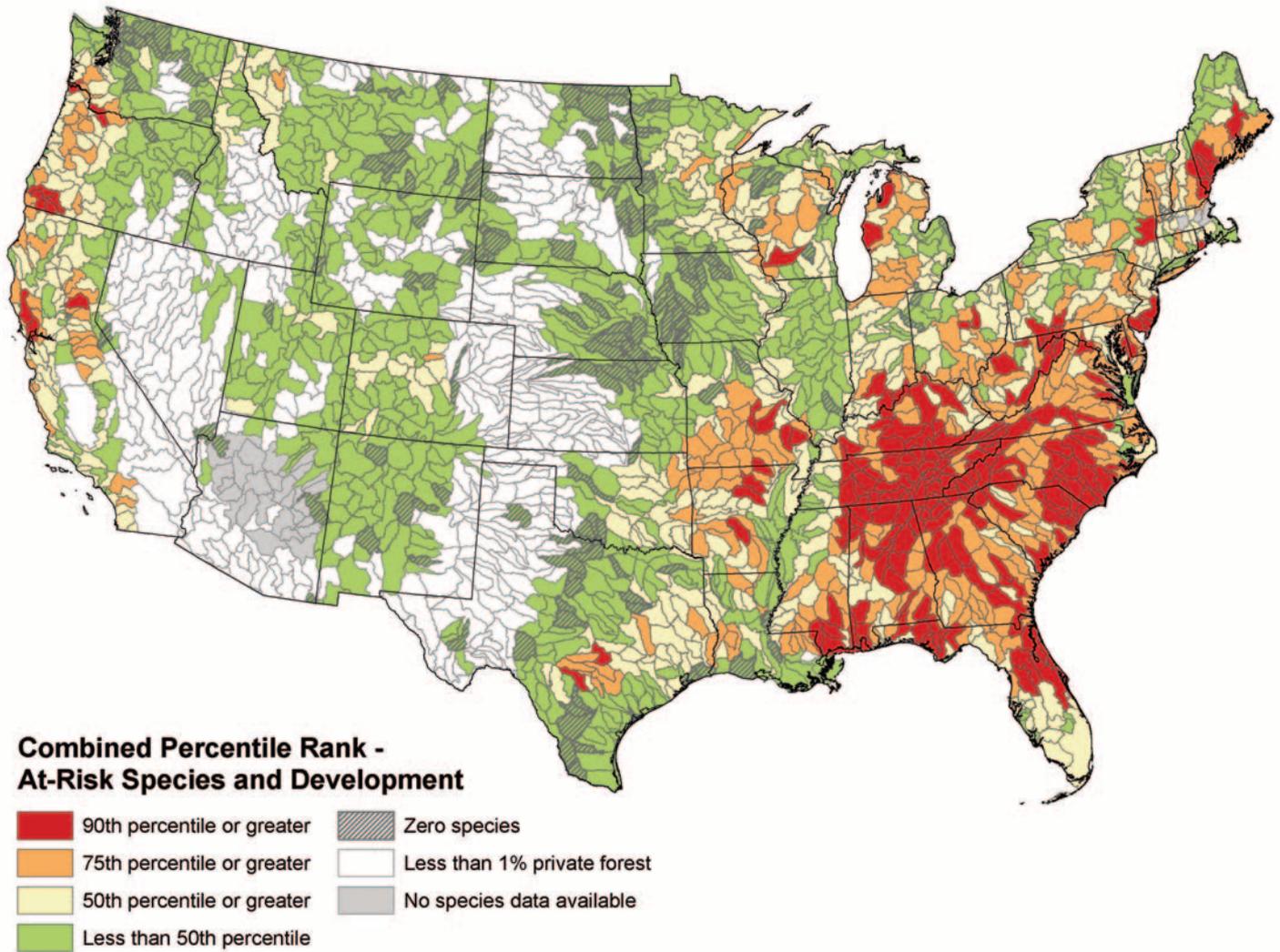
Figure 5. Development threat to at-risk species found on private forestland. Data from Steeves et al. 1994, National Atlas of the United States 2003, Smith et al. (in press).

sheds with the highest proportion of at-risk species that occurred exclusively on private forestland were found predominantly in and well dispersed throughout the eastern United States (Figure 4).

Overview of Three New Analyses on At-Risk Species, Development, and Corporate Forests

The purposes of the three analyses described here are to understand better the types of at-risk species that might be affected by development in high-ranking watersheds, to learn where across the conterminous United States at-risk species habitat might be most affected by development, and to understand more fully the contribution of corporate forests to at-risk species habitat.

At-Risk Species Associated with Private Forests to be Developed—Top 15 Watersheds

In terms of the number of private forest acres to be developed, the top 15 watersheds identified in the first FOTE report are located in the East and contain about 200,000–300,000 private forest acres projected to be developed (Table 1). To understand the numbers and types of at-risk species that might be affected by housing development in these watersheds, data were collected from the NatureServe Conservation Status Ranking System. The number of at-risk species associated with private forests in these watersheds ranges from 46 (in the Upper Green watershed in Kentucky) to 13 (in the Lower Penobscot watershed in Maine).

Studies of at-risk species found in these

watersheds suggest that land-use change can be a possible cause of their decline. The Roanoke bass (*Ambloplites cavifrons*), for instance, is found in North Carolina's Deep watershed; studies of Roanoke bass in Virginia point to deforestation and consequent siltation as a major cause of range reduction (Jenkins and Cashner 1983). Armored Rocksnail (*Lithasia armigera*) and Ornate Rocksnail (*Lithasia geniculata*) are both found in the Lower Cumberland watershed in Tennessee and Kentucky; research on these species indicates that both are threatened by habitat elimination and modification (Minton and Lydeard 2003). A recent study of the Diana Fritillary (*Speyeria diana*), a forest dwelling butterfly found in the Little Kanawha watershed in West Virginia, suggests that its decline is partially caused, in
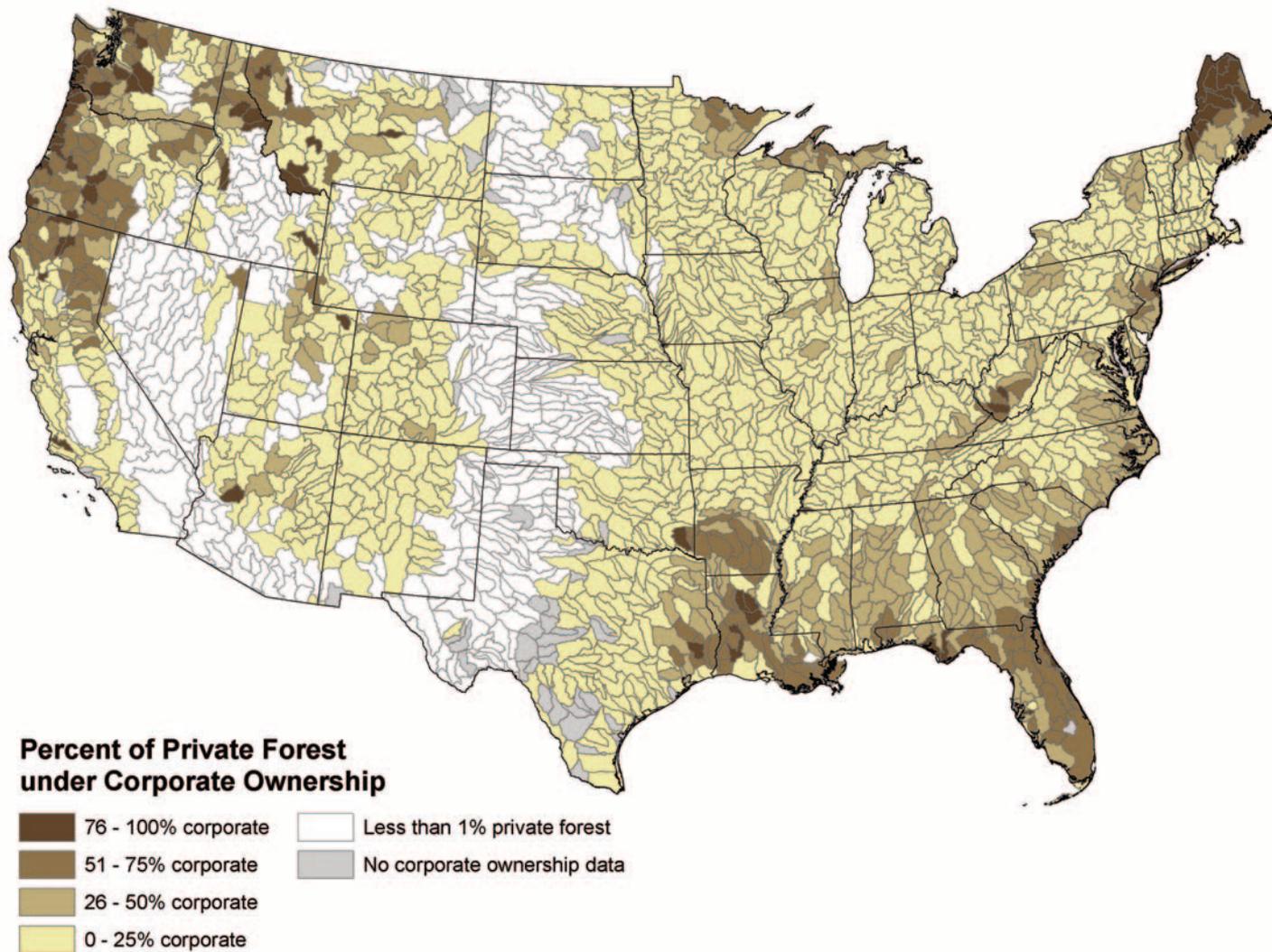
Percent of Private Forest under Corporate Ownership

- 76 - 100% corporate
- 51 - 75% corporate
- 26 - 50% corporate
- 0 - 25% corporate
- Less than 1% private forest
- No corporate ownership data

Figure 6. Percent of private forestland under corporate ownership. Data from Smith et al. (in press). Steeves et al. 1994, DellaSala et al. 2001, Vogelmann et al. 2001, National Atlas of the United States 2005.

part, by habitat destruction and pesticide use (Campbell et al. 2007).

Ranking All Watersheds According to At-Risk Species Numbers and Development

Where across the United States is at-risk species habitat most likely to be reduced due to increased housing density on private forests? To answer this question, we summarized each of two data layers by eight-digit watershed and then intersected them. The two data layers used were number of at-risk species associated with private forests and percentage of private forest projected to experience increased housing density. Data sources for these data layers are the same as those described by Stein et al. 2005 and Robles et al. 2008. For each data layer, a percentile ranking was assigned to each watershed. For example, watersheds in which

private forests provide habitat for the greatest number of at-risk species fell into the 90th percentile category, and watersheds containing the fewest at-risk species fell into

Table 1. At-risk forest-associated species in top 15 watersheds.

	Watershed	Acres to be developed	State	Number of at-risk species
1	Lower Penobscot	310,206	Maine	13
2	Deep	269,817	North Carolina	21
3	Upper Oconee	269,003	Georgia	12
4	Etowah	265,961	Georgia	23
5	Pamunkey	262,003	Virginia	9
6	Lower Cumberland	259,035	Kentucky and Tennessee	26
7	Upper Roanoke	257,110	Virginia	22
8	Lower Leaf	242,758	Mississippi	21
9	Lower Pee Dee	239,558	North and South Carolina	42
10	Little Kanawha	225,760	West Virginia	14
11	Middle Hudson	221,384	New York and Massachusetts	15
12	Upper Green	215,579	Kentucky	46
13	Lower Androscoggin	213,808	Maine and New Hampshire	15
14	Lower Kennebec	210,005	Maine	14
15	North Branch Potomac	209,187	Maryland, Pennsylvania, and West Virginia	42

Percentile Rank - Number of Species on Corporate Forestland

- **90th percentile or greater (12 - 65 species)**
- **75th percentile or greater (4 - 12 species)**
- **50th percentile or greater (1 - 4 species)**
- **Less than 50th percentile (0 - 1 species)**
- **Zero species**
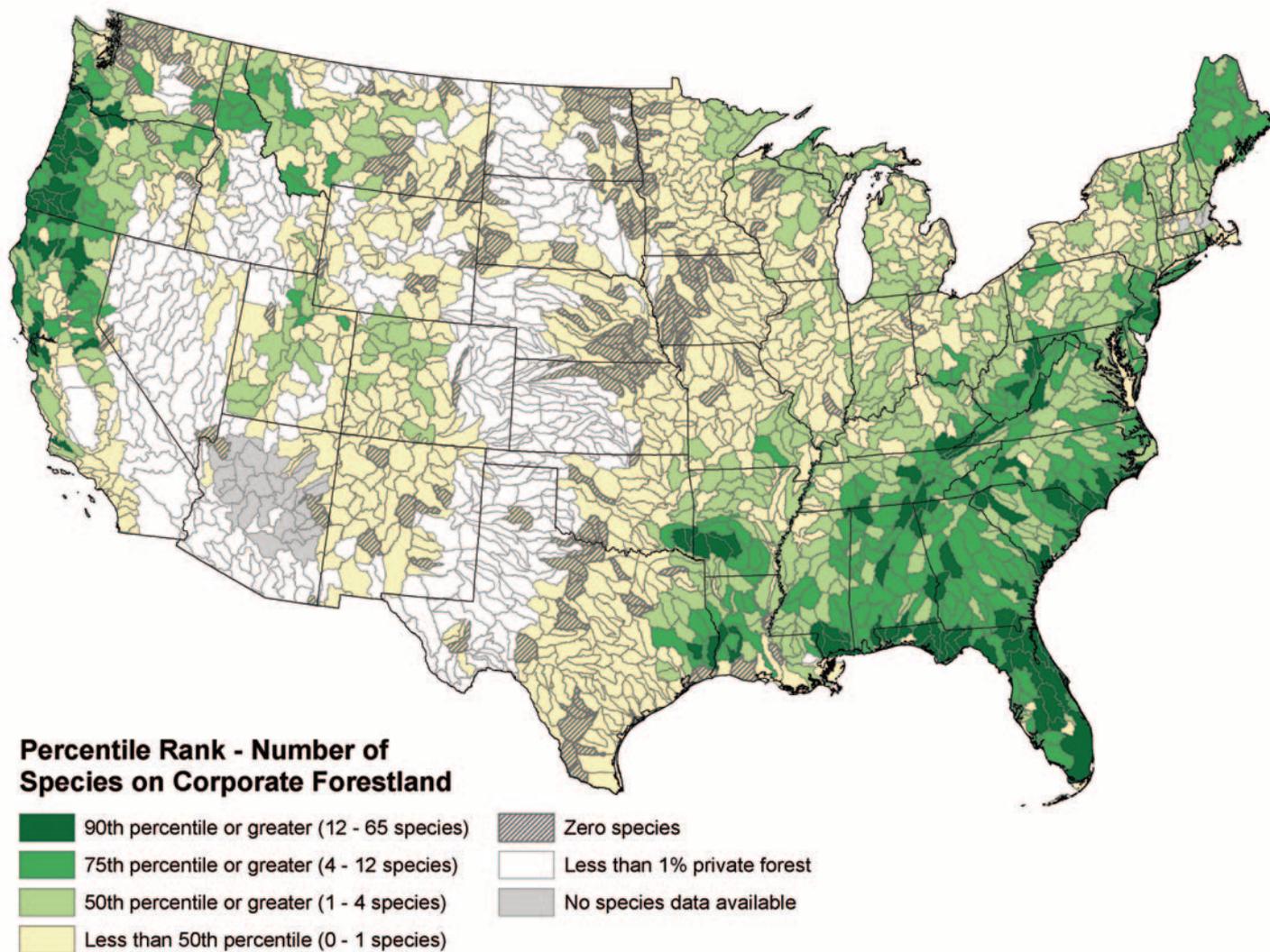- **Less than 1% private forest**
- **No species data available**

Figure 7. Estimated number of at-risk species found on private forestland under corporate ownership. Data from Steeves et al. 1994, DellaSala et al. 2001, Vogelmann et al. 2001, NatureServe 2004, Theobold 2005, National Atlas of the United States 2005.

categories below the 50th percentile. To identify watersheds that ranked highest for number of at-risk species and percentage of private forest to be developed, we intersected the two layers. We did this by calculating the average of the percentile rankings of the two layers, reranking the watersheds according to these averages and then assigning the watersheds to new percentile categories. The 1% screening criteria used in the Robles study was also used for this analysis for the sake of consistency. Unlike the analysis leading to the first FOTE report (Stein et al. 2005), watersheds in this analysis were ranked according to the percentage of private forest within each watershed projected to experience increased development, rather than the percentage of the entire watershed that contains private forest to be developed.

Watersheds that rank highest are those where future housing development on pri-

vate forest is likely to impact the conservation of the greatest number of at-risk plant and animal species. Watersheds receiving the highest ranks are concentrated in Tennessee and adjoining states (Figure 5). A string of small coastal watersheds, stretching from Louisiana to northern Florida and then up along much of the Atlantic Coast, also received high ranks. Additional high-ranking watersheds are found in southern Maine, the Great Lakes, and scattered across coastal areas of northern California, southern Oregon, and Washington.

The Importance of Corporate Forests to the Conservation of At-Risk Plant and Animal Species

Twenty-eight percent of all private forestland is currently under corporate ownership (Smith et al. 2009). This percentage varies somewhat by region, from as low as

13% in the Rocky Mountain region, to as high as 46% in the Pacific West Coast region. Percentages of private forest in the North and South are 22 and 31%, respectively (Smith et al. 2009).

To understand where across the conterminous United States corporate forests might be playing an important role in at-risk species conservation, a GIS layer of the percentage of private forestland in corporate ownership was intersected with the at-risk species layer to identify watersheds where corporate forestland and at-risk species are coincident. The methodology for intersecting these two data layers is the same as described in the previous section.

Watersheds that rank high in terms of percentage of private forestland in corporate ownership are concentrated in northern California and the Pacific Northwest, as well

as northern Idaho and western Montana (Figure 6). Highly ranked watersheds are also found in the southeast and cover southern Arkansas, much of Louisiana, and most of Florida as well as watersheds on the coasts of Georgia and South Carolina. Other areas of importance include northern Maine and watersheds around Lake Superior. Many watersheds with highest percentages of private corporate forest and highest numbers of at-risk species are located in the same areas described for the previous map and are also scattered throughout interior portions of the Southeast (Figure 7).

Are there watersheds where corporate forestlands might be further fragmented and developed as a result of corporate forestland sales? A comparison of Figures 5 and 6 indicates that many of the southeastern coastal watersheds ranking high in terms of percentage of corporate forestland are also ranked high in terms of development threat to private forest habitat for at-risk species. Future management (as well as sale and parcelization) of corporate forestlands in these watersheds could have critical implications for at-risk species, although it is unknown whether any new owners will implement materially different land-management policies.

Summary and Conclusions

Land-use conversion due to housing density increases is a primary determinant of environmental change in terrestrial and aquatic ecosystems. Decline in rural open space reduces overall habitat availability for a variety of species, including those that are at risk of extirpation and extinction. The projections provided here are based on past trends and these trends may be altered by the recent change in US economic conditions. However, residential development in America's rural landscapes has been occurring for a long time and projections indicate that by the year 2030, more than 80 million people will be added to the US population.

People and wildlife do not locate randomly on the landscape; it is no coincidence that most of the watersheds with private forests projected to experience the greatest increase in housing density are located in the East. Similarly, the majority of watersheds with the highest numbers of at-risk species are also located in the East, even when the results are adjusted to account for species density and the proportion of at-risk species located on private forests (as opposed to public forests). At-risk species numbers and

densities are also high along the West Coast, also an area of high human population density.

The percentage of private forestland under corporate ownership tends to be highest in coastal states of the East and West, including areas of northern California, the Pacific Northwest, and the Eastern Gulf and Atlantic Coasts. Not surprisingly, watersheds with highest percentages of corporate forestland and highest numbers of at-risk species are even more concentrated in coastal areas.

Watersheds containing a high percentage of private forest projected to be developed and a high number of at-risk species are concentrated in the Southeast and are also found in southern Maine as well as the coasts of California and the Pacific Northwest.

Sale of forested properties can result in owners with different land-management objectives and further parcelization. Many of the watersheds ranking high in terms of percentage of corporate forestlands are also ranked high in terms of development threat to private forest habitat for at-risk wildlife species.

To ensure that any new policies related to land use are cost-effective in design and implementation, managers and policymakers need information that allows them to anticipate, describe, and plan for future land development patterns and their associated impacts on wildlife. Increased monitoring of development affecting forests is warranted, including possible impacts from land divestment by the forest industry. Furthermore, conservation planners need a better understanding of the factors that affect development patterns and an increased capability to project changes in forestland values, because increasing values can stimulate increased development. Such information is critical to making conservation recommendations and affecting change in land-use policies designed to conserve species most at risk.

Endnotes

[1] At-risk species are those that are federally designated under the Endangered Species Act (endangered, threatened, candidate, or proposed), or designated as critically imperiled, imperiled, or vulnerable according to the NatureServe Conservation Ranking System.
[2] The term "watershed" refers to eight-digit watersheds as defined by the USGS.

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