CONTRIBUTED PAPER

Documenting the conservation value of easements

Peter Kareiva1 | Mark Bailey2 | Dottie Brown3 | Barbara Dinkins4 | Lane Sauls5 | Gena Todia6

1Aquarium of Pacific, Long Beach, California
2Conservation Southeast, Inc., Andalusia, Alabama
3Brown Environmental 13, Cary, North Carolina
4Dinkins Biological Consulting, LLC, Powell, Tennessee
5VHB, Raleigh, North Carolina
6Wetland Resources Environmental Consulting, Daphne, Alabama

Abstract
Placing conservation easements on private lands could contribute greatly to biodiversity protection in the United States. However, a paucity of data prevents us from knowing to what extent this potential is met. We discuss best practices for baseline documentation reports and biodiversity surveys of properties that could help mitigate this data shortage and contribute to a national database on private land biodiversity. We then examine 49 private properties totaling 3,048 ha in Alabama and tally high priority (i.e., at-risk) species that are recorded within this portfolio of land parcels protected by conservation easements. The number is 116 species in total, or 38 high-priority species per 1,000 ha. Not only is the number of these documented at-risk species per unit area high compared to the number documented from nearby Conecuh National Forest (~38 vs. ~5 per 1,000 ha), 92 of the species recorded from the private lands have not been recorded from the much larger Conecuh National Forest (33,993 ha). This emphasizes the opportunity for well-positioned easements to complement and be a valuable addition to large networks of public lands.

KEYWORDS
best practices, biodiversity surveys, easements, threatened and endangered species

1 | INTRODUCTION

Although the United States has a well-developed system of national parks and public conservation lands, the location of these conservation areas is mismatched to the location of unique biodiversity (Jenkins, van Houtan, Pimm, & Sexton, 2015). Because of this mismatch, the amount of habitat protected in the United States must be dramatically increased if species extinctions are to be averted (Fishburn, Kareiva, Gaston, & Armsworth, 2009; Wilcove, Rothstein, Dubow, Phillips, & Losos, 1998). The enhancement of habitat for at-risk species can be achieved by either expanding the amount of public land set aside for conservation or by establishing conservation practices on private lands. In this article, we focus on the opportunity associated with private lands—an opportunity that has been highlighted by several researchers who have noted large numbers of threatened and endangered species that are found only on private lands (Aycrigg et al., 2016; Groves et al., 2000; Scott et al., 2001).

Private lands can be purchased outright for the purpose of conservation, or they can be placed under an easement. Conservation easements are permanent restrictions on land use associated with a property deed. Easements may prohibit subdivision and development;
they may limit the extent of logging or ranching; they may prohibit mining, or they may limit the total building footprint on a property. The idea is that these restrictions preserve critical habitat, while allowing private landowners to own, use, sell, and bequeath the land subject to easement restrictions. Thus, easements allow land to remain private, yet also be protected in perpetuity for biodiversity (Draper, 2004). As a supplement to government-designated lands, conservation easements have become a prominent tool for protecting biodiversity in the United States (Armstead & Sanchirico, 2008).

The potential conservation benefits of a well-designed portfolio of easements are enormous, since private lands provide habitat for 95% of the federally listed species in the United States (Hilty & Merenlender, 2003). Well-placed easements could be geographically positioned to redress the mismatch in the location of public lands and biodiversity. For example, in 80% of the U.S.'s ecoregions, public conservation lands do no better than a random placement of the same amount of land in terms of protecting endangered species (Clancy et al., 2020). Ideally, easement placement would not be random, and hence should be able to substantially improve upon existing public conservation lands.

The predominant holder of conservation easements are nonprofit land trusts. Land trusts assess the conservation value of land before accepting it, and then if they do end up holding the easement, they have a responsibility to monitor the easement to make sure the restrictions are not violated. There are now over 1,300 land trusts operating in the United States (Keiter, 2018). The most recent land trust census report (Land Trust Alliance, 2015) indicates that these land trusts currently conserve 6.8 million hectares with easements. Tax incentives have played a major role in facilitating the use of easements as a conservation tool. In particular, the Tax Reform Act of 1976 created federal tax incentives for granting conservation easements on privately owned property and donating that easement to a land trust or government agency to manage (Parker, 2002).

The need, the opportunity and the potential for private land conservation in the United States is firmly established. What is missing are empirical studies that document the occurrence of high priority conservation species on existing easement lands (Hilty & Merenlender, 2003). Simply noting that private lands fall within the range of endangered species is not adequate, because one might be skeptical of the quality of habitat on lands that have been ranched or partially logged. This is not to say easements have been neglected by researchers. However, the bulk of easement research has examined their effectiveness as measured by compliance with restrictions, the type of habitat they protect (not species presence), their strategic placement in a landscape sense (corridors or stepping stones) and the extent to which they target lands at high risk of conversion (Capano, Toivonen, Soutullo, & Di Minin, 2019; Copeland et al., 2013; Newburn, Reed, Berck, & Merenlender, 2005; Shumba et al., 2020). The few studies that actually include data on species presence (e.g., Pocewicz et al., 2011) focus on a small number of pre-selected species—not an inventory of all high-priority species. Conspicuously absent are published reports from on-the-ground biological surveys of easements.

Here we describe best practices for surveys of conservation easements, and then use these best practices to document the conservation value of 49 easements in Alabama. The question of what species are found on easements is both biologically important and important from the perspective of public policy (Farmer, Knapp, Meretsky, Chancellor, & Fischer, 2011). Tax deductions are given on the assumption of public good—in this case delivering conservation value. Every conservation easement grantor attempting to get a federal tax deduction requires a “baseline documentation report” that describes what of conservation value is found on the property. These reports and their associated surveys are conducted by professional biologists. One of the goals of this article is to highlight the opportunity for advancing conservation practice and science by making full use of the data in baseline documentation reports. If data from the surveys associated with these baseline reports were curated, they could contribute to a national assessment of biodiversity on private lands. However, to maximize the scientific value of such survey data, more attention will need to be given to descriptions of the field methods used, and to a clearer presentation of data than is usually demanded of baseline documentation reports. We show in this article how field surveys of conservation easement properties might adopt some best practices along with flexible standardization of methods to yield unprecedented data on private-land occurrences of rare or at-risk species.

2 | SELECTING ALABAMA FOR A CASE STUDY OF THE CONSERVATION VALUE OF EASEMENTS

We synthesized data and best-practice examples of data reporting from a portfolio of 49 conserved properties in Alabama totaling 3,048 ha of undeveloped land. As can be seen in the map presented as Figure S1, these properties tended to be clustered together, and sometimes were adjoining. The placement of these easements was based,
in part, on their anticipated conservation value, as assessed by conservation nonprofits operating in Alabama (Atlantic Coast Conservancy and National Wild Turkey Federation). These organizations use a wide variety of sources to identify areas of potential conservation value (such as State Wildlife Action Plans, professional field experience, and the published literature).

We focused on Alabama because it is an iconic state in terms of having high biodiversity, a large number of federally endangered and threatened species, and an extraordinarily small percentage of public land. In other words, Alabama is a state that must rely on private land conservation and easements if it is to have any success at conserving its precious biodiversity. Moreover, Alabama harbors more federally listed species than any state in the lower 48, with the exception of California. If we list the top five states (excluding Hawaii) in terms of number of federally listed species, their ranking is: California at #1, Alabama at #2, Florida at #3, Tennessee at #4, and Texas at #5 (see Figure 1).

One striking feature of Alabama is how startlingly little of its land has any form of conservation protection, public or private, given its high biodiversity and large number of threatened or endangered species (Figure 2). For contrast, California with 283 federally listed species has over half of its land managed for biodiversity protection, whereas Alabama with 143 listed species has less than one-twentieth of its land managed for conservation. One reason for the discrepancy is that 52.5% of California’s land is public, whereas only 4.9% of Alabama’s land is public land (https://headwaterseconomics.org/public-lands/protected-lands/public-land-ownership-in-the-us/). The second reason is that only a very small percentage, 0.4%, of the private land in Alabama is under conservation easements. This is the second lowest percentage of lands under easement protection in the lower 48 states—only Mississippi has a lower rate of easement protection (0.36%).

3 | IDENTIFYING BEST PRACTICES FOR BASELINE REPORTS AND EASEMENT SURVEYS

Best practices for sampling biodiversity are well known and can be found in numerous articles and books on ecological methods (e.g., Hill, Fasham, Tucker, Shewry, & Shaw, 2005). Our goal here is to apply these best practices in the context of standard easement surveying, which is typically not viewed as a “sampling” exercise, but is instead simply an attempt to provide baseline documentation of the conservation value of land. In this sense, easement surveys are akin to rapid biodiversity assessments used around the world to establish priorities.
Our intent is to show how with only minor modifications, routine baseline surveys could provide scientifically valuable information on biodiversity in a form that would help the United States more effectively protect its biodiversity.

Properties under consideration for conservation easements vary enormously in size, remoteness, access, habitat character and quality, and the species present. It would be foolish to dictate a rigid protocol to be followed identically on different properties. However, a menu of best practices could make data from easement surveys a valuable conservation resource. We propose the following best-practice guidelines:

- Identify the spatial boundaries of the easement and estimate the percent of the area in different major habitat types within those boundaries.
- For any taxonomic group being surveyed, describe the survey method and, most importantly, quantify the sampling effort (time spent observing, length of plant transects walked and sampled, number of stream seine hauls, etc.).
- Examine (and ideally plot) the cumulative number of species observed as the sampling effort increases.
- To the extent possible, sample in multiple seasons in order to detect species that vary in their seasonal activities.
- Employ targeted sampling for species of high conservation value that might reasonably be expected on the parcel.
- Summarize for each easement property high priority conservation assets defined as all federally listed species, and all species with conservation status S1, S2, or S3 according to NatureServe.

3.1 Spatial delineation and habitat summary

No easement survey has scientific value unless the spatial coordinates of the parcel are provided along with its total area. In addition, there should be a general description of the parcel's habitat. Ideally, the approximate percentage of the easement in terms of its component major habitat types can be estimated using measuring tools such as those available on Google Earth Pro, or even visual inspection of aerial photographs. An example of aquatic habitat and terrestrial habitat assessments are in Table 1. The National Land Cover Database (NLCD) is not sufficiently accurate for the fine scale of these easements.
TABLE 1  Habitat Summaries from baseline easement surveys. (a) Aquatic habitats in an easement located in Escambia County, Alabama. (b) Terrestrial habitats in an easement located in Elmore County, Alabama

| (a)  | Habitat type                        | Area or stream length | Aquatic habitat characteristics                                                                 | Special comments                                                                 |
|------|------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
|      | Large streams (>5 m width)         | 3.64 km               | Big Escambia Creek is the single large stream associated with this parcel. It is a fifth order   | The riparian zone protecting Big Escambia Creek is intact throughout the southwest  |
|      |                                    |                       | stream averaging 27 m width and draining 860 km² at this location.                                | border of the property located at 31.019724, −87.284933 except for three power    |
|      |                                    |                       |                                                                                                  | line or pipeline rights of way. Intact riparian zones are considered vital to    |
|      |                                    |                       |                                                                                                  | the status of biodiversity at the site and downstream of the area.               |
|      | Small streams (<5 m width)         | 0.7 km (app. 0.12 ha) | Two first-order streams and other intermittent channels are present.                             | Only perennial streams included in this calculation. The riparian zones          |
|      |                                    |                       |                                                                                                  | protecting the unnamed tributaries on the property located at 31.019724,        |
|      |                                    |                       |                                                                                                  | −87.284933 are intact. Riparian zones are considered vital to the health of      |
|      |                                    |                       |                                                                                                  | aquatic life at the site and species, including rare species, occurring         |
|      |                                    |                       |                                                                                                  | downstream of the area.                                                        |
|      | Ponds                              | 7.3 ha                | 6.0% of total parcel area.                                                                      | Ponds varied in aquatic habitat quality. Older-appearing ponds with vegetative   |
|      |                                    |                       |                                                                                                  | shallow areas contained more potential habitat for aquatic species than ponds   |
|      |                                    |                       |                                                                                                  | with limited vegetation that appeared to be more recently constructed borrow    |
|      |                                    |                       |                                                                                                  | pits.                                                                           |

| (b)  | Habitat type                           | Percent area (%) |
|------|----------------------------------------|------------------|
|      | Early successional forest and pine plantation | 88               |
|      | Mature hardwood floodplain forest      | 5                |
|      | Seasonally inundated swamp             | 7                |

(Zhu et al., 2021), and does not pick up unique aquatic habitats or caves that contribute greatly to the biodiversity value of these lands. Moreover, many baseline surveys contain aerial photos of sufficient resolution that these photos plus “boots on the ground” promise much more accurate data than is available from NLCD.

3.2  The importance of noting sampling effort

In addition to reporting the major habitat types, the sampling or survey methods should be described, along with the sampling effort devoted to each method. Sampling effort can be recorded as person hours spent searching for and listening for birds, meters of line transect walked, number of stream and river seine hauls, and so on. Without any quantification of sampling effort, it is impossible to interpret data on number of species or individuals observed. Examples of how to report sampling effort are given in Table 2. Note that the dates of sampling should be specified as well as the amount of sampling. Currently, baseline reports tend not to document sampling effort even though the effort is known. By recording sampling effort, it is possible to have a better sense of the possibility that sampling effort underlies differences among easements in reported biodiversity elements.

3.3  Cumulative species number as a function of sampling effort

Species lists comprise the raw data of any survey. Often the construction of these lists will require the
collaboration of experts at species identification. Whereas for some purposes simply tallying up “operational taxonomic units” is acceptable, for easements, it is key to establish species identities. This is especially the case because records of species may reveal extensions of known ranges that are important to document.

Species counts are especially valuable if they are presented as a cumulative species curve as shown in Figure 3. When curves of cumulative number of species saturate or level-off, as is the case for plants in Figure 3, it is an indication that the surveying has been relatively thorough and has likely captured most of the plant biodiversity on the parcel for that particular season. The accepted convention for these curves is that they are fit to one of two equations—both of which pass through the origin (meaning no survey, no species recorded):

\[ S_E = S_{\text{max}} \left(1 - e^{-BE}\right) \text{ or } S_E = ES_{\text{max}}/(E + B). \]

where \( S_E \) is the number of different species noted after \( E \) units of sampling (where \( E \) could be days, hours, meters walked, traps set, etc.), and \( B \) and \( S_{\text{max}} \) are constants to be fit to the data. \( S_{\text{max}} \) is the number of species expected if the sampling effort went to infinity.

“Effort” \( (E \) in the above equations) need not be something as rigid as hours walking a line transect looking only for plants, or looking only for lizards. Effort can refer to hours multitasking and looking for birds, plants, and anything of conservation interest. As long as effort is aptly described, a species accumulation curve has scientific value. By plotting these curves, one can compare properties, seasons, survey methods, and different years and gain a sense of how rapidly and easily one

| Date               | No. biologists | Duration (hours) | Effort (person-hours) | Activity                                                                 |
|--------------------|----------------|------------------|------------------------|--------------------------------------------------------------------------|
| November 19, 2019  | 5              | 1.5              | 7.5                    | Four biologists/divers did a reconnaissance by boat and prepared dive equipment. One biologist inspected parcel for locations of aquatic habitats. |
| November 19, 2019  | 5              | 2.5              | 12.5                   | In the Alabama River, two biologists in SCUBA searched for mussels. One biologist tended divers. Two biologists in mask and snorkel searched shallow areas. |
| November 19, 2019  | 1              | 0.5              | 0.5                    | One biologist examined intermittent creek.                                |
| November 20, 2019  | 2              | 1                | 2                      | Two biologists tended crayfish traps.                                     |
| November 20, 2019  | 5              | 2                | 10                     | In the Alabama River, two biologists in SCUBA searched for mussels. One biologist tended divers. Two biologists in mask and snorkel searched shallow areas. |
| November 21, 2019  | 5              | 2                | 10                     | In the Alabama River, two biologists in SCUBA searched for mussels. One biologist tended divers. Two biologists in mask and snorkel searched shallow areas. |
| November 21, 2019  | 2              | 0.5              | 1                      | Two biologists tended crayfish traps.                                     |
| November 21, 2019  | 4              | 0.75             | 3                      | Four biologists seined accessible areas along right descending bank for fish and crayfish. |

**TABLE 2** Description of sampling effort for aquatic habitats on an easement property in Elmore County, Alabama

**FIGURE 3** The cumulative number of species as a function of sampling effort for plants in an easement in Elmore County, Alabama. The dashed line is the best-fit curve to the data, where the curve takes the general form of standard species accumulation curves as a function of sampling effort, with \( S(E) = \# \) of species observed after \( E \) sampling effort, \( S_{\text{max}} \) = maximum possible species, \( E \) = some measure of sampling effort, and \( B \) is a fitted constant: \( S(E) = ES_{\text{max}}/(E + B) \). For this specific case, \( E \) is in “hours” of surveying, \( S_{\text{max}} \) is the maximum possible number of plant species, and PLANTS represents the number of different plant species detected as a function of hours spent surveying.
accumulates species. They represent a rapid biodiversity assessment tool. In the absence of such a curve, at a minimum one should find some way of documenting thoroughness of sampling. For example, one might note, “we conducted five seine hauls for fish and stopped when four hauls in a row failed to capture any species we had not sampled in previous hauls.”

3.4 Sampling to account for seasonality

Many species vary seasonally in terms of their activity or visibility (Dybala, Truan, & Engilis Jr, 2015). Some species may be associated with the spring, others with the summer or fall, and perhaps some in the winter. As a result of seasonality, an easement property should be visited during multiple seasons. The merits of this are evident in Figure 4, which reports the accumulation of species from surveys of birds in a 35.68-ha easement in Taylor County, FL (30.149768, −83.929174). In this case, bird surveys were conducted on January 26, 2020, on April 30 and May 1, 2020, and on October 8, 2020. The winter survey was completed in about 5 hours by two professionals; the late spring/early summer survey was completed in 10.5 hr by two professionals, and the fall survey was completed in 4.5 hours by two professionals.

3.5 Targeted sampling methods for unique species of special conservation value

While birds, plants, and fish in streams can be straightforward to sample, other species of conservation value may require highly specialized sampling methods. A good example of this is bats. Bats are among the most imperiled terrestrial vertebrates in North America due to a combination of disease (white-nose syndrome), habitat loss, and the increasing presence of wind turbines (Hammerson, Kling, Harkness, Ormes, & Young, 2017). As a result, documenting their occurrence on land protected by easements is a priority. Surveys for bats are challenging, because they are fast fliers, active at night, and unless captured by a trained expert, seldom can be visually identified to species. They will forage and migrate great distances and are constantly changing areas and habitat types for ecological and seasonal needs. Habitat requirements will also differ between sex and reproductive status. Although typical survey methods include mist netting, acoustics, habitat assessments, and hibernacula surveys, these methods may need to be implemented in a variety of ways, habitat types, height and orientation, and times of the year to successfully document certain species. All of these require special permits and certifications, and a level of expertise that involves years of training and experience. Only with such highly specialized and technically sophisticated sampling can bat presence or specific species on a site be reliably detected.

3.6 Summarize what is of high conservation value on the land

Species lists and total number of species are useful indicators, but because of the limited and varied sampling
efforts, these lists are likely to always be incomplete. However—if a species is documented on the land—and if that species is designated to be at risk, then that occurrence is significant. In other words, the best indicator of a property’s conservation value is the presence of species that have been officially designated as conservation priorities by state and federal agencies, and by internationally accepted indices of vulnerability such as NatureServe designations (https://www.natureserve.org/). For this reason, baseline reports, and all reports of the species found on private lands, should highlight the presence of any species that are threatened, endangered, or a candidate for listing by the U.S. Fish and Wildlife Service (USFWS). These are species that are globally imperiled, and species for which any occurrence is of global importance. Also to be highlighted is the occurrence of any species assigned with the NatureServe at-risk categories of S1, S2, or S3 in the state of concern. These rankings indicate that in that state the species have been assessed as being critically imperiled (S1), imperiled (S2), or vulnerable (S3). Consistently, species receiving these ranks in a state are prioritized in state conservation plans. For each property that is surveyed, a best practice would be to summarize the conservation assets via a table such as Table 3 for an easement in Escambia County, Alabama.

The value of best practices is that they allow anyone consulting baseline surveys to better interpret the absences of organisms of high conservation value. Absences could occur because sampling effort is insufficient, or because sampling occurs during the wrong seasons, or because sampling entailed methods that are unlikely to detect special species such as bats. When baseline reports follow the above best practices and make clear sampling effort in terms of quantity, timing, and method, the absence of high priority species can be better assessed. In addition, embracing best practices would allow one to return to the same site and re-survey, and better interpret any changes that are noted. The best practices we have outlined are a modest step toward standardization. They ensure essential background information for interpreting the data that are reported for private lands; they provide an inventory of species; and they may allow documentation of range shifts. However, because the methods and effort will vary from property to property, they are not sufficiently standardized to track population trends in the way breeding bird surveys or other highly regimented large-scale censuses allow one to estimate population trends (Hudson et al., 2017).

If one were to design an ideal national sampling protocol for temporal trends in the abundance of high priority species on private lands, it would demand far more standardization and uniformity than we have outlined above. Such standardization is not feasible for the enormous variety of land trusts engaged in conservation, with their varied staffs and resources. The one federal effort at a National Biological Survey (NBS) in 1993 was ill-fated for numerous reasons—one of which was the resistance

| Scientific name                  | Common name                        | State rank | Federal status |
|----------------------------------|------------------------------------|------------|----------------|
| **Mammals**                      |                                    |            |                |
| Tadarida brasiliensis            | Brazilian Free-tailed Bat          | S3         |                |
| Perimyotis subflavus             | Tricolored Bat                     | S2         | UR            |
| Myotis austroriparius            | Southeastern Myotis                | S2         |                |
| **Reptiles**                     |                                    |            |                |
| Macrochelys temminckii           | Alligator Snapping Turtle          | S3         |                |
| **Fishes**                       |                                    |            |                |
| Fundulus escambiae               | Russetfin Topminnow                | S3         |                |
| Ammocrypta bifascia              | Florida Sand Darter                | S3         |                |
| Percina austroperca              | Southern Logperch                  | S2         |                |
| Elassoma evergladei              | Everglades Pygmy Sunfish           | S3         |                |
| **Plants**                       |                                    |            |                |
| Xyris drummondii                 | Drummond’s Yellow-eyed Grass       | S3         |                |
| Muscadina rotundifolia var. munsoniana | Munson Grape               | S1         |                |
| Myriophyllum laxum               | Loose Water-milfoil                | S2         |                |
| Nuphar lutea ssp. ulvacea        | West Florida Cow-lily              | S1         | UR            |
to top-down imposition of federal scientists and standards (Krahe, 2012). Since the NBS effort was abandoned in 1996, there has been no renewed effort at developing a biological inventory for species that covered all lands (Krahe, 2012). Aggregating species records obtained from baseline surveys is not a substitute for the NBS envisioned in 1993, but it may be the only inventory of high priority species that is feasible in the near future. Even if one cannot make cross-easement comparisons or identify temporal trends with such an ad hoc collection of data, simply knowing where species of high conservation value have been documented is invaluable. This is especially the case in light of climate change, which is creating a demand for studies of the possibility of range shifts or range contractions for at-risk species. Using the database we envision, one could revisit sites where occurrences have been previously documented and see if the species of interest were still there.

4 HOW EFFECTIVE ARE 49 EASEMENTS IN ALABAMA AT PROTECTING HIGH PRIORITY SPECIES?

A useful way to visualize the value obtained from the conservation of additional properties is to graph the cumulative number of high priority species protected by the conservation easements as one goes from one easement, to two easements, to three easements, and so forth. This type of curve is analogous to the more standard species area curve such as that depicted in Figure 3—only in this case, it is not all species—but rather just species designated as high conservation priority. Figure 5 shows these curves for the portfolio of 49 Alabama easements drawn in two different ways: by number of easements, or by cumulative area of easements. Both graphs show a staircase increase to 116 species, and it is likely that adding even more easement protection would drive the curves higher—especially if those easements were placed in different areas of the state or in different habitat types. Figure S1 in Supporting Information shows the locations of these 49 easements.

The most striking result is that 116 high priority species are documented within only 3,048 ha in total—that is an astonishing number of 38 high priority species per 1,000 ha protected by easements.

To put this in context, it is useful to compare these 49 easements to federal and state conservation lands in Alabama, and to similarly focus on high priority species (S1, S2, S3 state rankings or threatened and endangered federally). For comparison sake, we sought a large public conservation area, for which there is a history of biological surveys with catalogued data that was closest in habitat attributes and geography to the 49 properties in our portfolio of parcels protected by easements. The Conecuh National Forest (hereafter CNF), which is 33,993 ha of forested habitat, shares many of the same soil types and habitats. Specifically, both CNF and the portfolio of easements include riparian forest, isolated wetlands, seepage bogs, sandhills, and upland pine forest (Graham et al., 2015).
There are 159 high priority species documented for CNF (Alabama Department of Conservation and Natural Resources, State Lands Division, Natural Heritage Section: data request fulfilled October 29, 2020, and Alabama Natural Heritage Program, Auburn University, Alabama: data request fulfilled October 29, 2020). The list of these species is given in Table S2. The comparison of CNF species records to easement data is complicated because the sampling methods are not the same. The species list for CNF was obtained by unifying two data sets: Alabama Department of Conservation and Natural Resources, State Lands Division and the Alabama Natural Heritage Program, Auburn University. The observations that went into creating these data sets come from a variety of sources. One source is the concerted effort of biologists to report their findings voluntarily, and program staff scouring existing databases of university museums and herbaria. A second source is an effort by employees of the Natural Heritage Section to review research papers and museum specimens to contribute to the database. Finally, much of the data is acquired from annual reports filed by researchers who requested Scientific Collection Permits issued by the Alabama Wildlife and Freshwater Fisheries Division. This mix of methods does not lend itself to the easily interpreted cumulative species curves associated with adding easements to a portfolio of private land protection. Moreover, the State Lands Division database cannot be conveniently searched for date of first occurrence. The Heritage Program data does have a record of first occurrences that is readily obtained. To gain some sense of the prospect of finding more species with more sampling, we used the Heritage Program records of first occurrences, and generated a cumulative species curve for CNF (Figure 6).

What is evident from Figures 5 and 6 is that the curves are still increasing. This means more sampling will likely uncover more species records for CNF, and adding more easements is likely to increase the number of high priority species on private land.

In spite of sampling ambiguities, it is still informative to compare the data from the 49 private properties with the data from CNF. The 49 private land properties averaged a significantly larger number of priority species per unit area than did the large national forest: 38 high priority species per thousand hectares for the private lands versus 5 high priority species per thousand hectares in the national forest. As a result, with only 9% of the area of the CNF, the 49 private properties reported over 70% of the number of high priority species documented from the much larger CNF. Moreover, these small private properties reported 92 high priority species not documented in the larger national forest (see Table S3). This observation makes clear the complementarity of public land conservation and private land conservation—private lands are harboring species not found on public lands, and vice versa.

At first glance, it might seem surprising that small parcels of private land so dramatically outperform large public conservation areas. However, the intensity of sampling devoted to the 49 private properties likely greatly exceeds the intensity of sampling on public lands. Given more time for sampling, we might expect the contrast in species per thousand hectares between CNF and easement portfolio to diminish. Second, numerous studies have indicated that public lands often correspond to areas of low productivity and are sometimes placed opportunistically as opposed to for particular at-risk species (Scott et al., 2001). Public lands serve multiple functions such as recreation and watershed protection, whereas the easements in this study have been selected primarily for species targets.

The large number of high priority species might at first seem surprising. However, these parcels of land are a highly nonrandom sample. First, Alabama is a hotspot for threatened, and hence high priority species targets. Second, these properties tended to include caves or habitats attractive to bats, as well as an abundance of aquatic habitats. Finally, professional biologists working for land trusts have conducted baseline surveys to document conservation value for all 49 of the easements in this study. We doubt that randomly selected private lands would yield so many high priority species. It is also worth...
noting that many, if not most of these easements were at risk of habitat conversion either because they overlaid granite and rock deposits that are vulnerable to mining in pursuit of materials used in construction aggregates, or because they are in areas expected to see development from nearby cities. The key result that warrants highlighting is: the protection of private lands can secure habitats in which numerous high-priority species are documented. Since Alabama, compared to other states, is deficient in both private land conservation and public land conservation (Figure 2), these data confirm the value of increasing the amount of land devoted to conservation in Alabama—especially given the species accumulation curves shown in Figure 5.

Finally, the curves depicted in Figure 5 represent only the accumulation of at least one record for a species. In fact, as one adds land parcels under easement protection one adds multiple occurrences of species. We know from basic population biology that multiple occurrences of threatened and endangered species can enhance their chances of survival (Mace et al., 2008). This additional benefit is being realized in the 49 properties that comprise this analysis. Specifically, the federally threatened gopher tortoise is found on two different parcels of land and the federally threatened wood stork is found on five different parcels of land.

5 | DISCUSSION

Conservation biologists have long emphasized the importance of private land for the protection of biodiversity in the United States (Rissman et al., 2007). There are four strategies available for protecting species-at-risk on private land: (a) acquisition of the land by government, (b) acquisition of land by nonprofit land trusts with conservation missions, (c) involuntary government regulations, and (d) voluntary easement agreements that protect the lands in perpetuity. Easements offer the advantage of cost-effectiveness and maintaining the lands in the hands of private citizens who can sell the land or leave the land to their children, and can conduct certain activities in accord with the easement terms (Korngold, 2010; Parker, 2002; Parker, 2004). For that reason, conservation land trusts have increasingly turned to easements as the primary tool for private land conservation.

The open question is how effective are easements at protecting parcels of land for which there are documented occurrences of high priority species (Merenlender, Huntsinger, Guthey, & Fairfax, 2004). Effectiveness entails four key facets: (a) is habitat degradation or conversion halted? (b) from a landscape ecology perspective is the easement well situated? (c) is the land under risk of development or conversion? and (d) does an inventory of species document the presence of at-risk or high conservation value species? This article and the data we present address only the last dimension of effectiveness—are high priority species present? In some sense, this is the most fundamental question since an answer of “No” would suggest the other facets of effectiveness might not even be worth examining. In addition, as mentioned in the introduction, inventories of directly observed high priority species on easement lands are lacking in the peer reviewed literature.

Our results make clear that the easements surveyed in this study are highly effective when measured by the number of high priority species with documented occurrences. It is essential to extend this research to other states and habitat types so that we can determine the generality of our findings. There is certainly a possibility of conducting similar assessments across the nation, since professional biologists routinely visit easements in every state to provide baseline reports for land trusts. Something as simple as a PDF library of these reports could be searched for species occurrences. Even more useful would be an effort to moderately standardize the format of baseline survey reports. The Land Trust Alliance (LTA) describes itself “as the national leader in policy, standards, education and training” (https://www.landtrustalliance.org/what-we-do). The LTA formally accredits land trusts, holds annual meetings, and is the only national organization that reviews and establishes easement best practices. It was established in 1982 and has since grown to be a strong organization with a large membership representing all sizeable land trusts, and many of the professional biologists who conduct baseline surveys and easement monitoring. Consequently, it would make sense for the LTA in collaboration with local universities and the Natural Heritage program to promote this standardization. The data itself could be housed in the National Conservation Easement Database (NCED) (see https://www.conservationaleasement.us/about/). NCED is a national database of conservation easement information, compiling records from land trusts and public agencies. Spatial shape files are not always available but the hectares protected and general location of most of the nation’s easements can be found in NCED. It would not be much work to create an option of associating baseline survey data with each easement that is entered into the NCED. Another organization that could be helpful in initiating an easement data system is National Center for Ecological Analysis and Synthesis (NCEAS). NCEAS hosted landmark studies on federal recovery plans and on habitat conservation plans, and in the same vein could initiate a synthesis of easement data.
that could get this effort underway.

We hope with this article to prompt a conversation about the feasibility, possible pathways, and funding opportunities for curating data from baseline surveys of easements into a national inventory of biodiversity on private conservation lands. All of the best practices outlined in this article will enhance the quality of data associated with baseline surveys. However, two best practices are absolutely essential if the scientific value of baseline surveys is to be realized: (a) quantifying the amount of sampling effort that was involved in any survey, and (b) providing a clear description of the methods of surveying. In a time of rapid climate change and a nation with so much biodiversity on private land, the absence of these data mean we are “flying blind” in terms of protecting our nation’s priceless biodiversity. If we combined the threat of land conversion with these species surveys, we could evaluate the extent to which the placement of easements was optimal in terms of reducing extinction per dollar cost (Newburn et al., 2005). A national database would also benefit conservation practice by potentially detecting range shifts, and highlighting species that do not show up on any public or private conservation lands, and that hence need special attention.

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CONFLICT OF INTERESTS
The authors declare no financial or other conflicts of interest.

AUTHOR CONTRIBUTIONS
Peter Kareiva: Helped design the standardized best practices and took the lead on writing the manuscript and analyzing the data. Mark Bailey: Contributed to the study design and writing, and surveyed easement parcels for species. Dottie Brown: Contributed to the study design and writing, and surveyed easement parcels for species, and had primary responsibility for bat surveys. Barbara Dinkins: Contributed to the study design and writing, and surveyed easement parcels for species. Lane Sauls: Contributed to the study design and writing, and surveyed easement parcels for species. Gena Todia: Contributed to the study design and writing, and surveyed easement parcels for species.

DATA AVAILABILITY STATEMENT
The Supporting Information lists the high priority conservation species reported in each easement, along with the location and area of the easement. It also includes the list of high priority species in the Conecuh National Forest. These represent all of the original primary data in the paper, from which the major figures and conclusions are drawn. Any other data are from publicly available websites.

ORCID
Peter Kareiva https://orcid.org/0000-0002-5330-2585

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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