Received: 12 June 2022 | Revised: 17 November 2022 | Accepted: 28 January 2023

DOI: 10.1111/csp2.12897

CONTRIBUTED PAPER

Conservation Science and Practice
A journal of the Society for Conservation Biology
Open Access

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Leveraging private lands to meet 2030 biodiversity targets in the United States

Melissa Chapman | **Carl Boettiger** | **Justin S. Brashares**

Department of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley, California, USA

Correspondence
Melissa Chapman, Department of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley, CA, USA.
Email: mchapman@berkeley.edu

Abstract

Coincident with international movements to protect 30% of land and sea over the next decade ("30×30"), the United States has committed to more than doubling its current protected land area by 2030. While publicly owned and managed protected areas have been the cornerstone of area-based conservation over the past century, such lands are costly to establish and have limited capacity to protect areas of the highest value for biodiversity conservation and climate change mitigation. Here we examine the current and potential contributions of private land for reaching 30×30 conservation targets at both federal and state scales in the United States. We find that compared to publicly owned and managed protected lands, protected private lands (conservation easements) are more often in areas designated as high conservation priority, hold significantly higher mean species richness, and sequester more vulnerable land-based carbon per unit area. These and related findings highlight the necessity of mechanisms that engage private landholders in enduring conservation partnerships.

KEYWORDS

30×30, biodiversity, climate change mitigation, climate resilience, conservation easements, protected areas

1 | INTRODUCTION

Following another decade of accelerating biodiversity loss (Buchanan et al., 2020), the Convention on Biological Diversity (CBD) ratified a post-2020 global biodiversity framework in December of 2022. Largely coalesced around the promise of protecting 30% of the Earth's land and sea by 2030 ("30×30"), this framework will influence the next decade of global conservation policies and biodiversity outcomes (Maxwell et al., 2020; Tsioumani, 2020). In hopes of not repeating the shortcomings of past area-based conservation targets (Buchanan et al., 2020), scientists and policymakers have emphasized modern definitions of land conservation that recognize the importance of other effective area-based conservation measures (OECMs), Indigenous and Community Conservation Areas, and private protected areas for meeting biodiversity and climate mitigation goals (Clancy et al., 2020; Drescher & Brenner, 2018; Maxwell et al., 2020).

The United States was among countries to pass a legal mandate in response to early drafts of the post-2020 CBD biodiversity targets. In a 2021 Executive Order on "Tackling the Climate Crisis at Home and Abroad," the Biden administration committed to conserving 30% of United States lands and waters by the year 2030, with the broader goals of safeguarding food production and biodiversity while mitigating climate change (Exec. Order No. 14008, 2021). With less than 15% of current U.S. lands permanently protected in areas managed for biodiversity (USGS, 2018), meeting this target will require an unprecedented expansion of land protection over the next decade. While the definition of what lands will count towards the 30% target remains controversial, existing definitions have largely settled around areas classified as GAP 1 or GAP 2 ("managed for biodiversity"; USGS, 2018), of which fee-owned protected areas managed by local, state, and federal agencies account for a large portion in the United States. However, fee-owned protected areas can be legally cumbersome to implement (aside from National Monuments established under the Antiquities Act), costly, and have displaced communities and negatively impacted livelihoods (West et al., 2006), in some cases counter to equity goals integral to 30×30 objectives. Moreover, despite the increasing prevalence of tools to support spatial conservation planning and conservation prioritization (Dreiss & Malcom, 2022; McIntosh et al., 2017; Sinclair et al., 2018), several studies suggest protected areas established to date overlap poorly with priority areas for biodiversity conservation (Jenkins et al., 2015; Maxwell et al., 2020) and species climate refugia (Dreiss et al., 2022).

To meet ambitious area-based targets more equitably while effectively addressing their core ecological objectives, proposed pathways to 30×30 in the United States have emphasized broader engagement with conservation outside of traditional protected areas, including private and working land conservation. Private land protection measures, including private reserves, land trusts, and conservation easements, have long contributed to land conservation in the United States despite representing only a small fraction of the total land under protection (Ernst & Wallace, 2008). However, private lands are increasingly considered critical for creating functional, connected, and climate-resilient protected area networks (Bargelt et al., 2020; Dreiss et al., 2022; Gigliotti et al., 2022; Morgan et al., 2019). While private land conservation takes many forms, conservation easements—voluntary legal agreements that permanently limit the uses of private land to protect conservation values—have garnered particular interest from conservation initiatives in the United States and elsewhere due to their cost-efficacy and legal flexibility (Capano et al., 2019). While a large body of literature has examined drivers and impacts of conservation easement adoption (Stroman et al., 2017), management attributes (Rissman et al., 2007), and efficacy (Merenlender et al., 2004), quantifying the value of conservation easements for biodiversity at a national scale has been impeded by a lack of centralized data on parcel delineations.

Private and working land contributions to land protection provide the opportunity to engage broader portions of the population in conservation action. However, whether they simultaneously stand to reduce the mismatches between lands managed for biodiversity and biodiversity distributions themselves remains to be seen. Studies exploring the mismatch of protected areas and biodiversity to-date have largely ignored how OECMs, such as private land conservation, comparatively align with areas of high conservation priority (Jenkins et al., 2015; Maxwell et al., 2020). Those studies that have assessed the distributions of private land conservation measures contributions relative to biodiversity targets have done so at local or state scales (Graves et al., 2019; Kareiva et al., 2021) or without consideration for subnational differences and temporal trends (Clancy et al., 2020; Dreiss & Malcom, 2022). Without a systematic understanding of the relative capacity of private land conservation to target key biodiversity areas and opportunities for climate change mitigation, it is difficult to assess where and when the emphasis on private lands is a well-informed policy direction for expanding area-based conservation.

Here, we used the national compilation of spatial data on conservation easements (National Conservation Easements Database [NCED]) to quantify how well existing conservation easements have targeted land with high biodiversity and land-based climate mitigation value. Synthesizing data from the NCED alongside distributions of biodiversity priority areas (Jenkins et al., 2015), current species richness (IUCN, 2020), projected species richness under climate change (Lawler et al., 2020), and vulnerable above and below ground carbon (land-based carbon likely to be emitted in an average land conversion event) (Noon et al., 2021), we assessed the conservation value of (1) easements relative to fee-owned protected areas and (2) unprotected public lands relative to all other lands ("nonpublic") across the United States. Further, we explored how the distributions of protected areas and conservation easements relative to biodiversity and carbon priorities vary spatially (across subnational boundaries) and temporally (over the past two decades). Taken together, our analyses provide a view into the potential of private lands to complement traditional protected area contributions to meeting qualitative elements of 2030 conservation targets, such as climate change mitigation and climate resilient biodiversity protection.

2 | METHODS

2.1 | Data

We acquired protected area and conservation easement delineations from the United States Protected Area

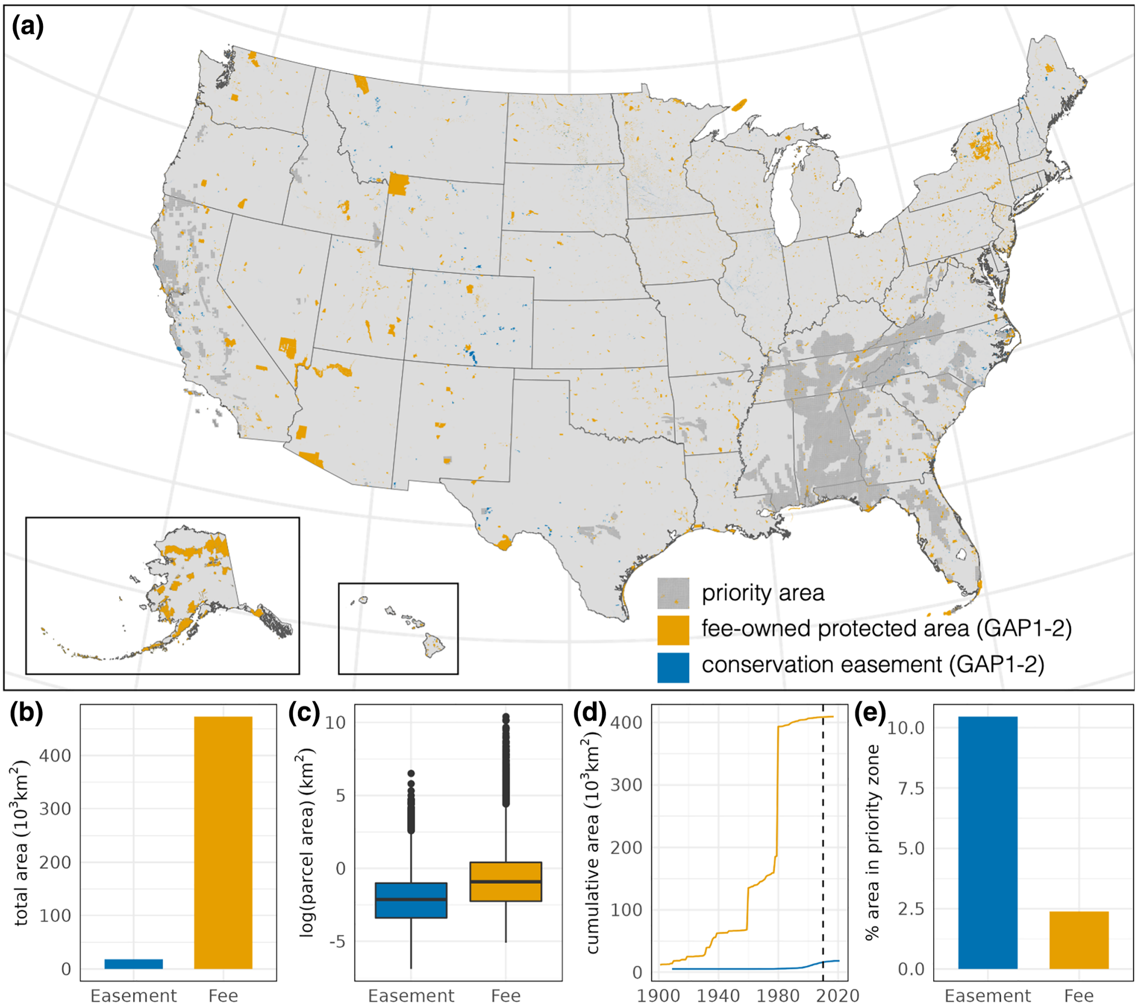

FIGURE 1 (a) Map showing GAP 1 and GAP 2 fee-owned protected areas and conservation easements across the United States. Dark gray areas indicate areas in the top 10th percentile according to a conservation priority ranking. (b) GAP 1 and 2 conservation easements account for a smaller area of land managed for biodiversity in the United States (3.9%) and are (c) on average smaller per individual management boundary than protected areas. (d) While conservation easements have a long history of contributing to protection in the United States, the past two decades have seen a significant increase in the area under easements managed specifically for biodiversity. (e) A higher percentage of GAP 1–2 conservation easements (10.4%) are within conservation priority zones compared to GAP 1–2 protected areas (2.4%).

Database (PAD-US 2.0) (USGS, 2018) and conservation easements data from the National Conservation Easements (NCED) (NCED, 2020), which contains over 130,000 easements (an estimated 60% of all U.S. easements). We restricted our analysis of "protected areas" to federal, state, and local fee-owned conservation lands managed for biodiversity (protected areas "managed for biodiversity" are classified as GAP 1 and GAP 2; USGS, 2018). Note that fee-owned conservation lands are not inclusive of all protected area designations or proclamations, just those parcels that are owned (USGS, 2018). Similarly, we include only conservation easements managed for biodiversity (also classified as GAP 1 or GAP 2) in the analysis of "protected" private land (Table S1). Protected area classification (GAP status) is imperfect but aligns with the definition used by current 30×30 policies in the United States. Throughout the paper, we refer to these two categories of land designations as simply "protected areas" and "conservation easements." Protected areas and conservation easements with invalid or missing geometries in the PAD-US dataset were excluded from the study. Our final dataset included 1362 protected areas and 4491 conservation easements managed under GAP 1 criteria (fully protected and allowing only for natural disturbances), and 21,502 protected areas and 16,382 conservation easements under GAP 2 criteria (fully protected and allowing for management action) (Figure 1a; Table S1). We compared biodiversity and climate mitigation values in our set of GAP 1 and 2 protected areas and conservation easements with those of all fee-owned public lands and all non-fee-owned public lands. For those analyses, we defined "public lands" as any federal, state, and local land in the fee-owned PAD-US database (regardless of GAP status). All other lands were considered "nonpublic land."

Biodiversity priority areas were delineated using land in the 10th percentile of biodiversity priority index values in the United States (details on biodiversity priority indices can be found in Jenkins et al., 2015). Current species richness and CRENVU (critically endangered, endangered, and vulnerable species) richness was estimated using IUCN data (IUCN, 2020). While there are several alternative methods for mapping species richness (e.g., species distribution models), there is no evidence to suggest that range maps would be systematically biased towards one given land protection measure over another. We calculated future species richness using projected range distributions from Lawler et al. (2020). Future ranges were estimated for each species under three high emissions (RCP 8.5) climate change scenarios (Lawler et al., 2020). To align with IUCN richness data, we approximated future richness as the number of species ranges that overlap in each pixel (5 km^2 resolution) using the mean of all three climate scenarios. While RCP 8.5 is not necessarily the most plausible climate trajectory, it was the only available scenario for projected species range data (Lawler et al., 2020) at the time of submission and provided an important contrast to current climate conditions. To assess climate change mitigation contributions of lands across management types, we used vulnerable carbon maps, which estimate the carbon that would be lost under a land conversion event (Noon et al., 2021).

2.2 | Analysis

We calculated mean species richness values for current, and future species distributions across public and private conservation units in R. Main figures represent overall differences in richness metrics and vulnerable carbon (area-weighted means across all conservation easements and public protected parcels). Differences in mean richness and carbon density values across individual protected areas and conservation easements through time were assessed using the Mann–Whitney test. Temporal analysis was based on the time of the protected area or easement establishment. We used propensity score matching to estimate the average marginal difference of mean species richness and carbon density between conservation easements and protected areas parcels accounting for the potentially confounding effect of the area of parcels (Tables S4 and S5).

3 | RESULTS

3.1 | Conservation in key biodiversity areas

Conservation easements managed for biodiversity (GAP 1 and GAP 2; see Section 2 for additional details) account for 3.9% of the total area of equivalently managed local, state, and federal fee-owned protected areas (Figure 1b). Additionally, conservation easements are on average smaller per management unit than protected areas (Figure 1c). Over the past 20 years, conservation easements have increased in their rate of adoption relative to protected areas (Figure 1d). While conservation easements are typically smaller and account for less total area than protected areas, they are more likely to overlap with land identified as a biodiversity priority (Figure 1e; see Section 2 for additional details). Despite a higher percentage of easements in biodiversity priority areas, the total area of conservation in biodiversity areas is predominately fee-owned protected areas (83%).

Both nonpublic lands and conservation easements have higher mean species richness than background U.S. lands (all lands within U.S. borders) (Figure 2a,b) and GAP 1 and 2 protected areas and public lands overall (public lands estimated as all lands not included in PAD-US Fee GAP 1–4; Section 2) (Figure 2). Overall, nonpublic lands have higher richness values across than public lands (GAP 1–4) and compared to total background values across all U.S. lands. However, when looking only at vulnerable, endangered, and critically endangered (CRENVU) species, public lands overall have higher mean richness values compared to nonpublic lands (Figure 2).

3.2 | Climate-resilient biodiversity conservation and land-based climate change mitigation

Under future climate change scenarios (high emissions: RCP 8.5), conservation easements and protected areas both poorly track projected background mean species richness values across all U.S. land (Figure 2c). However, conservation easements and nonpublic lands again have higher mean values than protected areas and public lands (Figure 2c). Contributions to climate mitigation also varied across protected areas and conservation easements. Easements and nonpublic lands had higher vulnerable carbon per unit area basis than protected areas and public lands (Figure 2d; Tables S3 and S5).

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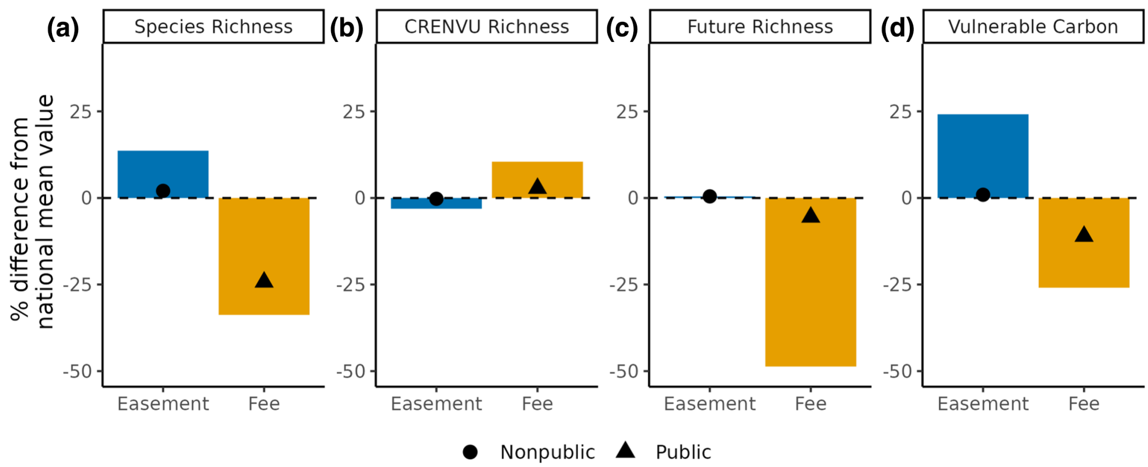

FIGURE 2 Plots show the percent difference of mean species richness in GAP 1 and 2 conservation easements and protected areas from background mean values (for all land in the United States). Black points indicate percent mean difference from background values for current public lands GAP 1–4 (as a proxy for background "public" land) and all land that is not public (as a proxy for background "nonpublic land"). Private lands under conservation easement more effectively track areas of the United States with (a) higher species richness, (c) projected future richness (2100; RCP 8.5), and (d) vulnerable carbon density (carbon likely to be lost in an average land conversion event) than GAP 1–2 fee-owned protected areas. (b) Fee-owned protected areas have a higher mean CRENVU (critically endangered, endangered, and vulnerable species) richness value than conservation easements. Nonpublic lands have higher mean values for all metrics (a, c, d) aside from CRENVU richness (b), which is slightly higher in public lands.

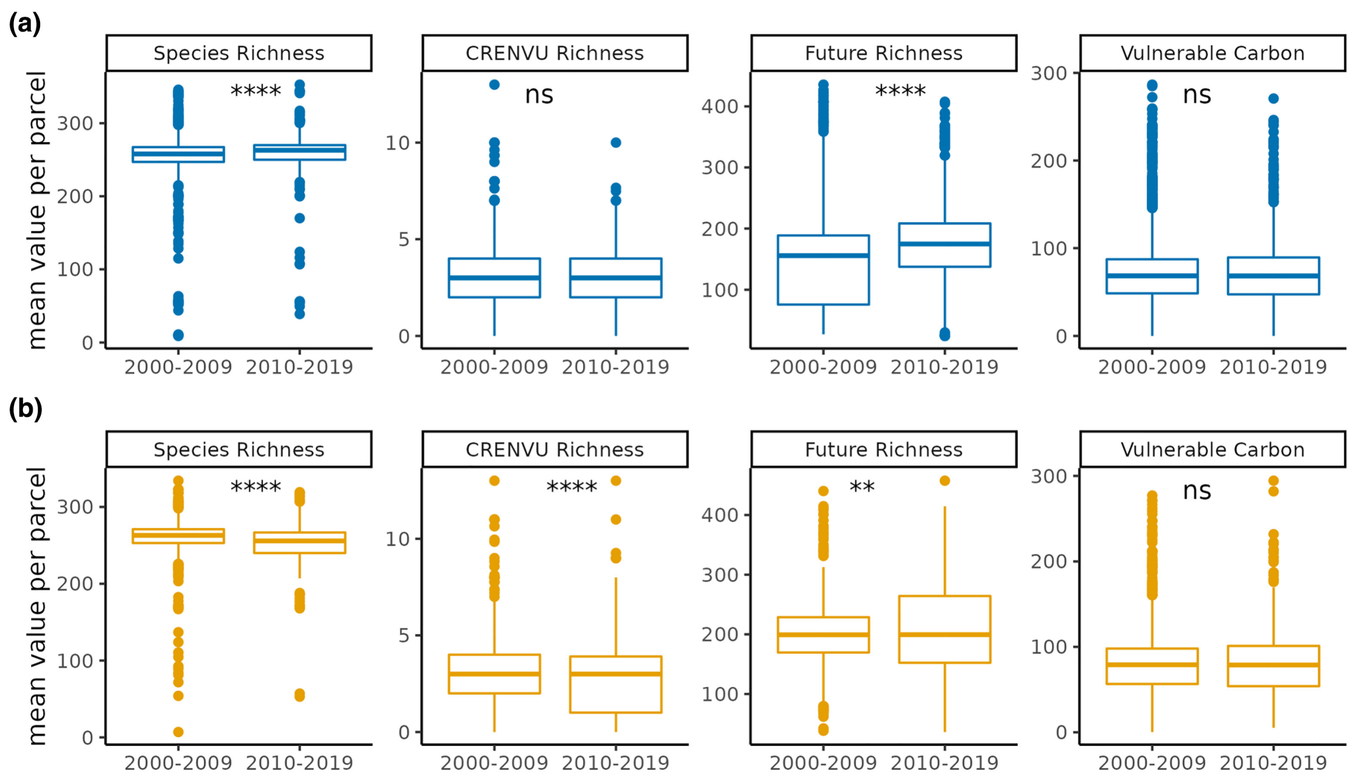

FIGURE 3 (a) Distributions of established conservation easements (GAP 1 and GAP 2) have on average better-tracked species richness and projected future richness over the past decade (2010–2019) in comparison to the previous decade (2000–2009). There has been no significant change in the mean vulnerable carbon density or CRENVU (critically endangered, endangered, and vulnerable species) richness in easements over the past two decades ($p > .05$; NS). (b) By contrast, established protected areas have decreased in species richness, CRENVU species richness, and future richness metrics and have not measurably changed across vulnerable carbon density (****, $p < .001$; NS, $p > .05$). Plots show mean values across all parcels, first quartile to the third quartile. The points extend from each quartile to the minimum or maximum.

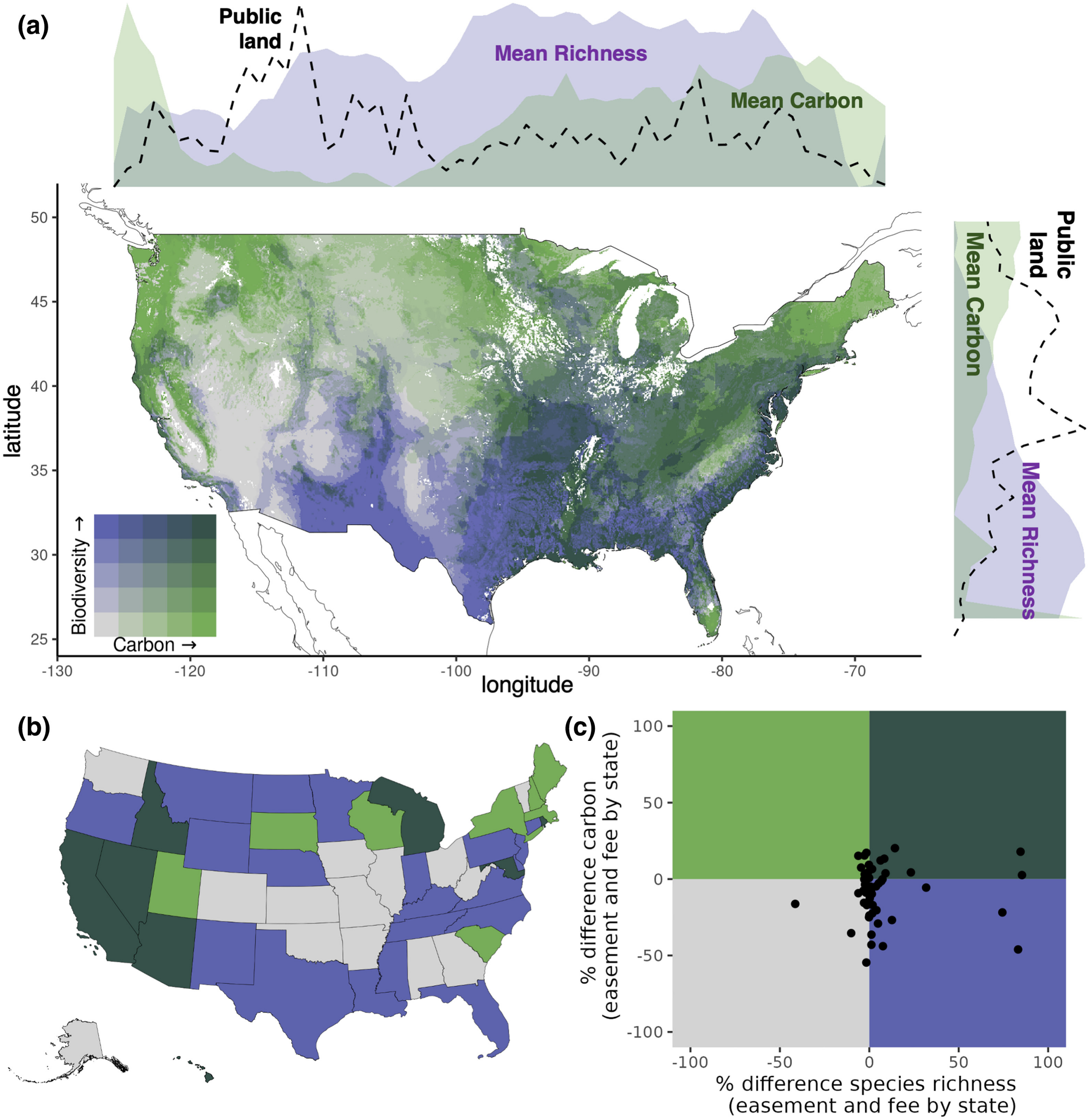

FIGURE 4 While public lands poorly track biodiversity and vulnerable carbon across the United States, particularly compared to private lands and conservation easements (Figure 2), these patterns do not hold true for all states. (a) Bivariate map showing the distribution of vulnerable carbon density and species richness across the United States. Side distribution graphs show the density per degree of public land, carbon density, and species richness across latitude and longitude. (b) In 36/50 states, conservation easements have higher mean richness and/or carbon density than fee-owned protected areas within the same state (all states not in grey). (c) However, the percentage difference between conservation measures between states varies across these metrics. Positive values represent higher metrics in conservation easements compared to fee owned protected areas in a given state.

3.3 | Changes in the distribution of conservation areas established during the 21st century

Distributions of conservation easements newly established over the past decade (2010–2019) have better-tracked species richness (mu = 259.6, SD = 22.8) and projected future richness (mu = 172.6, SD = 70.3), in comparison to species richness (mu = 256.3, SD = 22.5, $p < .001$) and projected future richness (mu = 145.6, SD = 75.0, $p < .001$) in conservation easements established in the previous decade (2000–2009) on a per parcel

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basis (Figure 3a). There has been no significant change in the mean vulnerable carbon density or CRENVU richness in easements established from 2000 to 2009 and from 2010 to 2019 (Figure 3a). By contrast, newly established protected areas over the past decade (2010–2019) have significantly decreased in mean CRENVU species richness (mu = 2.7, SD = 1.6) compared to mean CRENVU species richness of protected areas established in the previous decade (2000–2009) (mu = 3.2, SD = 1.6, $p < .001$). Species richness in parcels established 2000–2009 (mu = 260.5, SD = 25.19) was also higher than 2010–2019 (mu = 252.4, SD = 28.2, $p < .001$). There has been no significant change in mean future species richness (mu = 198.2, SD = 58.6), or vulnerable carbon density (mu = 82.4, SD = 40.3) in protected areas established between 2000 and 2009 compared to the future species richness (mu = 211.8, SD = 58.6, $p = .15$), or vulnerable carbon density (mu = 82.1, SD = 43.8, $p = .89$) in protected areas established between 2010 and 2019 (Figure 3b).

3.4 | Subnational distributions of conservation areas

Public lands and public protected areas do not track species richness or vulnerable carbon distributions as effectively as nonpublic lands and conservation easements across the United States (Figure 2a,d, Figure 4a). However, this pattern is more nuanced on a subnational scale. In 36/50 states (72%), conservation easements have higher mean richness and/or carbon density values than fee-owned protected areas within that state (Figure 4b,c).

4 | DISCUSSION

Meeting post-2020 biodiversity targets will undoubtedly rely on policies that synergistically incentivize expansion of a variety of conservation measures while targeting areas of high conservation priority. However, doubling the area of conservation land in the United States over the next decade while prioritizing land with high biodiversity and climate mitigation value will require significant investment in, and expansion of, private land conservation measures. We show that private land conservation instruments (conservation easements) better target areas with high biodiversity priority (Figure 1e), high species richness (Figure 2a), and high climate mitigation potential (Figure 2d) relative to federal and state-owned protected areas managed for biodiversity across the United States. Additionally, the average conservation value of public and nonpublic lands shows that nonpublic lands hold the majority of currently unprotected land with high biodiversity and climate mitigation value (Figure 2). Protected areas are well targeted towards regions with high CRENVU (critically endangered, endangered, and vulnerable species) richness compared to background land and conservation easements. Moreover, public land distributions more closely track CRENVU species richness relative to nonpublic lands (Figure 2c), highlighting the importance of complementary approaches to land protection. We also show that conservation easements, unlike public protected areas, have significantly improved their targeting of areas with high biodiversity and climate mitigation value over the past two decades (Figure 3), suggesting that private land conservation measures may have more capacity to respond to conservation priorities than public land acquisitions.

As conservation practitioners decide where and how to protect land, considering the potential impacts of climate-driven species range shifts is critical to ensure resilient networks of protected lands over the next decade. Examples of misguided land conservation due to shifting ranges of critical species are plentiful (Hannah et al., 2007). Our analysis shows that both protected areas and conservation easements were less targeted towards lands with high species richness under climate change (Figure 2) compared to the richness in current climate conditions (Figure 2), suggesting that climate resilient biodiversity conservation will require more effective prioritization of lands that are projected to be important for biodiversity. Similar to our analysis of current species richness distributions, nonpublic land holds the highest density of projected future species richness overall and thus should be central in designing climate resilient pathways to achieving 30% national protection.

While richness metrics are only one component of biodiversity, they are a commonly used proxy to prioritize and assess the distribution of conservation relative to key biodiversity areas (Jenkins et al., 2015; Mason et al., 2020). However, exploring other biodiversity metrics, such as functional and phylogenetic diversity, as well as considerations commonly used in planning reserve networks, such as complementarity, connectivity, and endemism, will be critical to prioritizing investment in all conservation areas to most effectively reach 30×30 objectives.

Designing climate resilient biodiversity protections is important given current emissions trajectories. However, simultaneously investing in land-based climate mitigation is critical to slowing climate change (Griscom et al., 2017) and its impact on biodiversity (Thomas et al., 2004; Urban, 2015). Land-based climate mitigation pathways (among other emissions reduction pathways) are a central objective of post-2020 area-based conservation targets (Exec. Order No. 14008, 2021). Unsurprisingly, conservation easements accounted for a smaller portion of total vulnerable above and below ground carbon than protected lands due to being only a fraction of the area of fee-owned protected areas. However, we found that conservation easements store significantly more vulnerable carbon than protected areas per unit area basis (Figure 2). Like the limited scope of richness metrics explored, vulnerable carbon densities only represent one component of land-based climate mitigation contributions and potential. While nonpublic lands hold the important potential for significant progress towards land-based climate mitigation, considerations beyond the vulnerable carbon are worthwhile to explore in any planning or prioritization process.

While area-based conservation targets, such as 30×30, risk incentivizing the protection of cost-effective and opportunistically available land rather than land with high biodiversity conservation and climate mitigation value (Baldi et al., 2017), further analysis on the relative costs of land acquisition and easements (Schöttker & Santos, 2019), as well as the alignment of priority areas and land costs (Nolte, 2020), will be critical to ensuring conservation of key areas.

In this paper, we compare only conservation easements and publicly managed fee-owned protected areas. While these two conservation measures are central components of the current 30×30 strategy throughout the United States, many OECMs will be critical to meeting 30×30 targets and their underlying objectives, particularly on nonpublic lands. Policies that prioritize long-term support for tribal establishment and administration of tribally protected landscapes and other tribally managed or co-managed areas are crucial for realizing the potential biodiversity and climate mitigation contributions of land conservation across the United States.

4.1 | Sub-national policy and private land conservation

Our analysis focused on private land conservation distributions nationally. However, implementation of 30×30 targets in the United States (and likely in other countries) will primarily be driven by sub-national governing bodies (Convention on Biological Diversity, 2020). On the sub-national scale in the United States, private land protections have already been featured in several state-based 30×30 executive orders (e.g., California). Patterns at a national scale suggest the critical contributions and potential of private land conservation measures for biodiversity and climate mitigation on the aggregate (Figure 1 and Figure 2). However, this is more nuanced at the state scale (Figure 4b,c). In some states, nonpublic lands and conservation easements possess mean values of species richness and/or carbon density that fall below background averages within that state. These same lands might be higher than background values at the national scale, driving the patterns seen on the aggregate. This does not negate the importance of national-scale patterns and their implications for federal 30×30 policy and pathways. Rather, it suggests that state-scale policy must consider the unique characteristics of localized ecology and land ownership patterns. A deeper exploration of the sub-national distribution of nonpublic and public land relative to biodiversity and carbon distributions will be critical to ensuring that policies align with the resources in a given governance unit rather than assuming national scale patterns are relevant at smaller scales (Kareiva et al., 2021).

Comparative analyses of the distributions of private land conservation measures across subnational boundaries will also be critical to understanding sociopolitical contexts that impact the distribution of private land conservation measures and how that can inform pathways to meeting large-scale conservation targets. Investigating differences in the conservation value of public and nonpublic lands across sub-national scales of governance may also help clarify the mechanisms driving the patterns of private and public land protections on the national scale. Additionally, understanding the structure of private land initiatives or public-private partnerships that are actively working towards spatial coordination of protection and biodiversity will be central to improving conservation targeting over the next decade.

4.2 | Avoiding pitfalls of private land conservation

Despite the promise of private land contributions to biodiversity protection and climate mitigation, conservation easements and other private land protection measures have been criticized for ineffective management and monitoring, as well as inequitable access and outcomes. Private land protections are often opaque in their implemented management practices, particularly when compared to publicly managed lands (Drescher & Brenner, 2018). Further, monitoring the impact of management practices on private land at a national scale is difficult and disjointed. But systematic monitoring of private lands will necessarily raise privacy concerns, potentially dissuading the adoption of agreements in critical areas. Further, private land conservation measures, including conservation easements, may disproportionately benefit high-income landowners, often limit public access, and are rooted in legacies of racial capitalism and environmental injustice (Van Sant et al., 2020). Mitigating these issues through broader community engagement, locally-defined monitoring protocols, and increasing public access will be critical to ensuring private land conservation contributes to the equity and access targets of post-2020 conservation goals.

Finally, it is notable that conservation easements typically conserve smaller parcels than protected areas (Figure 1c), potentially resulting in patchier landscapes and increasing the impact of edge effects (Woodroffe & Ginsberg, 1998). However, categorizing parcels of protection as either "small and targeted" or "large and mismatched" is a false dichotomy—parcel size of either conservation easements or protected areas is not correlated with species richness or carbon densities in the United States (Figures S1 and S2). When accounting for the area of the parcel as a covariate, easements had significantly higher richness values per parcel basis (Tables S4 and S5). Still, smaller parcels are likely to be more common in private land protections due to land ownership patterns in the United States. Thus, strategies to spatially cluster easements in high-priority areas may help ameliorate edge effects and improve connectivity.

5 | CONCLUSION

Despite numerous transnational environmental initiatives over the past 50 years, biodiversity loss, land conversion, and climate change continue accelerating (Butchart et al., 2010; IPCC, 2014). The urgency of expanding land protection to halt biodiversity loss will require flexible and expedient pathways to implementing protections on these lands. Achieving 30×30 targets will demand conservation actions that complement the historically unjust processes of implementing new federal and state parks. We show that private conservation has been an effective pathway to targeting areas with high biodiversity and land-based climate change mitigation value in the United States to date and that private lands hold significant unprotected potential for meeting this decade's area-based conservation targets.

AUTHOR CONTRIBUTIONS

Melissa Chapman contributed to the conceptualization, analysis, and writing of the manuscript. Justin S. Brashares and Carl Boettiger contributed to the writing and revising of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Code for all analysis and data visualization was done in the *R* programming language and is available freely at https://github.com/milliechapman/easements-biodiversity.

The data used that support the findings of this study are available from the following links/organizations for non-commercial purposes (1) Species Richness: IUCN (https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-download?qt-), (2) Protected Areas and Conservation Easements: USGS (https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-download?qt-science_center_objects=0#qt-science_center_objects), (3) vulnerable carbon distributions (https://doi.org/10.5281/zenodo.4091029), (4) projected richness under climate change (https://doi.org/10.5061/dryad.jm63xsj6d), and (5) biodiversity priority areas (https://biodiversitymapping.org/index.php/usa-priorities/).

ORCID

Melissa Chapman https://orcid.org/0000-0002-1377-1539
Carl Boettiger https://orcid.org/0000-0002-1642-628X

REFERENCES

Baldi, G., Texeira, M., Martin, O. A., Ricardo Grau, H., & Jobbágy, E. G. (2017). Opportunities drive the global distribution of protected areas. *PeerJ*, *5*, e2989. https://doi.org/10.7717/peerj.2989

Bargelt, L., Fortin, M. J., & Murray, D. L. (2020). Assessing connectivity and the contribution of private lands to protected area networks in the United States. *PLoS One*, *15*(3), e0228946.

Buchanan, G. M., Butchart, S. H. M., Chandler, G., & Gregory, R. D. (2020). Assessment of national-level progress towards elements of the Aichi biodiversity targets. *Ecological Indicators*, *116*, 106497. https://doi.org/10.1016/j.ecolind.2020.106497

Butchart, S. H. M., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J. P. W., Almond, R. E. A., Baillie, J. E. M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K. E., Carr, G. M., Chanson, J., Chenery, A. M., Csirke, J., Davidson, N. C., Dentener, F., Foster, M., Galli, A., … Watson, R. (2010). Global biodiversity: Indicators of recent declines. *Science*, *328*, 1164–1168. https://doi.org/10.1126/science.1187512

Capano, C., Gonzalo, T. T., Soutullo, A., & Di Minin, E. (2019). The emergence of private land conservation in scientific literature: A review. *Biological Conservation*, *237*, 191–199. https://doi.org/10.1016/j.biocon.2019.07.010

Clancy, N. G., Draper, J. P., Wolf, J. M., Abdulwahab, U. A., Pendleton, M. C., Brothers, S., Brahney, J., Weathered, J., Hammill, E., & Atwood, T. B. (2020). Protecting endangered species in the USA requires both public and private land conservation. *Scientific Reports*, *10*(1), 1–8.

Convention on Biological Diversity. 2020. *Update of the zero draft of the POST-2020 global biodiversity FRAMEWORK*.

Dreiss, L. M., Lacey, L. M., Weber, T. C., Delach, A., Niederman, T. E., & Malcom, J. W. (2022). Targeting current species ranges and carbon stocks fails to conserve biodiversity in a changing climate: Opportunities to support climate adaptation under 30×30. *Environmental Research Letters*, *17*(2), 024033.

Dreiss, L. M., & Malcom, J. W. (2022). Identifying key federal, state, and private lands strategies for achieving 30×30 in the United States. *Conservation Letters*, *15*(1), e12849.

Drescher, M., & Brenner, J. C. (2018). The practice and promise of private land conservation. *Ecology and Society*, *23*(2), 3. https://doi.org/10.5751/ES-10020-230203

Ernst, T., & Wallace, G. N. (2008). Characteristics, motivations, and management actions of landowners engaged in private land conservation in Larimer County Colorado. *Natural Areas Journal*, *28*(2), 109–120. https://doi.org/10.3375/0885-8608(2008)28[109:CMAMAO]2.0.CO;2

Gigliotti, L. C., Xu, W., Zuckerman, G. R., Atwood, M. P., Cole, E. K., Courtemanch, A., Dewey, S., Gude, J. A., Hnilicka, P., Hurley, M., Kauffman, M., Kroetz, K., Lawson, A., Leonard, B., MacNulty, D., Maichak, E., McWhirter, D., Mong, T. W., Proffitt, K., … Middleton, A. D. (2022). Wildlife migrations highlight importance of both private lands and protected areas in the greater Yellowstone ecosystem. *Biological Conservation*, *275*, 109752.

Graves, R. A., Williamson, M. A., Belote, R. T., & Brandt, J. S. (2019). Quantifying the contribution of conservation easements to large-landscape conservation. *Biological Conservation*, *232*, 83–96.

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., Schlesinger, W. H., Shoch, D., Siikamäki, J. V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R. T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M. R., … Fargione, J. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences*, *114*(44), 11645–11650. https://doi.org/10.1073/pnas.1710465114

Hannah, L., Midgley, G., Andelman, S., Araújo, M., Hughes, G., Martinez-Meyer, E., Pearson, R., & Williams, P. (2007). Protected area needs in a changing climate. *Frontiers in Ecology and the Environment*, *5*, 131–138. https://doi.org/10.1890/1540-9295(2007)5[131:PANIAC]2.0.CO;2

IPCC. (2014). *Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC.

IUCN (International Union for Conservation of Nature). (2020). The IUCN Red List of Threatened Species. Version 2020–3.

Jenkins, C. N., Pimm, S. L., & Joppa, L. N. (2013). Global patterns of terrestrial vertebrate diversity and conservation. *Proceedings of the National Academy of Sciences of the United States of America*, *110*, E2602–E2610. https://doi.org/10.1073/pnas.1302251110

Jenkins, C. N., Van Houtan, K. S., Pimm, S. L., & Sexton, J. O. (2015). US protected lands mismatch biodiversity priorities. *Proceedings of the National Academy of Sciences of the United States of America*, *112*, 5081–5086. https://doi.org/10.1073/pnas.1418034112

Kareiva, P., Bailey, M., Brown, D., Dinkins, B., Sauls, L., & Todia, G. (2021). Documenting the conservation value of easements. *Conservation Science and Practice*, *no. April*, 1–13. https://doi.org/10.1111/csp2.451

Lawler, J. J., Scott Rinnan, D., Michalak, J. L., Withey, J. C., Randels, C. R., & Possingham, H. P. (2020). Planning for climate change through additions to a national protected area network: Implications for cost and configuration. *Philosophical Transactions of the Royal Society, B: Biological Sciences*, *375*, 20190117. https://doi.org/10.1098/rstb.2019.0117

Mason, N., Ward, M., Watson, J. E. M., Venter, O., & Runting, R. K. (2020). Global opportunities and challenges for transboundary conservation. *Nature Ecology and Evolution*, *4*, 694–670. https://doi.org/10.1038/s41559-020-1160-3

Maxwell, S. L., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A. S. L., Stolton, S., Visconti, P., Woodley, S., Kingston, N., Lewis, E., Maron, M., Strassburg, B. B. N., Wenger, A., Jonas, H. D., Venter, O., & Watson, J. E. M. (2020). Area-based conservation in the twenty-first century. *Nature*, *586*, 217–227. https://doi.org/10.1038/s41586-020-2773-z

McIntosh, E. J., Pressey, R. L., Lloyd, S., Smith, R. J., & Grenyer, R. (2017). The impact of systematic conservation planning. *Annual Review of Environment and Resources*, *42*, 677–697. https://doi.org/10.1146/annurev-environ-102016-060902

Merenlender, A. M., Huntsinger, L., Guthey, G., & Fairfax, S. K. (2004). Land trusts and conservation easements: Who is conserving what for whom? *Conservation Biology*, *18*(1), 65–76. https://doi.org/10.1111/j.1523-1739.2004.00401.x

Morgan, J. J., Rhoden, C. M., White, B., & Riley, S. P. (2019). A state assessment of private lands wildlife conservation in the United States. *Wildlife Society Bulletin*, *43*(3), 328–337.

National Conservation Easements Database. 2020. *Conservation easements database of the U.S.*

Nolte, C. (2020). High-resolution land value maps reveal underestimation of conservation costs in the United States. *Proceedings of the National Academy of Sciences*, *117*(47), 29577–29583.

Noon, M. L., Goldstein, A., Ledezma, J. C., Roehrdanz, P. R., Cook-Patton, S. C., Spawn-Lee, S. A., Wright, T. M., Gonzalez-Roglich, M., Hole, D. G., Rockström, J., & Turner, W. R. (2021). Mapping the irrecoverable carbon in Earth's ecosystems. *Nature Sustainability*, *5*, 37–46.

Rissman, A. R., Lozier, L., Comendant, T., Kareiva, P., Kiesecker, J. M., Rebecca Shaw, M., & Merenlender, A. M. (2007). Conservation easements: Biodiversity protection and private use. *Conservation Biology*, *21*, 709–718. https://doi.org/10.1111/j.1523-1739.2007.00660.x

Schöttker, O., & Santos, M. J. (2019). Easement or public land? An economic analysis of different ownership modes for nature conservation measures in California. *Conservation Letters*, *12*(6), e12647.

Sinclair, S. P., Milner-Gulland, E. J., Smith, R. J., McIntosh, E. J., Possingham, H. P., Vercammen, A., & Knight, A. T. (2018). The use, and usefulness, of spatial conservation prioritizations. *Conservation Letters*, *11*, e12459. https://doi.org/10.1111/conl.12459

Stroman, D. A., Kreuter, U. P., & Gan, J. (2017). Balancing property rights and social responsibilities: Perspectives of conservation easement landowners. *Rangeland Ecology & Management*, *70*, 255–263. https://doi.org/10.1016/j.rama.2016.11.001

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B. F. N., de Siqueira, M. F., Grainger, A., Hannah, L., Hughes, L., Huntley, B., van Jaarsveld, A. S., Midgley, G. F., Miles, L., Ortega-Huerta, M. A., Townsend Peterson, A., Phillips, O. L., & Williams, S. E. (2004). Extinction risk from climate change. *Nature*, *427*, 145–148. https://doi.org/10.1038/nature02121

Tsioumani, E. (2020). Convention on biological diversity: A review of the post-2020 global biodiversity framework working group negotiations. *Environmental Policy and Law*, *50*(1–2), 55–59. https://doi.org/10.3233/EPL-200207

U. S. Geological Survey (USGS) Gap Analysis Project (GAP). (2018). Protected Areas Database of the United States (PAD-US) 2.1: U.S. Geological Survey data release. https://doi.org/10.5066/P955KPLE

Urban, M. C. (2015). Accelerating extinction risk from climate change. *Science*, *348*, 571–573. https://doi.org/10.1126/science.aaa4984

Van Sant, L., Hardy, D., & Nuse, B. (2020). Conserving what? Conservation easements and environmental justice in the coastal US South. *Human Geography*, *14*, 31–44. https://doi.org/10.1177/1942778620962023

West, P., Igoe, J., & Brockington, D. (2006). Parks and peoples: The social impact of protected areas. *Annual Review of Anthropology*, *35*, 251–277.

Woodroffe, R., & Ginsberg, J. R. (1998). Edge effects and the extinction of populations inside protected areas. *Science*, *280*(5372), 2126–2128. https://doi.org/10.1126/science.280.5372.2126

SUPPORTING INFORMATION

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

How to cite this article: Chapman, M., Boettiger, C., & Brashares, J. S. (2023). Leveraging private lands to meet 2030 biodiversity targets in the United States. *Conservation Science and Practice*, *5*(4), e12897. https://doi.org/10.1111/csp2.12897