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Environmental justice criteria for new land protection can inform efforts to address disparities in access to nearby open space

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E-mail: ksims@amherst.edu**Keywords:** conservation, environmental justice, land protection, conservation prioritization, conservation planningSupplementary material for this article is available [online](#)

Abstract

Substantial funding is being allocated to new land protection and access to protected open space for marginalized communities is a crucial concern. Using New England as a study area, we show striking disparities in the distribution of protected open space across multiple dimensions of social marginalization. Using a quartile-based approach within states, we find that communities in the lowest income quartile have just 52% as much nearby protected land as those in the most affluent quartile. Similarly, communities with the highest proportions of people of color have just 47% as much protected land as those in the lowest quartile. These disparities persist across both public and private protected land, within urban, exurban and rural communities, for different sized buffers around communities, and across time. To help address these disparities in future conservation plans, we develop a screening tool to identify and map communities with high social marginalization and low nearby protected open space within each state. We then show that areas prioritized according to these environmental justice (EJ) criteria are substantially different from areas prioritized according to conventional conservation criteria. This demonstrates how incorporating EJ criteria in conservation prioritization processes could shift patterns of future land protection. Our work provides methods that can be used broadly across regions to inform conservation efforts.

1. Introduction

The protection and restoration of land for recreation, sustainable food and resource production, cultural heritage, human health, and biodiversity is a core societal goal (UN General Assembly 2015). Globally, conservation actors are calling for 30% of the globe to be protected by 2030 and up to half protected in the long term (Dinerstein *et al* 2019, Díaz *et al* 2020). In the U.S., the recent bipartisan ‘Great American Outdoors Act’ will support up to \$900 million annually to fund investments in land and water conservation through the National Park Service (NPS 2020). The U.S. Department of Agriculture will spend \$6.7 billion per year on conservation programs (Congressional Research Service 2020) and voters have approved more than \$3.7 billion in local ballot initiatives for parks, public lands, and climate

resiliency (Trust for Public Land 2020a). The Biden Administration has pledged to meet the 30-by-30 goals (Gibbens 2021), with an emphasis on increasing access to open space for marginalized communities and others historically excluded from the benefits of conservation (America the Beautiful Interagency Working Group 2021).

The allocation of funding and organizational focus for these efforts will be informed by prioritization systems for land protection and restoration (Newbold and Siikamäki 2015, Rosa and Malcolm 2020). Yet despite growing awareness of structural inequality in access to environmental benefits (Schell *et al* 2020, Trust for Public Land 2020b) and the past inequities of conservation (Spence 1999, Taylor 2016), current land-protection prioritization rubrics do not systematically incorporate environmental justice (EJ) criteria. We address this knowledge gap in

the EJ and conservation literatures by assessing disparities in access to protected open space, developing new screening methods to identify conservation focus areas based on EJ criteria, and testing the extent to which conventional conservation rankings support EJ goals. In the absence of such methods to systematically identify underserved communities, the benefits of ambitious conservation efforts are likely to remain inequitably distributed across communities.

EJ requires equitable treatment in policy processes, decision-making, and outcomes for people regardless of their race, ethnicity, income, educational attainment, or other markers of marginalization (Taylor 2000a, Bonorris 2004, Agyeman 2008). Injustices have been well-documented across dimensions of race and income for environmental harms including air pollution, water pollution, toxic waste, and climate resiliency (Banzhaf *et al* 2019). EJ also has a positive component, affirming that all communities have a right to enjoy environmental benefits. Indeed, greater access to protected open space for recreation, social activities, mental and physical health, food production, and resilience to heat waves has been a goal of many local EJ organizations for decades (Taylor 2000a, Lanfer and Taylor 2005, Agyeman 2008).

Prior research documents disparities in equitable access to nearby open space within urban areas. Lower income neighborhoods often have less tree cover and plant diversity (Schell *et al* 2020), fewer, smaller, and lower quality parks (Jennings *et al* 2012, Trust for Public Land 2020b, Chapman *et al* 2021), and more summer heat (Rigolon *et al* 2018, Trust for Public Land 2020a). There is also case-based evidence of racial inequity in participation in outdoor recreation (Flores *et al* 2018, Winter *et al* 2020) and exclusion from local park spaces or public land for reasons including institutional discrimination and structural inequality in leisure time and access to transportation (Taylor 2000b, Roberts and Rodriguez 2008, Erickson *et al* 2009), as well as exclusion due to personal experiences of racism, limited access points, or congestion of park spaces (e.g. García and Baltodano 2005, Sister *et al* 2010, Finney 2014). Questions of access are also important for Native American and Indigenous communities and are further complicated by issues of tribal sovereignty, customary use, and land rights (e.g. Krakoff 2018, Deur and James 2020).

Prior work also documents the substantial benefits of access to open space (e.g. Hartig *et al* 2014), including material benefits for historically excluded and currently marginalized communities. However, even if those benefits were limited, disparities in access to environmental benefits that are patterned on race or other characteristics of marginalization are unacceptable (e.g. under Title IV of the Civil Rights Act 1964, EPA Executive Order 12898). Racial, class, or other caste disparities should be viewed as automatically requiring redress (Lado 2019).

Contributing to this prior literature, our work provides three substantial advances. First, we comprehensively analyze disparities in nearby open space within states at a regional scale for both public and private land protection, and do so in a way that could be scaled to other states or regions. Regional-scale analysis is crucial because marginalized groups live across the landscape and much of the new land that will be protected in the next decade is likely to occur in peri-urban communities and at landscape scales involving multiple states. Private land protection is important to study because it has grown rapidly in recent decades (Land Trust Alliance 2015), yet there is little understanding of how it may contribute to or mitigate potential disparities in available protected land.

Second, we move beyond documenting inequities by developing a potential prioritization system that identifies and assesses gaps in access to open space based on EJ criteria. While the majority of EJ scholarship has focused on establishing drivers of disproportionate harms, we contribute to work understanding access to environmental benefits and the specific social structures that can support thriving, healthy communities (e.g. Benner and Pastor 2015, Lado 2019, Beery 2020, Gulyas and Edmondson 2021). Our approach is informed by established EJ screening methods (Sadd *et al* 2011, U.S. Environmental Protection Agency 2019, Solomon *et al* 2016). Screening provides systematic information on demographic and socioeconomic characteristics that have historically been associated with disproportionate environmental harm, as well as direct information on indicators of exposure to environmental harm or risks such as air pollution and toxic waste (MA Department of Environmental Protection 2012, U.S. Environmental Protection Agency 2019, Connecticut Department of Energy and Environmental Protection 2020, August *et al* 2021). We follow EJ screening methods by first identifying communities with a high degree of social marginalization due to income and race, as well as English language isolation and low educational attainment (MA Department of Environmental Protection 2012, Luna 2019, U.S. Environmental Protection Agency 2019). We then combine this with spatial data on protected open space to identify communities that also currently have low access to nearby protected land. We map and characterize these EJ focus areas.

Finally, we examine whether and how an EJ focus would shift priorities for new land protection. To date, most conservation prioritization systems have centered on ecological or ecosystem service goals such as wildlife habitat, recreation opportunities, drinking water or carbon sequestration (Wilson *et al* 2006, Anderson *et al* 2016, Dinerstein *et al* 2019, Mandle *et al* 2020). Economists have also developed prioritization systems that seek

to maximize social welfare by considering both the benefits of conservation (including the threat of loss) and the costs (e.g. Ando *et al* 1998, Costello and Polasky 2004, Newbold and Siikamäki 2015, Nolte 2020). However, we are not aware of prior studies that have assessed whether conventional conservation prioritization would support or contradict EJ goals. We provide a novel test of differences in prioritization according to conventional conservation rankings versus EJ criteria.

2. Methods

2.1. Assessing disparities in access to protected lands

We use the New England region as a study case to understand how EJ criteria could matter for new land protection. We first assess access to nearby protected lands across dimensions of social marginalization including race and income, as well as educational attainment and language isolation. Our approach defines communities based on census tracts. Data on protected open space is from the Harvard Forest/Highstead Protected Open Space (POS) Dataset (see SI, figure S1 available online at stacks.iop.org/ERL/17/064014/mmedia). It includes data on public land as well as private land protected by legal easements or ownership by land trusts and conservation NGOs. Data on social characteristics is from the American Community Survey (SI table 1 and figure S2).

New England provides an important study case because conservation actors have succeeded in permanently protecting more than 24% of land overall, with approximately half of this protected in the decades since 1990 by a range of public and private actors (Harvard Forest/Highstead POS database). The rapid expansion of land protection observed in New England is likely to preview trends in many other regions where conservation by private actors and in densely settled areas is increasing (Land Trust Alliance 2015).

We define access to open space as the percentage of land area protected within each census tract or within distance-based buffer areas around that tract. Our main measure is the percentage of protected land inside or within a 1 km buffer of each tract. We prefer this measure because it adjusts with census tract area, is consistently available across the region, and encompasses protected land that is within community boundaries or close enough to reach without a car (see figure S1, SI). We also analyze different buffer sizes following case-based analyses that use different catchment sizes to define access (e.g. Nicholls 2001, Kim and Nicholls 2016a). More detailed information on specific access points or rules of use is not available at a regional scale as this information is not provided consistently across the underlying sources compiled to build the protected open space database (see SI for additional discussion).

To assess disparities in access to open space, we group census tracts into quartiles based on demographic data within each state. We use a state-based approach to account for overall differences in factors such as the cost of living or overall racial diversity across states. We then compare the distributions of percent of land protected across quartile groups for income and percent people of color (figure 1). We also characterize the continuous relationships using both bivariate and multivariate regression (SI). We analyze disparities according to multiple social characteristics for public vs. private protection, for urban, exurban and rural communities, and for historical vs. recent land protection (figure 1, SI).

2.2. Identifying focus areas based on environmental justice criteria

To identify potential EJ focus areas within New England, we calculate the within-state percentile rank of each census tract for median household income, percent people of color, percent people English-language isolated, and percent of nearby land protected. For each state, we identify the tracts that are in the lowest quartile of income and protection, and the highest quartile of percent people of color. While each of these criteria are separately important for social justice, we focus on tracts that fall within *all* of these criteria in order to emphasize the most marginalized communities within each state. This provides a method for screening that is based on widely-available census data and can be scaled-up across states. Statistics by state and examples of more detailed map areas are given in the SI (table S2, figures S6 and S7). We also identify a second set of alternative focus areas as communities with the least land protection, lowest income, highest percent people of color, and additionally in the highest quartile for degree of language isolation (see SI).

2.3. Comparing prioritization based on environmental justice versus ecosystem-based criteria

To evaluate whether conventional prioritization systems reduce or reinforce existing inequities in access to protected open space, we calculate the average conservation ranking scores of available land in each tract for three commonly used ecosystem-based priority systems. These are: the Nature Conservancy's index of resilient terrestrial sites for biodiversity conservation (Anderson *et al* 2016) which is designed to prioritize areas that can support the persistence of a high number of species under changing climate conditions; the USDA's Forests to Faucets assessment (U.S. Department of Agriculture 2018) which prioritizes areas that supply surface drinking water and face development threats; and a national assessment of terrestrial carbon stocks in above-ground vegetation (Kellndorfer *et al* 2013) which indicates opportunities for climate mitigation and can also proxy

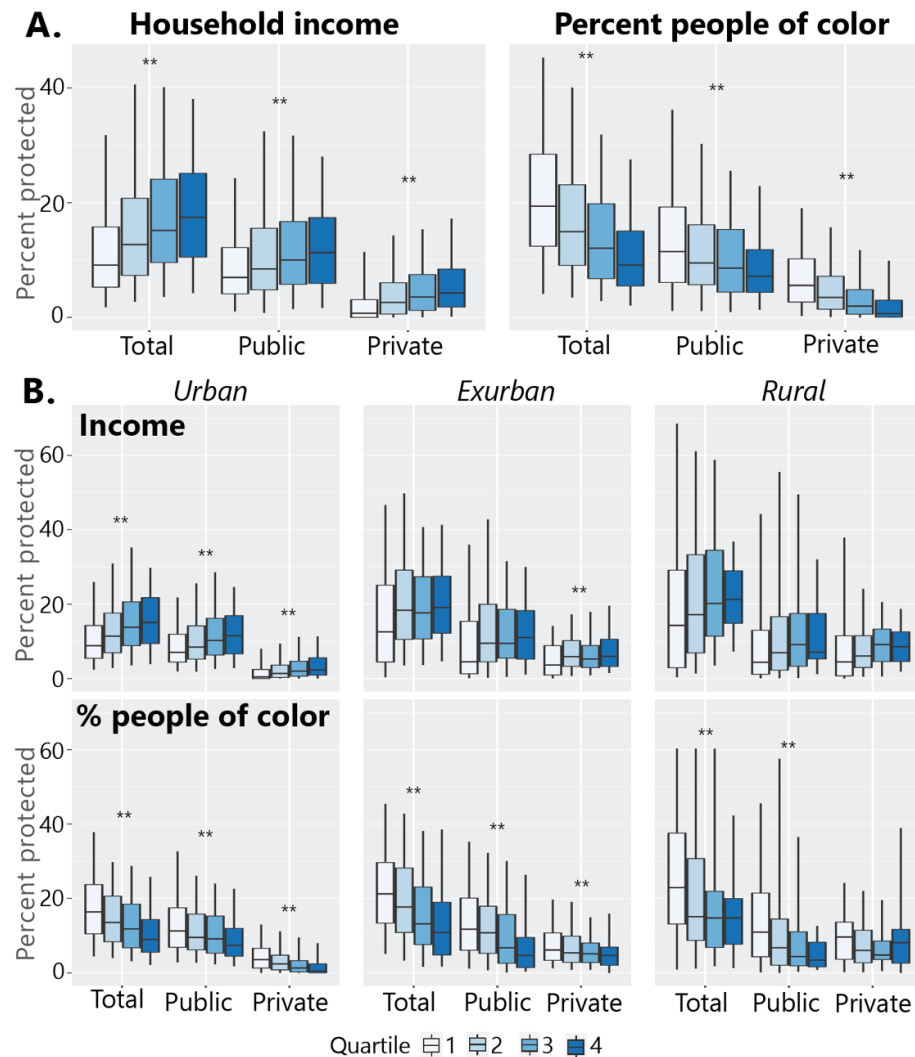


Figure 1. Disparities in protected open space by income and race. Distribution of the percent of land protected inside and within a 1 km buffer of census tracts by state-based quartiles of income and percent people of color. For each quartile group, boxplots show the median (line), 25th and 75th percentiles (box), and 5th and 95th percentiles (whiskers) of the percent protected. Stars indicate a statistically significant ($* p < 0.05$, $** p < 0.01$) correlation between percent protected and the percentile rank of income or percent people of color. For each set of quartiles, access to protected open space is analyzed for all protected lands, then by public and private ownership. (A) All tracts ($N = 3344$). (B) Subsets of each quartile that are: urban ($N = 2131$), exurban ($N = 918$) and rural tracts ($N = 295$) (also see table S9).

for local benefits of trees, such as cooling, biodiversity, and health benefits. Each of these scoring systems is currently in use by major conservation organizations and plays a role in funding decisions from local to regional levels. We define available land as land that is undeveloped according to the land-cover data and unprotected according to the POS data. Tracts receive a score if they have at least 10 acres of available land according to each layer (see SI for additional details). To test how census tracts would rank according to conventional conservation priorities vs. EJ criteria, we plot each tract according to its scores for resilience, carbon, or drinking water vs. the median income or percent people of color in that tract (figure 3). Finally, we additionally examine possibilities for re-development by overlaying EJ focus areas with identified brownfields sites (see SI).

3. Results

3.1. Disparities in access to protected land

We find substantial disparities in access to nearby protected land for more vs. less socially marginalized communities. These are illustrated by differences in the distributions of the percent of land protected across the state-based quartiles of demographic characteristics (figures 1(A) and S2). Households in census tracts in the lowest income quartile for each state (figure 1(A)) tend to have 52% as much protected open space inside or within a 1 km distance of that tract (total land protected: median = 9.1%, SE = 0.32%) as those in the highest quartile of income (total land protected: median = 17.4%, SE = 0.47%). The percentile rank of income and the percent of land protected are statistically significantly correlated for protected land as a whole ($\rho = 0.22$, $p < 0.0001$) as

well as for both public ($\rho = 0.13$, $p < 0.0001$) and private land ($\rho = 0.22$, $p < 0.0001$).

There are also substantial disparities in nearby protected land for communities with a higher proportion of people of color (figure 1(A), see SI). For census tracts in the highest quartile for percent people of color, only 9.1% (SE = 0.31%) of nearby land is protected, compared to 19.4% (SE = 0.55%) for tracts in the lowest quartile. This means that communities with a high proportion of people of color have just 47% as much protected land. There is also a significant negative correlation between the percentiles of people of color and percent land protected for all protected land ($\rho = -0.33$, $p < 0.0001$), as well as for both public protection ($\rho = -0.20$, $p < 0.0001$) and private protection ($\rho = -0.34$, $p < 0.0001$).

Prior work on environmental injustices has found that relationships between socioeconomic factors and outcomes can vary considerably across spatial context (e.g. Mennis and Jordan 2005, Grineski *et al* 2015, Kim and Nicholls 2016b, Chakraborty *et al* 2017). We further examine spatial variation in potential disparities by analyzing the subsets of tracts that are urban, exurban and rural, by using multiple regression, and by using geographically weighted regression (see figures 1–2–S5, tables S3–S7). We find that disparities by income and race persist strongly within urban tracts (figure 1(B)), with correlations of $\rho = 0.25$ ($p < 0.0001$) and $\rho = -0.28$ ($p < 0.0001$). Statistically significant disparities by income also persist for private protection within exurban tracts, and by race for protection as a whole within both exurban and rural tracts (figure 1(B)). We also find that disparities exist within all states in the region (table S8 and figure S8). In addition, we find substantial and statistically significant disparities by educational attainment and English language isolation (figures S2 and S5).

To evaluate access across a range of distances from highly walkable to requiring a car or public transit, we assess the percent of protected land within each tract and a 1 km buffer (our primary measure), as well as within each tract with no buffer, and each tract plus a 2, 10 or 25 km buffer (table S5 and figure S9). Disparities in nearby protected land are greatest when we consider land only within each census tract, and least when considering larger buffer areas. This indicates that disparities are often localized and that more access to open space exists for those with access to transportation. Unfortunately, disparities in access to transportation itself (Luna and Estrella-Luna 2021) currently limit access to sites that are not walkable, highlighting the importance of local protected open space.

To understand whether land protection in more recent decades has effectively contributed to the reversal of historic inequalities, we analyze the patterns of lands protected since 1990 and how they correspond to current demographic characteristics (figure S4, tables S6 and S7). We do not find that

more recent public or private land protection is correlated with characteristics of marginalization in ways that suggest it has contributed to reducing disparities (figure S4, tables S6 and S7).

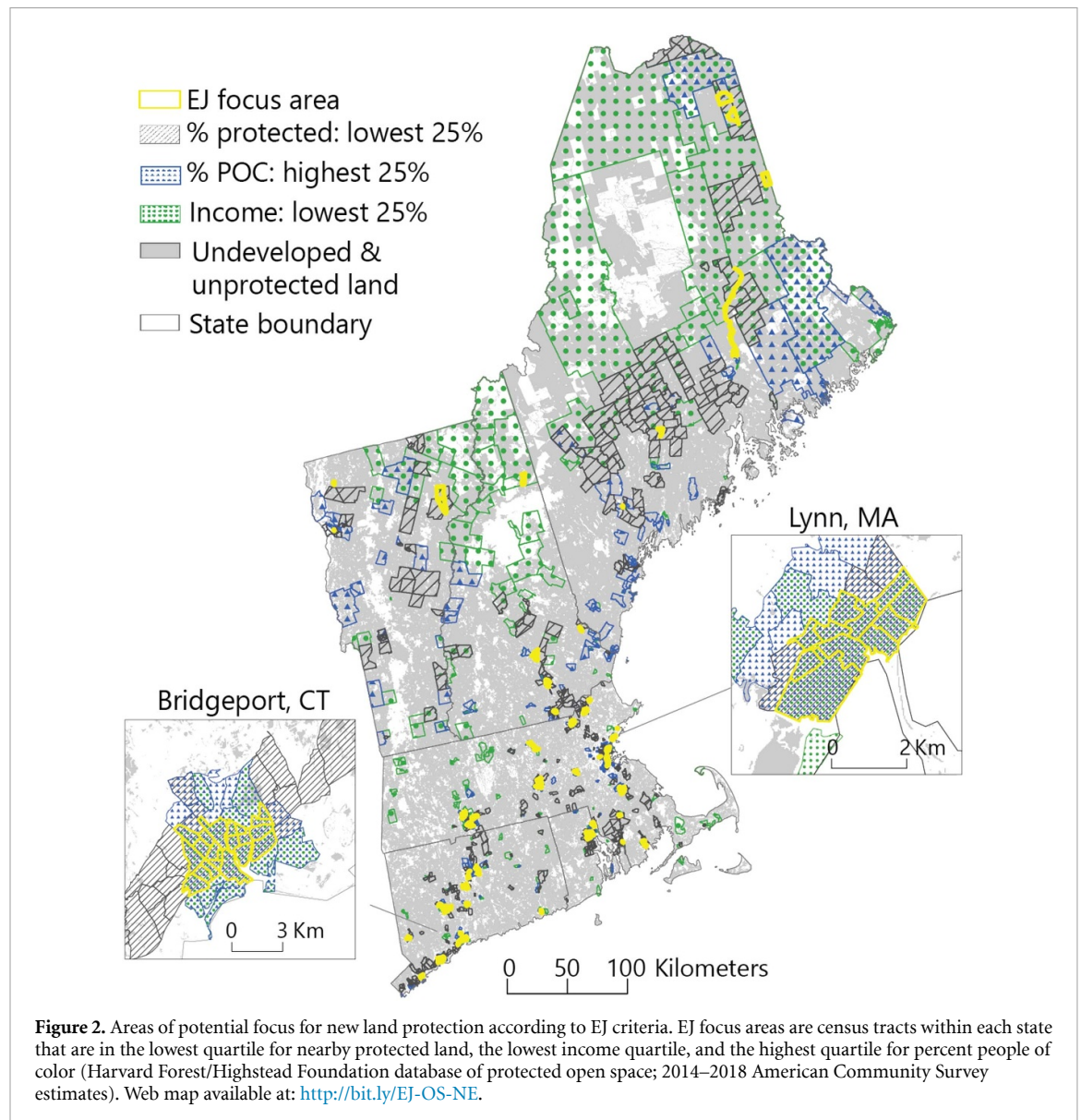
Finally, since characteristics of marginalization are often related to each other, we supplement our main analysis by using multiple regression to relate protected land to several tract characteristics simultaneously. The results indicate that for the region as a whole, structural inequality in access to education and high-paying jobs, as well as low land availability, are related to income-based and racial disparities in nearby protected land (SI text, tables S3 and S4).

Together, our analyses show that the distribution of nearby protected land is strongly negatively associated with characteristics of social marginalization, indicating environmental injustice in current patterns of land conservation. In addition to more comprehensive social reform to reduce marginalization itself and desegregate the landscape, moving towards greater EJ will depend on processes and patterns of future land protection that reduce these disparities in access to open space.

3.2. Focus areas based on environmental justice criteria

Priorities for land use must ultimately be determined by fair, locally-oriented and community-led processes, which can be assisted by appropriate screening tools. Figure 2 indicates the census tracts identified as EJ focus areas for each state given the criteria of having low availability of nearby protected open space and high degree of marginalization by income and race. While we highlight EJ focus areas on the map that meet all three criteria—low income, high percent people of color, and low protection—each of the criteria may also separately identify possible areas of need. The information shown in figure 2 is available at finer detail in a publicly available web map (viewable at: <http://bit.ly/EJ-OS-NE>, also see SI for examples). Table S2 provides the land area and number of focus areas in each state.

Many of the tracts we identify as potential focus areas from an EJ-based land protection standpoint also overlap with areas identified as experiencing an undue burden of air or water pollution or proximity to toxics sites according to the EPA's EJSCREEN (U.S. Environmental Protection Agency 2019) or individual state EJ criteria (e.g. MA Department of Environmental Protection 2012, Connecticut Department of Energy and Environmental Protection 2020). In our analysis, 96% of tracts identified as EJ focus areas also had at least one brownfield site listed by the EPA. This highlights the potential importance of redevelopment as a means to improve access to greenspace as well as the intersectionality of EJ concerns. In addition, we examined the distribution of the population in New England that identifies as Native American and found that some of the census tracts identified

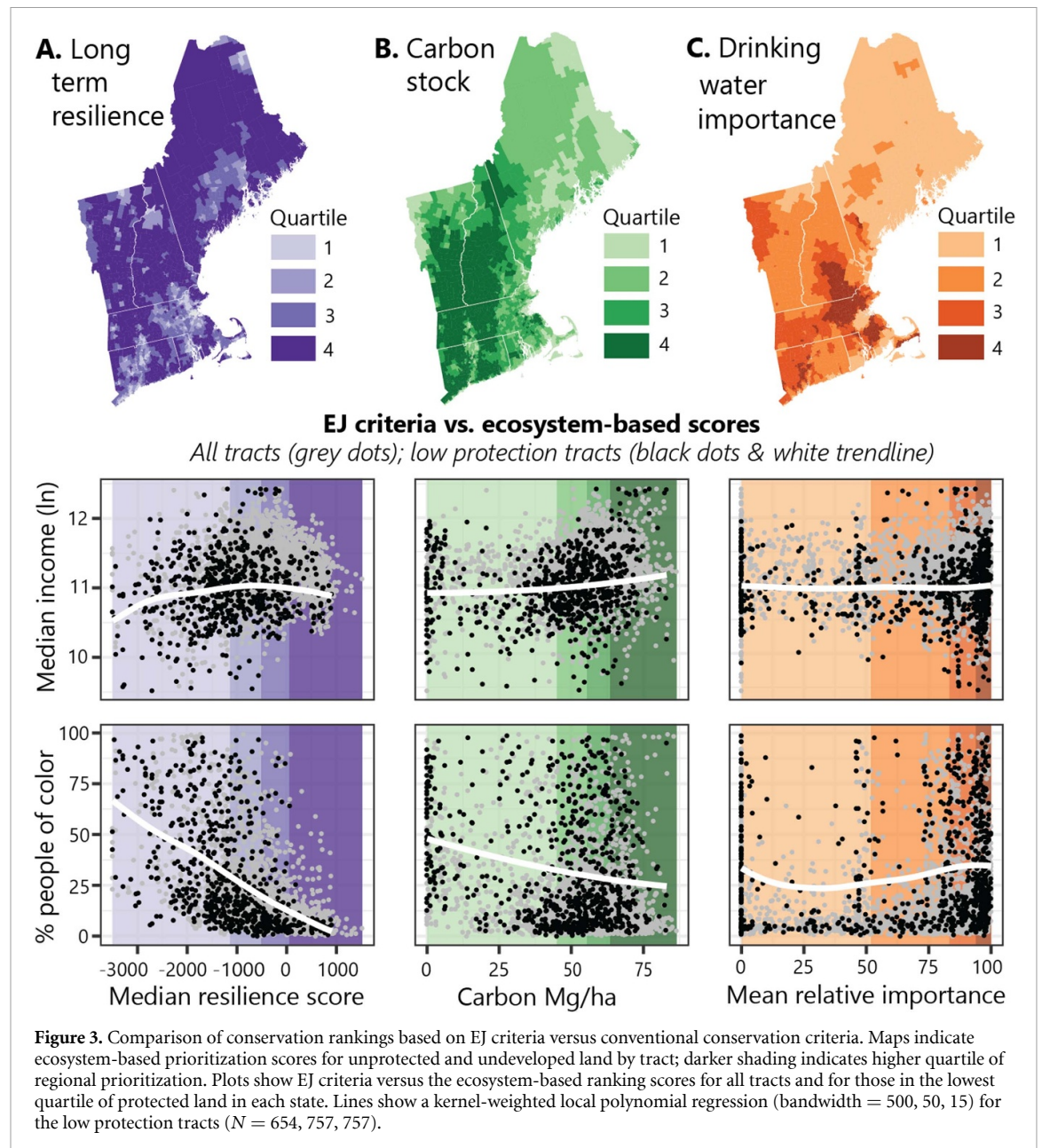


as potential EJ focus areas have high proportions of people identifying as Native American (see SI). Processes that maximize local autonomy when considering new land protection may be particularly important for these communities given the specific histories of dispossession.

3.3. Environmental justice criteria vs. conventional conservation priorities

We find evidence of substantial tradeoffs between EJ priorities and conventional conservation rankings, as well as some opportunities that rank highly according to both criteria. We present these relationships graphically in figure 3 by plotting each community according to its scores for resilience, carbon or drinking water vs. that community's median income or percent people of color (figure 3). The communities with low current availability of nearby open space are indicated by black dots, with all other communities represented by grey dots.

First, considering the relationship between income and ecological resilience, we find a statistically significant positive correlation ($\rho = 0.10$, $p < 0.0001$, $N = 2987$). In addition, very few low-income communities that currently have low protection are also among those with the highest resilience scores (figure 3(A); less than 3% or 20 out of 748 high resilience tracts are also in the lowest income quartile). These results suggest tradeoffs between prioritizing resilience and serving the lowest-income communities. However, among tracts that might be targeted for high resilience scores, we find that those with current low protection do have lower median incomes on average than those with high protection (figure 3(A)). Low protection tracts within the highest resilience quartile were on average \$15 800 less well-off according to median annual income, suggesting some scope to reach middle-income communities through targeting for ecological resilience.



We also find a steep tradeoff between prioritizations based on ecological resilience versus additional access to open space for communities of color. Among low-protection tracts, there is a very strong negative correlation between percent people of color and resilience prioritization scores (figure 3(A), $\rho = -0.51$, $p < 0.0001$, $N = 654$). Even using the state-based quartiles for percent people of color, less than 0.5% of communities in the highest quartile for resilience scores were also in the highest quartile for percent people of color and in the lowest quartile for protection. This indicates that conservation prioritizations that heavily weight resilience could actually exacerbate inequalities in access for racially diverse communities in our region.

Second, prioritization based on carbon scores also suggests likely tradeoffs with respect to both income and race. Among tracts with low current

levels of protection, carbon scores were positively correlated with income (figure 3(B), middle panel, $\rho = 0.13$, $p < 0.0005$, $N = 757$). Carbon scores for tracts with low current protection were negatively correlated with percent people of color (figure 3(B), bottom panel, $\rho = -0.22$, $p < 0.0001$, $N = 757$). Although these relationships are weaker than those for ecological resilience, they continue to indicate that protecting land based on conventional ecological priorities will not tend to reduce current disparities in access.

Finally, in contrast, we found that prioritization scores based on clean drinking water had somewhat greater potential to decrease racial or income disparities in land protection. Among tracts with high drinking water priority, those with current low protection tended to have lower incomes (difference of $\sim \$26\,000$). High drinking water prioritization scores

were also positively correlated with percent people of color among the low protection tracts (figure 3(C), bottom panel, $\rho = 0.09$, $p < 0.018$, $N = 757$). These correlations indicate more possibility for this conservation priority to contribute to reduced disparities in access.

4. Discussion

Achieving EJ requires reframing priorities to focus attention on the connections between human and ecological systems, as well as addressing the underlying causes of marginalization (Taylor 2000a, Agyeman 2008, Mandle *et al* 2020, Schell *et al* 2020). Globally, efforts to rapidly expand land protection could directly affect the livelihoods of more than a billion people, creating risks for community harms as well as potential opportunities (Alix-Garcia *et al* 2018, Naidoo *et al* 2019, Schleicher *et al* 2019, Zafra-Calvo *et al* 2019). Past conservation efforts have often actively and passively dispossessed marginalized people through displacement, loss of traditional user rights, environmental gentrification, exclusionary zoning and redevelopment that does not meet community priorities (Spence 1999, Heckert and Mennis 2012, Lang and Rothenberg 2017, Rigolon and Németh 2018, Anguelovski *et al* 2019, Carmichael and McDonough 2019).

Although the change needed is complex and multifaceted (e.g. Rigolon *et al* 2020), our work illustrates how the analysis of disparities in access to protected land and the explicit incorporation of EJ criteria in land conservation prioritization systems could play a role in future efforts to avoid and redress these injustices. Using New England as an example study region, we find that communities in the lowest income quartile or with the highest proportions of people of color have just half as much nearby protected land as those in the opposite quartiles. These disparities persist across alternate markers of marginalization, public and private land, within the urban to rural gradient, and within recent decades.

To inform efforts to redress these disparities, we identify and map potential EJ focus areas according to high social marginalization and low nearby protected open space. Our screening approach is state-based and uses data that would be broadly available for the U.S., thus providing a potential model for other regional or national analyses of EJ focus areas. Methods to systematically screen for disparities in access to open space can empower underserved communities and their allies with the necessary data to advocate for access and protections based on their own needs, goals, and aspirations. Additionally, our work offers conservation organizations insight into the full composition of the communities they seek to benefit. It provides guidance on who needs to be at the table and involved in conservation planning decisions, and can be if the door is opened.

Finally, to evaluate whether conventional conservation prioritization systems will likely reduce or reinforce existing inequities in access to protected open space, we assess conservation rankings for each community based on three commonly used prioritization layers. We find substantial differences in which areas rank highly according to EJ criteria versus conventional conservation criteria. These results illustrate that continuing to follow conventional conservation prioritization systems for new land protection may exacerbate existing inequalities. Crucially, our results indicate the need for future work to understand these relationships in other regions and for other conservation prioritization layers.

Our analysis of conservation prioritization focuses primarily on remaining undeveloped land, but future work should also consider the role that ecological restoration can play in providing access to nature's benefits. This will be particularly important in urban areas where most land is already developed (e.g. Ingram 2008, Gobster 2010, Tarrant *et al* 2013, Highstead Foundation 2020). Enhancements to urban greenspace can include permanently protecting spaces for urban food production (e.g. White 2011, Cahn and Segal 2016), improving forest canopy in marginalized communities (McDonald *et al* 2021), adding greenways along waterways or former rail lines, and promoting plantings that increase biodiversity. In addition to new greenspace, conservation organizations can also focus on institutional reform including changes in mission and programming or partnerships that can increase community access to existing spaces (e.g. García and Baltodano 2005, Sister *et al* 2010, Flores and Kuhn 2018, Rigolon 2019). Each of these avenues for change provides opportunities to better ensure future equity in access to the crucial benefits of protected land. As this previous work has highlighted, there is substantial heterogeneity in the purpose of land protection and access to that land according to legal provisions, services provided, transportation access, and institutional structures. Better information systems and screening tools that include specific access points and allowable land uses will be crucial to future efforts to improve EJ in conservation.

Access to nearby open space and the benefits of nature are fundamental aspects of a just society. Our work humbly offers an approach to support the deeper shift that several conservation organizations have called for: meaningful reform incorporating anti-racist and social justice goals and practices in their organizational structures and decisions (Land Trust Alliance 2020). The approach we present here will not by itself redress historic and ongoing environmental injustices. It aims to support people who work in and lead conservation organizations who are making the choice to respectfully engage and be led by historically excluded and currently marginalized communities in conservation decision-making.

Ultimately, EJ in future land protection will depend on improved processes of public engagement and decision-making in siting and management that meaningfully include and advance the priorities, concerns, and goals of historically marginalized communities (Estrella-Luna 2010, González 2018). In the U.S. context in particular, true equity will depend on much deeper structural shifts including institutional change, desegregation of the landscape, land restoration, and greater equality of income and wealth, all of which can promote more permanent equitable access to the benefits of open space.

Data availability statement

All data is available in the supplementary information or online.

The data that support the findings of this study are openly available at the following URL/-DOI: <https://harvardforest.fas.harvard.edu/harvard-forest-data-archive>.

Author contributions

All authors contributed to conception, analytical design, and writing. L G L and K R E S conducted analysis. K R E S, N E L and J R T led analysis.

Conflict of interest

Authors declare no competing interests.

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