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

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Social Media Abstract:
Using #EJ criteria in #conservation planning may address disparities in access to nearby #openspace
Abstract:

Substantial funding is being allocated to new land protection, but 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 relative to multiple dimensions of social marginalization. Communities in the lowest income quartile have just half as much nearby protected land as those in the most affluent quartile. Similarly, communities with the highest proportions of people of color have less than 60% as much protected land. These disparities persist across public and private protected land, within urban, exurban and rural communities, and across time. We develop a screening tool to identify and map communities with high social marginalization and low nearby protected open space. We then show that areas prioritized according to environmental justice criteria are substantially different from those prioritized according to conventional conservation criteria. This demonstrates how incorporating environmental justice criteria in conservation prioritization may shift patterns of future land protection. Our work provides methods that can be used broadly across regions to inform future 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 global 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, Diaz 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 (CRS 2020); voters have approved more than $3.7 billion in local ballot initiatives for parks, public lands, and climate resiliency (TPL 2020a) and the Biden Administration has pledged to meet the 30-by-30 goals (Gibbens 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, TPL 2020b) and the past inequities of conservation (Spence 1999, Taylor 2016), current land-protection prioritization rubrics do not systematically incorporate environmental justice criteria. We address this knowledge gap in the environmental justice and conservation literatures by assessing disparities in access to protected open space, developing new screening methods to identify conservation focus areas based on environmental justice criteria, and testing the extent to which conventional conservation rankings support environmental justice goals.

Environmental justice 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). Prior work includes analysis of 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, TPL 2020b, Chapman et al. 2021), and more summer heat (Rigolon et al. 2018, TPL 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 personal experiences of racism, limited access points, or congestion of park spaces (e.g., Garcia 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; see Methods).

Our work provides three substantial advances. First, we comprehensively analyze disparities in nearby open space at a regional scale for both public and private land protection, and do so in a way that could be scaled to other 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. Private land protection is important to study because it has grown rapidly in recent decades (LTA 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 environmental justice criteria. While the majority of environmental justice 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 environmental justice screening methods (Sadd et al. 2011, Solomon et al. 2016, EPA 2015). 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 (EPA 2015, MA DEP 2012, CT DEEP 2020, August et al. 2021). We follow established environmental justice 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 DEP 2012, Luna 2019, EPA 2021). We then combine this with the analysis of protected open space, identifying communities that also have current low access to nearby protected land.

Finally, we examine whether and how an environmental justice focus would shift priorities for new land protection. To date, most conservation prioritization systems have focused 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 Siikamaki 2015, Nolte 2020). However, we are not aware of prior studies that have assessed whether conventional conservation prioritization would support or contradict environmental justice goals. We provide a novel test of differences in prioritization according to conventional conservation rankings versus environmental justice criteria.

2. Methods

2.1 Assessing regional-scale disparities in access to protected lands

We use the New England region as a study case to understand how environmental justice 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 POS Dataset (See SI, Figure S1). 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, Figure S2).

We define access to open space as the percentage of land area protected within each census tract or within various 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 provide analyses for different buffer sizes following case-based analyses that use different catchment sizes to define access such as Nicholls 2001, Kim and Nicholls 2016a). More detailed information on specific access points is not available at a regional scale.

To assess disparities in access to open space, we group census tracts into quartiles based on demographics and compare the distributions of percent of land protected across quartile groups (Figure 1). We also characterize the continuous relationships using both bivariate and multivariate regression (Figure 1, 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 regional focus areas based on environmental justice criteria

To identify potential environmental justice (EJ) focus areas within New England, we calculate the percentile rank of each census tract for median household income, percent people of color, percent people English-language isolated, and percent of land protected within 1km of the tract. 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 groups are separately important for social justice, we focus on tracts that fall within all of these groups in order to emphasize the most marginalized communities. 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 area tracts which includes communities with the least land protection, lowest income, highest percent people of color, and highest degree of language isolation (see SI).
2.3 Comparing prioritization based on environmental justice versus ecosystem-based criteria

To evaluate whether conventional prioritization systems will likely 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 (USDA 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 (Kellendorfer et al. 2013) which indicates opportunities for climate mitigation and can also proxy 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 at 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. environmental justice 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 Regional-scale disparities in access to protected lands

We find substantial disparities in the percentage of nearby protected land for more vs. less socially marginalized communities. These are illustrated by differences in the average percent of land protected across quartiles of demographic characteristics (Fig. 1A, Fig. S2). Households in census tracts within the lowest income quartile tend to have only half as much protected open space inside or within a 1 km distance of that tract (total land protected: median = 8.2%, SE = 0.29%) as those in the highest quartile of income (total land protected: median = 18.3%, SE =
Using the continuous data, we find that income and percent protected land are statistically significantly correlated across all tracts ($\rho=0.23$, $p<0.0001$). These disparities across income gradients are statistically significant for both public and private land (Figure 1).

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, Chakroborty et al. 2017). We further examine spatial variation in potential disparities by urban, exurban and rural tracts, as well as by state and using geographically weighted regression (see Fig. 1 and Supplemental Materials). We find that disparities by income persist within urban, exurban, and rural census tracts (Fig. 1B) and within all states in the region (Table S8, Fig. S8).

There are also substantial disparities in nearby protected land for communities with a higher proportion of people of color (Fig. 1, see Methods). Within 1 km of census tracts within the highest quartile for percent people of color, 9.3% (SE=0.26%) of land is protected, compared to 16.6% (SE=0.58%) for tracts in the lowest quartile. This means that communities with a high proportion of people of color have less than 60% as much protected land. Percent protected and percent people of color are significantly negatively correlated for all tracts ($\rho=-0.26$, $p<0.0001$), with a strong correlation for private protection ($\rho=-0.36$, $p<.0001$) and a weaker but still statistically significant one for public protection ($\rho=-0.10$, $p<.0001$).

Patterns of disparity by race persist within urban tracts, with a median of 8.6% (SE= 0.33%) nearby protected land for the highest quartile of people of color and 14.3% (SE = 0.45%) for the lowest quartile, and a correlation of $\rho=-0.23$ ($p<.0001$). However, in exurban areas in the region, public land protection is actually positively correlated with a greater proportion of people of color ($\rho=0.13$, $p<.0001$). We also find substantial disparities by educational attainment and English language isolation (Fig. S2, Fig. 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 a 2 km, 10 km or 25 km buffer (Fig. S4). Disparities in nearby protected land are less for larger buffer areas, indicating that disparities are more local 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 the utility of sites that are not walkable, highlighting the importance of local protected open space.

To understand whether land protection occurring in more recent decades has contributed to the reversal of historic inequalities, we analyze the patterns of new protected lands since 1990 (Fig. S4, tables S6-S7). This could indicate that trends of new protection are contributing to greater environmental justice. Protection occurring since 1990 generally has not contributed to reducing overall disparities (Fig. S4, Tables S6-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-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 land conservation efforts. In addition to more comprehensive social reform to reduce marginalization itself and desegregate the landscape, moving towards greater environmental justice requires reducing these disparities in access to open space. This will depend on the processes and patterns of future land protection, which can be informed by screening tools.

### 3.2 Regional focus areas based on environmental justice criteria

Priorities for land use must ultimately be determined by fair, locally oriented and community-led processes, but can be assisted by appropriate screening tools. Figure 2 indicates the census tracts identified as focus areas according to 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 according to census tracts 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 (also see Table S2). 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).

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 (EPA 2015) or individual state EJ criteria (e.g., MA DEP 2012, CT DEEP 2020). We found that in our region, 93% of tracts that ranked highly on environmental justice criteria 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 environmental justice 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 do 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 environmental justice 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 (Fig. 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 see that very few low-income communities that currently have low protection (black dots) are also among those with the highest resilience scores (Fig. 3A, middle panel). This suggests little opportunity to serve the lowest income communities if resilience is a primary conservation focus. 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 (Fig. 3A,
middle panel). Low protection tracts within the highest resilience quartile were on average $20,000 less well-off according to median 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 (Fig. 3A, \( \rho = -0.55, p<0.0001, N=701 \)). Less than 1% of communities in the highest quartile for resilience scores were also in the highest quartile for percent people of color. 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 race and income. Among tracts with low current levels of protection, carbon scores were positively correlated with income (Fig. 3B, middle panel, \( \rho = 0.25, p<0.0001, N=770 \)). Carbon scores for tracts with low current protection were negatively correlated with people of color (Fig. 3B, bottom panel, \( \rho = -0.18, p<0.0001, N=770 \)). Although these relationships are weaker than those for ecological resilience, they continue to indicate that protecting land based on top 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 positive 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 \(~$30,000\)). High drinking water prioritization scores were also positively correlated with percent people of color among the low protection tracts (Fig. 3C, bottom panel, \( \rho = 0.30, p<0.001, N=770 \)). For tracts in the highest quartile of Forests to Faucets scores, 22% were in the lowest quartile for income and 38% were in the highest quartile for percent people of color, indicating more possibility for this conservation priority to contribute to reduced disparities in access.
**Discussion:**

Achieving environmental justice 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, Schell et al. 2020, Mandle 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, Schleicher et al. 2019, Naidoo et al. 2019, Zafra-Calvo 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).

Our work illustrates how analysis of disparities and explicit incorporation of environmental justice 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 have just half as much nearby protected land as those in the highest income quartile and communities with the highest proportions of people of color have less than 60% as much protected land as those with the lowest proportions. These disparities persist across alternate markers of marginalization, public and private land, within the urban to rural gradient, and within recent decades.

We identify potential environmental justice focus areas as those with high social marginalization and low nearby protected open space. 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 environmental justice organizations for decades (Taylor 2000a, Lanfer and Taylor 2005, Agyeman 2008). Several conservation organizations have also recently called for meaningful reform that incorporates anti-racist and social justice goals in their organizational structures and decisions (LTA 2020). Yet scholarship developing access to open space as an environmental indicator has lagged behind these calls. Our research addresses this gap by
illustrating a systematic way to screen for disparities in access to protected open space across all communities. Our analysis focuses on New England, but the screening approach uses data that would be broadly available for the U.S., thus providing a potential model for other regional or national analyses.

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 environmental justice 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 screening tool 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 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., Garcia and Baltodano 2005, Sister et al. 2010, Flores and Khun 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.

Ultimately, environmental justice 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 income equality, all of which can promote more permanent equal access to the benefits of open space.
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 quartiles of income and percent people of color. Protected open space is analyzed in total (all protected lands), then by public and private ownership. 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<.05, ** p<.01) correlation between percent protected and income or percent people of color. A) All tracts (N=3344) B) urban (N=2131), exurban (N=918) and rural tracts (N=295).
Figure 2: Areas of potential focus for new land protection according to environmental justice criteria. EJ focus areas are census tracts in the lowest quartile for nearby protected land, the lowest income quartile, and the highest quartile percent people of color (Harvard Forest/Highstead Foundation database of protected open space; 2014-2018 American Community Survey estimates). Web map available at: http://bit.ly/EJ-OS-NE
Figure 3. Comparison of conservation rankings based on environmental justice criteria versus conventional conservation criteria. Maps indicate ecosystem-based prioritization scores for unprotected and undeveloped land by tract; darker shading indicates higher quartile of prioritization. Plots show environmental justice criteria versus the ecosystem-based ranking scores for all tracts and for those in the lowest quartile of protected land. Lines show a kernel-weighted local polynomial regression (bandwidth=500, 50, 15) for the low protection tracts (N=701, 770, 770).
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SUPPLEMENTARY INFORMATION:

1. Detailed description of methods

We analyze protected land, characteristics of marginalization, and conservation scores for communities in the New England region. Our unit of analysis is the census tract. We collect and analyze four pieces of information for each tract: demographics from the U.S. Census, percent of land area protected, average “score” for several conservation prioritization layers, and the number of brownfields (remediation sites). All data sources are summarized in Table S1.

1.1 Protected open space data and measures of access

Data on protected open space in New England comes from the Harvard Forest/ Highstead POS Dataset (Fig. S1). The POS dataset includes public land as well as conservation easements and private acquisitions of land by conservation NGOs and small local land trusts. It records a year of protection for a majority of sites (which allows us to investigate historical vs. recent protection). The data was compiled from over a dozen sources including direct data from local land trusts and other institutions supporting conservation in the region. In addition to regional, state, and local sources, this version of the POS layer contains data from the Protected Areas Database of the United States (PAD-US) 2.1, which substantially improved the representation of urban open space due to PAD-US 2.1’s inclusion of the Trust for Public Land’s ParkServe data (U.S. Geological Survey Gap Analysis Project 2020).

Data on specific entry points to protected lands or allowable public uses of each parcel is not comprehensively available at a regional scale. Our primary measure of access to open space is the percent of land protected inside or within a 1 km buffer of each census tract (Fig. S1). This is intended to represent protected open space within a community or within a feasible walking distance. We use the percent of land protected rather than an absolute amount because census tracts (and buffers) vary considerably in size. Buffers are important to capture access for people near the boundaries of the census tracts, particularly for communities immediately adjacent to park areas. Some parks receive their own census tracts (code range 9800’s; Boston’s Emerald Necklace area is an example) and would not be counted as part of any community without buffers.

We apply a series of additional buffers (2km, 10km, 25km) to census tracts to understand the distribution of protected open spaces at varying scales, which may proxy for access to open space on foot versus by car or public transportation. Further analysis of specific travel times is not possible due to a lack of availability of data on entry points to protected open spaces. While such data exists for many urban areas, it is not available comprehensively at a regional scale.
Nearby protected open space is assessed altogether as well as by different categories according to ownership (public or private) and year of protection (before or after 1990) (Fig. S1). Public open spaces in the dataset (~13% of the region’s land area) include state parks, national parks and national forests, as well as municipal parks and conservation land. Nearly all public open spaces in our region allow public access (limited exceptions include military lands / restricted drinking water supply areas), motivating the separate analysis of their distribution as they are particularly important for recreation access. Private open spaces (~12 % of the region’s land area) are conservation lands owned by individuals, mission-oriented organizations, and more than 300 local and regional land trusts. This includes land with permanent legal restrictions on development (“conservation easements”). Given traditions in the region of allowing public access to protected open space, the majority of private lands in our region also allow public access, but data on use rules is not comprehensively available (Daigle et al. 2012). Protected lands that do not allow public access still provide many locally important ecosystem services including flood protection, pollination services, biodiversity protection, cooling during extreme weather events, and amenity value. This motivates our focus on access to all types of protected lands in the main analysis (Foster et al. 2017, Sims et al. 2019, Mandle et al. 2020).

Our focus on permanently protected open space may underestimate current access to nature in rural communities. However, we feel that the focus on permanently protected land is appropriate because of ongoing and increasing loss of rural open space which threatens future access. A recent report highlights that the loss of natural land cover due to development has also been borne disproportionately by low income and high minority communities (Rowland-Shea et al. 2020). Indeed, the COVID-19 pandemic has led to dramatic pressures on home prices and development in many exurban and rural areas that highlight these threats (Kolko et al. 2021).

The POS layers were rasterized at 10m resolution prior to analysis, a resolution that is small enough to represent smaller and narrow protected open spaces (e.g. riparian corridors or pedestrian walkways) and large enough to feasibly run analyses at a regional scale. Although census tract boundary data comes with land and water area estimates for each tract, when calculating percent of land protected we define land area using the 2016 NLCD for consistency with land area estimates for buffered census tracts.

1.1.1 Characteristics of social marginalization

We use the five-year 2014-2018 American Community Survey (ACS) estimates for census tracts including total housing units, total population, median household income, race, educational attainment, and English proficiency (Manson et al. 2020b, 2020c). These data are the basis for the four demographic variables critical to our analysis: median household income, percent people
of color, percent of people 25 or older without at least a 4-year degree, and percent of people 5 or older who do not speak English at home and speak English less than ‘very well’. In our analysis, the percent people of color variable is measured by including all people who identify with categories other than White, non-Hispanic. This includes people who self-identify as Black, Asian, Native American, Native Hawaiian or Pacific Islander, multiracial, and White Hispanic or Latino. Figure S2 shows the distribution of demographics relevant to social justice within the region. These variables are joined to the 2018 TIGER/Line census tract boundaries (Manson et al. 2020a).

Access to land is a particularly important issue for Native and Indigenous people, who lived throughout this region prior to the arrival of colonial settlers and subsequent dispossession of nearly all land in the area. According to the ACS data, 0.15% of the population of New England currently identifies as Native American. We also calculated that 0.28% of New England’s land area is currently controlled by federally recognized tribes, which are sovereign nations with powers of self-government (U.S. Bureau of Indian Affairs 2018). Additional land is owned by communities that lack federal or any official recognition, but we are not aware of systematic data on this beyond population estimates.

Publicly and privately owned protected open spaces may have a role to play in supporting land access or land back for Native and Indigenous communities, if deemed appropriate by those communities. Native and Indigenous people may have distinct motivations for pursuing land protections, including but not limited to the protection of sacred sites or ensuring access to traditional foods and medicines (Krakoff 2018, Deur and James 2020). While full analysis of the ways protected open spaces may be accessible or inaccessible to Native and Indigenous people in the region is beyond the scope of the paper, the analysis and maps do identify some census tracts with a high proportion of Native American people as potential environmental justice focus areas. Ensuring processes that maximize local autonomy regarding land protection may be additionally important for these communities given the specific histories of dispossession.

1.1.2 Definitions of urban, exurban and rural

Total housing units are divided by the census-provided land-area estimate to determine each tract’s housing density. Tracts are classified as urban, exurban, or rural according to housing density following the cutoffs in Radeloff et al. 2005 (Urban: >128 housing units/km², exurban: 16–128 housing units/km²; rural: <16 units/km²). We visually inspected these classifications and reclassified one tract from rural to exurban because it was surrounded by neighboring tracts that were majority urban and was far away from any other rural tracts. We excluded tracts from statistical analysis if they had no housing units, fewer than 100 people, or were missing income
data (n = 26). The final dataset comprises N= 3344 tracts: Urban N=2131, exurban N=918 and rural tracts N=295. The distribution of urban, exurban and rural tracts, as well as the excluded tracts, are shown in Figure S3.

1.1.3 Ecosystem-based prioritization layers

To analyze conventional conservation priorities, we calculated average scores from three datasets used to aid in conservation prioritization (Table S1) for land that is still available for conservation. 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.

Resilience: The Nature Conservancy’s terrestrial resilience layer is a national dataset that ranks the long-term resilience of the land with a relativized, unitless index at 30m resolution (Anderson et al. 2016). We use the median index score within 1km buffered census tracts. Since the layer does not include scores for areas that are classified as developed, we exclude those areas from the median score calculation. The total number of tracts scored is 2,987 out of the 3,344 total.

Clean drinking water: USDA’s Forests to Faucets 2.0 Assessment is a national layer that ranks sub-watershed importance for cleaning drinking water using a unitless index (U.S. Department of Agriculture Forest Service 2018). We use the relative importance which reflects the percentile rank of each watershed at the national level and allows for comparison across watersheds. We rasterize this layer at 30m resolution for analysis with ArcGIS and use the mean relative importance score within 1km buffered census tracts. The total number of tracts scored is 3,212 out of the 3,344 total.

Carbon: The National Biomass and Carbon Dataset for the Year 2000 is a collection of national maps including aboveground biomass estimates circa 2000 at 30m resolution (Kellndorfer et al. 2013). We mosaic the maps for zones 65 and 66, which together cover all of New England, and use the mean of each map’s pixels in areas of overlap. We estimate metric tons of carbon per hectare (C Mg/ha) using the map’s original units of kg/m² x 10. To do so, we first estimate biomass within each 1km buffered census tract by multiplying the sum of pixels within each tract by 0.09 (which accounts for the proportion of a hectare in each 30m pixel) as described in the dataset user guide (Kellndorfer et al. 2013). We divide this estimate by each tract’s available land area to determine biomass Mg/ha. Finally, we divide by two to convert biomass Mg/ha to C Mg/ha (Schlesinger 1991). The total number of tracts scored is 3,211 out of the 3,344 total.

Undeveloped land: To estimate undeveloped land in 1990 and 2016, we use Landsat-derived land cover classifications. For 1990, land cover information is derived from two sources: the
Continuous Change Detection and Classification (CCDC) algorithm (Olofsson et al. 2016) and the National Land Cover Database (NLCD) (Homer et al. 2015). CCDC is an annual product covering the majority of New England but excluding northwest Vermont and northeast Maine. Because it was developed specifically for New England, we considered it to be the more accurate data source for 1990 and used it first where available. Where CCDC data was not available, we filled the remainder of the study area with the 1992 NLCD. For 2016, we used the 2016 NLCD, which has more detail on developed land uses compared to CCDC.

1.1.4 Brownfields data

To assess redevelopment potential, we analyzed overlap between the EPA’s data on the locations of brownfields and the census tracts (U.S. Environmental Protection Agency 2020). We provide a count because the EPA data is in points.

1.2 Analysis methods

1.2.1 Assessing disparities in access

To assess disparities in access to protected open space by demographic characteristics, we group census tracts into quartiles based on their demographics and compare the distributions of percent of land protected across quartile groups as shown in the boxplots (Fig. 1). We also characterize the continuous relationships between protected open space and characteristics of marginalization, as indicated by the stars representing statistical significance of correlation between variables (Fig. 1).

In addition to Figure 1 as described in the main text, Figure S4 indicates the percent of land protected before and after 1990, by quartiles of income and percent people of color. Figure S5 analyzes patterns of disparities using educational attainment and language isolation rather than income and race (see SI for additional description).

1.2.2 Identifying regional focus areas

To identify potential EJ focus areas within New England, we calculate the percentile rank of each census tract for median household income, percent people of color, percent people English-language isolated, and percent of land protected within 1km of the tract. We identify the tracts that are in the lowest quartile (percentile rank less than or equal to 0.25) of income and protection, and the highest quartile (percentile rank greater than or equal to 0.75) of percent people of color and percent language isolated. While each of these groups can be considered social justice communities, we consider tracts that fall within all of these groups as focus areas to
narrow the focus to the most marginalized communities. Statistics by state and examples of more detailed map areas are given in the SI (Table S2, Figs. S6 and S7).

1.2.3 Multivariate analysis of disparities and land protection patterns

The patterns of disparity in nearby open space that we observe are potentially driven by a complex set of intersecting factors, including development pressure, land availability, historical patterns of settlement across the region, and discrimination in siting. Fully disentangling the potential causal influence of these multiple factors is outside of the scope of our analysis, but we use multiple regression to analyze how access to nearby protected land is jointly related to several key factors, as well as to understand patterns of protection by distance and since 1990 (see SI Tables S3-S8, Fig. S8).

2. Supplementary results and discussion

2.1 Assessing disparities in access

Since 1990, more than 5 million acres of open space were protected in the region, allowing us to meaningfully examine both historical and more recent patterns of land protection. We find clear disparities by income across time, with more land protected in high income areas before 1990. (Fig. S4) The gradient of difference by income is much less post-1990, but there is no indication that the pattern of protection since 1990 has reversed this trend. When we consider patterns by the percent people of color, we see that pre-1990, land was actually more equitably distributed and that land protected post-1990 has tended to be in areas with fewer people of color. Much of this pattern is driven by the greater availability of undeveloped land in rural versus urban areas. The gradients of difference are smaller when we compare the amount of nearby protected area within urban, exurban, and rural tracts (Fig. S4). Regardless, the ultimate impact is that new land protected since 1990 has not contributed to reducing overall disparities in nearby protected land for communities with lower incomes or higher percent people of color.

Figure S5 analyzes patterns of disparities using educational attainment and language isolation. This confirms that very similar patterns of disparities result when we consider educational attainment or language isolation as markers of marginalization. Communities where fewer people have a four-year degree or where there is more language isolation also have substantially less nearby protected land.

2.2 Identifying regional focus areas

We break down EJ quartile groups and focus areas by state; each New England state has EJ communities identified at the regional scale (Table S2). While states differ in their relative
abundance of each EJ group, all states have communities that fall in at least one regional-level EJ quartile group. All states except Vermont have at least one regional EJ focus area. The focus area tracts with high conservation value from an environmental justice perspective collectively include 5.3% of the population and 0.25% of land area in New England.

We further identify focus areas with and without the inclusion of language isolation as a criterion and find that 90% of focus areas identified using our three core criteria (income, race, protection) are also in the highest quartile of English-language isolation. This highlights the ways in which many communities are cumulatively marginalized and demonstrates the importance of translation and interpretive services for community engagement.

Figure S6 shows EJ focus areas in four different parts of New England using three criteria. The figure shows in more detail how the tracts presented in Figure 2 overlay in different parts of the region. Figure S6 also highlights that we identify EJ focus areas in a range of communities, from a large, heavily urbanized city like Boston to smaller cities in more exurban environments like Concord, New Hampshire.

Figure S7 shows a screenshot of the web map, which includes census tracts in the highest quartile of language isolation and the focus areas identified with four criteria, in addition to those shown in Figure 2 and Figure S6. Protected open space and brownfields data add conservation context to the map. The user can click on protected areas or census tracts to see the underlying data. For census tracts, we provide the unique tract ID, tract type, demographic information, and land protection information. For protected open space, we provide the owner type (public or private), year protected, and area name.

2.3 Multivariate regression analysis of disparities and land protection patterns

In Table S3, we relate the percentage of land protected inside or within a 1 km buffer of each census tract to race, income, settlement density (urban/rural/exurban) and educational attainment (percent with a college degree). We find a strong and statistically significant negative relationship between the percent of people of color in a tract and the percent of land protected (Column 1; coefficient = -0.123, SE = 0.007). We also find a strong and statistically significant positive relationship between income and the percent of land protected nearby (Column 2; coefficient = 0.729, SE = 0.059). The coefficient on percent people of color diminishes as we add median household income, whether or not a tract is urban or exurban, and the percent of individuals 25 years or older who do not have a college education (Column 5; coefficient = -0.018, SE = 0.008). This change indicates that income, location in more densely settled areas, and educational opportunity are correlated with both the percent of people of color and the
percent of available protected land. This is consistent with the idea that historical structural inequality—differential access to educational opportunities, jobs, and residential areas on the basis of race—likely plays a crucial role in present day access to protected land.

We also examine these partial relationships by estimating the same models for public and private protected land separately (Table S4). From this table, we find that the percent of people of color has a less negative relationship with public versus private protected land (Columns 4-6 vs. 1-3). Indeed, when we include structural factors of income, urban/exurban/rural and educational attainment in the model, race does not significantly predict access to public land and the coefficient is zero or slightly positive (Columns 2 and 3). For privately protected land, however, the relationship remains negative and statistically significant (Column 6).

In Table S5, we show the relationship between land protected, percent people of color and income for different size buffer areas around each tract. Prior literature of specific cases has used a wide variety of catchment areas in defining access (Flores et al 2018, Castaneda 2017, Kim and Nicholls 2016, Nicholls 2001). We find that relationships between tract characteristics and land protected are smaller in magnitude as the catchment area increases.

In Table S6, we examine how new protection inside tracts or within a 1km buffer since 1990 relates to tract characteristics. We find strong negative correlations between new land protected and the percent people of color (Columns 1 and 2). This indicates that new protection since 1990 has not reduced disparities in nearby protected land inside census tracts or within 1 km. However, these patterns appear to be nearly entirely explained by the amount of land that is actually available for protection by 1990. As shown in column 3, the percent of land available in 1990 is a strong predictor of the percent protected between 1990 and the present, with $R^2$ of 24.4% of the variation in new land protected. Adding other variables measuring race, income, urban/exurban/rural status and educational attainment explains little additional variation in new land protected (column 5, $R^2 = 26.2\%$). This indicates strong co-occurrence of marginalized communities and areas with little land left to be protected by 1990. The same holds true for today, with strong correlation between the percent people of color in the recent ACS estimates and the percent of land currently available ($\rho = -0.605, p < 0.0001$). This suggests that future land protection that proceeds along similar lines to protection since 1990 will very likely result in further increasing disparities in access to protected land.

Table S7 indicates that new protection of both public and private land since 1990 has not been able to reduce disparities. New land protected inside or within 1 km of census tracts is negatively correlated with percent people of color and positively correlated with income for both public and private land.
Table S8 investigates bivariate regressions of the percent protected on income and percent people of color by each state in the region. The coefficients indicate a strong positive gradient between median household income and land protection in all states except New Hampshire. The coefficients also indicate that all states had a negative relationship between the percent protected and percent people of color. This relationship is weakest in Maine, which also has the least racial diversity within the dataset. Vermont’s coefficients are consistent with our overall findings but have limited precision due to the smaller number of census tracts. Overall, these results indicate that there is substantial disparity either by income or race within each state in the region.

Nevertheless, local variation is important and should be a crucial part of ultimate decisions about funding allocation or focus areas. In Figure S8 we show the results from geographically weighted regressions of the main bivariate relationships described in Figure 1 and Table S3 between the percent protected and income or race. These figures are helpful in indicating some areas of the region where relationships may be different, for example close to the federally protected White Mountains area in New Hampshire. This further highlights the importance of robust community-centered processes that consider the actual amount of land currently protected and local information on access to that land in decisions about focus areas for new protection or restoration.
SUPPLEMENTARY FIGURES

Figure S1: Study area and nearby protected open space by census tracts. Left panel provides a map of all protected lands in New England, broken down by public and private ownership. Right panel shows a map of the census tracts in the region. Tracts are color coded according to the percent of land area that is in protected open space inside or within 1 km of each census tract.
Figure S2: Distribution of income, race, education, and language isolation by states
Figure S3: Distribution of tract types and tracts not used in statistical analysis. Map shows the census tracts classified as rural, exurban and urban according to housing density. (Urban: >128 housing units/km², exurban: 16–128 housing units/km²; rural: <16 units/km²).
Figure S4: Disparities in land protected since 1990. Percent protected before and after 1990 within a 1 km buffer of current census tracts by quartiles of income and percent people of color. Boxplots show the median (line), 25th and 75th percentiles (box), and 5th and 95th percentiles (whiskers). Stars indicate a statistically significant (* p<.05, ** p<.01) correlation between percent protected and income or percent people of color. A) All tracts (N=3344) B) urban (N=2131), exurban (N=918) and rural tracts (N=295).
Figure S5: Disparities in land protected by degree of language isolation and educational attainment. Percent publicly and privately protected within a 1 km buffer of current census tracts by quartiles of percent without a four-year degree and percent language isolated households. Boxplots show the median (line), 25th and 75th percentiles (box), and 5th and 95th percentiles (whiskers). Stars indicate a statistically significant (* p<.05, ** p<.01) correlation between percent protected and educational attainment or English-language isolation. A) All tracts (N=3344) B) urban (N=2131), exurban (N=918) and rural tracts (N=295).
Figure S6: Areas of potential focus for new land protection according to environmental justice criteria: examples of detail for four metro-areas.
Figure S7: Example of web-based map showing focus areas for environmental justice in Boston, Massachusetts, the largest city in New England. The web map shows the same data as shown in Figure 2, plus data on language-isolated census tracts. Additional layers including protected open space (shown below), brownfields (not shown), and tract scores for the three conservation prioritization layers in Figure 2 (not shown) add conservation context. The user can click on map features to see data in pop-up windows. View map online: http://bit.ly/EJ-OS-NE.
Figure S8: Coefficients for income and percent people of color in bivariate geographically weighted regression. The maps show an overall positive relationship between income and percent protected and an overall negative relationship between percent people of color and percent protected. Histograms show that the OLS coefficients (columns 1 and 2 of Table S3) are approximately in the center of the distribution of GWR coefficients and represent the regional average. Local regressions in GWR are calculated using an adaptive kernel of 100 neighbors, which results in a smaller kernel in more densely populated areas and larger kernel in more sparsely populated areas.
SUPPLEMENTARY TABLES

Table S1: Data sources

<table>
<thead>
<tr>
<th>Layer or variable</th>
<th>Source</th>
<th>Year</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Census tract boundaries</td>
<td>Manson et al. 2020a</td>
<td>2018</td>
<td>Tract</td>
</tr>
<tr>
<td>Total housing units</td>
<td>Manson et al. 2020b</td>
<td>2014-2018</td>
<td>Tract</td>
</tr>
<tr>
<td>Median household income</td>
<td>Manson et al. 2020c</td>
<td>2014-2018</td>
<td>Tract</td>
</tr>
<tr>
<td>Percent people of color, total population</td>
<td>Manson et al. 2020c</td>
<td>2014-2018</td>
<td>Tract</td>
</tr>
<tr>
<td>Percent language isolated</td>
<td>Manson et al. 2020c</td>
<td>2014-2018</td>
<td>Tract</td>
</tr>
<tr>
<td>Percent with less than a 4-year degree</td>
<td>Manson et al. 2020c</td>
<td>2014-2018</td>
<td>Tract</td>
</tr>
<tr>
<td>Protected open space</td>
<td>Harvard Forest and Highstead Foundation 2021</td>
<td>2021</td>
<td>10m</td>
</tr>
<tr>
<td>Land area, undeveloped land area</td>
<td>National Land Cover Database 2016</td>
<td>2016</td>
<td>30m</td>
</tr>
<tr>
<td>Undeveloped land area</td>
<td>Olofsson et al. 2016 + National Land Cover Database</td>
<td>1990</td>
<td>30m</td>
</tr>
<tr>
<td>Terrestrial resilience</td>
<td>Anderson et al. 2016</td>
<td>2016</td>
<td>30m</td>
</tr>
<tr>
<td>Forests to Faucets 2.0</td>
<td>U.S. Department of Agriculture Forest Service 2018</td>
<td>2018</td>
<td>30m</td>
</tr>
<tr>
<td>National Biomass and Carbon Dataset 2.0</td>
<td>Kellndorfer et al. 2013</td>
<td>2000</td>
<td>30m</td>
</tr>
<tr>
<td>Brownfields</td>
<td>U.S. Environmental Protection Agency</td>
<td>2020</td>
<td>points</td>
</tr>
</tbody>
</table>

Table S2: Area and number of tracts with high environmental justice value characteristics

<table>
<thead>
<tr>
<th>State (code)</th>
<th>All total area (acres) # of tracts</th>
<th>Lowest quartile income % area # of tracts</th>
<th>Highest quartile % people of color % area # of tracts</th>
<th>Lowest quartile nearby PAs % area # of tracts</th>
<th>Lowest income + highest % POC + lowest nearby PAs % area # of tracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT (9)</td>
<td>3,090,870</td>
<td>2.7%</td>
<td>7.1%</td>
<td>9.9%</td>
<td>1.04%</td>
</tr>
<tr>
<td></td>
<td>823</td>
<td>182</td>
<td>302</td>
<td>280</td>
<td>94</td>
</tr>
<tr>
<td>ME (23)</td>
<td>19,730,036</td>
<td>71.6%</td>
<td>0.2%</td>
<td>29.5%</td>
<td>0.22%</td>
</tr>
<tr>
<td></td>
<td>351</td>
<td>169</td>
<td>5</td>
<td>184</td>
<td>3</td>
</tr>
<tr>
<td>MA (25)</td>
<td>4,990,524</td>
<td>4.2%</td>
<td>3.8%</td>
<td>2.2%</td>
<td>0.31%</td>
</tr>
<tr>
<td></td>
<td>1455</td>
<td>304</td>
<td>447</td>
<td>185</td>
<td>7</td>
</tr>
<tr>
<td>NH (33)</td>
<td>5,735,184</td>
<td>19.1%</td>
<td>0.1%</td>
<td>3.3%</td>
<td>0.03%</td>
</tr>
<tr>
<td></td>
<td>292</td>
<td>49</td>
<td>10</td>
<td>56</td>
<td>7</td>
</tr>
<tr>
<td>RI (44)</td>
<td>664,631</td>
<td>5.2%</td>
<td>3.5%</td>
<td>11.8%</td>
<td>1.33%</td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>80</td>
<td>71</td>
<td>101</td>
<td>33</td>
</tr>
<tr>
<td>VT (50)</td>
<td>5,912,137</td>
<td>22.4%</td>
<td>0.0%</td>
<td>5.6%</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>183</td>
<td>52</td>
<td>1</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>All states</td>
<td>40,123,382</td>
<td>42.1%</td>
<td>1.2%</td>
<td>17.0%</td>
<td>0.25%</td>
</tr>
<tr>
<td></td>
<td>3344</td>
<td>836</td>
<td>836</td>
<td>836</td>
<td>211</td>
</tr>
</tbody>
</table>
### Table S3: Percent protected within census tract and 1 km buffer as a function of tract characteristics

<table>
<thead>
<tr>
<th>Dep var: % protected in 1 km buffer</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% people of color (2014-2018 ACS)</td>
<td>-0.123***</td>
<td>-0.097***</td>
<td>-0.034***</td>
<td>-0.018**</td>
<td></td>
</tr>
<tr>
<td>Median HH income 2018 ($10,000s)</td>
<td>0.729***</td>
<td>0.476***</td>
<td>0.596***</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td>Urban (1/0)</td>
<td>-8.644***</td>
<td>-9.692***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exurban (1/0)</td>
<td>-3.943***</td>
<td>-4.118***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% without college education</td>
<td>-14.088***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.070</td>
<td>0.051</td>
<td>0.088</td>
<td>0.135</td>
<td>0.159</td>
</tr>
</tbody>
</table>

Ordinary least squares regression with robust standard errors; *** p < .01; ** p < .05; * p < .10

### Table S4: Public and private land protected as a function of tract characteristics

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Percent public land protected in 1 km buffer</th>
<th>Percent private land protected in 1 km buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>% people of color</td>
<td>-0.040*** 0.000 0.011 -0.080*** -0.033*** -0.028***</td>
<td></td>
</tr>
<tr>
<td>(2014-2018 ACS)</td>
<td>(0.006) (0.007) (0.007) (0.003) (0.003) (0.003)</td>
<td></td>
</tr>
<tr>
<td>Median HH income 2018</td>
<td>0.467*** 0.102 0.136*** -0.049</td>
<td></td>
</tr>
<tr>
<td>($10,000s)</td>
<td>(0.054) (0.077) (0.027) (0.037)</td>
<td></td>
</tr>
<tr>
<td>Urban (1/0)</td>
<td>-2.760*** -3.450*** -5.599*** -5.949***</td>
<td></td>
</tr>
<tr>
<td>(0.970) (0.970)</td>
<td>(0.529) (0.523)</td>
<td></td>
</tr>
<tr>
<td>Exurban (1/0)</td>
<td>-1.615 -1.730* -2.200*** -2.258***</td>
<td></td>
</tr>
<tr>
<td>(1.007) (1.000)</td>
<td>(0.545) (0.541)</td>
<td></td>
</tr>
<tr>
<td>% without college education</td>
<td>-9.271***</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3344</td>
<td>3344</td>
</tr>
<tr>
<td>R²</td>
<td>0.011</td>
<td>0.038</td>
</tr>
</tbody>
</table>

Ordinary least squares regression with robust standard errors; *** p < .01; ** p < .05; * p < .10

### Table S5: Percent protected by race and income within buffers of different sizes

<table>
<thead>
<tr>
<th>Dep var: % protected in tract and buffer</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% people of color (2014-2018 ACS)</td>
<td>-0.097*** -0.083*** -0.042*** -0.010*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median HH income 2018 ($10,000s)</td>
<td>0.476*** 0.442*** 0.172*** 0.073*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
</tr>
<tr>
<td>R²</td>
<td>0.088</td>
<td>0.079</td>
<td>0.025</td>
<td>0.003</td>
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</table>

Ordinary least squares regression with robust standard errors; *** p < .01; ** p < .05; * p < .10
Table S6: Protection since 1990 related to tract characteristics and land availability in 1990.

<table>
<thead>
<tr>
<th>Dep var: % protected in 1 km buffer Since 1990</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% people of color (2014-2018 ACS)</td>
<td>-0.074***</td>
<td></td>
<td>-0.008**</td>
<td></td>
<td>-0.002</td>
</tr>
<tr>
<td>(0.00)</td>
<td></td>
<td></td>
<td>(0.00)</td>
<td></td>
<td>(0.00)</td>
</tr>
<tr>
<td>Median HH income 2018 ($10,000s)</td>
<td>0.094***</td>
<td>0.007</td>
<td>-0.083***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent land available in 1990</td>
<td>9.261***</td>
<td>5.910***</td>
<td>6.555***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.34)</td>
<td>(0.51)</td>
<td>(0.54)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban (1/0)</td>
<td>-3.158***</td>
<td>-3.049***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.56)</td>
<td>(0.57)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exurban (1/0)</td>
<td>-1.414**</td>
<td>-1.384**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.56)</td>
<td>(0.56)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% without college education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-2.426***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.56)</td>
</tr>
<tr>
<td>N</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
<td>3344</td>
</tr>
<tr>
<td>R^2</td>
<td>0.114</td>
<td>0.004</td>
<td>0.244</td>
<td>0.259</td>
<td>0.262</td>
</tr>
</tbody>
</table>

Ordinary least squares regression with robust standard errors; *** p < .01; ** p < .05; * p < .10

Table S7: Public and private protection since 1990 related to race and income

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Percent public land protected in 1 km buffer</th>
<th>Percent private land protected in 1 km buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>% people of color (2014-2018 ACS)</td>
<td>-0.021***</td>
<td>-0.051***</td>
</tr>
<tr>
<td>(0.00)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>Median HH income 2018 ($10,000s)</td>
<td>0.054***</td>
<td>0.044***</td>
</tr>
<tr>
<td>(0.01)</td>
<td>(0.02)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3344</td>
<td>3344</td>
</tr>
<tr>
<td>R^2</td>
<td>0.026</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Ordinary least squares regression with robust standard errors; *** p < .01; ** p < .05; * p < .10
Table S8: Percent protected within census tract and 1 km buffer as a function of tract characteristics by individual states

<table>
<thead>
<tr>
<th>Dep var: % protected in 1 km buffer</th>
<th>CT</th>
<th>MA</th>
<th>RI</th>
<th>NH</th>
<th>ME</th>
<th>VT</th>
</tr>
</thead>
<tbody>
<tr>
<td>% people of color (2014-2018 ACS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.117***</td>
<td>-0.178***</td>
<td>-0.143***</td>
<td>-0.484***</td>
<td>-0.047</td>
<td>-0.236</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.011)</td>
<td>(0.017)</td>
<td>(0.058)</td>
<td>(0.060)</td>
<td>(0.212)</td>
</tr>
<tr>
<td>N</td>
<td>823</td>
<td>1455</td>
<td>240</td>
<td>292</td>
<td>351</td>
<td>183</td>
</tr>
<tr>
<td>R²</td>
<td>0.127</td>
<td>0.147</td>
<td>0.147</td>
<td>0.098</td>
<td>0.001</td>
<td>0.008</td>
</tr>
<tr>
<td>Dep var: % protected in 1 km buffer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median HH income 2018 ($10,000s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.336***</td>
<td>0.900***</td>
<td>1.556***</td>
<td>-0.115</td>
<td>0.628***</td>
<td>0.301</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.071)</td>
<td>(0.277)</td>
<td>(0.316)</td>
<td>(0.233)</td>
<td>(0.518)</td>
</tr>
<tr>
<td>N</td>
<td>823</td>
<td>1455</td>
<td>240</td>
<td>292</td>
<td>351</td>
<td>183</td>
</tr>
<tr>
<td>R²</td>
<td>0.025</td>
<td>0.084</td>
<td>0.176</td>
<td>0.000</td>
<td>0.012</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Ordinary least squares regression with robust standard errors; *** p < .01; ** p < .05; * p < .10