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RESEARCH ARTICLE

Citizens of local jurisdictions enhance plant community preservation through ballot initiatives and voter-driven conservation efforts

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Abstract Open space areas protected by local communities may augment larger scale preservation efforts and may offer overlooked benefits to biodiversity conservation provided they are in suitable ecological condition. We examine protected areas established by local communities through ballot initiatives, a form of direct democracy, in California, USA. We compare ecological conditions of wooded habitats on local ballot protected sites and on sites protected by a state-level conservation agency. Collectively, we found few differences in ecological conditions on each protected area type. Ballot sites had greater invasive understory cover and larger trees. Community dissimilarity patterns suggested ballot sites protect a complementary set of tree species to those on state lands. Overall, geographic characteristics influenced onsite conditions more than details of how sites were protected. Thus, community-driven conservation efforts contribute to protected area networks by augmenting protection of some species while providing at least some protection to others that might otherwise be missed.

Keywords Ballot propositions · Conservation measures · Grassroots · Nature reserves · Park systems · Protected area networks

INTRODUCTION

Establishment of protected areas to provide habitat for the world's biota is one of the most important biodiversity conservation strategies despite inherent complexities in the process (Watson et al. 2014). Protected area networks generally consist of open spaces (i.e., vegetated or green spaces like wildlife preserves or public parks) protected through the efforts of multiple government and non-government actors operating over various scales (Poiani et al. 2000; Bode et al. 2011; Scarlett and McKinney 2016). For example, in the United States of America (U.S.), national, state, and local government agencies all contribute to establishment and management of protected areas at different scales of governance. Several non-government agencies (NGOs) like The Nature Conservancy and National Audubon Society also work to establish protected areas such as wildlife sanctuaries and nature reserves in the U.S. and internationally, often in coordination with government agencies and local communities (Anderson 2010; TNC 2020).

There are many different models through which local communities support preservation efforts worldwide (Kothari 2006b; Oviedo 2006). Examples of community preserved areas range from sacred forests and sites in Africa and Asia to indigenous territories in South America. While these protected areas are highly diverse in terms of their size, uses, and regulations, they share a common thread in that they all directly involve local communities in conservation and management decisions (Kothari 2006a). Recent estimates indicate that over 370 million ha of land are under some level of conservation management by local communities worldwide, making them significant contributors to global efforts (Kothari 2006a; Smyth 2006).

In the U.S., one such model for community conservation takes the form of city or county level protected areas established through local ballot initiatives, a form of community-driven direct democracy (see Appendix S1 for further detail on ballot initiatives and direct democracy in

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California and elsewhere). With this mechanism, local communities vote to protect land that provides amenity values and ecosystem services such as recreational opportunities, clean water, or agricultural space in their immediate surroundings (Ando and Shah 2010; SCAPOSD 2012; Buijs et al. 2017). Resulting protected areas have the potential to advance large-scale biodiversity conservation goals, whether or not doing so was a goal of protection (Crain et al. 2011; Kroetz et al. 2014; Buijs et al. 2017; Crain et al. 2020). Within the U.S., the State of California has been a forerunner in establishment of protected open space areas and management of environmental issues through local ballots and direct democracy (Gordon 2004).

Protected areas are established and managed to meet various objectives, however (Campbell and Vainio-Mattila 2003; Bode et al. 2011), and differences in habitat conditions among protected area types seem likely given jurisdictional constraints (Abbitt et al. 2000; Crain and White 2011; Scarlett and McKinney 2016), what their goals for protection are (Vangansbeke et al. 2017), funding availability (Martín-López et al. 2009), and management strategies (e.g., Kraaij et al. 2017; Rupprecht 2017; Schuch et al. 2017). Each of these factors can influence habitat conditions in protected areas, and thereby their potential contributions towards biodiversity preservation. Evaluating habitat conditions on protected areas acquired and managed through different mechanisms and agencies is critical for gauging their contributions towards meeting shared conservation goals across multiple scales (Coetzee 2017). Such information would enable conservation organizations to identify potential synergies in their efforts and provide opportunities to optimize biodiversity conservation gains (Crain et al. 2015; Kang et al. 2015).

Recent assessments of what contributions protected areas acquired through local ballot initiatives provide to biodiversity protection have been limited to larger scales and only address the geographic positioning of protected areas and not the habitat conditions onsite (Kroetz et al. 2014; Crain et al. 2020). Publicly available land use data are generally not at a sufficient resolution to evaluate detailed habitat quality measures within individual protected areas, and field work is required to assess onsite conditions.

Here we examine diversity measures and habitat conditions on protected areas acquired and established by local communities through direct democracy. We focus on local ballot initiatives in California as an interesting example of community-driven conservation. Because we are particularly interested in the contribution local communities make by establishing protected areas, we concentrate on parcels of land acquired and protected through ballot measures passed by cities, municipalities, and counties. For comparison, we use the California Department of Fish and Wildlife (CDFW) as an example of a larger scale conservation actor active in land protection. CDFW operates throughout the state and manages close to 450,000 ha of habitat on 749 properties (CDFW 2018). We compare geographic attributes of selected parcels protected through local ballots to others protected by CDFW and then quantify the potential biodiversity conservation value of habitats on each protected area type based on plant diversity measures and vegetation conditions. We anticipate that environmental and geographical differences in ballot and CDFW protected areas could result in differences in diversity measures and habitat conditions found onsite.

MATERIALS AND METHODS

Identification of survey sites

We identified a series of land holdings preserved (i.e., purchased and/or managed) with funding from city or county ballot initiatives in California. We first used The Trust for Public Land's LandVote Database and Ballotpedia's database on local ballot measures to identify successful city and county level initiatives dealing with open space preservation (Appendix S1). We then obtained data on specific properties acquired and/or preserved with ballot funds from agencies in charge of planning and managing these open spaces (generally city or county level parks and open space agencies). We conducted field surveys of onsite plant diversity and vegetation conditions on representative sites from each jurisdiction included in our analyses. For comparison, we also selected a series of open space areas purchased and/or managed through state legislation and resources from a statewide agency, CDFW, who is responsible for protection and management of plant and wildlife diversity across California (CDFW 2018). We surveyed CDFW properties nearest to the ballot protected areas chosen for our analysis. Collectively, we surveyed 54 open space preserves (27 ballot and 27 CDFW) occurring across 15 counties in central California (Fig. 1). The majority of these protected areas were located in the San Francisco Bay area and adjacent counties but the distribution extended south to San Luis Obispo County.

Field survey protocols

Field surveys focused on evaluating plant diversity and vegetation conditions on comparable habitat patches on each site. Our goal was to evaluate whether comparable habitats on ballot protected parcels were in a significantly different condition and were protecting different species than those on sites protected by a larger, state-run conservation agency. We emphasize this comparison because

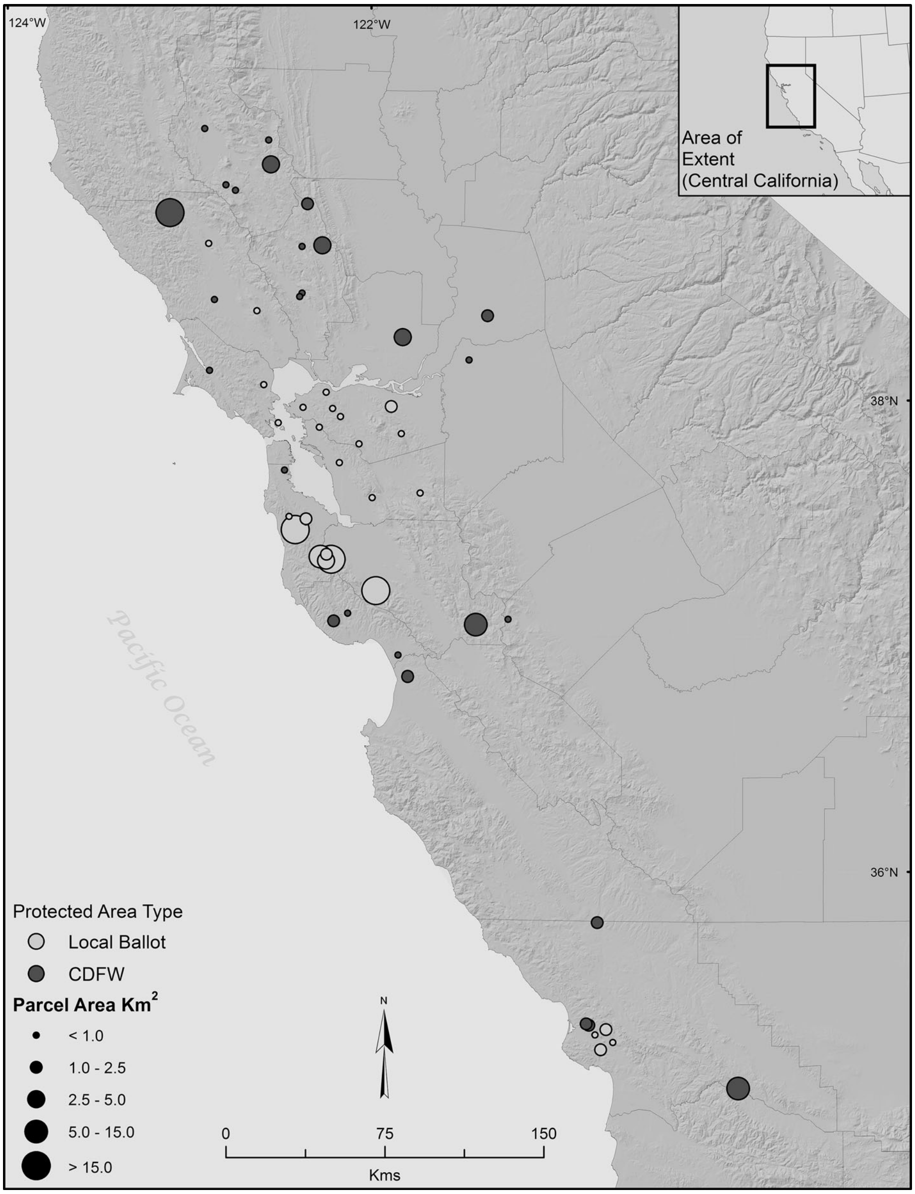

Fig. 1 Distribution of local ballot protected areas and California Department of Fish and Wildlife (CDFW) protected areas in central California surveyed in the present study. Light markers indicate ballot protected areas whereas darker markers indicate CDFW protected areas. The overall size of the markers indicates the approximate size of each protected area

parcels protected by larger conservation agencies are routinely counted towards achievement of conservation objectives, while efforts of local communities are often overlooked. Because of the inherently heterogeneous attributes of the parcels involved, we needed a survey design for sampling parcels of different sizes, at different locations, and containing a range of habitat types.

We began by using ArcGIS 10.1 to identify the latitude of each parcel's center, its size, and its distance to the nearest urban area. Field surveys entailed sampling vegetation and plant diversity on three 100 m^2 plots within each protected parcel (162 plots altogether). For comparative purposes, all sample plots were established in wooded habitats as close to the parcels' center as possible to minimize potential edge effects (Murcia 1995). We focused on wooded areas, as opposed to wetlands or grasslands for example, as this general habitat type occurred on all sites in the study. Individual plots on each survey site were separated by a minimum distance of $\approx$ 10 m. Elevation (masl) was recorded on each site. Whenever possible, survey sites were located in distinct forest types to capture variability in vegetation cover. It should be noted, however, that the goal of our study and sampling design was to compare the conditions of analogous habitats on the different protected area types, and not necessarily the overall conditions on the entire site, which would require additional efforts beyond the scope of our study.

The design for data collection at each sample plot was based on a combination of vegetation survey methods presented by Peet et al. (1998), Parkes et al. (2003), and the California Native Plant Society Vegetation Committee (CNPSVC 2007). Canopy cover was recorded with a concave spherical densiometer at the center of each plot. Trees within each plot that were $\geq$ 10 cm diameter at breast height (DBH; measured at a height of 1.37 m) were counted, identified to species level, and classified as native or exotic (Stuart and Sawyer 2001; Baldwin et al. 2012). Total number of tree species on the site, proportion of tree species that were exotic, and proportion of trees that were exotic were calculated. The height (ft) of each tree was recorded with a clinometer. Because potential size varies greatly among tree species, height and DBH measurements were adjusted to represent the proportion of estimated size at maturity for each species (hereafter referred to as standardized height and DBH). Last, all evidence of site impacts or habitat disturbances, e.g., grazing, logging, or litter (CNPSVC 2007), observed inside the plots or that were visible up to 10 m from their boundaries were documented and the total number was recorded.

Within each 100 m^2 sampling plot, 1 m^2 sub-plots were also established for evaluating attributes of ground cover vegetation. On each sub-plot, a 1 m^2 point frame consisting of 100 nodes separated by 10 cm was positioned on the southwest corner of the larger sampling plot. Herbaceous plants, shrubs, and seedlings occurring at each node were identified and classified as native or exotic (DiTomaso and Healy 2007; Keil and Harms 2010; Baldwin et al. 2012; Crain and White 2013; Beidleman and Kozloff 2014). The total number of plant species was tallied and the proportion of species that were exotic quantified. Percentage of the overall ground cover that was exotic was also quantified. Collectively, the field surveys yielded data on ten distinct variables related to plant diversity and vegetation conditions for analysis.

Data analysis and statistical modeling

We used General Linear Models (GLMs) to test for associations between our ecological indicators for individual sites and protected area type while controlling for other protected area characteristics. Our basic model formulation was:

$$g(y_i) = \alpha + \beta_1 x_{1i} + \beta_2 \boldsymbol{x_{2i}} + \varepsilon_i \quad (1)$$

where g is the relevant link function, y_i is one of our ecological indicators on site i, α and the various β values are coefficients to be estimated, x_{1i} is a binary variable taking a value of 1 on ballot protected sites and 0 on CDFW sites, $\boldsymbol{x_{2i}}$ is a vector of other site characteristics, and ε_i the site specific unobservable contribution. GLMs were employed because several of our response variables consisted of count or proportional data. We selected the appropriate model family and link function based on the specific type of response variable in each model.

When making comparisons between ballot protected sites and CDFW sites, we add additional variables to control for potentially confounding geographic attributes that can affect plant diversity and vegetation conditions ($\beta_{2\text{-}5}$). To account for the latitudinal gradient in species richness, (Rosenzweig 1995) we included the latitude of the centroid of each protected parcel. Similar effects can result from elevation gradients, and therefore, we also included the mean elevation (m) of our survey sites (Seabloom et al. 2002). We controlled for parcel area (km^2) as well because size of a given parcel is also likely to influence overall habitat conditions and species richness (Merenlender et al. 1998; Nielsen et al. 2014). Furthermore, the proximity of protected areas to urban areas can affect their capacity for maintaining biodiversity (McKinney 2008). Accordingly, we included the shortest distance (km) between urban centers and each protected area as an additional covariate. We used Wilcoxon–Mann–Whitney tests to compare the median values of the covariates we include in our subsequent regression model fitting: latitude, elevation, parcel size, and distance to urban areas for ballot and CDFW sites to identify potential differences between these measures on the two protected area types we consider.

We also tested whether these same variables were associated with species turnover and differences in community composition between sites (i.e., beta diversity) for tree and herbaceous species using a multiple regression on distance matrices (MRM) approach (Lichstein 2007). First, as an indicator of community dissimilarity between each pair of sites, we computed Sorensen–Dice dissimilarity indices for trees and herbaceous species. We compared the resulting dissimilarity matrices (our response variables in these analyses) to differences between pairs of sites when measured in terms of the same five predictor variables we used in the GLMs. For the protected area type predictor, pairwise dissimilarity entries took a value of 0 if the sites were of the same type and a value of 1 if the sites were of different type. We used the "MRM" function in the "ecodist" R package (Goslee and Urban 2007) to regress the dissimilarity matrices against a linear combination of the resulting environmental distance matrices for each predictor variable. MRM assesses significance with a permutation test and we used 5000 permutations for each inference.

Before running our models, we tested for collinearity among predictor variables. Because some predictor variables were not normally distributed (e.g., the key predictor of interest is binary), we relied on Spearman's correlation analyses and visual inspection to evaluate collinearity. Predictor variables were only weakly correlated with one another (correlation coefficients for all variables < 0.35; Evans 1996).

RESULTS

Geographical attributes of protected areas

Geographic characteristics of local ballot and CDFW protected areas included in the survey were similar (Table 1). Wilcoxon–Mann–Whitney tests indicated no significant differences in the latitude, elevation or parcel size between the surveyed ballot and CDFW protected areas. At the same time, the surveyed ballot protected sites tended to be closer to urban areas than CDFW sites. Nevertheless, the median distance between urban areas and protected parcels of either type was relatively short.

Plant diversity and vegetation conditions on protected areas

Plant diversity measures and vegetation conditions on local ballot and CDFW protected areas were variable (Table 2). When it comes to explaining the variation in different indicators of plant diversity and vegetation conditions on individual sites, the majority of our regression models (Table 3) had reasonably good predictive capacity; seven of twelve models were highly significant (p-values were ≤ 0.01) and an additional model was marginally significant (p-value of 0.08). Pseudo R^2 (GLMs) and R^2 (MRMs) estimates in these models were generally above accepted thresholds for goodness of fit (≥ 0.2–0.4 is considered acceptable; Hensher and Johnson 2018).

The GLMs indicated that plant diversity and vegetation conditions were similar on ballot and CDFW protected areas. Specifically, values of β_1 were not significant in most cases after controlling for basic geographic

Table 1 Descriptive statistics for geographic predictor variables related to plant diversity and vegetation conditions for surveyed sites protected by local ballot initiatives (n = 27) and by the California Department of Fish and Wildlife (CDFW; n = 27) with results of Wilcoxon–Mann–Whitney tests comparing geographic predictors on ballot sites and CDFW sites

Covariate	Ballot sites (Quartiles)	CDFW sites (Quartiles)	Wilcoxon (W)	p-value
Latitude (°)	37.32/37.59/37.93	37.05/38.25/38.70	37.05	0.07
Elevation (m)	131.83/198.00/365.33	127.83/159.33/459.17	127.83	0.70
Parcel size (km^2)	0.18/0.79/1.27	0.23/0.65/2.20	0.23	0.76
Distance to urban areas (km)	0.00/0.10/1.82	0.76/5.62/11.36	0.76	< 0.01

Table 2 Descriptive statistics for response variables related to plant diversity and vegetation conditions for surveyed sites protected by local ballot initiatives (n = 27) and by the California Department of Fish and Wildlife (CDFW; n = 27)

Response variable	Ballot sites			CDFW sites		
	Median	25th percentile	75th percentile	Median	25th percentile	75th percentile
Tree spp. (#)	3.00	2.00	4.50	3.00	2.00	3.50
Herbaceous spp. (#)	10.00	7.50	13.50	10.00	7.50	13.00
Canopy cover (%)	95.68	88.60	98.68	92.90	86.47	97.12
Standardized tree DBH (%)	105.40	83.17	125.75	90.08	82.13	125.93
Standardized tree height (%)	186.67	138.57	222.17	161.35	122.29	213.54
Exotic tree spp. (%)	0.00	0.00	< 0.01	0.00	0.00	< 0.01
Exotic trees (%)	0.00	0.00	< 0.01	0.00	0.00	< 0.01
Exotic herbaceous spp. (%)	40.00	28.57	71.43	50.00	28.57	57.74
Exotic herbaceous cover (%)	29.67	7.17	44.17	48.00	20.33	65.83
Disturbances (#)	4.00	3.00	5.00	4.00	3.00	5.00

Table 3 Results from General Linear (GLM) and Multiple Regression on Distance Matrices (MRM) models of vegetation conditions on selected protected areas in California

Response variable: y_i	Constant/ intercept (SE): α	Protected area type (SE): β_1	Latitude (SE): β_2	Mean elevation (SE) $\times 10^{-3}$: β_3	Parcel size (SE) $\times 10^{-1}$: β_4	Distance to urban areas (SE) $\times 10^{-2}$: β_5	Model Family	Link Function	Model p-value	Pseudo R^2/ R^2
Tree spp. (#)	− 2.24 (2.98)	0.09 (0.18)	0.08 (0.07)	0.14 (0.36)	0.17 (0.11)	− 1.58 (1.47)	Poisson	Log	0.30	0.03
Herbaceous spp. (#)	− 1.20 (1.63)	0.01 (0.10)	0.09 (0.04)*	0.44 (0.19)*	0.01 (0.07)	0.33 (0.70)	Poisson	Log	0.01	0.04
Canopy cover (%)	10.09 (1.14)**	0.08 (0.06)	− 0.20 (0.03)**	− 0.21 (< 0.01)	0.47 (0.07)**	0.28 (0.51)	Binomial	Logit	0.30	0.07
Standardized tree DBH (%)	− 4.59 (4.03)	0.74 (0.26)**	0.11 (0.10)	− 2.24 (0.54)**	− 0.08 (0.19)	8.80 (1.84)**	Gaussian	Identity	< 0.01	0.17
Standardized tree height (%)	− 7.44 (4.78)	0.38 (0.31)	0.18 (0.12)	0.47 (0.63)	0.40 (0.23)	1.24 (2.19)	Gaussian	Identity	0.17	0.05
Exotic tree spp. (%)	24.78 (5.24)**	− 0.33 (0.35)	− 0.70 (0.13)**	− 5.68 (2.84)**	− 10.57 (6.86)	3.46 (6.10)**	Binomial	Logit	< 0.01	0.31
Exotic trees (%)	34.46 (14.12)*	− 0.21 (0.74)	− 0.93 (0.36)*	− 7.94 (1.62)*	− 3.32 (1.60)*	7.16 (2.71)	Binomial	Logit	< 0.01	0.29
Exotic herbaceous spp. (%)	1.67 (3.26)	0.37 (0.21)	− 0.04 (0.08)	− 1.89 (0.41)**	− 0.29 (0.16)	4.57 (1.52)**	Binomial	Logit	< 0.01	0.12
Exotic herbaceous cover (%)	− 3.52 (0.59)**	0.09 (0.04)*	0.08 (0.01)**	− 2.18 (0.08)**	− 0.50 (0.04)**	6.77 (0.28)**	Binomial	Logit	< 0.01	0.24
Disturbances (#)	5.90 (2.26)**	0.13 (0.16)	− 0.11 (0.06)*	− 0.56 (0.35)	− 0.12 (0.14)	0.82 (1.09)	Poisson	Log	0.08	0.04
Tree spp. dissimilarity (*DSC*)	0.79	0.05**	0.03**	− 0.03	− 0.03	0.20	na	na	< 0.01	0.06
Herbaceous spp. dissimilarity (*DSC*)	0.83	7.32×10^{-3}	0.03**	− 0.02	0.00	0.01	na	na	0.17	0.04

Model parameters for GLMs (family, link function) and coefficients for the five predictor variables used in each analysis are listed along with standard errors for these coefficients. β_1: Protected area type = ballot protected area (1) or CDFW (0). Data for standardized tree heights and diameters (DBH) were standardized using a z-transformation. Similar coefficients for MRM models examining turnover in species composition are given in the last two rows. Response variables for MRMs were matrices of pairwise Sorensen–Dice dissimilarity indices (*DSC*) for tree species and herbaceous species on the sites and predictors were pairwise distance matrices for each of the covariates. For the protected area type predictor, pairwise dissimilarity entries took a value of 0 if the sites were of the same type and a value of 1 if they were of different type. * indicates coefficients with p-values < 0.05, ** indicates p-values < 0.01. Pseudo-R^2 values for GLMs were calculated using McFadden's formula and standard R^2 values were calculated for MRMs. Significance tests for MRMs based on permutation tests with 5000 permutations differences between the two protected area types. The relationship between ballot protected status and the number of tree or herbaceous species that occurred on sites was not statistically significant. Nor was the relationship with percent canopy cover on the sites. There was a significant positive relationship ($p < 0.01$) however, between ballot protection and the mean standardized DBHs of trees on the survey sites. Trees on ballot sites tended to have DBHs closer to (or greater than) estimated diameters at maturity for their given species (Stuart and Sawyer 2001). At the same time, there was no difference in mean standardized tree height between the two protected area types.

Furthermore, there were no significant relationships ($p > 0.05$) between ballot protected status and the proportion of tree or herbaceous plant species that were exotic, nor with the proportion of trees that were exotic. Ballot sites did, however, have a significant association ($p < 0.05$) with the percent cover of exotic herbaceous plants. Specifically, ballot sites had greater exotic herbaceous cover than CDFW sites. The regression models examining number of habitat disturbances showed no significant relationship with ballot protected status.

We also examined patterns of community dissimilarity and turnover between pairs of sites. When examining dissimilarities between tree community compositions, our MRM revealed a significant positive relationship ($p < 0.05$) between protected area type and turnover in species across sites (Table 3), indicating a difference in the set of species found on ballot and CDFW sites. The model for herbaceous species showed no effect of protected area type on differences in community composition.

The additional covariates we considered were important for explaining variation in how the two types of protected area performed in terms of plant diversity and vegetation conditions (Table 3). GLMs revealed that protected parcels at higher latitudes had greater numbers of herbaceous plant species, smaller proportions of exotic tree species, smaller proportions of exotic trees, and fewer disturbances. They also had lower percentages of canopy cover and higher proportions of exotic herbaceous plant cover. MRMs showed that increased differences in latitude between pairs of protected sites were associated ($p < 0.05$) with increased turnover in tree and herbaceous species among sites (Table 3).

GLMs also showed that higher elevation sites had more herbaceous species, lower proportions of tree species and trees that were exotic, lower proportions of exotic herbaceous species, and lower percentages of exotic herbaceous cover (Table 3). Elevation was also negatively associated with tree sizes. Sites at higher elevations had trees with smaller standardized DBHs for their given species. MRMs indicated no association between elevational differences among sites and species turnover.

Additionally, GLMs showed that there was a significant positive relationship between size of the protected areas in our study and canopy cover. Negative relationships existed between size of the protected areas we studied and the proportion of trees that were exotic as well as percentage of exotic herbaceous cover. Protected area size differences did not have a significant effect on community dissimilarity for tree and herbaceous species according to MRMs (Table 3).

Distance to the nearest urban center was positively associated with standardized DBHs of trees on the survey sites. Surprisingly, however, increasing distances to urban centers also had a significant positive association with the proportion of tree and herbaceous species on a site that were exotic, as well as with the percent cover of exotic herbs. MRMs showed no significant effect of differences in distances to urban areas on tree and herbaceous species turnover (Table 3).

DISCUSSION

Ballot vs. CDFW protected areas

Local open space preservation efforts are constrained by geographic limitations and these efforts often arise to meet potentially different objectives than those motivating state or national level conservation agencies and practitioners (Berkes 2007). Understanding what local protection efforts provide in terms of habitat preservation and benefits to biodiversity will help larger scale conservation actors coordinate better with local efforts. In California, local ballot initiatives have helped protect more than 700 parcels of land that could potentially provide habitat to an array of species (Crain et al. 2020). In some cases, specific parcels of land were targeted in ballot initiatives (MCP 2020) whereas others provided funds to protect open space areas in general and did not necessarily target specific properties (SCAPOSD 2012). The sample of sites protected through local ballots considered in this study alone provided an additional 67.62 km^2 of preserved open space to California's protected areas network beyond the 88.67 km^2 provided by the CDFW sites we surveyed. While the CDFW specifically targets larger areas of higher habitat quality and connectivity (CDFW 2018), in several instances, ballot protected areas were adjacent to other protected areas established by government and non-government organizations and served to increase the collective size and connectivity of these protected areas networks (SCAPOSD 2012; MCP 2020). The question that has remained up to this point, however, is how suitable the habitat conditions on these protected areas are for biodiversity conservation, and how they compare to conditions found on other protected area types. Are locally protected areas more heavily used, less well-managed, e.g., greater emphasis is placed on goals aside from biodiversity preservation, or otherwise in a more ecologically degraded condition? How do they complement or reinforce biodiversity protection offered by other types of protected areas?

We found that the ecological conditions of wooded habitats on protected areas established through local ballot initiatives were comparable to those found on protected areas established by one of the principal statewide conservation agencies. Regression models indicated ballot protected areas exhibit comparable estimates of plant diversity and vegetation conditions to those on areas managed by CDFW (Table 3). These similarities could reflect some of the overlap in the array of goals and management objectives motivating open space preservation through local ballots and CDFW. For example, numerous ballot protected areas are established and managed to provide recreational opportunities as well as to preserve plant diversity and habitats (SCAPOSD, 2012). Supporting a variety of recreational activities, wildlife, and biodiversity habitat are also key goals on many CDFW sites (CDFW 2018).

At the same time, we did find some ecological differences between the two types of protected areas. Trees on ballot sites tended to have larger diameters on average (Tables 2, 3), and may provide better habitat for species that depend on mature trees for activities such as foraging, roosting, or nesting (Call et al. 1992; Baker et al. 2008). Ballot sites also tended to have higher levels of exotic plant cover indicating CDFW sites might be better for maintaining native plant communities. From a management perspective, greater coverage of exotic plants on ballot sites suggests that eradication of exotic species and other restoration efforts may be needed to optimize benefits to native herbaceous plant communities.

Our analyses of community composition suggest that there are significant differences between the set of tree species found on ballot and CDFW protected sites after controlling for effects of other site characteristics like latitude. For tree species, ballot sites can be thought of as complementing the protection to biodiversity offered by CDFW sites (Aycrigg et al. 2013). In contrast, we did not find significant differences in turnover of herbaceous species between ballot and CDFW sites. For herbaceous species, ballot sites can be thought of as reinforcing protection for species already represented in the protected area network by preserving additional sites on which these species occur. At the same time, it should be noted that adding ballot sites to the overall protected area network will still increase the number of herbaceous species represented, but not at a disproportionately faster rate than adding more CDFW sites.

Implications of geographic attributes

Our results also indicated that geographic attributes such as latitude, elevation, parcel size, and distance to urban areas have more important effects on plant diversity and vegetation conditions on protected areas than does the particular mechanism of establishment. Each of these variables was identified as a significant predictor of our ecological indicators more frequently than protected area type. This finding supports conclusions from other studies (e.g., Durán et al. 2016) that explore effects of spatial features on species richness. We also found that latitudinal differences between protected areas were associated with greater turnover in species for both herbaceous and tree species, allowing more species to be represented within the protected area network. These results again suggest that the mechanism through which a protected area is established and funded may not be as important for determining ecological conditions as other site characteristics.

Indeed, what geographic differences there are between the two protection types suggest that ballot and CDFW protected areas may provide complementary benefits that might not be afforded by either one on its own. For example, we did find significant differences in the sets of tree species preserved by each type of protected area. Also, the fact that ballot protected areas were located closer to urban centers suggests ballot protected sites could foster direct exposure of urban populations to the benefits of biodiversity through areas that might not be prioritized by larger scale agencies (Campbell and Vainio-Mattila 2003; Bijker and Sijtsma 2017). Likewise, such sites could support more accessible recreational and educational opportunities for urban populations while providing important local ecosystem services such as reduction of urban heat islands (Gago et al. 2013). Ballot protected areas' proximity to urban centers, where threat of habitat conversion is high, also indicates that these sites might be critical for protecting some of the more vulnerable habitats in the state. As such, ballot sites might help to offset biases in large-scale protected area networks that tend towards including sites at greater distances from city centers (Joppa and Pfaff 2009). Given that numerous countries worldwide have some mechanism for community-driven conservation, it becomes apparent that larger protected areas networks could greatly benefit from incorporating local efforts such as ballot initiatives, sacred forests, and indigenous reserves, for example, into their broader planning strategies.

Extensions for biodiversity conservation on ballot and CDFW protected areas

While we examined plant diversity and vegetation conditions on ballot and CDFW sites, the status of several other components of biodiversity and ecosystem functionality still need to be assessed. For example, similarities in habitat conditions on the two types of protected areas do not necessarily mean that they fulfill all of the specific needs of wildlife or special status taxa. Systematic assessments of the habitats and management practices as they relate to the precise requirements of individual species of interest will be important extensions of this work (Poiani et al. 2000; Watson et al. 2014; Coetzee 2017).

Another extension would involve examining in more detail the added conservation benefits provided by local ballot sites to the protected areas network as a whole. Our community dissimilarity findings are relevant here but only focus on species representation. Future analyses could explore, for example, how ballot protected areas enhance connectivity of the protected area network for particular target species (Morrison and Boyce 2009).

Finally, our focus in this first field-based study was on describing how patterns of plant diversity and vegetation conditions were similar or different between ballot and CDFW sites. While an informative first step for conservation, these results do not yet reveal whether protection per se caused improvements in biodiversity onsite. That level of inference would require a formal causal inference design as well as data on site history and management, but may be possible if working in locations or over spatial extents where more sites are available from which to sample and for which more data are available (e.g., McConnachie et al. 2016).

CONCLUSIONS

Overall, results of our study of protected areas established through local ballot initiatives in California, U.S. suggest that conservation efforts of local communities support important habitats. Prior studies demonstrate that the spatial configuration of ballot protected areas in California overlaps with the ranges of numerous species (Crain et al. 2020). Our current findings are the first to highlight that wooded habitats on these protected areas are largely in a comparable ecological condition to those protected by a state-level conservation agency and to examine patterns of complementarity and redundancy using species composition data collected onsite. Local ballot areas add to the overall size and breadth of the protected areas network in California, providing new opportunities for habitat conservation and restoration agendas (Campbell and Vainio-Mattila 2003). Consequently, preservation of open spaces through local ballot measures is a noteworthy strategy that could enhance opportunities for biodiversity preservation, particularly when coordinated with efforts of larger scale conservation agencies (Scarlett and McKinney 2016).

The system studied here suggests more broadly that the numerous and varied habitat protection efforts led by local communities should not be idly dismissed on grounds that locally protected sites are somehow in poorer ecological condition than those established and managed by large-scale actors. To use conservation resources effectively, we need to account for, value, and integrate the efforts of many different conservation actors, including the important roles played by local communities.

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