Landscape and Urban Planning 127 (2014) 114–123

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research paper

An historical land conservation analysis in the San Francisco Bay Area, USA: 1850–2010

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HIGHLIGHTS

- We reconstructed the process of decadal conservation land acquisition from 1850 to 2010.
- We assessed the representation of land-cover types within the conservation network.
- Conservation network growth was gradual with a fill-in effect to a total of 26% of the study region.
- Intermediary governance levels aimed at providing a specific service (Special Districts) purchased most land.
- Land cover in properties acquired around the 1900s and after the 1970s changed the least.

ARTICLE INFO

Article history:
Received 27 November 2013
Received in revised form 4 April 2014
Accepted 5 April 2014

Keywords:
Governance levels
History
Land-cover types
Metropolitan conservation network
Representation
Timeline

ABSTRACT

The last century has seen large changes in land-use and land-cover. We reconstructed the history of conservation land acquisition (where, when, how much and what) from 1850 to 2010 in the San Francisco Bay Area, California, U.S.A. We hypothesized that the process of land acquisition would be characterized by a fill-in effect – as acquisitions are pursued over time, they complement prior acquisitions by adding more area and new or underrepresented land-cover types. We also hypothesized that strategic land acquisition over time would result in representation of all land-cover types, and that these types would subsequently show little transition, except in heavily disturbed locations, such as previously logged redwood forests. Acquisition of conservation lands was continuous and currently represents 31.7% of the Bay Area. Special Districts (local government units delivering a specific service – parks) acquired more area, and cities acquired numerous small properties. There was a fill-in effect with fewer and larger parcels acquired before 1940 while later acquisitions were more numerous but smaller. At least 20% of every land-cover type is currently conserved, showing the historic complementarity of strategic acquisitions. Land-cover change was less than 40% in early acquisitions, between 70 and 80% on degraded lands in mid-century, and 45% in recent acquisitions. The history of conservation land acquisition has led to a representative conservation network in the San Francisco Bay Area. We believe that reconstructing conservation history can unveil past trends, permit assessment of success, and identify challenges to represent biodiversity within a conservation network.

1. Introduction

Unprecedented rates of change in land-use and land-cover over the last century challenge the ability of conservation networks to meet their objectives of conserving biodiversity, and other goals. While reserve network characteristics such as number, size, spatial location and proximity, and presence of stepping stone reserves (Heller & Zavaleta, 2012) reflect what is today the accepted rationale for the systematically planned development of a conservation network (Margules & Pressey, 2000), this has not always been the case (Knight, Rodrigues, Strange, Tew, & Wilson, 2013) especially in rapidly growing metropolitan areas. Earlier conservation land acquisition efforts pursued a variety of values in an ad hoc fashion rather than explicit objectives (Cowling, Pressey, Lombard, Desmet,

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http://dx.doi.org/10.1016/j.landurbplan.2014.04.011
0169-2046/

& Ellis, 1999). Further, the timing of historic acquisitions may have had an effect on whether conservation goals as currently defined have been met (Meir, Andelman, & Possingham, 2004). The timing of conservation action may be a function of multiple factors, such as delays linked to requests for more information, the inherent dynamics of natural systems, and insufficient traction (funding, policies, etc.), among others (Czech, 2004; Grantham et al., 2010; Knight et al., 2008). We thus propose to take a step back and reconstruct the conservation history of a given location, through which we can track the process of growth of the conservation network within a growing metropolitan area, and assess the contribution of land additions at different time periods to the overall success of conservation as measured by current conservation goals. Since conservation decisions are intrinsically a human decision making process, the likely future behaviour of a human society is strongly tied with its past (Szabó & Hédl, 2011).

While historical acquisition of conservation land may have been for goals other than biodiversity such as aesthetics or resource reserves, the evolution of conservation thought has modified the goals, priorities, and direction of conservation land acquisition to include biodiversity, ecosystems and other motivations such as to counteract or mitigate the impacts of urban growth. Reconstructing the conservation history of a region first requires the identification of the mechanisms through which land becomes part of a conservation network. In the United States, for example, in order for land to become part of the conservation network it can: be acquired and then managed for conservation; be donated to a conservation organization; or, be assigned an easement where private ownership is maintained but management is conservation oriented (Rissman & Merenlender, 2008). A timeline is needed that identifies when each land parcel was added to the conservation network independently of the motivation for its addition. This is far from being a trivial task, as records are spread out, incomplete, sometimes fully missing, inaccessible, and not digital (e.g. http://www.stanford.edu/group/spatialhistory/cgi-bin/site/index.php). The use of digital geographical analysis for historical conservation reconstructions is a relatively new approach (for example see Radeloff et al., 2013), and the temporal data is often incomplete. The reconstruction of the conservation history can be enriched by the analysis of conservation results and their change over time. Representation is a metric of conservation output (Kirkpatrick, 1983), and it defines the proportion of a population or area of a given conservation target that is included within the conservation network (Cowling et al., 1999). Representation has been widely used to measure past and current conservation network achievements (Austin & Margules, 1986; Kujala, Moilanen, Araújo, & Cabeza, 2013; Meir et al., 2004) and identify future expansions (BAUHG, 2011).

For conservation to take place there is a need to adopt long-term and regional perspectives (Heller & Zavaleta, 2012). These practices have been very important to the development of the current conservation network in the San Francisco Bay Area in California (Walker, 2007). This region has experienced both large population growth (Thorne, Santos, & Bjorkman, 2013), and has a long history of successive efforts to conserve Open Space (Walker, 2007). Open Space here refers to publicly held conservation lands, and is more formally defined as "*lands protected through fee title ownership by a public agency or non-profit land conservation organization*" (GreenInfo Network, 2013). Many groups share the goal of continuing Open Space acquisition in the Bay Area – Bay Area Upland Habitat Goals project (BAUHG, 2011). The motivation for additional Open Space is the preservation of agriculture and ranching, biodiversity, and of ecosystem functions such as ground water recharge. Historic and continuing implementation of Open Space in the Bay Area contributes to its widely recognized high quality of life (Thorne et al., 2013).

Our objective was to reconstruct the conservation history for the San Francisco Bay Area by (1) describing the process of conservation land acquisition, number of properties and area, and the acquiring governance levels from 1850 to 2010, (2) describing the representation of land-cover types over time, and (3) determining whether there is a relationship between the time since acquisition and land-cover change. Our starting hypothesis was that the process of conservation land acquisition had a fill-in effect, whereby as acquisitions are pursued over time, they complement prior acquisitions both in area (adding more area to the total conservation network) and land-cover type (adding new or underrepresented land-cover types). In the Bay Area, large conservation land tracts were likely acquired earlier, when land was more available, and later acquisitions were complementary, more numerous and smaller in area. As the motivation for and the science behind land conservation changed over time so would the land-cover types represented, in response to changes in aesthetics, restoration, land use pressures, and more recently the need to add underrepresented land-cover types to the conservation network (Czech, 2004). Finally, we hypothesized that changes in land-cover types inside Open Space were likely smaller in magnitude and in different direction than changes in non-Open Space areas. Alternatively, changes in land-cover types inside Open Space could be bigger than changes in non-Open Space areas, as the result of restoration or improved management of land-cover types. This change could be due to the effect of natural succession or active restoration of lands that were previously used for other purposes (for example redwood logging in the 1800s) prior to their acquisition as conservation land.

2. Methods

Study area: the study area encompasses the 9 counties of the San Francisco Bay Area (hereafter referred to as the Bay Area): Marin,

Fig. 1. Study area location. Black outline represents the extent of the historic land-cover maps and thus delimits the area under study.