Landscape and Urban Planning 92 (2009) 106–116

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

# Impacts of conservation easements for threat abatement and fire management in a rural oak woodland landscape

Kristin B. Byrd[a], Adena R. Rissman[a,b], Adina M. Merenlender[a,*]

[a] Department of Environmental Science, Policy and Management, University of California, Berkeley, 137 Mulford Hall #3114, Berkeley, CA 94720-3114, USA
[b] Department of Forest and Wildlife Ecology, University of Wisconsin at Madison, 1630 Linden Drive, Madison, WI 53706, USA

ARTICLE INFO

*Article history:*
Received 16 January 2008
Received in revised form 3 March 2009
Accepted 6 March 2009
Available online 21 April 2009

*Keywords:*
Conservation effectiveness
Rural residential development
Exurban
Fire management
General plan
Development footprint

ABSTRACT

Rural residential development can impact habitat and complicate fire management. Conservation easements are created to prevent development but are rarely assessed for their influence on development patterns. In the Lassen Foothills, California, The Nature Conservancy (TNC) holds over 37,000 ha of mostly public-funded conservation easements on ranchland dominated by blue oak (*Quercus douglasii*) woodland. For this region we modeled land use through 2050 under two scenarios, with and without conservation easements, using a rule-based growth model. We mapped development footprints on 760 rural residential parcels through automated remote sensing. From calculated footprint sizes we projected site-level habitat loss for each scenario. We also projected the influence of development patterns on fire management. With easements present the Lassen Foothills would gain about 184 new homes, compared with 223 homes if easements were absent. With an average residential footprint size of $0.34 \pm 0.25$ ha (mean $\pm$ SD), we found that easements slightly reduce vegetation conversion, protecting an additional 16.8 ha than were protected by the general plan alone. Without easements, scattered development may alter fire management on 12,370 ha (17.5% of undeveloped wildfire containment areas) by requiring more fire suppression and reducing options for prescribed burning. Low development pressure and county land use policies maintain very low residential densities in the Lassen Foothills. The easement program may increase options for fire management by preserving large landscapes. This case illustrates the limited effectiveness of land acquisition in preventing development in a low-threat landscape, and demonstrates the utility of growth models for prioritizing conservation investments.

Published by Elsevier B.V.

## 1. Introduction

Rural residential development is the fastest growing land use type in the United States (Brown et al., 2005). This low density development impacts biodiversity and ecosystem processes and fragments habitat (Hansen et al., 2005). Many conservation efforts to reduce development and protect habitat rely heavily on conservation easements (Merenlender et al., 2004), but the extent that conservation easements effectively alter development levels and reduce habitat conversion has not been fully examined.

Seeking the "natural amenities of rural landscapes" such as open space, outdoor recreation, and a clean environment, people have chosen to live in low density areas on small "ranchettes" or subdivisions in rural areas or at the urban fringe (Rasker and Hansen, 2000; Rudzitis, 1999). Rural residential development, or exurban development, is low density housing on large parcels (Brown et al., 2005; Theobald, 2005) outside of urban service boundaries, which requires a reliance on septic systems and well-water. Exurban area increased five-fold since 1950 (Brown et al., 2005), occupies five to ten times more area than urban and suburban land use, and is expanding by 10–15%/year (Theobald, 2000, 2001).

Despite calls for research on the impacts of human settlement (Miller and Hobbs, 2002) particularly beyond the urban fringe (Fraterrigo and Wiens, 2005; Theobald, 2005), attempts to quantify exurban development and assess its impacts are only just beginning. Low density development is difficult to map and monitor using existing land cover data because tree canopy cover often remains dense in the surrounding area (Sutton et al., 2006). Exurban landscapes tend to be heterogeneous (Bock et al., 2006) and support a wide variety of land use activities such as horse grazing and small scale agriculture. These dispersed activities and related

* Corresponding author at: Department of Environmental Science, Policy and Management, University of California, Berkeley, 137 Mulford Hall #3114, Berkeley, CA 94720-3114, USA. Tel.: + 1 707 744 1424; fax: +1 707 744 1040.
*E-mail addresses:* kbbyrd@gmail.com (K.B. Byrd), arrissman@wisc.edu (A.R. Rissman), adina@nature.berkeley.edu (A.M. Merenlender).

0169-2046/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.landurbplan.2009.03.003

low density developments modify the landscape and complicate land management, especially adjacent to protected areas (Cole and Landres, 1996; Theobald, 2004).

Rural residential development has particularly influenced fire management in California. The highest fire frequency and greatest area burned occur at intermediate population densities (~35 to 45 people/km$^2$) where development intermingles with wildland vegetation (the Intermix Wildland-Urban Interface) (Syphard et al., 2007). Human-caused fire ignitions have increased with population and wildland recreation, while fire suppression efforts have prevented total burn area from increasing (Stephens, 2005). The dollar amount of damage caused by wildfires and suppression costs have increased dramatically. Suppression costs from the 2004 to 2005 fire season were $170.1 million and the average annual financial loss from 2001 to 2005 was $288.3 million (California Department of Forestry and Fire Protection, 2007).

The threat of development drives many initiatives to protect open space on private land, including local ballot initiatives, private and public fundraising campaigns, acquisition of land and conservation easements, and regulatory land use planning. Conservation easements have emerged as a dominant tool for land trusts and government agencies to protect natural resources (Hansen et al., 2005; Land Trust Alliance, 2006). Conservation easements are individually negotiated agreements used frequently on working landscapes (Rissman et al., 2007) in which a landowner agrees to limit subdivision, development, and other land use, usually in perpetuity. In exchange, landowners may receive a direct payment or reduction in income, estate, and property taxes (Gustanski and Squires, 2000).

Since the 1980s the use of conservation easements has increased sharply, funded by millions of dollars in private donations, federal and state tax deductions, public grants, and local and statewide ballot initiatives (Fairfax et al., 2005; Land Trust Alliance, 2006). Yet the effectiveness of conservation easements for preventing development and protecting habitats is relatively unquantified (Merenlender et al., 2004; Rissman et al., 2007). Conservation easements are designed to prevent development permanently, so their effectiveness is related to the likelihood of future development. Their effectiveness is also linked to the amount of development permitted in the conservation easement, which is often a compromise agreement and can permit new residential dwellings (Rissman et al., 2007). Build-out models are one method of projecting future development with estimates of population growth allocated into land use classes that can be used to compare alternative protection scenarios (Johnston and Shabazian, 2003).

We examined how effectively conservation easements protect against rural residential development threats in a Northern California blue oak (*Quercus douglasii*) woodland landscape dominated by large, unfragmented cattle ranches. We explored the effectiveness of conservation easements in the context of county land use planning, and assessed the capacity of conservation easements to protect oak woodland habitat and permit fire management and planning. We employed a novel remote sensing approach to quantify and map the development footprint on low density residential parcels.

Our study addressed three main questions. (1) What is the expected low density development pattern in our study area based on a county build-out model, and how does the presence of conservation easements alter that development pattern? (2) How much does low density development contribute to direct habitat conversion, and do conservation easements minimize these impacts? Finally we ask, (3) to what extent is fire planning and management influenced by conservation easements? This study represents a novel approach to assessing conservation easement outcomes by projecting future development and forecasting the effects on habitat conversion and fire management across a greater rural landscape.

## 2. Methods

### 2.1. Study area

Starting in the 1990s, The Nature Conservancy (TNC) has been conserving land in the Lassen Foothills, one of the largest unfragmented landscapes in California, which spans the eastern half of Tehama County and extends into Shasta County to the north and Butte County to the south (Fig. 1). The Lassen Foothills project area covers over 364,000 ha, and extends from Mount Lassen to the Sacramento River. Blue oak woodlands in the project area are mostly held in large privately owned cattle ranches. TNC's primary conservation strategy is the purchase of conservation easements that limit development, woodcutting, and other extractive uses, and allow the landowners to continue ranching.

TNC invested in conservation easements here to protect a relatively unfragmented blue oak woodland landscape, extensive vernal pool complexes, California's largest migratory deer herd, and Federally listed anadromous fish (The Nature Conservancy, 2007). Easements were established on over 37,000 ha of land between 1997 and 2007. The total amount of public funding used for these easements was $12,970,000.00, or $349.80/ha. One of TNC's primary land management strategies is fire management aimed to reduce the cover of invasive non-native plants, and enhance deer habitat and forage quality (Hujik, 2000).

We developed a build-out model for Tehama County since the county covers most of the Lassen Foothills project area and necessary input data are aggregated at the county level. Tehama County encompasses 7770 km$^2$ with a strong east–west topographic gradient from the Pacific Coast Range to the Sacramento River Valley to the ridgeline of the Sierra Nevada Mountains.

Tehama County's landscape reflects its rural character, with over half its land area designated as cropland (valley agriculture) or grazing land (upland agriculture) according to the county general plan (Tehama County Planning Department, 2000). Urban and commercial centers and most of the county's population [61,424 in 2006 (State of California Department of Finance, 2006)] are located in the Sacramento Valley near Interstate 5 and Highway 99. To the east and west of these transportation corridors, the land is dominated by large ranches and federal and state government land holdings.

Tehama County's population density was 17.3 people/km$^2$ in 2000, compared to the state average of 83.9 people/km$^2$. Only about 15% live in the incorporated cities of Red Bluff, Corning, and Tehama. The remaining population lives in small, unincorporated communities or in residences scattered throughout the county (PMC, 2006).

### 2.2. Rural residential build-out scenarios

UPlan is a rule-based urban growth model that operates in ESRI's ArcView 3.1 or higher (Johnston and Shabazian, 2003). The model allows the user to change parameters in order to test future development scenarios, which has made it a popular tool for county planning agencies in California (Johnston et al., 2003; Merenlender et al., 2005). In UPlan population and employment projections determine the extent of development in seven land use classes. The general plan plus user-defined weighted development attractions (e.g. highways), discouragements (e.g. slope), and masked areas (e.g. public lands), determine spatial allocation of development. The user inputs a general plan (recoded in UPlan general land use categories, Fig. 2A) and attraction, discouragement, and mask data as 50-m grids. The model projects development within high-, medium-, low-, and very low density residential, high- and low density commercial, and industrial land use classes. While many urban-growth models are available (U.S. Environmental Protection Agency, 2000), we chose UPlan because