Biological Conservation 158 (2013) 107–115

Contents lists available at SciVerse ScienceDirect

Biological Conservation

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

Examining the knowing–doing gap in the conservation of a fire-dependent ecosystem

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ARTICLE INFO

Article history:
Received 23 March 2012
Received in revised form 15 August 2012
Accepted 22 August 2012
Available online 28 November 2012

Keywords:
Longleaf pine ecosystem
Red-cockaded Woodpecker
Research-implementation gap
Social context
Spatio-temporal logistic regression

ABSTRACT

Scientifically informed conservation goals do not always align with what is accomplished in practice, leading to the so-called "knowing–doing gap". One reason why the knowing–doing gap exists may be that scientific recommendations often do not account for the "real-world" social context of conservation. The social context may be particularly important for ecosystem restoration involving prescribed burning. In the longleaf pine ecosystem, scientists and conservationists have called for large-scale restoration using prescribed burning; however, recent levels of burning may be insufficient to accomplish restoration. We studied the knowing–doing gap in the longleaf pine ecosystem by investigating where recent burns had been conducted. We used spatio-temporal logistic regression to relate recent burning in the Onslow Bight, North Carolina, to site and landscape attributes that burn practitioners there had previously said were important. Our results show that prescribed burns were preferentially placed on high-quality sites rather than on degraded sites, suggesting a knowing–doing gap in longleaf pine conservation in which burning is not used for restoration. In addition, sites that had not been burned for at least 4 years showed an increased probability of burning as distance from development increased, suggesting that sites with high fuel loads near development were not likely to be burned. Finding ways to encourage burning on degraded sites near development, such as rewarding practitioners for successfully conducting difficult burns, would help narrow the knowing–doing gap in conservation of this and other fire-dependent ecosystems.

1. Introduction

When scientifically informed conservation goals do not align with what is accomplished in practice, the so-called "research-implementation" or "knowing–doing" gap occurs (Knight et al., 2008). This gap has been recognized in a number of disciplines within and related to conservation science, including conservation planning (Knight et al., 2008), restoration ecology (Higgs, 2005), and invasion ecology (Esler et al., 2010). One reason why the knowing–doing gap exists is because conservation research may not reach practitioners (Fazey et al., 2005; Knight et al., 2008). This issue has been widely acknowledged and many efforts are underway to promote closer communication between scientists and practitioners (e.g. Anonymous, 2007). Another reason why the knowing–doing gap exists may be that the goals or recommendations resulting from research do not take into account the "real-world" social context of conservation. The importance of considering conservation's social dimension when setting goals has been recognized by conservation biologists recently because social factors can constrain the opportunities available to implement conservation actions (Knight et al., 2006, 2010).

In fire-dependent ecosystems, the social context of conservation can affect what can be accomplished through limitations related to the costs, risks, and logistical challenges associated with fire use. Constraints such as the cost of implementing prescribed burning and shortage of trained personnel can limit the use of fire (Cleaves et al., 2000). In addition, there is potential for damage to human health or property if smoke or fire spread to populated areas. In landscapes that contain a mixture of protected, residential, and commodity producing lands, fire use is particularly constrained because of the wildland–urban interface (WUI). The WUI is defined as the area where homes and other structures meet or intermix with natural vegetation. In the WUI, fear of liability for damage to human health or property could decrease the likelihood of letting wildfires burn or using prescribed fire, especially because residents tend to have negative perceptions of fire use as a management tool (Winter and Fried, 2000; McCaffrey, 2004; Schindler, 2007). Conversely, suppressing wildfires or failing to implement burning also carries longer-term increase in risk of negative effects from future

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http://dx.doi.org/10.1016/j.biocon.2012.08.025

wildfires because of fuel accumulation. Avoiding short-term damages that could result from fire use in some locations may be more compelling to land managers than conducting fire management, which may have benefits that are poorly quantified and realized over the long term (Maguire and Albright, 2005; Donovan and Brown, 2007). All of these factors in concert can limit fire use, result in few conservation accomplishments in the long-term, and bring further ecosystem degradation (Stankey et al., 2003).

In the longleaf pine (*Pinus palustris*) ecosystem in the southeastern United States, there is a difference between stated goals and actual accomplishments in fire use for conservation. A major conservation goal for the longleaf ecosystem is large-scale management using prescribed fire to restore and maintain the rich diversity of plant and animal species found there (America's Longleaf, 2009). Indeed, more burning is done in the Southeast than in any other part of the country (Haines et al., 2001). However, several challenges, along with the ones described previously, likely present limitations to burning in longleaf pine ecosystems. With increased time since the last burn in the ecosystem, plant growth and pine needle accumulation in the understory, along with infill of woody plants in the midstory, lead to a buildup of fuels and increased potential for higher intensity fires (Varner et al., 2005). In addition, the Southeast as a whole also contains the largest land area in the WUI (Radeloff et al., 2005). Researchers have suggested that current prescribed burning programs are not accomplishing ecosystem-wide restoration of longleaf pine (Van Lear et al., 2005). This shortcoming is in part because the overall amount of prescribed burning is insufficient to burn large extents with a frequent return interval (Van Lear et al., 2005). The overall amount burned is often limited by lack of funding or other resources (Cleaves et al., 2000). It is also important to establish whether fire managers are able to place the burns they do conduct on sites that are in need of restoration. Avoidance of challenges, risks and conflicts associated with burning may be as influential in determining whether a site is burned as the site's ecological condition. For example, fire managers may be inclined to conduct burns on areas they know they will be able to burn in the future, rather than burning larger areas that may not be feasible to maintain. Examining where burns have been conducted will inform strategies for ensuring that prescribed burning accomplishes regional longleaf pine restoration.

We examined recent burning of the longleaf pine ecosystem by land management agencies in the Onslow Bight region of North Carolina (NC), a region containing a mix of urban, residential, and commodity-producing lands in which stakeholders previously acknowledged the need for restoration of longleaf pine via prescribed burning. Our objective was to investigate which site and landscape attributes best explained the placement of prescribed burns in order to determine whether prescribed burning was being conducted in areas in need of restoration. We posed the following three questions relating to the placement of prescribed fire and the knowing–doing gap in restoration of longleaf pine within protected areas across the region:

1. Have recent prescribed burning activities focused on maintaining sites in good ecological condition, or on restoring poor-quality sites?
2. Which site and landscape attributes related to non-ecological factors such as human health and commodity production contribute to determining whether a site is burned?
3. How much influence do these non-ecological attributes have on burning, compared with ecological attributes?

We hypothesized that prescribed burning activities have focused on maintaining high-quality sites because of the risks associated with burning poor-quality sites, where fuel loads are usually higher. Because of previous research showing that risks of prescribed burning are high in the WUI, we also hypothesized that location of the WUI was a major non-ecological factor in determining which sites were burned. Specifically, we predicted that sites located farther from the WUI were burned more often than sites closer. Finally, we hypothesized that non-ecological attributes of sites and surrounding landscapes were more important than ecological attributes in determining which sites would be burned because of the challenges non-ecological factors present for conducting burns. Investigating the factors associated with the placement of prescribed burns in the longleaf pine ecosystem will help us identify relevant strategies for accomplishing conservation goals in this important ecosystem.

2. Methods

2.1. The longleaf pine ecosystem and conservation

The longleaf pine ecosystem was once the dominant habitat in the southeastern US along the coastal plain and outer piedmont from Texas to Virginia (Frost, 1993). When frequently burned (every 1–3 years), the understory communities in longleaf pine ecosystems have among the highest levels of plant species richness of any ecosystem in the world (up to 40 species per m^2 and 140 species per 1000 m^2, Peet and Allard, 1993). Due to widespread timber harvesting, fire suppression, and development, longleaf pine forests have been severely degraded and fragmented, reducing this forest type to only 3% of its pre-European settlement range (Frost, 1993). As a result, populations of plant and animal species that depend on longleaf pine habitat, including the Federally-endangered Red-cockaded Woodpecker (*Picoides borealis*) have declined (Van Lear et al., 2005). This decline has prompted Noss and others (1995) to designate longleaf ecosystems as "critically endangered," and others to call for large-scale restoration efforts involving prescribed burning to conserve and restore habitat connectivity (Landers et al., 1995; Hoctor et al., 2006).

2.2. The Onslow Bight region

The Onslow Bight is a 1 million ha region of the North Carolina (NC) coastal plain (Fig. 1) where a multiagency partnership has been established for conservation of the longleaf pine ecosystem. Prior to European settlement, an estimated 48% of the Onslow Bight was covered in longleaf or mixed pine habitat, much of it wet or mesic longleaf pine–wiregrass savanna (Frost and Costanza, unpublished data). Today, approximately 19% of the landscape is longleaf pine (Southeast Gap Analysis Project, 2008). Managed pine plantations cover 22% of the Onslow Bight, and 21% is either developed or has been converted to agriculture (Southeast Gap Analysis Project, 2008). Major public landholdings comprise 15% of the Onslow Bight and include US Marine Corps Camp LeJeune and Cherry Point (US Department of Defense), Croatan National Forest (US Forest Service), Cedar Island National Wildlife Refuge (NWR, US Fish and Wildlife Service), and several designated game lands (NC Wildlife Resources Commission, NC WRC). The Nature Conservancy (TNC) also manages 1% of the land in the Onslow Bight. These six land management agencies have joined to form the Onslow Bight Fire Partnership (OBFP) to increase the capacity for prescribed burning (OBFP, 2005).

2.3. Prescribed burn data

We compiled GIS data delineating the locations of prescribed burn compartments and prescribed burns conducted between 1989 and 2007 from the six Onslow Bight land-management agen-