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Frequent policy uncertainty can negate the benefits of forest conservation policy

B. Alexander Simmons[a,b,*], Raymundo Marcos-Martinez[c,d], Elizabeth A. Law[a,b,e], Brett A. Bryan[f], Kerrie A. Wilson[a,b]

[a] School of Biological Sciences, The University of Queensland, St. Lucia, QLD 4072, Australia
[b] ARC Centre of Excellence for Environmental Decisions, The University of Queensland, St. Lucia, QLD 4072, Australia
[c] CSIRO Land and Water, Black Mountain, Canberra, ACT 2601, Australia
[d] School of Commerce, University of South Australia, Adelaide, SA 5002, Australia
[e] Conservation Biogeography, Humboldt-Universität zu Berlin, 10099 Berlin, Germany
[f] Centre for Integrative Ecology, Deakin University, Burwood, VIC 3125, Australia

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ABSTRACT

Policy-driven shifts from net deforestation to forest expansion are being stimulated by increasing social preferences for forest ecosystem services. However, policy uncertainty can disrupt or reverse the positive effects of forest transitions. For instance, if the loss of remnant (primary) forest continues, the ecological benefits of net forest gains may be small. We investigated how peak periods of uncertainty in forest conservation policy affected forest transition outcomes in Queensland, Australia, as well as a globally-relevant biodiversity hotspot in the state, the Brigalow Belt South (BBS) bioregion. Political, socioeconomic, and biophysical factors associated with net forest cover change and remnant forest loss from 1991 to 2014 were identified through spatial longitudinal analysis. This informed a Bayesian structural causal impact assessment of command-and-control regulation and policy uncertainty on remnant and non-remnant forest cover. The results indicate that forest cover was negatively influenced by increasing temperatures, food prices, and policy uncertainty, and positively influenced by strengthening regulation. Regulation during 2007–2014 avoided 68,620 ± 19,214 km^2 of deforestation (with 18,969 ± 10,340 km^2 of this in remnant forests) throughout Queensland, but was ineffective on remnant forests in the BBS. For state-wide remnant forests, perverse effects from policy uncertainty (e.g. pre-emptive deforestation) were strong enough to negate regulatory impacts. This study reveals a cautionary tale for conservation policy: despite strict environmental regulations, forest transition can be delayed (or reversed) when political inconsistency or instability provoke unintended reactions from landholders.

1. Introduction

1.1. Deforestation and policy feedbacks

Since 1990, over 185,000 km^2 of forests have been converted to other land uses around the world (Food and Agriculture Organization (FAO, 2016a), with others estimating a complete loss of 50% of global forest cover prior to the 21st century (Food and Agriculture Organization (FAO, 2016b). Agricultural expansion is the most commonly cited proximate driver of deforestation (Barbier and Burgess, 2001a; Hosonuma et al., 2012), and it is estimated to account for roughly 80% of global deforestation (Kissinger et al., 2012). However, despite a wealth of case studies, few generalizations can be made regarding the causes of deforestation (Allen and Barnes, 1985; Deacon, 1994; Busch and Ferretti-Gallon, 2017). The drivers of deforestation often occur in complex feedbacks, operate at different scales, and are spatially and temporally dynamic; regulation of deforestation will likely not have homogenous effects on all stakeholders (Rudel et al., 2009; Seabrook et al., 2006). In many instances, the causes of forest loss in tropical deforestation hotspots can be linked to general characteristics of the countries' development, including less secure property rights, political corruption, and desires for rapid economic growth (Angelsen and Kaimowitz, 1999; Barbier and Burgess, 2001a,b; DeFries et al., 2010). Deforestation rates in developed countries receive much less attention and scholarly treatment.

Evidence suggests that societal preference for forest conservation and expansion represented through policy could result in forest transition (Rudel et al., 2005). While significant environmental and

* Corresponding author at: School of Biological Sciences, The University of Queensland, St. Lucia, QLD 4072, Australia.
E-mail address: b.simmons@uq.edu.au (B.A. Simmons).

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socioeconomic benefits may be expected from sustained forest transitions, forest conservation policies place significant constraints on landholders by introducing restrictions on property rights, profitability, and tenure security in some cases (Alston et al., 2000; Aldrich et al., 2012). Such constraints could disrupt or reverse transition processes and outcomes, particularly when influential policies change frequently, as the threat of future restrictions may provoke unintended behavioural responses, such as pre-emptive deforestation (Brown et al., 2016). Further, if forest conservation policies fail, are poorly implemented, or provoke perverse responses, this can result in delays, inconsistencies, and reversals of forest transition (Barbier et al., 2010). Political timelines are significant drivers of policy change (Kingdon, 2003; Pierson, 2004), and fluctuations in the number and intensity of policies may provoke higher policy uncertainty for landholders, resulting in increased deforestation (Zhang, 2001; Gasparri and Grau, 2009; Knill et al., 2012). The frequent use of ‘command-and-control’ regulations—i.e. direct regulations defining legal and illegal activities (McManus, 2009)—may also encourage negative feedbacks, as these tactics are often polarizing, inflexible, and may reduce landholders’ inherent motivations to protect the environment (Smith and Vos, 1997; Dresner et al., 2006; Jordan and Matt, 2014).

1.2. Contentious forest policy in Australia

Australia, and particularly the state of Queensland, represents an important and globally relevant case study in the impacts of policy on forest transition and the differential effects on net forest cover and remnant forest loss. Global deforestation patterns are mirrored in Australia, where rapid industrialization and agricultural expansion resulted in the loss of nearly 15% of native forests, with 7% of primary forests lost since 1972 (Bradshaw, 2012; Evans, 2016). Deforestation drivers in Australia may represent a suite of characteristics reflective of both developed and emerging economies, such as potential profitability of the land (Bartel, 2004; Lindenmayer, 2005), agricultural prices (Kaimowitz and Angelsen, 1998; Seabrook et al., 2006), remoteness (Geist and Lambin, 2002; Simmons et al., 2018), property characteristics (Turner et al., 1996; Seabrook et al., 2007), and command-and-control regulations (Angelsen and Kaimowitz, 1999; Assunção et al., 2012). Recent rates of deforestation marked Australia with one of the highest annual deforestation rates in the world during 1990–2000 (Lindenmayer, 2005). While some reports have listed Australia amongst the top countries for reported forest area and annual net forest gain (e.g. Food and Agriculture Organization (FAO, 2016a), remnant (primary) vegetation continues to be lost throughout the State of Queensland, Australia (Simmons et al., 2018), and the ecological value of remnant forests often cannot be easily substituted by recent reforestation efforts (Bowen et al., 2009).

Deforestation in Queensland constitutes over 60% of all deforestation in the country in recent history (Evans, 2016) and the state entered the forest transition phase as late as 2008, though recent spikes in deforestation since 2013 may signal a reversal of this transition (Marcos-Martinez et al., 2018). These transitions have occurred in conjunction with the Queensland Government’s introduction of regulations on remnant deforestation on private lands via the controversial *Vegetation Management Act 1999 (QLD)*. Since its introduction, the policy has been fraught with debate over its design, implementation, and impacts on landholders (Productivity Commission, 2004; Senate Inquiry, 2010). The policy has undergone considerable regulatory fluctuations over time. After placing a moratorium on clearing permits in 2003, Parliament entered a policy transition phase, allowing a cap of 5000 km^2 of ‘broad-scale’ clearing (large-scale clearing for crops and pastures). This was followed by a period of growing policy restrictions, including a complete ban on broad-scale clearing and protection of ‘high-value’ regrowth (secondary) vegetation. Following a change in Parliament’s majority political party in 2012, amendments to the Act subsequently eliminated high-value regrowth protection, added new clearing exemptions, and allowed landholders to self-assess their clearing practices (Simmons et al., 2018). Despite some evidence that the broad-scale clearing ban in 2007 resulted in reduced deforestation (Evans, 2016) and greater net forest gains (Marcos-Martinez et al., 2018), this political inconsistency has produced some perverse outcomes, such as pre-emptive or ‘panic’ clearing during policy introduction (Simmons et al., 2018).

This study investigates the influence of the broad-scale clearing ban and peak periods of policy uncertainty on deforestation rates alongside more traditional biophysical, socioeconomic, and property-based drivers frequently identified in the literature. We applied a spatial longitudinal analysis to distinguish significant drivers of net forest cover change from drivers of remnant forest loss. This allowed us to determine the role of various factors on two forest metrics with different ecological ramifications and at different scales. We then used Bayesian time series models to estimate the causal impact of the broad-scale clearing ban on deforestation trends under different conditions. To identify potential scale-specific effects, we apply these models to the entire State of Queensland and to the Brigalow Belt South bioregion, a historical biodiversity and deforestation hotspot within the state. We show that command-and-control regulation can spur forest transition, but its effectiveness can be limited or counteracted by frequent policy uncertainty. The results of this study highlight the importance of creating strong and stable deforestation regulations to avoid potential perverse responses from landholders during frequent political regime changes.

2. Methods

2.1. Study areas

The State of Queensland spans 2.04 M km^2 of diverse habitats, including tropical, temperate, and desert bioregions. Prior to significant deforestation, the state was dominated by eucalypt woodlands along the eastern coast, acacia-dominated open forests in the southern interior, and tussock grasslands in the west (Neldner et al., 2017). Today, however, much of the forests have been cleared, leaving highly fragmented acacia forests and eucalypt woodlands in the south-central bioregions (Fig. 1). The Brigalow Belt South (BBS) bioregion encompasses approximately 0.22 M km^2 of south-central Queensland. The bioregion exhibits cyclic and highly variable rainfall typical of subtropical patterns, with an annual mean rainfall of 500–750 mm (Crimp and Day, 2003; Lloyd, 1984). The dominating vegetation types within the BBS include dry and alluvial eucalypt woodlands and acacia forests (e.g. brigalow, *Acacia harpophylla*) (Seabrook et al., 2006, 2008). These woodlands are frequently structured as ‘open’ woodlands or forests, containing a diverse composition of plant species and generally maintaining shrub- or low tree-layers (Lucas et al., 2014). This biodiversity hotspot provides habitat for 492 resident bird species, as well as numerous endemic and endangered reptiles, plants, and mammals (McAlpine et al., 2011; Ponce Reyes et al., 2016).

2.2. Forest cover data

Our analysis relies on binary forest cover data (25 m resolution) generated through supervised classification of Landsat imagery for the Australian Government’s National Carbon Accounting System – Land Cover Change Program (NCAS-LCCP) (Caccetta et al., 2012). Forests in such datasets, and throughout this study, are areas of vegetation with potential to reach at least 20% or greater crown cover and 2 m of height (Macintosh, 2007). Land cover estimates based on remote sensing data may, however, contain transition errors when temporal dependencies are uncontrolled for (Marcos Martinez and Baerenklau, 2015). Thus, we used transition rules to control for illogical forest cover changes in each year (t) relative to the conditions observed at $t \pm 1$ and $t \pm 2$. Because we do not have data for 2015, we do not include $t + 2$ for 2013, and we