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Trees on farms: Investigating and mapping woody re-vegetation potential in an intensely-farmed agricultural landscape

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ABSTRACT

Deforestation, to meet agricultural demands, has driven woody vegetation cover change across many landscapes globally. The further intensification of farming has created greater pressures on ecosystems and increased the need for re-establishing woody vegetation on farms to restore or enhance ecological processes. This study aimed to investigate the influence of landowner and property-related characteristics, as well as landowner perceptions and attitudes, on the potential for woody vegetation change across an intensively-farmed agricultural landscape in Canterbury, New Zealand. A survey was carried out to collect relevant socio-economic data, data regarding landowner perceptions of woody vegetation, as well as spatial information regarding current and possible future woody vegetation quantities. Statistical models were used to assess the factors that were most associated with woody vegetation intentions. Survey data were also used to map the distribution of current woody vegetation at the landscape scale, as well as the potential future woody distribution given stated landowner intentions. Survey results showed linear shade and shelterbelts, riparian strips, and small native remnants communities to be the three typical woody vegetation features. The majority of surveyed properties had less than 20 per cent woody vegetation cover. These current woody vegetation patterns were best described by the combination of property characteristics, landowner factors and landowner's perception and attitude (full model). A GIS spatial analysis, incorporating results from the survey, indicated that a potential increase in woody vegetation of over a five per cent was achievable if landowners' intentions towards woody re-vegetation became realised. We conclude that a better understanding of socio-economic factors, landowner perceptions, and the spatial distribution of potential sites for re-vegetation are all required to facilitate the development of multifunctional agricultural landscapes.

1. Introduction

In many parts of the world, modern agricultural practices have resulted in the conversion of diverse forested ecosystems into homogenous agricultural landscapes containing small, fragmented patches of non-crop, woody vegetation (Robinson and Sutherland, 2002). The detrimental effects of this type of large-scale intensification are well-recognised, particularly in terms of reductions in vital ecosystem services (Diaz et al., 2005) and biodiversity (Fischer et al., 2010). As a result, there has been ongoing debate regarding possible trade-offs between agricultural production and ecosystem services, and function under land-sharing versus land-sparing strategies (Tscharntke et al., 2012). Land-sharing, or "wildlife friendly farming", proposes the integration of both biodiversity conservation and food production at the farm scale across a given agricultural area. Land-sparing, on the other end of the spectrum, suggests a separation of agriculture and conservation land, where the use of high yield agricultural practices on large land parcels enables conservation areas to be spared from agricultural development. While there is evidence for ecosystem service benefits from both land-sharing and land-sparing, recently there has been a call for more balanced, multifunctional approaches to agricultural land management in order to reconcile both ecological and production aims across agro-ecosystems (Rey Benayas and Bullock, 2012). It is likely, however, that the success of such approaches will require insight regarding landowners' perceptions regarding the benefits gained from "non-production" uses of their land, such as the planting of non-crop woody vegetation (Seabrook et al., 2008). Additionally, methods will be needed to help visualise how such perceptions might lead to changes in the quantities and patterns of non-crop vegetation at the landscape scale.

Increasing landscape heterogeneity via the re-establishment of woody vegetation across highly modified agricultural landscapes can act to mitigate lost or impaired ecosystem services

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(Bullock et al., 2001). Indeed, the linear vegetation features that are prevalent in many agricultural landscapes, such as shelterbelts, hedgerows, riparian strips, and road-side plantings, have been shown to serve numerous functions (Brandle et al., 2004), including the provision of essential habitat for a range of taxa (Mize et al., 2008), sequestration and storage of carbon (Nair et al., 2009; Czerepowicz et al., 2012), and enhancement of biodiversity and ecological function (Devictor and Jiguet, 2007; Gurr et al., 2003; Kramer et al., 2011). Nonetheless, landowners' intentions and behaviour with respect to the use and management of such marginal woody vegetation features on farms are highly variable. Landowner demographics (e.g., Herzon and Mikk, 2007), economic factors (Herzon and Mikk, 2007; Seabrook et al., 2008) and environmental perceptions and attitudes (Durpoix, 2010; Welsch, 2011) can all influence these decisions. For example, the priority given to woody vegetation by farm owners can often be low because the economic benefits are either minimal or, at the very least, not apparent (Jay, 2005). In other cases, the potential ecosystem services and biodiversity benefits offered by woody vegetation features are often not well understood, or are perceived to be in conflict with production (Crabb et al., 1998; Benjamin et al., 2008). Indeed, policies and programmes (e.g., agri-environmental schemes) directed at achieving a greater integration of non-crop vegetation into intensively farmed agricultural landscapes have achieved varying degrees of success (e.g., see Kleijn and Sutherland, 2003). Thus, the development of feasible woody restoration strategies for intensively farmed landscapes requires an understanding of the potential socioeconomic factors and motivations underpinning landowners' intentions towards woody vegetation management within a given country or region (Greiner and Gregg, 2011).

Different landowners will likely hold differing views regarding the types, amounts, and locations of woody vegetation features that might be acceptable on their properties in the future. Landowners may be inclined to maintain current areas and spatial configurations of woody features, remove some or all of them, or potentially increase woody quantities on areas of their properties that are currently not productive. Thus, information from landowners regarding the locations of land features deemed suitable for woody vegetation plantings, as well as the amount of likely areal increase or decrease of woody features on their properties, could be used to quantify and map both existing and potential future distributions of woody vegetation at a landscape scale (Duncan and Dorrough, 2009). Spatial projections of potential woody vegetation change could provide a useful means to facilitate discussion among the public, landowners, and policy makers regarding possible scenarios for woody vegetation conservation, establishment, and management at a landscape scale (Sherren et al., 2011). This information may also provide insight into the possible motivations behind land management decisions made by landowners, particularly in the context of different land uses.

In this study, we investigate current, and future potential, woody vegetation quantities and distributions on agricultural properties across a case study area on the Canterbury Plains, New Zealand. Extensive land clearing and intensive agriculture practices over more than a century have resulted in the removal of almost all of the Canterbury Plains' original native flora and fauna (Walker et al., 2006), which has been primarily replaced with small, exotic woody vegetation features on farmland, mainly in the form of shelterbelts and hedges. Further, New Zealand currently has no specific policy instruments for incentivising farmers to retain or increase non-crop vegetation quantities or heterogeneity on their land. Thus, the New Zealand situation provides an ideal setting within which to examine the potential for woody re-vegetation and the possible implications of this for future policy development.

Within this research setting, we address three main objectives. First, we use data collected from a survey of farm landowners to characterise current woody vegetation cover on these farms and to help quantify intended (i.e., potential) future changes in woody vegetation cover relative to existing levels, given current land uses. Second, we use statistical modelling to determine how a range of property, landowner, and perception/attitudinal factors influence the potential for non-crop woody vegetation change. Third, we aim to map woody re-vegetation potential at a landscape scale by linking available GIS-based spatial datasets with survey responses regarding landowners' intentions to either increase or decrease woody vegetation on their properties. In addressing these objectives, we discuss the possible implications of this work with respect to woody vegetation management and restoration in intensively-farmed agricultural systems.

2. Methods

2.1. Study area

The focal area for this study comprised the lowland areas and lower foothills of the Waimakariri District on the Canterbury Plains, just north of the city of Christchurch (Fig. 1). This area of about 133,000 ha is typical of the Canterbury Plains agricultural landscape and other intensively-farmed agricultural landscapes found throughout lowland areas in New Zealand. In general, the dominant land uses across the District are a mixture of production agricultural types, including: sheep, cattle, and deer grazing (58 per cent), dairy farming (16 per cent), and annual cropping (6 per cent). A portion of the area also comprises small rural 'lifestyle' properties (5 per cent), typically characterised by small pieces of farmland used for a variety of agricultural purposes, often serving as a second source of income for property owners. Thus, approximately 86 per cent of the lowland areas and foothills of the District are being used for some form of agricultural production. The remaining land uses in the District are non-agricultural, including forestry plantations (5 per cent), roads, infrastructure and urban areas (16 per cent).

2.2. Survey of agricultural landowners

To address our first objective, a survey was conducted to collect information relevant to quantifying and describing existing woody vegetation features on farms within the study area, as well as potential future changes in woody vegetation features over the next five years. Between September and December 2010, 100 landowners from across the study area were identified as potential survey participants, with the aim of including a range of property sizes, locations, land uses and varying proportions of remnant (native) vegetation on their land. While we aimed to include and represent all major types of land uses, none of the cropping farmers responded positively to participating in the study. In total, 30 landowners, comprising dairy farmers ($n = 4$), sheep and beef farmers ($n = 15$), and lifestyle property owners ($n = 11$), agreed to participate in the survey. Sample sizes were generally reflective of the relative proportions of these land use types in the district (see Section 2.1), although fewer dairy farmers agreed to participate than was desired. Nonetheless, the respondents varied overall in terms of farm location, demographics and farm characteristics, and the sample was therefore considered a relatively good representation of the expected variation in these three types of landowners across this agricultural area. The survey was carried out in two parts: a questionnaire focussed on gathering general information regarding landowner demographics and property characteristics; and an interview aimed at elucidating landowner perceptions regarding non-crop vegetation, potential future planting decisions and reasons why they choose particular areas on the property. This survey approach was similar to the approaches used by Wilson (1992) and Watkins et al. (1996).