Environmental Modelling & Software xxx (2014) 1–14

Contents lists available at ScienceDirect

Environmental Modelling & Software

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

Modeling the effect of social networks on adoption of multifunctional agriculture☆

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ARTICLE INFO

Article history:
Received 23 July 2013
Received in revised form
17 July 2014
Accepted 17 September 2014
Available online xxx

Keywords:
Multifunctional agriculture
Land change
Rotational grazing
Social networks
Agent based model

ABSTRACT

Rotational grazing (RG) has attracted much attention as a cornerstone of multifunctional agriculture (MFA) in animal systems, potentially capable of producing a range of goods and services of value to diverse stakeholders in agricultural landscapes and rural communities, as well as broader societal benefits. Despite these benefits, global adoption of MFA has been uneven, with some places seeing active participation, while others have seen limited growth. Recent conceptual models of MFA emphasize the potential for bottom-up processes and linkages among social and environmental systems to promote multifunctionality. Social networks are critical to these explanations but how and why these networks matter is unclear. We investigated fifty-three farms in three states in the United States (New York, Wisconsin, Pennsylvania) and developed a stylized model of social networks and systemic change in the dairy farming system. We found that social networks are important to RG adoption but their impact is contingent on social and spatial factors. Effects of networks on farmer decision making differ according to whether they comprise weak-tie relationships, which bridge across disparate people and organizations, or strong-tie relationships, which are shared by groups in which members are well known to one another. RG adoption is also dependent on features of the social landscape including the number of dairy households, the probability of neighboring farmers sharing strong ties, and the role of space in how networks are formed. The model replicates features of real-world adoption of RG practices in the Eastern US and illustrates pathways toward greater multifunctionality in the dairy landscape. Such models are likely to be of heuristic value in network-focused strategies for agricultural development.

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Software availability

Name of software: Social networks in rotational grazing dairy farming
Developers: Multifunctional Agricultural Project at the University of Minnesota
Contact address: Steven Manson, Department of Geography, Environment, and Society, University of Minnesota, Minneapolis, MN 55455 USA; Telephone: 612 625 4577; Fax: 612 624 1044; Email: manson@umn.edu
Availability: Free download at hegis.umn.edu
Year first available: 2014
Hardware required: IBM compatible PC, Apple Macintosh, or Linux compatible PC
Software required: Netlogo, using the Java Runtime Environment
Programming language: Netlogo 5.x
Program size: 67 to 89 MB (Netlogo), 20kb (Model file)

1. Introduction

Multifunctional agriculture (MFA) promises benefits over many other forms of agriculture but its potential is unrealized in many places (Jordan and Warner, 2010). Agriculture is considered multifunctional when it produces standard commodities such as food or biomass as well as social and ecological outputs. These range from economic contributions such as ecotourism in agricultural landscapes to provision of ecological services including

☆ Thematic Issue on Modelling Systemic Change.
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http://dx.doi.org/10.1016/j.envsoft.2014.09.015
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Please cite this article in press as: Manson, S.M., et al., Modeling the effect of social networks on adoption of multifunctional agriculture, Environmental Modelling & Software (2014), http://dx.doi.org/10.1016/j.envsoft.2014.09.015

denitrification and protection of human systems from climate change impacts (Flora, 2001; Renting et al., 2009). Despite these benefits, MFA adoption has been very uneven, with some locales like New Zealand and several European countries seeing active participation and growth, while others including the United States have not (Jordan and Warner, 2010).

Why is MFA distribution uneven? It does well under top-down policies that explicitly support it as a form of production satisfying broader social and environmental goals (Potter and Burney, 2002; Uthes et al., 2011). Less clear is how MFA grows absent such support. As detailed below, some recent explanations emphasize 'bottom-up' processes and self-reinforcing feedbacks of systems at a variety of scales. These feedbacks rely on linkages among social and environmental systems that connect farmers, farmers to markets, organizations, and environments that benefit from MFA and subsequently support it (Jordan and Warner, 2010; Selman and Knight, 2006).

Social networks that help create linkages among social and environmental systems are critical to these explanations of MFA growth, but there are unanswered questions about how and why these networks matter. In this paper, we draw on an empirical case study to develop a stylized model of social networks and systemic change for a form of MFA called rotational grazing dairy farming (RG). We are particularly interested in differentiating between the effects on farmer decision making of weak-tie social relationships, which bridge across disparate people and organizations, and strong-tie relationships, which are shared by groups with closely integrated members. We also examine the effect of spatial distance on network formation and activation on RG practices within a broader context of confinement practices in dairy farming (CP). We draw on existing research and our own empirical work to develop an agent based model (ABM) that explores these networks and their spatiotemporality. This model of dairy farmers in the United States examines how social networks affect adoption of new forms of agriculture, and in turn how social and spatial factors influence these networks. The model is kept fairly abstract to examine general dynamics of these networks and the agricultural system.

This work makes several contributions to modeling and analysis of the role of social networks in land use change. The study of social networks in landscape dynamics and in agricultural extension is both important and relatively neglected (Beilin et al., 2013; Entwisle et al., 2008; Hellin, 2012), which has led to calls for research on the role of social networks in complex resource systems such as MFA (Agrawal et al., 2013; Bodin and Crona, 2009). This paper answers these calls by specifying possible impacts of different kinds and configurations of networks. This work also addresses the need to understand MFA dynamics at the farm scale (Renting et al., 2009), especially because the effectiveness of policy interventions must be measured and understood at the farm scale (Uthes et al., 2010). Finally, this work meets the specific need to create ABM to understand MFA (Van Berkel and Verburg, 2012) and addresses the more general paucity of tools to understand and design multifunctional landscapes (O'Farrell and Anderson, 2010; Rossing et al., 2007; Zander et al., 2007).

The remainder of this section describes multifunctional agriculture in the United States and the potential roles that social networks could play in the greater adoption of one kind of MFA, dairy production based on rotational grazing (RG). Section 2 describes methods centered on a stylized yet empirically based model of network dynamics and their role in the growth of RG in the northern United States. Section 3 offers results and discussion, focusing in particular on the impact on RG of network processes that were reported by farmers about their transition to RG production. Section 4 concludes with a recap of results and examines future research and policy directions.

1.1. Social networks and multifunctional agriculture in the US

MFA in the United States is less established and studied than elsewhere (Jordan and Warner, 2010). The top-down policies that support MFA in other contexts are largely absent and are likely to remain so given a policy focus on standard commodity production (Uthes et al., 2011). Other countries design policies to encourage MFA for broader social and environmental reasons, ranging from preservation of rural livelihoods to encouraging biodiversity (Baylis et al., 2008; Cocklin et al., 2006; Potter and Burney, 2002). In contrast, US agricultural programs are largely incidental to MFA. They focus instead on specific environmental issues such as minimizing soil erosion by taking land out of production, and economic concerns such as supporting commodity agriculture. There is concomitantly less known about the biophysical and social nature of MFA in the US (Boody et al., 2005; Polasky et al., 2011).

How might MFA arise in the absence of top-down policies? One promising route is for farmers and other stakeholders to endogenously develop networks that create self-reinforcing flows of information and resources about multifunctionality (Jordan and Warner, 2010; Selman and Knight, 2006). This perspective posits an important role for social networks that are composed of nodes (people or other actors) that are joined by ties (relationships that convey information or resources). Networks can serve as conduits for information and resources, exert social influence, and shape actions (Knoke et al., 2008; Wasserman and Faust, 1994). Social networks link farmers to a broader array of actors and human-environment systems (Ortiz-Miranda et al., 2010; Sonnino and Marsden, 2006; Steyaert et al., 2007). These systems can include farmers and their neighbors trading production strategies (Conley and Udry, 2001), farmers and consumers forging links with cultural, social, and ecological meaning such as increased landscape amenity or healthful food (Van Huylenbroeck et al., 2007), or environmental organizations and scientists sharing information about benefits of multifunctionality (Ploeg, 2003).

Research on the social context of natural resources management and agriculture points to critical distinctions among kinds of relationships in networks (Moore and Westley, 2011). Such network ties are of three types: bonding or strong ties, bridging or weak ties, and linking or vertical ties (Woolcock and Narayan, 2000). Strong ties are relationships within largely homogeneous groups such as families that provide benefits to members. Weak ties bridge nodes among heterogeneous groups across sociocultural or geographical gaps, creating flexible networks that can transmit new ideas. Vertical ties are a variant of weak ties that serve as conduits among nodes at one level with nodes at another level of organization, such as between farmers and state agencies.

Network effectiveness is contingent on its structure and dynamics. A combination of weak and strong ties may be necessary for propagating new practices like MFA, judging by the work on related forms of production like agroforestry and sustainable agriculture. Weak ties in particular may help information generation and alliance building (Nelson et al., 2014; Olsson et al., 2006), creating knowledge across sectors (Steyaert et al., 2007), and developing ties among disparate organizations (Ortiz-Miranda et al., 2010; Sonnino and Marsden, 2006). Networks can form and dissolve as a function of physical space, social distance, and happenstance in ways that affect their ability to convey information and resources (Carolan, 2005; Nelson et al., 2014; Olsson et al., 2006). The structure of networks can affect how they function in natural resource situations (Bodin and Crona, 2009), including how well the effects of networks at one spatial scale or level of organization are manifested at other scales, or across different sectors of social systems (Moore and Westley, 2011).

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