Agricultural Systems 129 (2014) 93–102

Contents lists available at ScienceDirect

Agricultural Systems

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

Development of a farmer typology of agricultural conservation behavior in the American Corn Belt

Irem Daloğlu [a,*], Joan Iverson Nassauer [a,1], Rick L. Riolo [b,2], Donald Scavia [c,3]

[a] 440 Church Street, School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI 48109, USA
[b] 317b West Hall, Center for the Studies of Complex Systems, University of Michigan, Ann Arbor, MI 48109, USA
[c] 625 E. Liberty St Suite 300, Graham Environmental Sustainability Institute, University of Michigan, Ann Arbor, MI 48104, USA

ARTICLE INFO

Article history:
Received 26 February 2013
Received in revised form 7 May 2014
Accepted 12 May 2014
Available online 26 June 2014

Keywords:
Farmer typology
ABM
Agroecosystem
Water quality
Agricultural policy
SWAT

ABSTRACT

Farmers' decisions about adopting conservation practices are inherently dynamic, affected by changes in environmental, economic, and social conditions, including interactions with other farmers. Water quality models that are used to assess agricultural policy interventions, such as the Soil and Water Assessment Tool (SWAT), lack the dynamic social component of farmer's decisions. While agent-based models (ABM) can represent and explore these decision dynamics, ABMs have not been connected to water quality models that can measure environmental outcomes of farmer decisions. Connecting ABMs and SWAT could advance the development of targeted conservation policies. Toward this aim, we developed a typology of Corn Belt farmers based on farmer characteristics that could be employed in an ABM and be relevant to water quality outcomes. Because our typology was developed for use in an ABM and to link to an existing water quality model (SWAT), it had distinctive simplicity (to optimize utility of the ABM) and relevance to characteristics modeled by SWAT. To identify farmer characteristics, we reviewed the literature on conservation practices that could be represented in SWAT models and their adoption by Corn Belt farmers. We found that land tenure arrangements, farm size, source of income, and information networks were consistently identified as farmer characteristics that influence conservation practice decision-making, were simple and relevant. Employing these characteristics, we identified four types of farmers to populate an ABM that will be linked to SWAT: (1) "Traditional": small operations relying primarily on on-farm income; (2) "Supplementary": small operations relying primarily on off-farm income; (3) "Business-oriented": medium to large operations relying primarily on on-farm income and well connected to information networks; (4) "Non-operator": absentee and/or investor farmland owners with limited connection to local information networks. This typology represents the heterogeneity of Corn Belt farmers relevant to their adoption of conservation practices. It gives us the conceptual framework for an ABM that can be linked with SWAT to explore coupled social and biophysical processes within Corn Belt agroecosystems, focusing on alternative approaches to targeting conservation policy to effectively reduce sediment and nutrient runoff.

1. Introduction

Agriculture continues to be a major contributor to water pollution, soil degradation, climate change, and biodiversity loss. The highly cultivated watersheds of the Corn Belt are major sources of non-point source pollution (Nassauer et al., 2007; National Research Council, 2010; Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008). Agricultural runoff is often the cause of algal blooms, poor water clarity, and summer hypoxia (low oxygen) in the Gulf of Mexico (Ribaudo and Johansson, 2006) and Lake Erie (Hawley et al., 2006). Hypoxia has severely impacted commercial and sport fisheries, with trophic cascades affecting aquatic and coastal food webs (Carpenter et al., 1998).

Federal policy strongly affects the management choices of American farmers and thus the landscape characteristics and water quality of farms and downstream ecosystems. Farmers are defined in this analysis as owners or renters of farmland where cash crops are grown. The US Farm Bill, which is renewed approximately every five years, is the federal policy that most directly affects

* Corresponding author. Tel.: +1 734 647 2464.
E-mail addresses: daloglu@umich.edu (I. Daloğlu), nassauer@umich.edu (J.I. Nassauer), rlriolo@umich.edu (R.L. Riolo), scavia@umich.edu (D. Scavia).
[1] Tel.: +1 734 763 9893.
[2] Tel.: +1 734 763 3323.
[3] Tel.: +1 734 615 4860.

http://dx.doi.org/10.1016/j.agsy.2014.05.007
0308-521X/

agricultural land use and practice. Since the 1930s, the Farm Bill has included specific soil and water conservation programs, as well as support for production of certain crops (Nassauer and Kling, 2007). Yet, Farm Bill support for crop production has substantially and consistently outweighed incentives for conservation (Doering et al., 2007).

Developing more effective agricultural policies necessitates a better understanding of the motivations and underlying socio-economic circumstances of farmers (National Research Council, 2010). However, these attributes are not homogenous or static among farmers responding to conservation policies.

The relationship between farmers' decisions about adoption of conservation practices and water quality outcomes is part of a complex coupled human and natural system and, as such, coupled social–biophysical models can be valuable tools for better targeting federal investments (Jackson-Smith et al., 2010). Such approaches can incorporate farmer decisions in exploring whether or not substantial changes in water quality can be expected as a result of specific policy interventions. Knowledge of the socio-economic factors that influence farmers' conservation-related decisions is essential for the construction of such a model.

Typologies have been suggested (Kostrowicki, 1977; Duvernoy, 2000; Valbuena et al., 2008) as a means to effectively represent the heterogeneity of farmers' motivations and socio-economic circumstances related to conservation behavior. This paper describes the basis for a farmer typology that we developed for use in an agent-based model (ABM) to be coupled with the Soil and Water Assessment Tool (SWAT) and employed to compare how different policy interventions may affect spatial patterns of adoption of conservation practices and by modeling their impacts on downstream water quality (Fig. 1). SWAT is a river basin scale water quality model, developed and maintained by the US Department of Agriculture to assess the water quality benefits of conservation practices (Gassman et al., 2007; Osmond, 2010). This model is a distributed and spatially explicit continuous-time water quality model that divides watersheds into subbasins (Arnold et al., 1998). It is a process-based model of surface hydrology, weather, sedimentation, soil temperature, crop growth, nutrients, pesticides, and groundwater that can simulate the effects of climate and land use changes on nutrient and sediment delivery from watersheds that is used widely for evaluating and predicting impacts of conservation practices (Arabi et al., 2008).

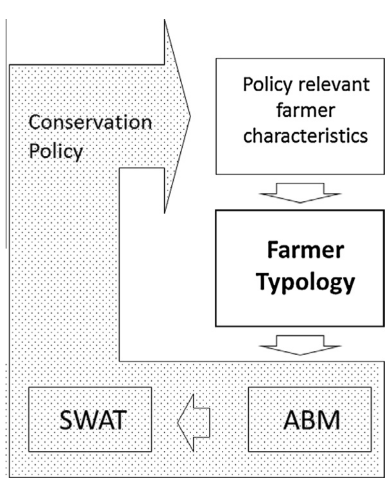

Fig. 1. Using a farmer typology in a coupled human and natural system of farmers' adoption of conservation practices and effects on water quality. We constructed our farmer typology using farmer characteristics relevant to adoption of conservation practices that are applicable in SWAT models and we built this typology to be implemented in an ABM.

Because our typology was intended as a basis for an ABM that we would link with SWAT (Daloğlu et al., in press), we developed it to be distinctly parsimonious – defining a small number of types that are highly relevant to the Corn Belt agricultural policy and cropping system we were investigating – and distinctly focused on management characteristics modeled by SWAT. Typologies are key components of ABMs, computational methods that model decentralized decision-making in a given heterogeneous system to predict emergent characteristics.

1.1. Geographic setting of farmer types

Our study site, the Sandusky Watershed, Ohio drains into Lake Erie (Fig. 2), and is typical of the Corn Belt, which occupies portions of the states of Ohio, Indiana, Illinois, Iowa, Minnesota, Michigan, Missouri, Nebraska, and South Dakota. Consequently, we developed a policy-relevant farmer typology by reviewing and synthesizing the literature on the adoption of conservation practices by farmers in the Corn Belt. The highly cultivated watersheds of the Corn Belt are major sources of non-point source pollution in Lake Erie (Hawley et al., 2006), as well as the Mississippi River and its tributaries (Ribaudo and Johansson, 2006).

Farmers specialize in cash-crop (corn, soybean) production – the focus of this farmer typology, with livestock production less common (USDA, 2009). In the Sandusky Watershed, like much of the Corn Belt, most farmers rent at least some of the land they farm, and about half declare their primary occupation to be non-farming (Table 1). While most farms in the Corn Belt and the Sandusky Watershed are small (less than 180 acres), large farms (more than 500 acres) make up a much larger proportion of the total area harvested and large-scale, commercial farms dominate the landscape (Fig. 3).

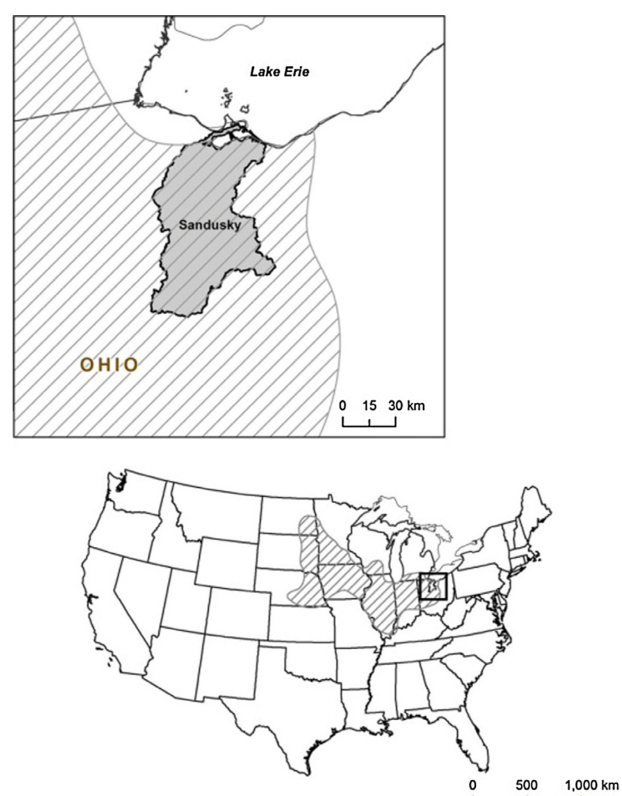

Fig. 2. Map of the geographic setting of farmer types, showing the Corn Belt (dashed) and the Sandusky Watershed, OH.