Agricultural Systems 115 (2013) 129–136

Contents lists available at SciVerse ScienceDirect

Agricultural Systems

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

Man vs. manure: Examining the effects of residential demand on dairy farming in rural America

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ARTICLE INFO

Article history:
Received 1 June 2010
Received in revised form 6 June 2012
Accepted 11 September 2012
Available online 10 November 2012

Keywords:
Manure
Rural zoning
Agent based simulation
Dairy farm expansion

ABSTRACT

Spatial concerns are growing in many rural regions in the United States. Exurban sprawl and residential development can often surge past urban boundaries and encroach on historically rural areas. These emerging "co-existence" problems affect both farms and non-farming rural residents. One area of particular concern has been zoning and land use regulation laws associated with livestock waste handling. In this research, we develop an agent based simulation/case example of a representative county in rural Vermont to illustrate how the proximity of non-farm rural residents (NFRRs) to existing dairy farms in the region can curtail potential farm expansion, primarily through laws governing livestock waste disposal and pit location. The disposal problem is further exacerbated by certain physical land features as many NFRR homes are located on escarpments, as well as other physical features which tend to run diagonally, the latter situation being one that further complicates field manure disposal traffic patterns. Thus, the co-existence issue in dairy farming in much of rural America has an important spatial dimension.

1. Introduction

While on-going change in agriculture and rural life in America has been driven by a number of issues, spatial factors are becoming increasingly critical in many rural regions in the United States. Exurban sprawl and residential development often surge past urban boundaries and encroach on historically rural areas. These emerging "co-existence" problems affect both farms and non-farming rural residents. Private development of rural land can generate intense rivalries between farm and non-farm land uses, leading to spatial market interactions approaching the spirit of the classic Von Thunen model of land rent (Segal, 1977). Farmers seeking more land in these areas can be priced out of land markets as residential demand drives up land prices beyond their ability to pay. The encroachment of very low density development on rural agricultural land also has the potential to "trap" farms into islands, again curtailing their ability to expand. Ultimately, these factors can affect regional agricultural competitiveness if farms are forced to incur increased transportation costs and/or are unable take advantage of economies of size and scale, a situation that could well outweigh any protection provided to farmers through existing "Right-To-Farm" legislation (USDA, 2006).

In this paper, we develop a simulated case example based on a typical Vermont county to illustrate how close proximity of non-farm rural residents (NFRR) to existing dairy farms can curtail dairy expansion, primarily through laws governing manure disposal and pit location (Telega, 2005). Manure and its disposal represents a clear example of a spatial externality between agricultural and residential markets. While several recent papers have examined measurable characteristics of externalities in similar agricultural and land markets (for example, Isik, 2004; Irwin and Bockstael, 2002), to our knowledge this paper represents one of the first efforts at modeling the dairy and manure land use issue as a complex system and comparing the performance of alternative policies through (agent-based) simulation.

In addition, the subsequent manure disposal problem is further exacerbated by the presence of certain physical land features. In many cases, NFRR homes are located on escarpments or other physical features which tend to run irregularly or diagonally, a situation which further complicates field manure disposal traffic patterns. Thus the co-existence issue between dairy farming and residential development carries an important spatial dimension.

2. An agent-based model of farming and residential development – man vs. manure

The set of spatial interactions that can occur between dairy farmers and rural residents in this region are modeled using agent based simulation. Agent based models (or ABM) are micro-level computer-based simulations that facilitate explicit development of dynamic behavior for hundreds or even thousands of interacting

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http://dx.doi.org/10.1016/j.agsy.2012.09.004

agents located on a landscape (Parker et al., 2003). Much of the growing popularity of ABM in agricultural modeling also stems from its ability to incorporate feedback/feedforward effects into individual behavior (Happe and Balmann, 2003).

In this study, three general classes of rural agents co-exist. These are dairy farmers, other farmers and non-farmer residential developers. They are situated (in silico) on a simulated landscape typical of the state of Vermont in the United States. Using actual farming data, a synthetic, heterogeneous population of farming agents is developed. These synthetic agents are then incorporated into the agent-based computer software, where they function as simulated dairy or non-dairy farms in a randomized business environment. To this end Fig. 1 is a map showing what the farming landscape under analysis (Addison County, Vermont) looks like, using data formatted to resemble the land plots used in the simulation analysis. Individual farm agent behavior is described in detail later, but is founded on the related work of Freeman et al. (2009). For instance, we assume farmer agents possess an inherent desire to grow and prosper, leading them to dynamically compete and interact with other farm agents in farmland purchase and leasing markets. In turn, demand for farmland comes from: (1) the developer agent seeking to purchase land for NFRR development and (2) farmer agents seeking to expand. Farmland available for purchase is supplied through either voluntary farm exit associated with retiring farmers who are not succeeded by farming offspring, by forced downsizing in order to alleviate financial stress, or by involuntary exit through technical bankruptcy.

As in Freeman et al. (2009), farmland can also be leased and this is treated as a secondary market. Demand for leased land comes from farmer agents seeking to expand but who are unable to meet the capital and credit demands associated with land purchases, or are simply unsuccessful in the farmland purchase auction. In this model, leased land is supplied by retired farmers or land holders who did not receive their reservation price in the purchase market.

The major sources of system feedback occur via the following; (1) farmland pricing, as current land values are passed back into the market system; (2) evolving farm structure; and (3) individual dairy farm competitiveness as dairy farmers in this region are forced to search for land amenable to (cow) manure application. Farmland auctions and the resulting plot prices generate feedback through asset valuation in a "balance sheet effect" whereby increased/decreased asset values increase/decrease an individual's ability to secure additional credit. Finally, lessors in the model also use farmland values to set their expectations about "fair" cash leases.

Ultimately, over several generations, success or failure in farmland markets also affects regional structure through farm business survival. Overly-optimistic or unlucky farmers who pay too much for farmland may find themselves forced to downsize or to exit. Pessimistic or overly conservative farmers may be unable to expand during their lifetime, making them progressively less competitive and unable to generate sufficient equity to pass their farming operation to the next generation.

The simulated landscape consists of 20 acre (8.1 hectare) plots differing over the following attributes; (1) geography/location; (2) land use; (3) tenure/management; (4) agricultural productivity/capacity; (5) residential development suitability; and (6) manure application zoning regulations. Geographic attributes include location, including distance from a primary highway and distance from the farm homestead (if applicable). In addition, four land

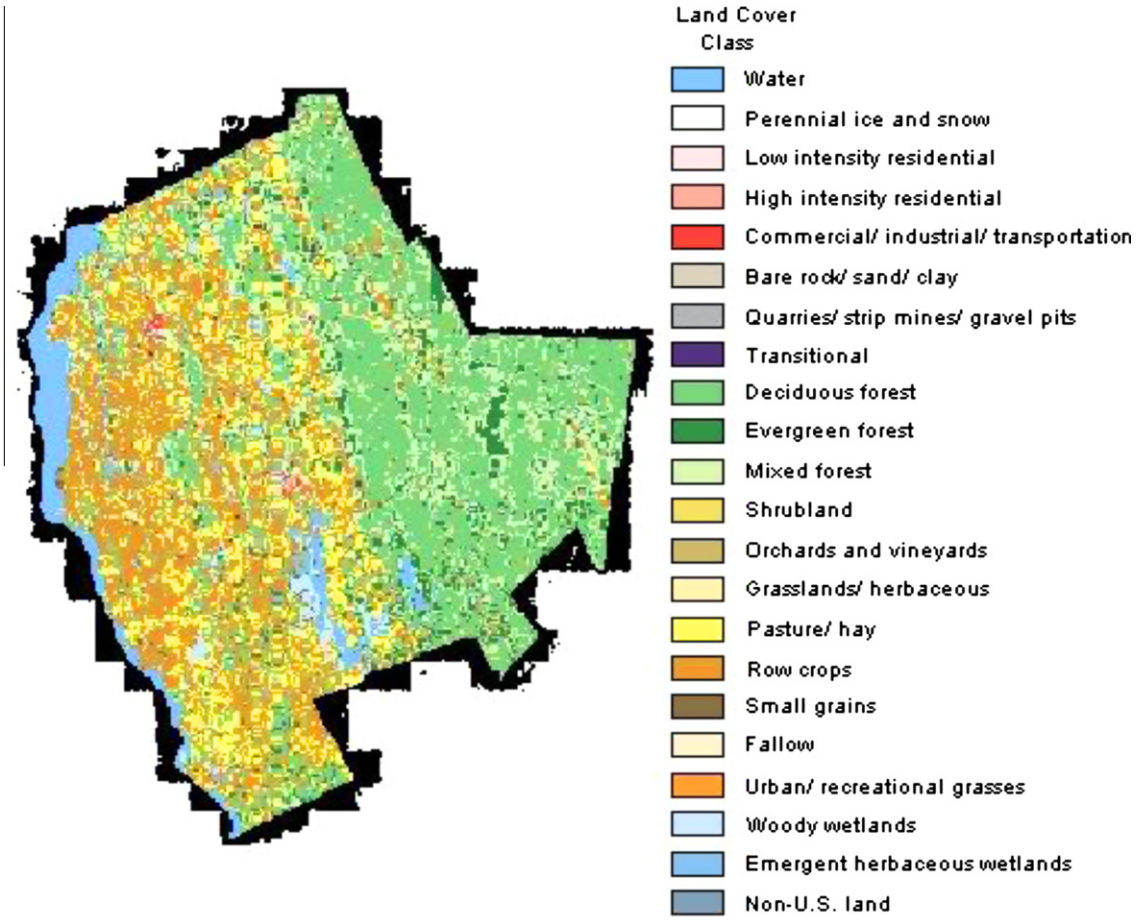

Fig. 1. Detailed land-use, Addison county Vermont, ca. 2002 source: http://www.nationalatlas.gov/natlas/Natlasstart.asp (Freeman et al., 2006).