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# EXPLORING THE SOCIO-ECOLOGICAL DIMENSIONS OF AGRICULTURAL EXPANSION IN NEW HAMPSHIRE

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# EXPLORING THE SOCIO-ECOLOGICAL DIMENSIONS OF AGRICULTURAL EXPANSION IN NEW HAMPSHIRE

BY

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DISSERTATION

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## Dedication

For my mother, Frances C. Wilhelm.

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EXPLORING THE SOCIO-ECOLOGICAL DIMENSIONS OF AGRICULTURAL EXPANSION IN NEW HAMPSHIRE

By

Jennifer Ann Wilhelm

University of New Hampshire, May 2017

## Abstract

Forest ecosystems and agriculture represent coupled socio-ecological systems that are shaped by human activity. The extensification of agriculture (expansion of food production on the landscape) can cause significant changes in land use, and can contribute to the degradation of biodiverse ecosystems and the services these systems provide. Yet the need to increase food production capacity, either through agricultural intensification or extensification, continues to rise. In this dissertation, I address the critical issue of agricultural extensification from several angles.

The first chapter assesses agricultural expansion through the lens of urban and peri-urban agriculture (UPA) through systematic review of the literature. I considered the availability of global data sets regarding UPA's impact on ecosystem services and disservices, as well as its land sparing potential. This literature review showed that while there has been an increase in research exploring the intersection between UPA and ecosystem services, there is still a need to include the quantification of ecosystem services and functions to shed light on the ecological tradeoffs associated with agricultural production in the built environment.

The second, third, and final chapters focus on a mixed-methods study aimed at exploring New Hampshire resident perception of agricultural expansion in the state. New Hampshire is experiencing a landscape shift back to agricultural production, as the numbers of farms and area in agricultural production are increasing. As a predominately forested state, increasing agricultural production in New Hampshire would require some forestland conversion, a change residents may not favor.

I surveyed two populations in New Hampshire, self-identified food system stakeholders (e.g., farmers, public health professionals, and technical assistance providers) and a sample from the general population. Roughly 600 residents completed the survey, including 494 individuals from the statewide sample population, and 103 food system stakeholders. The survey included traditional written questions, as well as sets of images to understand how resident perception (visual preference) might influence potential future agricultural land use.

Objectives of this study were to understand resident: (1) general perception of forestland conversion to agriculture, (2) measured level of acceptance of agricultural expansion on the landscape, (3) perception of ecosystem services from different types of farm landscapes, (4) willingness to live next to farms, and (5) consumer behavior related to locally grown food. Additionally, I sought to identify socio-economic factors that account for the differences between each population in terms of their landscape perception and preference.

My findings suggest that there are differences in agricultural landscape preferences and perceptions between the general population and those who consider themselves food system stakeholders. While the response patterns were similar between each population, not surprisingly, food system stakeholders indicated that they were more accepting of agricultural expansion and more willing to live next to farms. In terms of landscape appeal, the statewide sample population rated forestland more appealing than cropland, while the food system stakeholders preferred cropland to forestland. My results show an interesting relationship between agricultural landscape preferences and consumer behavior. I found that overall

consumer behavior favors local food purchasing, but while consumers may want to purchase locally grown food, they may not want to live next to the working farms that produce that food. Additionally, my findings suggest that household income and gender are the two most important socio-economic predictor variables related to agricultural landscape perception and preference, and consumer behavior of locally grown foods.

The complexity of human attitudes and behaviors is a challenge for interest groups focused on increasing food production in the state. While my findings are just a snapshot in time, an improved understanding of how residents perceive agricultural expansion in the state, including forestland conversion, their willingness to live next to agricultural land, as well as their consumer behavior of locally grown foods could assist policymakers and land use planners in decision-making related to increasing agricultural production in the state.

# Ecosystem services and land sparing potential of urban and peri-urban agriculture: A review

**Wilhelm, J.A. and Smith, R.G.** **(2017)** ***Renewable Agriculture and Food Systems.***

**Abstract**

Agricultural expansion contributes to the degradation of biodiverse ecosystems and the services these systems provide. Expansion of urban and peri-urban agriculture (UPA), on the other hand, may hold promise to both expand the portfolio of ecosystem services available in built environments, where ecosystem services are typically low, and to reduce pressure to convert sensitive non-urban, non-agricultural ecosystems to agriculture. However, few data are available to support these hypotheses. Here we review and summarize the research conducted on UPA from 320 peer-reviewed papers published between 2000 and 2014. Specifically, we explored the availability of data regarding UPA's impact on ecosystem services and disservices. We also assessed the literature for evidence that UPA can contribute to land sparing. We find that the growth in UPA research over this time period points to the emerging recognition of the potential role that UPA systems play in food production worldwide. However, few studies (n = 15) place UPA in the context of ecosystem services, and no studies in our review explicitly quantify the land sparing potential of UPA. Additionally, while few studies (n = 19) quantify production potential of UPA, data that are necessary to accurately quantify the role these systems can play in land sparing, our rough estimates suggest that agricultural extensification into the world's urban environments via UPA could spare an area approximately twice the size of the US state of Massachusetts. Expanding future UPA research to include quantification of ecosystem services and functions would shed light on the ecological tradeoffs associated with agricultural production in the built environment. As food demand increases and urban populations continue

to grow, it will be critical to better understand the role urban environments can play in global agricultural production and ecosystem preservation.

***Key Words***

Agroecology, food security, land use, multifunctional agriculture

**Introduction**

Agricultural systems, including crop and pastureland, currently cover approximately 40 percent of terrestrial land area (Ramankutty et al., 2008). In large part, these systems are located in rural areas and are considered to be associated with low levels of regulating and supporting ecosystem services compared to the natural ecosystems that they replaced (Foley et al., 2011). Ecosystem services (ES) are the benefits humans obtain from ecological systems, and include regulating (e.g., water filtration and carbon sequestration), supporting (e.g., crop pollination and soil formation), provisioning (e.g., food, feed, and fiber production), and cultural (e.g., recreation opportunities) services (MA, 2005). They are present in both natural environments and actively managed systems such as agricultural ecosystems, and can be both positively and negatively affected by land use change (Carpenter et al., 2009). Changes in ES that result from converting non-agricultural lands to agriculture (agricultural expansion or 'extensification'), such as changes in the regional carbon sink capacity of a landscape, could have broad environmental, economic, and social impacts at the regional, national, and global levels (Tilman et al., 2011). Thus, further expansion of agriculture via conversion of non-agricultural ecosystems to agricultural uses (i.e., agricultural extensification) is generally considered an undesirable strategy for meeting current and future food demand (Tilman et al., 2011; Foley et al., 2011).

Limiting further agricultural extensification into rural landscapes and its attendant effects on biodiversity and ES will be challenging, however, given that world population is predicted to reach over 9 billion by mid-century (UN, 2012). This increase in population, along with a shift toward greater consumption of meat and dairy in many diets, will result in unprecedented pressure to increase net agricultural productivity via either agricultural intensification (i.e., produce more on existing agricultural land) or extensification (Tilman et al., 2011). But what if the ecosystems that are converted to agriculture are already extremely low functioning in terms of ES, including food provisioning services? Is it possible that agricultural extensification in these cases could result in a net increase in ES? And if so, which services are most likely to be enhanced?

Urban and Peri-urban agriculture (hereafter UPA) is the production and distribution of food, fiber, and fuel products in and around cities (Zasada, 2011). As described in Figure 1, UPA represents a form of agricultural extensification that may enhance net ES, as these types of agricultural systems are typically established in vacant lots and other open areas in built environments (i.e., the human-engineered environment ranging from buildings to parks (e.g., Fig. 1C) where ES are typically low (Larondelle and Haase, 2013). Additionally, if expansion of food production services in UPA systems offsets the demand for agricultural extensification into rural areas (e.g., Fig. 1A), where ecosystems tend to be more biologically diverse and ES tend to be higher, UPA could represent a mechanism for preserving and protecting sensitive natural ecosystems and their associated ES (i.e., land sparing). Thus, one could hypothesize that there are potentially two means by which UPA may contribute to net ES: by enhancing ES in built environments (by extensification of agriculture into urban environments with low ES), and by reducing pressure to convert ecosystems with high ES value to agricultural systems (reducing agricultural extensification into rural ecosystems). In other words, while converting rural ecosystems (such as forest) to agricultural production can increase food provisioning ES, the loss of those ecosystems leads to a net decrease in the supporting, regulating, and cultural ES that are available across the landscape (e.g., Foley et al. 2011). In contrast, it is possible that converting urban and peri-urban ecosystems (such as vacant lots) to agricultural production can increase both food provisioning ES and supporting, regulating, and cultural ES across an urban landscape that would otherwise have no or very low ES value. Additionally, by increasing the food production capacity of urban environments, the need for additional agricultural extensification may decrease, thereby contributing to land sparing and the preservation of ecosystems with high intrinsic ES value.

Despite the appeal of these hypotheses, their validity has not, to our knowledge, been formally assessed. Hence, the purpose of this review was to analyze the peer-reviewed UPA literature to address four main questions: 1) What are the temporal trends in UPA research and the availability of data, particularly in the context of ES? 2) Based on available data, what are the ES associated with UPA and how do these compare to other types of "habitat" found in urban areas? 3) Are there potential ecosystem disservices associated with UPA? 4) What is the evidence that UPA can contribute to land sparing?

**Materials and Methods**

We conducted a comprehensive search of the peer-reviewed scientific literature using the ISI Web of Science, Agricola, and Google Scholar databases in January of 2015. Search terms included "urban agriculture" and "peri-urban agriculture." This initial search yielded 618 prospective articles. Each article was then examined and any duplicates, books, book reviews, articles with anonymous authors, and non-peer reviewed articles were discarded. Articles that a) were not published in English, were not published between the years 2000 to 2014, did not contain at least one research objective directly related to UPA, and were not related to current research (i.e., focused on historical aspects of UPA) were also discarded. The 371 articles that remained were then assessed to determine their relevance to our objectives. Of these, 320 unique articles met the criteria for this review (see supplemental material).

To efficiently search the 320 articles and assist our review process, we used the qualitative analysis software, NVivo 9 (QSR International Pty. Ltd., 2010), as an organizing tool. Bazeley and Jackson (2013) describe the applications of NVivo as a computer assisted qualitative data analysis software, including the various search functions that assist with simultaneously exploring multiple text files. We employed NVivo as a searchable database, where each article was manually imported into the software and classified by year and the study's location (city, country, and development status). After all of the literature was imported, we conducted multiple searches (queries) of the database using a list of key words ("ecosystem services," "production potential," "production capacity," "land sparing," "food security," "food insecurity," and "food safety"). Of the 320 articles, six were not interpretable by the NVivo software and therefore could not be imported into the database. We individually searched these six articles by hand for the same key words used in the NVivo queries.

Additionally, we also reviewed literature that evaluated ES provided by other types of habitat found in urban environments (e.g., lawns, green space, etc.) to provide a baseline against which UPA systems could be compared. We searched the ISI Web of Science database using the terms "urban ecology" and "ecosystem services AND urban." We did not conduct an exhaustive investigation of this literature, but rather reviewed articles for supplemental data to inform our review of the UPA literature. The articles found through these searches included studies of various urban environments from impervious surfaces to urban greenways.

## Results and Discussion

### *Trends in UPA Research and Availability of Ecosystem Services Data*

Our first research question pertained to the temporal trends in UPA research, and in particular the availability of data regarding ES within UPA systems. With regard to temporal trends in UPA research, our review found that from 2000 to 2006 the number of peer-reviewed articles reporting research conducted in UPA was fairly low with moderate or no increase in numbers from one year to the next. Since 2007, however, there has been a dramatic increase in the number of publications reporting on UPA research, evidenced by the fact that 62% of the total publications included in our review were published between 2010 and 2014. These results are congruent with the work of Lichtfouse et al. (2010), who reported that urban agriculture ranked third in their top ten list of emerging topics in agroscience between 1999-2009.

Not only have the total numbers of publications reporting UPA research increased over this time period, but the scope and focus of the UPA research appears to have shifted as well. Prior to 2008, the majority of UPA research was focused on developing countries; however, since that time there has been a substantial increase in UPA research focused on developed countries. We defined regions as "developed," which included countries in North America, Europe, Japan, Australia, and New Zealand; and "developing," which included countries in Africa, Latin America, Asia, and the Middle East. These overall trends may reflect, in part, the global economic downturn that began in 2008, as well as the fact that UPA systems have historically been considered as resources for the food insecure, but more recently are being viewed as viable food production systems that challenge "the common belief that crops should be cultivated in rural areas" (Lichtfouse et al. 2010; Lovell, 2010).

Of the UPA research assessed in this review, only 15 (4.7%) of the publications focused on ES, and of these, almost all were concerned with UPA in developed countries. Additionally, the explicit consideration of ES within different function areas (i.e., publication explicitly refers to supporting, regulating, provisioning, or cultural services), appears to be a relatively recent focus in UPA research, with 14 of the 15 ES-focused articles having been published between 2010 and 2014.

While ES related to urban landscapes have received some attention over the last two decades (e.g., Bolund and Hunhammar, 1999; Gomez-Baggethun and Barton, 2013), in general, the availability of data related to ES in UPA systems specifically, is lacking. Of the 15 articles that explicitly address ES, only five quantitatively assess one or more services (Table 1). Interestingly, a number of studies evaluated various aspects of ES within UPA systems, such as nutrient cycling (Abdalla et al., 2012) or reducing wastewater contamination (Kurian et al., 2013), without specifically referring to these functions as ES. Among the studies that addressed ES, either qualitatively or quantitatively, there was no one category of ES that appeared to be represented disproportionately relative to the others (Table 1).

***Ecosystem Services Associated with UPA and other Urban Land Uses***

How an agricultural system is managed determines the degree to which ES are degraded or enhanced (Power, 2010; Hale et al., 2014). Diversified agroecosystems located in rural landscapes can be multifunctional, providing services other than food provisioning alone, including regulating, supporting, and cultural ecosystem services; land preservation; and a variety of socio-economic opportunities (Renting et al., 2009). Thus, despite the fact that conversion of rural ecosystems that initially have high ES value to agricultural uses results in a net decrease in the levels of regulating and supporting ES, diversified agricultural systems can still provide a variety of valuable services (Tilman et al., 2002; Power, 2010; Bommarco et al., 2013). These same types of services are likely promoted in built environments when low ES value urban areas are converted to UPA systems. Our second research question, therefore, concerned the nature and magnitude of ES associated with UPA systems relative to those associated with other types of habitat and land uses found in urban environments.

Relatively few studies have quantitatively assessed ES in UPA systems (Table 1); however, a number of studies have assessed ES in urban environments that have relevance to UPA. A summary of the ES assessed in urban environments, including in UPA systems, is presented in Table 2. These ES include wildlife habitat (Lowenstein et al., 2014; Orsini et al., 2014), nutrient cycling (Livesley et al., 2010), temperature regulation (Qiu et al., 2013), cultural information and recreation (Kuo and Sullivan, 2001; Brinkley, 2012), carbon sequestration and soil organic matter formation (Edmondson et al., 2014), and water filtration and flood prevention (Farrugia et al., 2013).

Our review found that UPA systems have the potential to contribute to the enhancement of a number of supporting ES compared to other types of urban habitats and land uses (Table 2). For example, unlike extensification of agriculture into rural landscapes, which is associated with decreases in biodiversity (Donald et al., 2001; Jenkins et al., 2003), UPA systems have been shown to host more wildlife than the urban space from which they are derived (Li et al., 2005; Lowenstein et al., 2014; Orsini et al., 2014).

Several regulating ES may also be enhanced within UPA systems (Table 2). For example, one low-input means of managing insect pests affecting urban agriculture is through the use of natural biocontrol services, which have been found to vary depending upon the plant heterogeneity of the urban habitat (Yadav et al., 2012). Additionally, both nematode population density and microbial biomass nitrogen, two measures of ecosystem productivity that contribute to soil fertility services, have been found to be higher in urban vacant lots than nearby agricultural soils (Knight et al., 2013).

Greenhouse gas emissions can be relatively high in some urban environments (Jacobson 2010) and UPA systems might help to offset these emissions through carbon storage and sequestration. For example, Kulak et al. (2013) found that peri-urban production could potentially reduce greenhouse gas emissions by up to 34 t $CO_2$e ha-1 yr-1 (carbon dioxide equivalents per hectare per year). While this reduction may seem small, it is higher than carbon sequestration rates for urban park and forest green spaces (Kulak et al., 2013). Similarly, Edmondson et al. (2014) found that soil organic carbon concentrations and C:N ratios in urban allotments were 32% and 36% higher than in pastures and arable fields, respectively. These studies support the idea that UPA systems can reduce greenhouse gas emissions on the production-side, while greater availability of agricultural products in densely populated areas could decrease emissions related to transportation on the supply-side.

Another regulating ES that UPA systems may contribute is temperature moderation in cities. While our review found no articles that expressly quantified UPA's contribution to temperature, several studies have found that urban vegetation plays a role in regulating temperatures in these environments. For example, Jenerette et al. (2011) evaluated 30 years of data from Phoenix, AZ and established "an ecosystem services trade-offs approach" to calculate the risk of urban heat effect. They found that vegetation in urban environments supported a surface cooling effect of nearly 25°C in comparison to bare soil. Additionally, urban vegetation in various environments (from treed parks to grassy fields) was found to reduce the urban heat island effect by 0.5-4.0°C, while the cooling effects of green roofs on ambient air temperature and roof surface temperature ranged from 0.24-4.0°C and 0.8-60.0°C, respectively (Qiu et al., 2013). These data support the hypothesis that agricultural vegetation associated with UPA could help moderate the effects of global warming in urban areas.

In addition to supporting and regulating ES, UPA systems have been shown to enhance cultural ES, including preserving cultural customs and traditions (Colasanti et al., 2012), increasing income generation opportunities and gender equality (Flynn, 2001; Bryld, 2003), and absorbing a surplus of urban wastes (Lydecker and Drechsel, 2010). The use of UPA for enhancing food security, a provisioning ES (Yeudall et al., 2007; Barthel and Isendahl, 2013), is well-documented, though most often not couched in ES terms. Urban home gardens, one of the many forms of urban agriculture, have been shown to enhance services on marginal lands, suggesting that UPA may also have a role to play in remediating degraded land (Calvet-Mir et al., 2012).

In Table 2, we summarize which ES have previously been empirically assessed in the literature, and specify in which type of urban environment the study was conducted. We also created a conceptual model, based on the current literature cited in Table 2, to visualize how ES might differ between four types of urban environments: 1) impervious surface (i.e., the absence of vegetation), 2) soil or grass, 3) green space (e.g., city parks), and 4) urban agricultural systems (Fig. 2). By considering the nature and magnitude of ES quantified in different urban environments, from built environments absent of vegetation to those with an abundance of vegetation it is possible to hypothesize on the nature and magnitude of ES within UPA systems. For example, green spaces within urban environments, such as public parks, and UPA systems are likely similar in that they support a multitude of ES at relatively high levels, with the exception being that UPA also provides food provisioning services. In contrast, impervious surfaces likely have very little ES value relative to UPA systems or even abandoned lots or grass lawns (Fig. 2). Additional research on ES in UPA and other urban habitats will be necessary to fully assess the validity of these hypotheses.

***UPA and Ecosystem Disservices***

Though there are several ES linked to UPA systems, there are also potential ecosystem disservices (ecosystem functions that cause negative consequences for human wellbeing) associated with crop production in built environments (Lyytimaki and Sipila, 2009). Here we assess the literature to understand the potential ecosystem disservices within UPA systems specifically. Globally, the pressure to increase agricultural production is currently experienced most in developing countries where the burgeoning urban population is resource poor. While UPA is not widespread in most cities in developed countries, developing countries within Africa, Asia, and Latin America use UPA as a necessary means of meeting nutritional requirements for many residents (Zezza and Tasciotti, 2010). Although the use of waste can be a means of recycling organic material, it can often result in contamination of soil, water, and ultimately crops. A number of studies have shown that the use of city waste and waste water can increase heavy metals in soils and bacterial contamination of food crops (Amoah et al., 2007; Abdu et al., 2011). Additionally, standing water associated with UPA systems can provide a source for disease-carrying insects (Klinkenberg et al., 2008). Depending upon the type of production system, UPA has been cited as contributing to the degradation of already fragile ecosystems by draining water tables, causing landslides due to farming on slopes, and blocking drainage systems (Matagi, 2002).

In addition to the potential disservices, there are also concerns about the safety of growing food in urban environments. Urban areas are exposed to more soil, water, and air pollution than rural landscapes (Wortman and Lovell, 2013), yet may not have the regulating services necessary to processes these contaminants. Pollution in urban environments can contaminate agricultural products (Agrawal et al., 2003; Amoah et al., 2007; Egwu and Agbenin, 2013) and pose health risks to both farmers and consumers (Diaz et al., 2012). Moreover, the policies needed to secure land for agricultural use, ensure that the land is safe, and support the infrastructure necessary to make agricultural production possible, currently do not exist in most urban municipalities (Redwood, 2009; Lovell 2010).

***UPA's Potential Role in Land Sparing***

To consider what role UPA systems might play in both contributing to the increased food demand and reducing the conversion of ecologically important landscapes, we reviewed the UPA literature related to land sparing, and calculated a rough estimate of the global land sparing potential of UPA systems. Traditionally, land sparing involves intensifying agricultural production on existing agricultural land to produce higher yields from the same area, while intentionally preserving neighboring landscapes that are biologically diverse (Fischer et al., 2008). Land sparing and land sharing—the use of less intensive production techniques that conserve biodiversity on farmland—have both been cited as a means of producing agricultural crops while maintaining or enhancing biodiversity (Green et al., 2005). When compared to land sharing, land sparing was shown to contribute more to conserving plant species richness (Egan and Mortensen, 2012). However, within the land sparing and land sharing literature there is controversy around how to quantify tradeoffs between the natural (e.g., stacking ecosystem services) and the managed aspects of the system (e.g., food provisioning alone) on a landscape scale (Grau et al., 2013; Fischer et al., 2014). While the details of land sharing are beyond the scope of this article, we mention it here as context for the concept of land sparing.

We found no studies that explicitly examined the potential of UPA to contribute to sparing of rural land or sensitive habitat from conversion to agriculture. Previous work suggests that future increases in agricultural production will likely come through a combination of both intensification and extensification; however, the distribution of those two approaches will likely depend on a nation's developmental status (Tilman et al., 2011). If global agricultural trends continue, extensification will occur most widely in ecologically sensitive areas of developing countries (e.g., biologically diverse rain forest), while intensification will primarily occur in wealthier nations (Green et al., 2005; Tilman et al., 2011). Given the importance of protecting high-diversity ecosystems, many of which occur in areas of the world that are most at risk of loss due to agricultural extensification, it is therefore particularly noteworthy that UPA has not yet been examined for its potential to contribute to land sparing. Although the scale of individual UPA systems may be small, the worldwide contribution of small-scale farming to global food production is large (Altieri, 2004). Small farms, less than two hectares in size, comprise an estimated 60 percent of the world's arable land and include 85 percent of farmers (Lowder et al., 2014), suggesting that UPA has the potential to contribute both to food production as well as ecosystem preservation.

To accurately estimate land sparing potential of UPA systems, researchers must understand both the extent of urban production on the landscape and production potential of various urban spaces. Though no literature expressly assessed land sparing potential through UPA systems, we did find several studies that attempt to quantify the extent of UPA. The exact number of people involved in UPA activities globally is currently unknown, though qualitative data from a 1996 publication is often cited as empirical evidence of its widespread implementation (Cheema et al., 1996). This publication estimates that as of 1993, 800 million people were involved in urban agriculture worldwide. These estimates were based on researcher observation and extrapolation and are now over twenty years outdated (Smit et al., 2001). Hamilton et al. (2014) estimate that 266 million households are engaged in urban agriculture in developing countries, and note that more comprehensive surveys and inventories are needed to more accurately measure the extent of urban agriculture. Several other studies cite various statistics at the scale of individual cities and countries, though again, they are not based on comprehensive, quantitative data sets. In Africa, for example, Owusu (2007) found that approximately one third of all residents in Kampala, Uganda are involved with UPA, and it is estimated that 90% of the vegetables consumed in cities of Ghana were grown within cities (Keraita et al., 2008). In Beijing, China, assessments suggest that 80,000 residents were directly involved with UPA in 2005, and 524,000 were engaged in UPA related activities (Zhang et al., 2009).

More recently there have been a small number of assessments aiming to quantify urban agriculture systems and outputs more precisely. In North America, several studies have been conducted detailing existing and potential UPA sites, and in some cases making production estimations (Table 3). One study of Cleveland, Ohio found that there are an estimated 4,000 residents involved with UPA on some portion of the approximately 13.35 km2 existing vacant lots (Bagstad and Shammin, 2012). McClintock et al. (2013) reported that there are about 485.6 ha of arable land in Oakland, CA. The authors estimate that if just over 200 ha of this land were put into agricultural production, a projected one third of the city’s vegetable consumption could be met. In Burlington, VT, researchers found that up to 108% of the daily recommended minimum fruit consumption could be met for all Burlington residents through urban food forests (Clark and Nicholas, 2013). Several other studies have been conducted in Portland, OR; Seattle, WA; Toronto, Ontario; and Montreal, Quebec, but not published in peer reviewed journals (Kaethler, 2006), and thus were not included in our analysis. Overall, nine of the studies reviewed were specifically aimed at identifying the number of existing UPA systems, or the potential for developing new systems (Table 3).

Although some estimates exist for individual cities and countries, most production estimates for UPA are anecdotal and not based on empirical data. Overall there is a general lack of quantitative research conducted on production capacity of UPA systems. Of the 320 articles reviewed in this study, just 45 (14%) reported the size of the UPA systems studied. The type and size of UPA systems varied greatly, with systems as small as <0.01 ha in total size, and took the form of home and community gardens, subsistence farming with and without livestock, rooftop production, and market gardens. The lack of reliable quantitative data accounting for the scope and scale of UPA hinders the ability of researchers to estimate production capacity and land sparing potential.

With those caveats aside, our review of the literature does allow us to develop a rough, back-of-the-envelope calculation of the land sparing potential of UPA. Our calculation is based on a recent study by Martellozzo et al. (2014), who estimated that converting one third (21.43 Mha) of global urban area to agricultural production could provide all the vegetables required by urban residents. By applying the framework of land sparing to the analysis by Martellozzo et al. (2014), we can get a rough estimate of UPA’s potential role in land sparing (Table 4). Several studies have shown that small-scale production methods have a higher land use efficiency ratio compared to conventional production. For example, one study found that onion yields were three times higher under small-scale, biologically-intensive production methods compared to mechanized production (Moore, 2010). Algert et al. (2014) found production practices in urban community gardens to be more similar to biologically-intensive farming, producing 3.63 kg of vegetables/m2, compared to conventional agricultural practices, which produced an average of 2.90 kg/m2.

Given that small-scale production methods are typically biologically-intensive, and UPA systems are inherently small-scale, we can assume that yields are usually higher in these systems compared to conventional, large-scale agriculture. Based on the data reported by Algert et al. (2014), we can estimate that biologically-intensive production is 1.25 times more productive than conventional production. If one third of global urban space were converted to agricultural production, the area identified by Martellozzo et al. (2014), extensification could be reduced by an estimated 5.36 Mha (53,599 km2), an area nearly twice the size of the US state of Massachusetts. Due to a variety of factors, including zoning laws, land contamination, lack of sunlight due to tall buildings, and competition for land use, among other challenges, converting one third of total urban area to agricultural production may be unrealistic. However, our review suggests that converting even a fraction of this land area could still result in substantial sparing of ecologically sensitive habitat, while at the same time increasing provisioning and other ES services in urban centers, where there is perhaps greatest demand.

## Conclusions

The growing body of UPA literature and the diversity of research conducted within this field, points to an increasing recognition of the contribution of UPA to the agricultural landscape worldwide (Lichtfouse et al. 2010). Our review of this literature suggests, however, that the majority of UPA research is lacking an ecological focus. Researchers in developing countries have recognized the important role of UPA systems as a means of subsistence for many urban residents, and therefore the majority of the articles from these regions are focused on food security. Although a food security and safety focus is an important framework for UPA research, understanding the ecology of UPA is equally as important, particularly in the context of UPA's potential to enhance ES and spare ecologically sensitive land.

Most ES have yet to be quantified within UPA systems. Our review found that 15 articles included an ecosystem services perspective, of which only five studies quantified ES in UPA systems specifically. We found that soil quality, production potential, belowground biocontrol services, wildlife habitat, and carbon storage are maintained or enhanced compared to other urban, and in some cases rural, landscapes. While there are ES benefits of UPA systems, there are also potential ecosystem disservices, as well as health safety concerns. No studies explicitly explored land sparing in direct relation to urban agricultural production. Production potential, key for understanding land sparing, was measured in only 19 studies and included various urban food production systems ranging from fruit trees to green roofs. Though these studies suggest that UPA can contribute substantively to the food matrix, the scale and scope of the data that are available is currently limited. To better understand and quantify the potential of UPA in land sparing it will be necessary to develop better assessments of land availability in highly populated areas around the world, especially in regions where sensitive ecosystems are currently being threatened by expansion of agriculture.

The context of UPA systems research has implications for both policy and land use planning in urban environments (Lovell, 2010; Cohen and Reynolds, 2014). The available data suggests that UPA has the capacity to improve urban environments and enhance provisioning, regulating, and supporting ES. To that end, our review promotes two main concepts relevant to land use planners and policymakers. First, UPA systems can be managed to enhance ES that are of greatest importance to urban environments, including increasing the food production capacity. The ES inherent in UPA systems may be a means of offsetting costly maintenance of urban infrastructure such as storm water management, and reduced energy costs through mitigation of the urban heat island effect (Lydecker and Drechsel, 2010; Jenerette et al., 2011). Developing a catalog of how such services are mediated in urban ecosystems could contribute to best practices for both UPA practitioners and land use planners, and could potentially minimize the occurrence of ecosystem disservices. Second, while UPA has typically involved biologically-intensive vegetable or fruit production, one could envision a greater diversity of agricultural systems being practiced in urban and peri-urban environments. By viewing urban and peri-urban environments as an alternative agricultural space, larger tracts of contiguous land could, for example, be conserved for pasture-based and other low-intensity forms of agricultural production, or for preserving wild habitat (e.g., Table 4). Therefore, studies that analyze the spatial extent of undeveloped urban and peri-urban land could contribute to a database of potential land available for different types of UPA production.

Our review highlights the need to recognize the inherent multifunctionality of UPA systems and to pursue more ecologically-focused research in these systems. As agriculture expands to meet the food, feed, fiber, and fuel needs of a growing global population, two-thirds of which reside in urban areas (UN, 2014), it will become increasingly critical to understand UPA's potential role in a global food system that produces adequate amounts of food while protecting the ecosystem services that underpin human wellbeing.

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**Table 1.1** Summaries of the 15 peer-reviewed studies published between 2000 and 2014 that mention ecosystem services in the context of urban and peri-urban agriculture (UPA) systems. Ecosystem services mentioned within each source include provisioning services (PS), regulating services (RS), supporting services (SS), and cultural services (CS). Five papers quantitatively evaluated ecosystem services within UPA systems.

| Main Objective | Mentioned ES | ES Quantified | References |
|---|---|---|---|
| Developed a conceptual framework for urban greening of Beijing Province | PS | - | Li et al., 2005 |
| Developed a framework for landscape performance based on ecological principals | PS & CS | - | Lovell and Johnston, 2009 |
| Literature review of urban agriculture as multifunctional for land use planning | PS, SS, RS, & CS | - | Lovell, 2010 |
| Four-year study explored options for supporting urban agriculture in Sydney basin in Australia | PS, SS, RS, & CS | - | Merson et al., 2010 |
| Evaluated value of services provided by peri-urban agriculture | PS, SS, RS, & CS | Total market value of ES | Brinkley, 2012 |
| Qualitative assessment of ecosystem services provided by home gardens in northeastern Spain | PS, SS, RS, & CS | - | Calvet-Mir et al., 2012 |
| Assessment of householder behavior related to garden management | PS, SS, RS, & CS | - | van Heezik et al., 2012 |
| Quantified belowground biocontrol activity (of soil food web) in urban gardens and vacant lots | SS & RS | Soil organism sampling | Yadav, 2012 |
| Focus on institutional framework related to policy that supports urban forests as sites of production | PS, SS, RS, & CS | - | McLain et al., 2012 |
| Quantitative assessment of urban food forestry | PS, SS, RS, & CS | Climate-food-species matrix | Clark and Nicholas, 2013 |
| Quantitative assessment of soil quality in urban agriculture systems compared to conventional agriculture systems | SS & RS | SOC, total N, C:N ratio, bulk density | Edmondson et al., 2014 |
| Case study evaluating social preferences for multifunctional peri-urban agriculture in Spain | PS, SS, RS, & CS | - | Marques-Perez et al., 2014 |
| Case study quantifying production potential of rooftop vegetable production in Bologna, Italy | PS, SS, RS, & CS | Habitat density and production potential | Orsini et al., 2014 |
| Developed a multiscalar and multidisciplinary research framework of the social and ecological dimensions of home gardens | PS, SS, RS, & CS | - | Taylor and Lovell, 2014 |
| Analyzed the suitability of urban areas for conversion to agricultural production using a GIS-based Multi Criteria Suitability Model | PS, SS, RS, & CS | - | La Rosa et al., 2014 |

**Table 1.2** Ecosystem services provided by urban habitats, including peri-urban agriculture (UPA) systems, organized by functional group. Urban environments described in each study were defined by the individual study authors. Examples presented here represent a small selection of available studies focusing on urban habitats and is not intended to be an exhaustive list.

| Ecosystem Service Functions | Example | Urban Environment | References |
|---|---|---|---|
| ***Supporting*** | | | |
| Wildlife habitat | Flowering plants in urban spaces serve as important habitat for pollinators | Densely populated neighborhoods | Lowenstein et al., 2014 |
| Niche habitat and refuge | Urban gardens can create a network of green corridors | Rooftop gardens | Orsini et al.., 2014 |
| Soil formation | Management of small-scale urban food production can increase soil organic carbon and C:N ratios | Urban allotments | Edmondson et al., 2014 |
| ***Regulating*** | | | |
| Nutrient cycling | Specific management practices, such as mulching, can increase carbon sequestration in urban settings | Lawn and wood chip mulched garden areas | Livesley et al., 2010 |
| Pest and pathogen resistance | Belowground soil foodweb can help mediate biocontrol services in urban gardens | Vacant lots and vegetable gardens | Yadav et al., 2012 |
| Water regulation | Urban settings benefit from increase inflitration capacity, which enhances flood prevention | Urban green space | Farrugia et al., 2013 |
| Temperature regulation | Vegetation in dense urban environments can reduce the urban heat island effect | Urban green space | Jenerette et al., 2011; Qui et al., 2013 |
| ***Provisioning*** | | | |
| Food production | Urban food production can contribute to food security of urban municipalities | Urban and peri-urban agriculture systems | e.g. Hara et al., 2013; McClintock et al., 2013; Algert et al., 2014 |
| Ornamental resources | Resources for worship and decoration can be harvested from urban environments | Home gardens | Calvet-Mir et al., 2012 |
| ***Cultural*** | | | |
| Recreation | Urban greenways have the potential to create areas for recreation | Urban green space | Li et al., 2005 |
| | Agritourism offers alternative opportunities to involve/benefit the larger community | Peri-urban agriculture systems | Brinkley, 2012 |
| Cultural information | Community development enhances as crime rates can be reduced with increased vegetation in urban neighborhoods | Urban green space | Kuo and Sullivan, 2001 |

**Table 1.3** Selected studies that have attempted to estimate production capacity of urban and peri-urban agriculture (UPA) systems on the meso- to macro-scale (city-wide to global urban area).

| Location | Estimated Production Capacity | Production Area | References |
|---|---|---|---|
| Bologna, Italy | The estimated potential of rooftop gardens is >12,000 t year−1 vegetables, which would satisfy 77 % of the residents' requirements | Rooftop gardens | Orsini et al., 2014 |
| Brooklyn, NY, United States | 70% of suitable land (23 ha) could produce as much as 45% of residents' annual supply of dark green vegetables (85,000 people) | Vacant lots | Ackerman et al., 2014 |
| Burlington, VT, United States | Urban forestry could meet 108% of the daily recommended minimum intake of fruit for all city residents | Urban forests | Clark and Nicholas, 2013 |
| Cleveland, OH, United States | Vacant lots in Cleveland could generate between 22% and 100% of resident demand for fresh produce (vegetables and fruits), 25% and 94% of both poultry and shell eggs, and 100% of honey | Vacant lots | Grewal and Grewal, 2012 |
| Global | Roughly one third of the total global urban area would be needed to meet the global vegetable consumption of urban dwellers | Urban area | Martellozzo et al., 2014 |
| New York City, NY, United States | 70% of suitable land (~2016 ha) could meet the produce needs of between 103,000 and 160,000 people | Vacant lots | Ackerman et al., 2011 as cited in Ackerman et al., 2014 |
| Oakland, CA, United States | Committing 40 ha (of >335 ha identified) to vegetable production could contribute more than 5% of current residents' needs | Vacant lots | McClintock et al., 2013 |
| Pittsburgh, PA, United States | Up to 129,000 L of sunflower-based biodiesel could be produced on marginal lands | Marginal lands | Niblick et al., 2013 |
| Toronto, Canada | Approximately 2,317 hectares of food production area would be needed to meet current resident demand, including rooftop space | Urban area and rooftop gardens | MacRae et al., 201 |

**Table 1.4** Land area and production calculations used to derive a rough estimate of urban agriculture's potential role in land sparing.

| Figure | Description | References |
|---|---|---|
| 64.30 Mha | Total global urban space | Martellozzo et al., 2014 |
| 0.75 lb/ft$^2$ | Average crop production in biointensive agriculture | Algert et al., 2014 |
| 0.60 lb/ft$^2$ | Average crop production in conventional agriculture | Algert et al., 2014 |
| 21.43 Mha | One third of global urban space under biointensive urban agriculture | Authors' calculations |
| 26.79 Mha | Land area needed to meet the same productivity as one third urban agriculture under conventional agriculture | Authors' calculations |
| 5.36 Mha | Area of land spared | Authors' calculations |

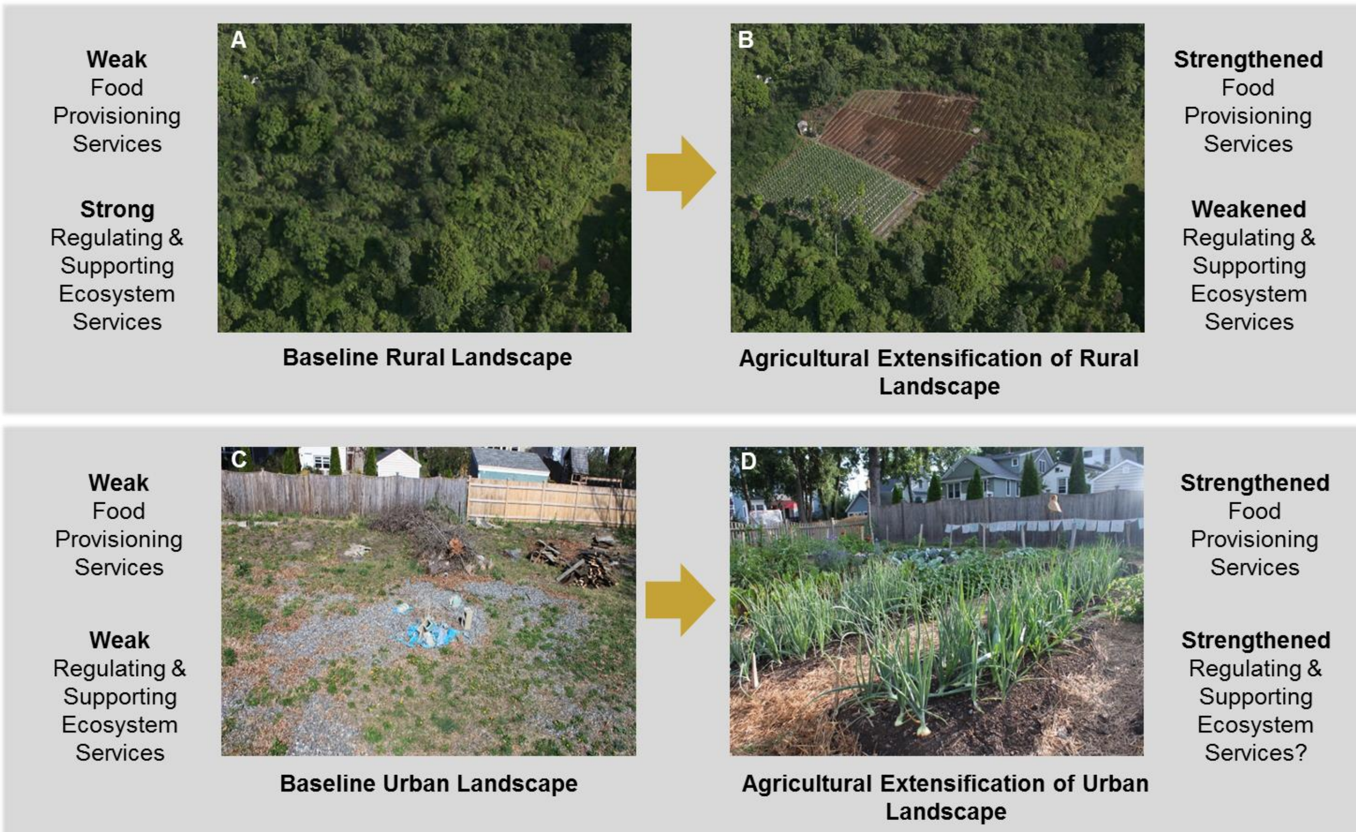


**Figure 1.1** Hypothetical examples of agricultural extensification into rural (A and B) and urban (C and D) landscapes, as conceptualized by the authors based on current literature. Images A and C represent the baseline landscape pre- agricultural conversion and images B and D represent the same landscapes post-conversion. The rural baseline landscape is assumed to have weak food provisioning services but strong regulating and supporting services, while conversion to crop production strengthens food provisioning but weakens regulating and supporting services. The urban baseline landscape is assumed to have both weak provisioning and regulating and supporting services, while all services are assumed to increase with conversion to crop production. Though crop production is highest in rural landscapes, potential tradeoffs with ecosystem services are higher. On the other hand, expanding agricultural production into urban landscapes may be more likely to enhance ecosystem services. Sources: Image B by Kate Evans/CIFOR, image A altered version of B by authors. Images C and D by Jennifer Wilhelm.

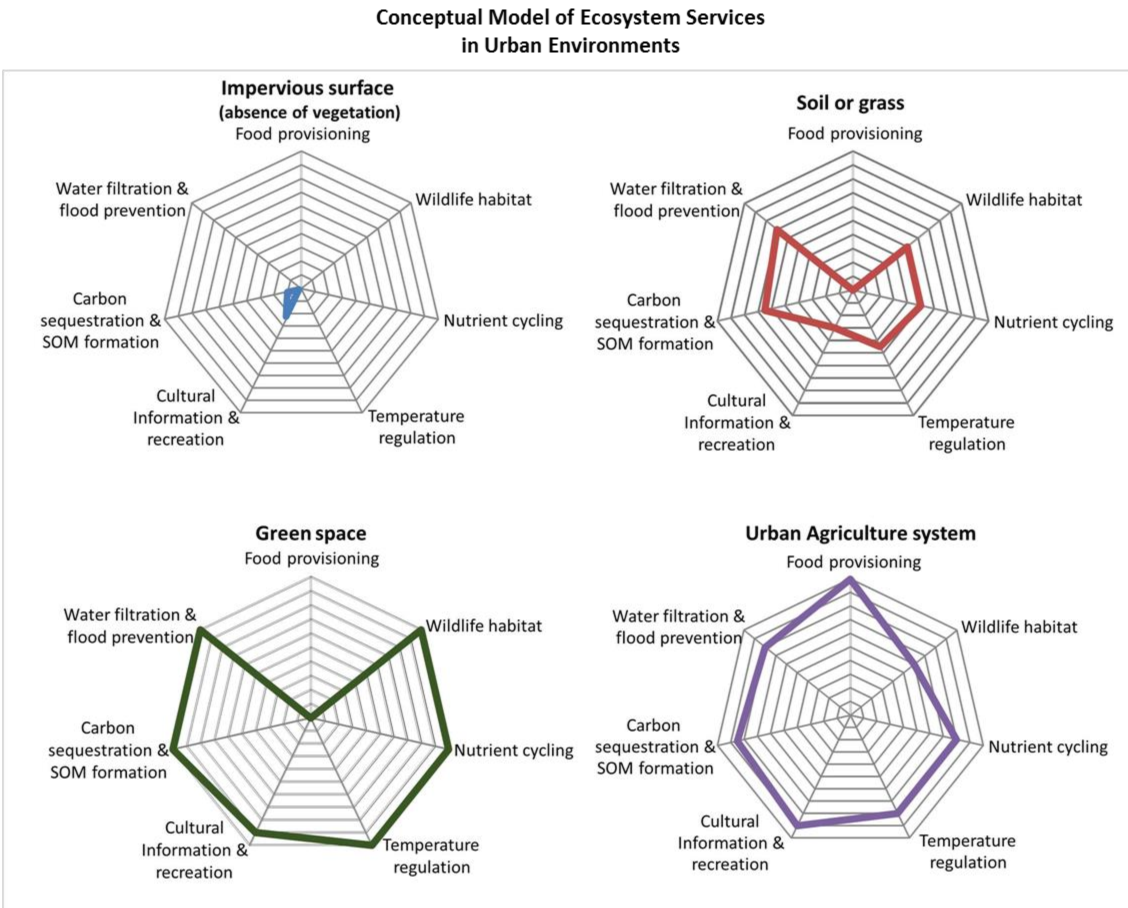


**Figure 1.2** Conceptual model, developed by the authors, describes the potential for different urban environments and land uses to provide seven ecosystem services. Differences in ecosystem services shown in each radar plot are hypothetical and not based on standardized values, but were informed by current literature (Table 2). Each axis of the plot represents a different ecosystem service; the outermost point on the axes represents the highest level of service, with service provisioning decreasing towards the center. The symmetry of each plot indicates the estimated relative balance of all the services; therefore, the larger and more symmetrical, the higher the overall potential ES benefits.

# Gauging New Hampshire residents' appetite for agricultural expansion and willingness to live next to farms

**Abstract**

Forest ecosystems and agriculture represent coupled socio-ecological systems that can be shaped by land use decisions occurring at local and regional scales. New Hampshire provides a unique test case for understanding these types of coupled human-natural systems, as the state is heavily forested, strongly reliant on local governance, and is currently experiencing a resurgence in agricultural production, with multiple stakeholder groups calling for a significant expansion of agriculture in the state. Given that an expansion of agriculture in New Hampshire would likely require significant forestland conversion, stakeholder acceptance of different forms of agriculture and preference for living with and seeing agriculturally-driven land use change across the landscape will be key variables that determine whether such changes occur. Specifically, our objectives were to: estimate the social carrying capacity for forestland conversion ($SK_c$) (i.e., the overall minimal acceptable rate of forest conversion to agriculture); determine the acceptability of agricultural expansion on the New Hampshire landscape; assess resident willingness to live next to different types of farms; and identify which socio-economic factors account for the differences between each population in terms of their landscape perception and preference. We sought to survey two populations in New Hampshire, self-identified food system stakeholders (e.g., farmers, public health professionals, and technical assistance providers) and a sample from the general population, to explore how perception of agricultural expansion on the landscape, might differ between populations. Roughly 600 residents completed the survey, including 494 individuals from the statewide sample population, and 103 food system stakeholders. In general, across both populations, respondents had a high tolerance for seeing forestland converted to agriculture, though food system stakeholders consistently rated all agricultural expansion questions higher than the statewide sample. While the overwhelming majority of both populations were willing to live next to a vegetable farm (>90%), a much lower percentage of the population indicated that they were willing to live next to a farm that uses pesticides (<24%). Within the statewide sample, household income was found to be negatively correlated with willingness to live next to farms ($p < 0.001$). Understanding agricultural landscape preferences among different segments of the population, particularly where there are areas of agreement, could help facilitate agricultural land management and policymaking.

***Key Words***

Agricultural expansion, visual preference, local agriculture, forestland conversion, New England, surveys, socio-ecological systems

## Introduction

World population is predicted to reach over 9 billion by mid-century (UN, 2012). This increase in population, along with a shift toward greater consumption of meat and dairy in many diets, will result in unprecedented pressure to increase net agricultural productivity either via producing more on existing farmland or through conversion of non-agricultural ecosystems to agricultural production (Tilman et al., 2011). New England’s landscape was once dominated by farmland, with less than half the region’s land area covered in forest (Compton and Boone, 2000). By the mid-1800s, many farms were abandoned; the land has since re-grown into forest, particularly in New Hampshire, which is now the second most forested state in the nation with >80% forestland (NHDFL, 2010). Now, over 150 years later, New England is experiencing an agricultural revival, and is currently leading national trends in local food production. New Hampshire has a strong local food economy as measured by direct-to-consumer sales. Sales at farm stands, farmers' markets, and other venues have continued to increase, with roughly one third of New Hampshire farms selling directly to consumers (USDA, 2012[a]). Moreover, New Hampshire has seen a 37% increase in the number of farms selling directly to consumers between 2007 and 2012 (USDA, 2012[a]).

Complementing the rise in agricultural production and local food consumption, a regional collaborative network, Food Solutions New England (FSNE), and a local state network, the NH Food Alliance, are working to help grow the emerging local food economy. The recent publication "A New England Food Vision," put forth by FSNE, suggests a future scenario where 50% of New England's food is produced in New England by 2060, and would require an increase in agricultural production in New Hampshire from 3% active farmland (percentage of farmland that is not forested) to 16% by the year 2060 (Donahue et al., 2014). The vision was developed to spark conversation and inspire research that explores the regional food system, and was not intended to serve as a plan for FSNE or the region. Grogan et al. (in review) assessed the feasibility of achieving FSNE's vision, and found that it is feasible to produce 50% of New England's food on 2,428,113 hectares (6 million acres) (an increase of 1,671,351 hectares in total farmland area from 2007 figures), but that it would require all farmland to be managed at medium to high productivity. However, if farming operations are poorly managed, or extreme weather events reduce yields, such a production target could require as much as twice the land area.

The NH Food Alliance spent several years engaging with stakeholders throughout the state, and synthesized dozens of food systems reports to identify the challenges and opportunities facing farmers in New Hampshire. Through this research they found that land access and "Right-to-Farm" challenges (protection from nuisance complaints against day-to-day farm operations), were among the top priorities for New Hampshire farmers (NH Food Alliance, 2015). These priorities suggest that competition for farmland and nuisance complaints from neighbors of farms, are two potential impediments to agricultural expansion in the state. Previous research also suggests that land owner and resident perception may not be aligned with the realities of increased agricultural production. In the nearby state of Connecticut, researchers found that residents support the idea of local food production, but in practice prefer open pasture farmland with iconic farm structures to a working agricultural landscape (e.g., row crop production) (Kent and Elliot, 1995). Another study exploring perception of agricultural production in the state of Maine, found that Maine residents felt protecting farmland was important, but that protecting natural resources/wild landscapes was more important (Walker and Ryan, 2008). Additionally, previous research has shown that local interest groups can and do shape land use policy decisions (e.g., Hawkins, 2011; Grossmann, 2012). Despite the increased interest in local food consumption, there is a lack of data about how New Hampshire residents perceive agriculture on the landscape and whether perceptions might be at odds with FSNE's vision.

To better understand how resident perception might influence future agricultural land-use, we used normative theory (Vaske et al., 1995; Carothers et al., 2001) to explore acceptability of agricultural expansion, acceptability of forestland conversion to agriculture, willingness to live next to farms, and a suite of demographic factors. Understanding social norms, or what is considered "acceptable" in a particular social context, has been used widely in natural resource management and biodiversity conservation (e.g., Vaske and Whittaker, 2004; Manning, 2007; Tynon and Gomez, 2012). Expanding the use of social norms to the agricultural landscape, we build on the work of Bettigole et al. (2014), which explored the social carrying capacity for development ($SK_d$). Social carrying capacity, not strictly defined in the literature, is most often measured within a specific spatial range and defined population (Mauerhofer, 2013), and has been assessed for different types of land uses (DeRuyck et al., 1997; Lawson et al., 2003; Leujak and Ormond, 2007). Following similar protocol to Bettigole et al. (2014), we assessed the acceptable level of forestland conversion to agriculture, or what we are calling, the social carrying capacity for conversion ($SK_c$) as determined by New Hampshire residents.

This study integrates both visual and cognitive methodologies into a mixed methods survey to determine how residents perceive agriculturally-driven land use change in New Hampshire. Visual preference methods are used frequently within land use planning to obtain public feedback on various landscape features (Manning and Freimund, 2004; Zabik and Prytherch, 2013; Sheppard et al., 2011), making use of images to measure environmental preference (Kaplan, 1985). Additionally, photo-realistic visualizations have been used to explore landscape perceptions among various social groups (Hunzlker et al., 2008), and stakeholder groups (Sheppard and Meitner, 2005). Though customary within planning, the use of the visual preference survey method to evaluate agricultural land use change is less common.

Our results are not a forecast of how land use change will occur in the future, but rather a snapshot of two sub-populations of current New Hampshire residents' perceptions (a sample from the general population and a group of food system stakeholders). Specifically, our objectives were to: (1) estimate the social carrying capacity for forestland conversion ($SK_c$) (i.e., the overall minimal acceptable rate of forest conversion to agriculture); (2) determine the acceptability of agricultural expansion on the New Hampshire landscape; (3) assess resident willingness to live next to different types of farms; and (4) identify which socio-economic factors account for the differences between each population in terms of their landscape perception and preference.

## Methods

### *Study Area*

The study area included the entire state of New Hampshire, which covers about 2,322,896 hectares (5.74 million acres) and has roughly 1.3 million residents (U.S. Census Bureau, 2014). New Hampshire encompasses 191,847 hectares (474,065 acres) of farmland, 64% of which is forested farmland (USDA, 2012[b]). Though largely rural, over the last several decades, New Hampshire has been the fastest growing state in the Northeast, with an increase in population from 1.2 to 1.3 billion (2%) between 1990 and 2014 (US Census Bureau, 2015). This rapid increase is contributing to a shift in population from rural to suburban and urban landscapes, and to the permanent loss of farm and forestland to development (US Census Bureau, 2015; Jeon et al., 2013). At the same time, the number of farms and number of hectares in production are also increasing (USDA, 2012[b]). Many of the characteristics that make land suitable for farming are also attractive for development, which can create conflicts for land use.

New Hampshire's population is predominantly white (93.9%, compared to 77% nationally in the U.S.), well-educated (34.4% of residents have a bachelor's degree or higher, compared to 29.3% nationally), wealthy (average income is $65,986, compared to $53,482 nationally), and rural, with a growing suburban population (57 people/km2, compared to 34 nationally) (US Census Bureau, 2015). Additionally, most forestland (80%) in the state is privately owned (US Census Bureau, 2012).

### *Survey Development*

We developed an online mixed methods survey using the Tailored-Design Method (Dillman et al., 2014). The two surveyed populations were recruited June 6-29, 2016. The survey included traditional written questions, as well as sets of images to understand how resident perception (visual preference) might influence potential future agricultural land use.

Survey participants were presented with three sets of photo-simulated images at different spatial scales: Figure 2.1 displays the statewide scenarios of agricultural expansion (State maps at the macroscale), Figure 2.2 represents different forestland conversion to agriculture (aerial images at the mesoscale), and Figure 2.3 illustrates different farmland use (street-level images at the microscale). Additionally, we included five distinct sets of written questions to strengthen our evaluations of landscape preferences: (1) local food consumer behavior (evaluated in a companion paper (chapter 4), (2) willingness to see change on the landscape, (3) perception of the importance of ecosystem services provided by various farm types (addressed in chapter 3), (4) support for farm-friendly regulations (also addressed in chapter 4), and (5) demographics. These questions were intended to expand our understanding of the nuances that influence landscape preferences and inform our results from the visual preference factors.

To develop the scenario images, we used data developed by NH EPSCoR as part of the NH EPSCoR Land Cover Scenarios (NHLCSP) depicting two different land-use change scenarios based on trends in development and agricultural expansion from the present projected to year 2100 (Thorn et al., in revision). The maps and accompanying narratives were the result of stakeholder input and evaluation of existing landscape plans, and were used in ecosystem models to explore how ecosystem services could change under different future scenarios. The current research used two of the NHLCSP maps to illustrate how proportions of agriculture on the landscape could potentially change over time from the year 2020 to the year 2060 (Figure 2.1). Both scenarios show an increase in agricultural production based on the current agricultural footprint of 5% total land area in New Hampshire. The first scenario shows a smaller increase in agricultural land area (2.5%) to total 5.5% land cover in the year 2060, while the second scenario shows a larger increase (13%) to total 16% land cover in agriculture in 2060.

We created these images using ArcGIS 10.3 (ESRI, Redlands, CA) by downloading the raster data, developed by NHLCSP, for each scenario, and color-coding the unique values to reflect six different land uses in each (developed, agriculture, forest, other, wetland, and surface water). The maps were then paired with two Google Earth aerial images of representative landscapes that reflect the mix of forestland and agriculture in each scenario. These two sets of images were presented side-by-side in the survey to highlight for survey participants the difference in the forestland to agricultural land ratio between each scenario.

The second set of images explicitly illustrate forestland to agriculture conversion and were created in a three-step process. First, we used the NHLCSP raster data within ArcGIS 10.3 (ESRI, Redlands, CA) for each scenario and zoomed-in to an area predominately covered by agriculture at the 1:6000 scale. Next, we imported and overlaid satellite imagery (USDA FSA in NAIP) onto the raster data, connecting the raster data layer with aerial imagery. Lastly, we exported the file into PowerPoint (Microsoft Office, 2016), removed the raster layer to uncover the NAIP image, and digitally edited each image by removing/adding forestland/farmland to represent a gradient from 100% forested to 40% forested (Figure 2.2). To estimate the ratio of forestland to agriculture in each image, we used ImageJ 1.x image processing program (Schneider et al., 2012).

We also developed street-level images of four different agricultural landscapes to assess resident preference for, and willingness to live near, different types of farms. These microscale images were developed using a purchased image from iStockPhoto LP (2016) and altering various elements in Adobe Photoshop CC 2015.5. We created farm images with the following elements: (1) forest regrowth, (2) hayfields, (3) livestock pasture, and (4) row crop production (Figure 2.3). By maintaining a "base image" with common elements (the farm buildings and skyline) and only changing the foreground production area and trees line, we minimized the variation from image to image, and thus reduce uncertainty in respondent preference for specific farm-scape elements (Kaplan, 1985; Sheppard, 2001). Respondents were asked to rank the visual appeal of each image (most visually appealing to least visually appealing). Additionally, respondents were asked to state their willingness to live next door to different types of farms that corresponded with the visual images.

***Sampling Methodology***

Unless a paper version was requested (n=12), survey participants completed the survey online, using Qualtrics Survey Research Suite (Qualtrics, Provo, UT). To recruit survey participants from the public, postcard mailings were sent to a random population of 12,000 New Hampshire residents throughout the state (for a target of 500 completed surveys). The added step of going from the postcard to an electronic device with internet access to complete the survey (or making a phone call to request a paper copy), was expected to reduce the response rate. Given that the survey was conducted online, contacting residents via conventional mail and giving the option to request a paper version of the survey, was intended to reduce bias in our final sample population (Dillman et al., 2014). Two waves of mailings were sent out; the first notified residents to the survey, and the second was sent to the same population of 12,000 residents as a reminder. Given that raffle prizes have been shown to boost completion rates (Dillman et al., 2014), all participants who completed the survey had the option to enter a drawing to win one of six, $50 gift cards.

To compare potential differences between the public and those who do work related to food systems, either professionally or civically, we included a second sample population; this population was recruited through the New Hampshire Food Alliance network. Stakeholders identified as Food Alliance partners were solicited through email to complete the survey, and additionally invited to encourage their food system constituents to complete the survey (for a target of 100 completed surveys). To ensure that this focus group of stakeholders was truly representative of food system professionals, a question was added to the beginning of the survey, "Which food system sector best describes where you work in your professional or civic work? (check all that apply)." One survey from the stakeholder population did not have a response to this question and therefore was discarded and excluded from all analyses.

***Statistical Analysis: Social Carrying Capacity for agricultural expansion***

Using Stata (StataCorp, 2015) for all statistical analyses, we first measured responses to overall acceptance of agricultural expansion on the landscape by calculating the mean acceptability rating to each illustration in Figures 2.1 & 2.2. Following similar methods to Bettigole et al. (2014) for measuring social carrying capacity for development ($SK_d$), we measured the 'social carrying capacity for forestland conversion' ($SK_c$), which we use to define the minimal acceptable condition of forestland converted to agriculture based on current New Hampshire residents' opinions. To calculate the $SK_c$ in New Hampshire, we created acceptability curves, by calculating and graphing the mean acceptability rating for each of the conversion images included in the visual preference portion of the survey (Figure 2.2). Respondents were asked to rate the acceptability on a scale of very acceptable to not at all acceptable, which we related to a numbered scale ranging from +2 (very acceptable) to -2 (not at all acceptable) for statistical analyses. We used Van der Eijk's measure of agreement (A) to calculate the level of consensus around each mean on the curve (Van der Eijk, 2001). Agreement values closer to ‘1’ indicate a higher level of consensus. The $SK_c$ occurs at the level of forestland conversion to agriculture where acceptability is equal to zero, or “the point at which average acceptability ratings move from the positive range to the negative range” (Bettigole et al., 2014).

***Acceptance of agricultural expansion across different groups***

We combined three dependent variables from Figures 2.1 and 2.2, representing acceptance of macro-scale expansion (statewide agricultural expansion scenarios) and acceptance of meso-scale expansion (local aerial forestland conversion to agriculture images), representing one latent variable, or score. The latent variable, *expansion score* (i.e., overall acceptance of agricultural expansion on the landscape) was determined by a factor analysis with principal component factors and varimax rotation. The questions (dependent variables combined into one score), factor loadings, eigenvalues, and measures of reliability for each question are reported in Table 2.1. Variables loading together on the first factor with a value ≥0.40, generally accepted as an acceptable cut-off (Costello and Osborne, 2005), were combined as one latent variable, acceptance of agricultural expansion. This reduced a total of five variables to three; the images representing the most agricultural expansion grouped together (i.e., scenario showing a 13% increase in agricultural expansion and forestland to agriculture images representing a shift to 35% agriculture and 60% agriculture). In other words, respondents who rated these questions as “very acceptable” and “somewhat acceptable” were highly correlated and had the most favorable perception of agricultural expansion. We then assessed the internal validity of this latent variable using Cronbach’s alpha, maintaining the variables with a coefficient ≥0.70, which is typically accepted as the minimum cut-off for reliability (Nunnally, 1978). We used the expansion score and several demographic factors in subsequent correlations and regression analyses to test for differences between the sample populations.

Additionally, two written questions were developed to further explore respondents' perceptions of agricultural expansion on the landscape. The first question, placed at the start of the survey, asked respondents, "Do you think that more food should be grown in New Hampshire?" The second, placed at the end of the survey, asked "Do you believe that more land in the state of New Hampshire should be available for farming?" To determine if responses to these two questions differed, we calculated the means and compared the distribution of responses within both populations, using Wilcoxon signed-rank test.

***Willingness to live near farms***

Respondents were asked to consider their willingness to live next door to seven farms with different management practices including farms that spread manure, use pesticides, sell agricultural products, and host agritourism events, as well as different types of farms including vegetable farms, livestock pasture, and dairies. The list of farms was not intended to be a comprehensive list, nor are the farm types necessarily mutually exclusive. Instead, the list was intended to represent a range of farm types commonly found in New Hampshire. We calculated descriptive statistics (means and standard deviations) for each question. We also performed a MANOVA to test for differences between how both populations rated their willingness to live next to each type of farm.

We examined which socio-economic factors account for the differences between each population in terms of their landscape perception and preference. We used Pearson's correlation matrices to identify significant relationships ($p < 0.05$) with each of the demographic variables, which were compared to subsequent analyses. Responses to eight potential demographic covariates were assessed: attendance at town meeting (yes, no), resident location (rural, sub-urban, urban), number of years lived in New Hampshire, household size, gender, age, highest level of education, and current annual household income (see supplemental materials for complete questions, scale, mean, and standard deviation).

**Results**

Of the 515 online and 8 paper surveys completed, 494 were analyzed as part of the sample population (thepublic), resulting in a response rate of 4.44%. Incomplete surveys (i.e., less than 75% of questions had responses) were excluded from analyses (n = 29). The food system stakeholder population completed 121 online surveys (no paper copies were requested), with 103 surveys analyzed within this focus group population (Table 2.2). Response rate was not calculated for the stakeholder population as the total number of stakeholders in the state is unknown.

Despite the population differences, we did not calculate probability weights for any analyses. As the food system stakeholder population is a focus group, it is not intended to be representative of New Hampshire's population, and therefore it is unnecessary to use weighting (Solon et al., 2015). The difference between the statewide sample and New Hampshire's population, particularly the education variable was substantial. We ran regressions on both weighted and un-weighted data and found that the spread in confidence intervals was higher in the weighted data set (Appendix C). As shown by Solon et al. (2015), in some instances, weighting can reduce the efficiency of estimates. We believe that the difference in confidence intervals suggests that uncertainty would increase, and weighted estimates might not accurately represent New Hampshire residents' perceptions. The results from this study should therefore, be considered within the context of our survey population.

***$SK_c$ for forestland conversion to agriculture & acceptance of agricultural expansion***

Mean acceptance ratings for both sample populations decreased as the level of agricultural expansion (Figure 2.1) and the proportion of forestland conversion to agriculture (Figure 2.2) increased. Scenario A (Figure 2.1), showing a modest increase in agricultural land (+2.5%) had relatively high scores for both the public and stakeholder populations (means = 1.406 and 1.582 respectively); while Scenario B, which showed a more substantial increase in agricultural land (+13%) had lower overall scores (means = 0.913 and 1.311 respectively). We found a similar trend with the forestland conversion illustrations, with the highest acceptance rating for the image representing 25% agriculture (means = 1.468 and 1.686 respectively), and the lowest ratings for the image representing a shift to 60% agriculture. Results for each forestland conversion question, with means and measure of agreement (A) are presented in Table 2.3. The minimal acceptable landscape condition ($SK_c$) differed between the populations. The public had an average score below $SK_c$ (mean = -0.111), while the stakeholder population rated the acceptability just above the neutral acceptability line (mean = 0.366) (Figure 2.4).

There were no significant (at the $p < 0.05$ level) socio-economic predictor variables of expansion score for either sample population, and no significant differences were found by location (i.e., county; or urban, suburban, and/or rural areas) for either population. Within the public population, we found a positive relationship between expansion score and the number of years lived in New Hampshire ($t = 1.86$, $p = 0.063$). In other words, the longer a respondent has lived in New Hampshire, the more likely they are to find agricultural expansion acceptable.

Additional measures of acceptance of agricultural expansion are described in Table 2.4. Results from a Wilcoxon signed-rank test indicated that the public rated question 1 higher than question 2 ($z = 4.535$, $p < 0.001$). On the other hand, the stakeholder population had no difference in the distribution of responses, meaning that both questions were rated similarly. Additionally, a Multivariate Analysis of Variance (MANOVA) on all agriculture expansion questions (Tables 2.3 and 2.4), showed that between sample populations, the stakeholders were more accepting of both agricultural expansion and forestland conversion to agriculture than the state sample population ($F = 3.34$, $p = 0.002$).

**Willingness to live near farms**

Table 2.5 includes questions, means, and standard deviations for respondents' willingness to live next to different types of farms. Respondents' willingness to live next to different types of farms varied depending on the type of farm, with vegetable farms rated highest ($n > 90\%$ for both populations) and farms that use pesticides rated lowest (n between 12-20%). While residents' willingness to live next to different types of farms followed the same trend in both survey populations, the food system stakeholders had consistently higher percentages for each type of farm (Figure 2.5). A MANOVA showed significant difference between the populations, with the stakeholders more willing to live next to farms in general ($F = 3.19$, $p = 0.003$).

Across both populations, perception of agricultural appeal (as determined by responses to ranking images in Figure 2.3) was positively correlated with their willingness to live next to a similar type of farm (Table 2.5). Specifically, we compared the livestock image with responses to willingness to live next to a livestock pasture (question 3, Table 2.5); and the crops image with willingness to live next to a vegetable farm (question 1, Table 2.5). Across both populations, respondents who ranked the visual appeal of the livestock image high, indicated that they were also willing to live next to a livestock pasture ($p = 0.08$). Respondents who gave high ranks to the visual appeal of the crops image indicated that they were willing to live next to a vegetable farm ($p = 0.01$).

Within the statewide sample, a multivariate regression showed that the variable that best explained respondents' willingness to live next to farms was household income. Household income was negatively correlated with willingness to live next to all farm types except "farm that uses pesticides." Table 2.6 includes all significant demographic factors associated with each willingness to live question for the statewide sample. Overall multivariate regression model p values were >0.05 for the stakeholder population, which indicates that there are no significant predictor variables for this group.

## Discussion

### *Study Limitations*

According to the US Census Bureau, Current Population Survey (October 2012), New Hampshire has the highest percentage of individuals with home internet access (79.5% compared to the national average 69.1%), and 83.5% have internet access outside the home. Thus, an electronic survey with the option to request a paper copy was an appropriate choice given our location. However, though our use of postcard mailers reached a broader, more diverse population than email would have, it still required residents to take the additional step of getting onto an electronic device with internet connection, which may have deterred some residents from participating. While our statewide survey population was adequately represented geographically, it was skewed toward an older, well-educated population. Additionally, though our study helps to shed light on resident perception of agricultural expansion, it does not address *why* respondents favored one illustration over another or were more, or less, willing to live next to a farm.

### *Landscape preferences*

In general, across both populations, respondents had a high tolerance for seeing agricultural expansion on the landscape, despite the tradeoff of forestland conversion. The social carrying capacity for forestland conversion ($SK_c$) (i.e., the overall minimal acceptable rate of forest conversion to agriculture) was high for both groups, indicating that residents were not only accepting of seeing agricultural expansion on the landscape, but were willing to accept the tradeoff of converting forestland into farmland. In the development of the survey, we decided to include additional written questions aimed at assessing perception of agricultural expansion on the landscape to determine if responses to these questions differed from how respondents rated acceptability (i.e., check the "robustness" of our visual preference data). We asked two questions: (1) S*hould more food be grown in NH? and* (2) *Should more land be available for farming in NH?* These questions are essentially the same, but the second question gets at "how" more food would be produced. We sought to avoid bias in development of these questions by effectively evaluating our research objectives, as the way and order in which questions are asked can affect responses (Bradburn et al., 2004). Our findings showed that the responses to these questions were consistent with visualization responses both with the trend in acceptance, as well as the difference between populations; there was a significant difference in how the public rated these two questions, but there was no difference for the stakeholders. Theoretical support for production does not necessarily equate to acceptance of potential landscape changes. Given that food systems stakeholders are familiar with food production, it is not surprising that their support for and perception of agricultural expansion would be the same. Those respondents most accepting of agricultural expansion tend to have lived in the state for >10 years (years lived in New Hampshire is negatively correlated with education and household income). As one of the fastest growing states in Northern New England, a changing demographic may change the social norms around agricultural expansion. As the demographic shifts towards new residents from out of state, it is possible that we could see the acceptance of agricultural expansion decrease.

Additionally, respondents were willing to live next to all types of farms except farms that use pesticides or other chemicals. While there were several socio-economic factors correlated with willingness to live next to farms, the most consistent factor was household income, which was negatively correlated with each farm type (except farms that use pesticides or other chemicals). There has been a shift from consumer interest in organic food to locally grown food (Adams and Salois, 2010). However, as Berlin et al. (2009) found with residents in Vermont, consumers might associate locally grown food with "organically grown." Though this association is unfounded (only a tiny fraction of the farms in Vermont are certified organic), it speaks to the disconnect between perceptions and reality of agricultural production. Our results suggest that respondents were also potentially associating local with organic management practices, as respondents may have associated the term *pesticides* with non-organic production. There are two problems with this: first, organic farms use a variety of organic pesticides; and second, < 0.04% of farms in New Hampshire are certified organic (USDA, 2012).

Attendance at town meetings was also identified as a predictor variable for willingness to live next to farms, and is positively correlated with household income. These demographics make understanding the socio-economic factors mediating agriculturally-driven land use change particularly important for agricultural land use planners, as household income is highest in counties with the largest numbers of farms. In other words, this suggests that respondents who currently live in areas with a higher density of farms, do not want to see an increase in the number of farms in their area, despite their overall acceptance of agricultural expansion and forestland conversion to agriculture in the state.

This distinction in resident preference could be classified as the "Not in My Backyard" (NIMBY) phenomena (Schively, 2007). However, previous research suggests caution when using NIMBY to describe the publics' attitudes toward various environmental uses, as perception is highly nuanced and influenced by a variety of factors (Wolsink, 2007). For instance, we included an optional open-ended question at the close of the survey, where respondents could leave comments and questions. While the question was optional, 185 respondents (1/3 of total statewide survey population) left comments. The overwhelming theme that emerged centered around "sustainable agriculture." Respondents suggested that they would be willing to see more agriculture on the landscape, but only if it was "sustainable." Although the respondents who left comments were a self-selecting group, their comments do give insight into potential reasons for landscape preferences. These data could be used in conjunction with follow up interviews to create a more comprehensive narrative around which types of farms and the location of farms that is most acceptable to New Hampshire residents.

***Conclusions & suggestions for future research***

Overall, acceptance of forestland conversion and agricultural expansion, and willingness to live next to farms was high (>50% for all questions except willingness to live next to a farm that uses pesticides), indicating that food system stakeholders have an opportunity to work with New Hampshire residents to increase food production in the state. Grossmann (2012) found that agricultural advocacy groups, such as the Farm Bureau and Farmers Union, were commonly credited with agricultural policy change. As food system stakeholders work to advance their agenda of increasing local food production, they may find it beneficial to collaborate with residents, given that acceptance of a "farm neighbor" may have caveats around the location, type of farm, and management strategies employed. Understanding landscape preferences has been demonstrated to inform the identification of land use conflict (Brown and Raymond, 2014), which could help facilitate increasing agricultural production in the state, and alleviate potential farm-neighbor conflicts. As a rural state that is moving towards urbanization, the social norms of New Hampshire residents suggest that while agricultural expansion is overwhelmingly supported, the acceptance of the type of expansion that “should” occur is less certain. Furthermore, the conversion of forestland to agriculture poses tradeoffs in ecosystem services that must be considered by land use planners, policymakers, and food system and other stakeholders in the state. Gaining perspective on the opportunities and challenges of residents’ land-use perceptions should aid the work of local food system advocates (e.g., Food Solutions New England and the NH Food Alliance). Our study focused explicitly on forestland conversion to agriculture, and did not include questions about, or images depicting, how development could affect both forest and farmland. We intentionally excluded development to isolate forestland conversion to agriculture, and better understand how respondents perceive agricultural expansion specifically. However, land use change is multifaceted, and will include socio-economic and socio-ecological tradeoffs. Results from this study can be used, in combination with USDA Census of Agriculture data, US Census Bureau statistics, population models, and land cover data to better understand competing land use interests for future land use planning decisions. As population increases over the next decade, New Hampshire may see competing land use interests challenge the type and location of agricultural operations.

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**Tables**

**Table 2.1** Scores and latent variable developed for statistical analyses, with measure of reliability. Numbered statements indicate sub-sections of a question. (Only sub-sections included in determining latent variables shown here. For a comprehensive list of questions, see supplemental material.) Factor loadings and alpha scores for all questions and both populations were well above generally accepted cut-off values (>0.5 and >0.7 respectively). Expansion score question scale: +2=very acceptable, +1=somewhat acceptable, 0=I don't know, -1=not very acceptable, -2=not at all acceptable.

| | | Population | | | | | |
|---|---|---|---|---|---|---|---|
| | | Public | | | Stakeholders | | |
| Latent Variables | Question / statement | Eigenvalue | Factor loading | Cronbach's α | Eigenvalue | Factor loading | Cronbach's α |
| *Expansion score* | 16% agriculture in 2060 | 2.35 | 0.88 | 0.81 | 2.39 | 0.821 | 0.81 |
| | 35% forest conversion to agriculture | | 0.89 | | | 0.904 | |
| | 55% forest conversion to agriculture | | 0.86 | | | 0.796 | |

**Table 2.2** Demographic variables of a sample from the public and food system stakeholder focus group compared with New Hampshire state population. While representation was fairly reflected by county and gender, education and age were skewed toward and older, more educated residents. *Data source: US Census Bureau Population estimates, July 1, 2015, (V2015). Age estimated from categories 20-24 (missing 18 and 19-year-olds and therefore could be conservative).

| Variables | Percent of state population | Percent of Public | Percent of Stakeholders |
|---|---|---|---|
| *County* | | | |
| Belknap | 4.56 | 4.86 | 9.71 |
| Carroll | 3.55 | 3.24 | 5.83 |
| Cheshire | 5.70 | 6.48 | 9.71 |
| Coos | 2.35 | 3.44 | 4.85 |
| Grafton | 6.71 | 6.88 | 18.45 |
| Hillsborough | 30.56 | 28.54 | 13.59 |
| Merrimack | 11.12 | 11.94 | 22.33 |
| Rockingham | 22.68 | 23.08 | 7.77 |
| Strafford | 9.53 | 8.91 | 6.80 |
| Sullivan | 3.23 | 2.63 | 0.97 |
| *Education* | | | |
| High School or Less | 37.1 | 6.50 | 1.94 |
| Some College | 28.6 | 23.17 | 3.88 |
| Bachelor's Degree | 34.4 | 29.47 | 32.04 |
| Postgraduate work | N/A | 40.85 | 62.14 |
| *Age* | | | |
| 18-44 | 31.00 | 23.22 | 36.27 |
| *45-74* | 38.00 | 70.67 | 59.80 |
| *75+* | 6.00 | 6.11 | 3.92 |
| *Gender* | | | |
| Male | 50.6 | 47.25 | 32.04 |
| Female | 49.4 | 52.65 | 67.96 |
| Trans/Non-Binary | N/A | 0.20 | 0.97 |

**Table 2.3** Agricultural expansion questions, count, mean, Van der Ejik's Agreement (A), and minimum and maximum response values. Question response scale: +2=very acceptable, +1=somewhat acceptable, 0=I don't know, -1=not very acceptable, -2=not at all acceptable. Both populations had similar trends in how they rated acceptance of agricultural expansion on the landscape, with levels of agreement (A) decreasing as expansion increased.

| | Population | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Public | | | | | Stakeholders | | | | |
| Question | Count | Mean | A | Min | Max | Count | Mean | A | Min | Max |
| Based on your preferences, rate the acceptability of agricultural expansion represented in each (scenario). | | | | | | | | | | |
| 5.5% agriculture in 2060 | 467 | 1.41 | 0.75 | -2 | 2 | 98 | 1.58 | 0.78 | -2 | 2 |
| 16% agriculture in 2060 | 492 | 0.91 | 0.75 | -2 | 2 | 103 | 1.31 | 0.70 | -2 | 2 |
| Based on your preferences, please rate the acceptability of the amount of forestland-to-agriculture conversion represented in the images. | | | | | | | | | | |
| 25% forest conversion to agriculture | 491 | 1.47 | 0.77 | -2 | 2 | 102 | 1.69 | 0.84 | -2 | 2 |
| 35% forest conversion to agriculture | 488 | 0.81 | 0.51 | -2 | 2 | 102 | 1.28 | 0.69 | -2 | 2 |
| 55% forest conversion to agriculture | 487 | -0.11 | 0.27 | -2 | 2 | 101 | 0.37 | 0.30 | -2 | 2 |

**Table 2.4** Wilcoxon matched-pairs signed-ranks test results include z scores and p values testing for differences in the distribution of two questions related to perception of agricultural expansion. The null hypothesis is that both distributions (question 1 and question 2) are the same. Results indicate that there was a significant difference in how respondents from the public rated the two questions, whereas food system stakeholders' responses did not differ.

| | Population | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Public | | | | | | | Stakeholders | | | | | | |
| Question | Count | Mean | SD | Min | Max | z | p | Count | Mean | SD | Min | Max | z | p |
| (1) Should more food be grown in NH? | 493 | 0.771 | 0.492 | -1 | 1 | 4.535 | <0.001 | 102 | 0.912 | 0.318 | -1 | 1 | 0.883 | 0.3774 |
| (2) Should more land be available for farming in NH? | 490 | 0.669 | 0.573 | -1 | 1 | | | 103 | 0.893 | 0.340 | -1 | 1 | | |

**Table 2.5** Willingness to live next to farm questions, count, mean, standard deviation (SD), and minimum and maximum response values. Question response scale: +1=willing, 0=I don't know, -1=not willing. Both populations had similar trends in how they rated willingness to live next to farms.

| | Population | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Public | | | | | Stakeholders | | | | |
| Question | Count | Mean | SD | Min | Max | Count | Mean | SD | Min | Max |
| How willing are you to live next door to a… | | | | | | | | | | |
| *(1) Vegetable farm* | 491 | 0.939 | 0.320 | -1 | 1 | 102 | 0.971 | 0.221 | -1 | 1 |
| *(2) Dairy farm* | 489 | 0.348 | 0.869 | -1 | 1 | 102 | 0.539 | 0.753 | -1 | 1 |
| *(3) Livestock pasture* | 493 | 0.535 | 0.797 | -1 | 1 | 103 | 0.825 | 0.513 | -1 | 1 |
| *(4) Farm that spreads manure* | 491 | 0.200 | 0.911 | -1 | 1 | 103 | 0.505 | 0.791 | -1 | 1 |
| *(5) Farm that uses pesticides or other chemicals* | 491 | -0.603 | 0.705 | -1 | 1 | 103 | -0.388 | 0.854 | -1 | 1 |
| *(6) Farm that hosts functions such as weddings and/or educational workshops* | 492 | 0.291 | 0.856 | -1 | 1 | 103 | 0.515 | 0.765 | -1 | 1 |
| *(7) Farm that sells farm products (meat, dairy, vegetables, fruit, etc.) on site* | 493 | 0.809 | 0.526 | -1 | 1 | 102 | 0.912 | 0.375 | -1 | 1 |

**Table 2.6** Multivariate regression results including coefficient (coef.), standard error (SE), t score, and p value (only significant variables shown here). Asterisks indicate *significant at the <0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level.

| | | Statewide Population | | | |
|---|---|---|---|---|---|
| Variable | Predictor Variable | Coef. | SE | t | p |
| How willing are you to live next door to a… | | | | | |
| *(1) Vegetable farm* | Household income | -0.018 | 0.008 | -2.26 | 0.025* |
| *(2) Dairy farm* | Age | 0.066 | 0.033 | 2.01 | 0.045* |
| | Household income | -0.051 | 0.020 | -2.52 | 0.012* |
| *(3) Livestock pasture* | Resident location | -0.148 | 0.055 | -2.72 | 0.007** |
| | | -0.043 | 0.012 | -2.31 | 0.021* |
| *(4) Farm that spreads manure* | Town meeting attendance | 0.164 | 0.048 | 3.40 | 0.001** |
| | Household income | -0.059 | 0.021 | -2.77 | 0.006** |
| *(5) Farm that uses pesticides or other chemicals* | Gender | -0.205 | 0.070 | -2.93 | 0.004** |
| *(6) Farm that hosts functions such as weddings and/or educational workshops* | Town meeting attendance | 0.139 | 0.046 | 3.03 | 0.003** |
| | Household income | -0.047 | 0.020 | -2.31 | 0.022* |
| *(7) Farm that sells farm products (meat, dairy, vegetables, fruit, etc.) on site* | Resident location | -0.078 | 0.035 | -2.22 | 0.027* |
| | Household income | -0.042 | 0.012 | -3.50 | 0.001** |

**Figures**

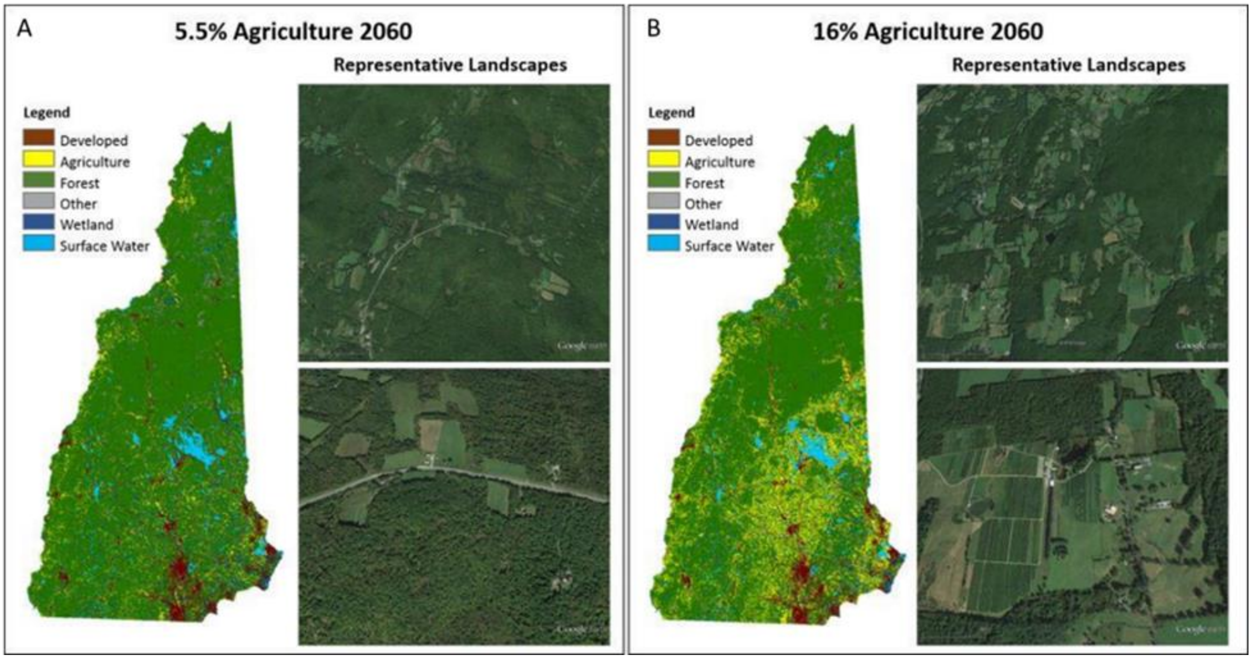


**Figure 2.1** Future land use scenarios developed by Thorn et al. (in review) depict land cover for six different land uses including: developed, agriculture, forest, other, wetland, and surface water. Both scenarios represent potential land cover shifts in the year 2060, with scenario A showing a small shift toward agriculture (2.5% increase) and a larger shift in scenario B (13% increase). Land cover maps were paired with two satellite images (Google Earth) that represent how agricultural land use might look in each scenario, but are not the same as depictions of 5.5% and 16% scenarios.

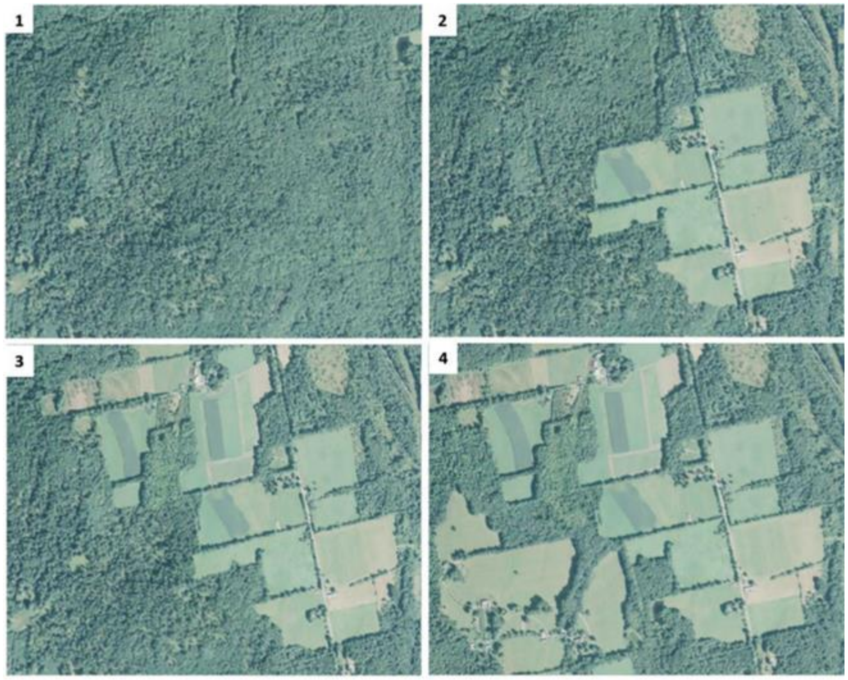


**Figure 2.2** This series of images represents agricultural expansion, specifically forestland conversion to agriculture. The first image represents 100% forest, image number two represents 75% forest and 25% agriculture, the third represents 65% forest and 35% agriculture, and the last image represents 40% forest and 60% agriculture. Images were sourced from USDA Farm Service Agency National Agriculture Imagery Program and were digitally altered by the authors.


**Figure 2.3** Four street-level images were developed to represent livestock pasture, hay production, row crop production, and forest re-growth on abandoned farmland. In each image, only key features were altered, maintaining fundamental elements such as the farm buildings and sky. Base image was purchased from iStock, with image features from a USDA Flickr account, and digitally edited by Karrah Kwasnik.

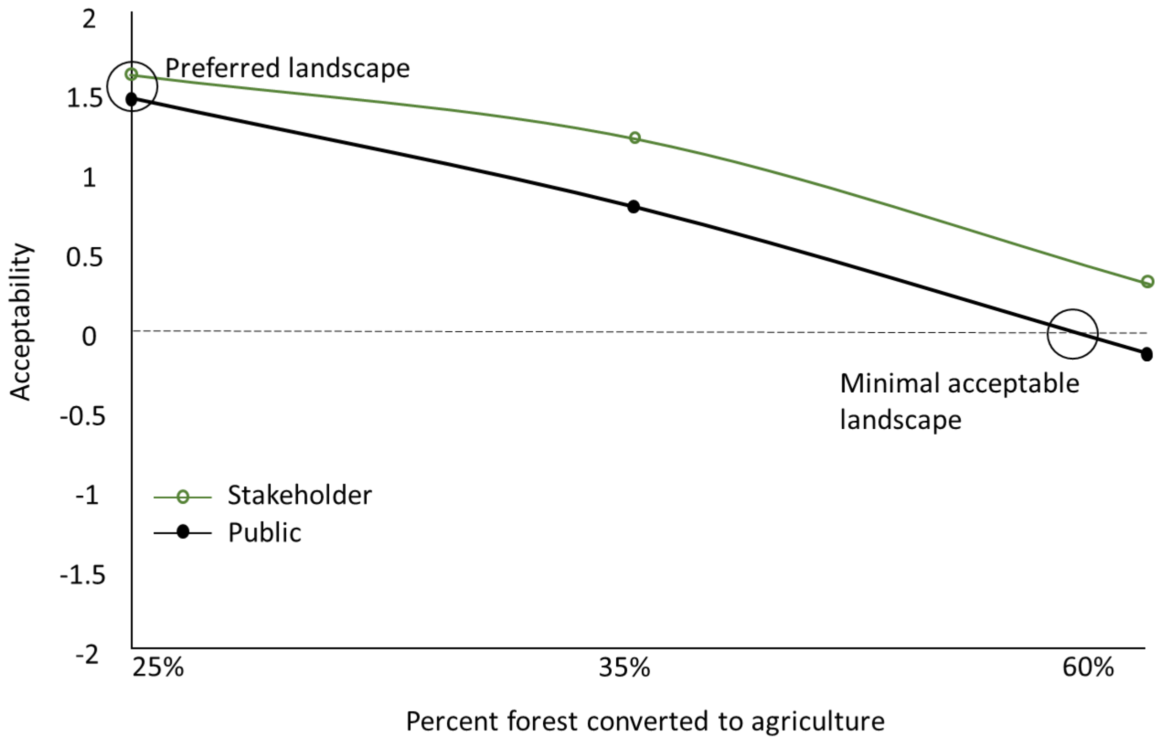


**Figure 2.4** Acceptability curves for the public and the stakeholder populations. Each curve shows the mean acceptability ratings for the three forestland-to-agriculture conversion images presented in Figure 2.2. While the average minimal acceptable condition for the state was reached, the average for the food system stakeholders did not cross the acceptability threshold (minimal acceptable condition = 0). For both populations, measure of agreement (Van der Ejik's A) was strongest for the scenario and images representing the least agricultural expansion and weakest for image 4.

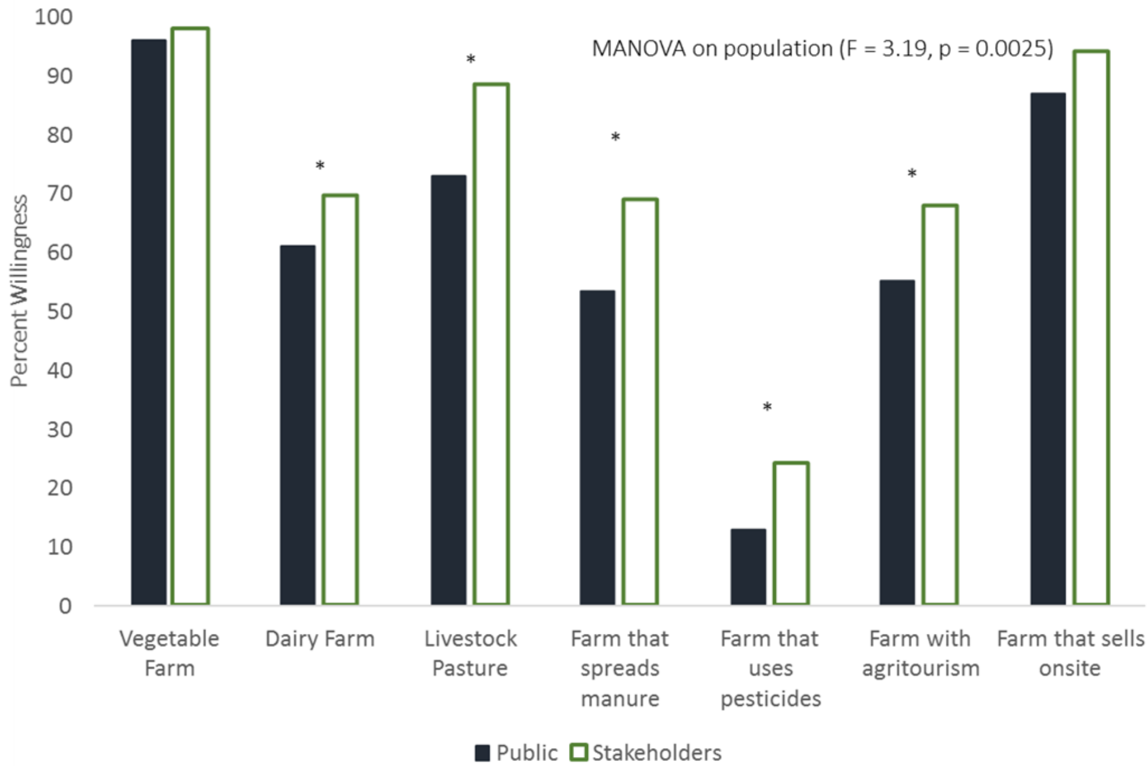


**Figure 2.5** Percent of respondents in public sample population and stakeholders focus group who responded 'yes' to "how willing would you be to live next door to a…" (1) vegetable farm, (2) dairy farm, (3) livestock pasture, (4) farm that spreads manure, (5) farm that uses pesticides or other chemicals, (6) farm that hosts functions such as weddings and/or educational workshops, and (7) farm that sells farm products (e.g., meat, diary, vegetables, fruit, etc.) on site. MANOVA results show a significant difference between how each population rated willingness" (F = 3.19, p = 0.0025).

## Supplemental Materials

**Table S.2.1** Demographic data including question, scale, count, mean, standard deviation (SD), and minimum/maximum of response scale.

| | | Population | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Public | | | | | Stakeholders | | | | |
| Question | Scale | Count | Mean | SD | Min | Max | Count | Mean | SD | Min | Max |
| Have you ever attended a town meeting in your town? | 1 = Yes<br>0 = No | 491 | 0.251 | 0.969 | -1 | 1 | 103 | 0.515 | 0.862 | -1 | 1 |
| Do you consider your place of residents to be in a rural, sub-urban, or urban environment? | 1 = rural environment<br>2 = Suburban environment<br>3 = Urban environment | 492 | 1.596 | 0.691 | 1 | 3 | 102 | 1.48 | 0.700 | 1 | 3 |
| How many years have you lived in NH? | 1 = < 5 years<br>2 = 5-10 years<br>3 = >10 years | 492 | 2.671 | 0.688 | 1 | 3 | 103 | 2.767 | 0.581 | 1 | 3 |
| How many people live in your household? | 1 = 1<br>2 = 2<br>3 = 3<br>4 = 4<br>5 = 5<br>6 = 6 or more | 491 | 2.456 | 1.159 | 1 | 6 | 103 | 2.544 | 1.161 | 1 | 5 |
| What is your gender? | 1 = Female<br>0 = Male | 490 | 0.527 | 0.500 | 0 | 1 | 102 | 0.686 | 0.466 | 0 | 1 |
| What is your age? | 1 = 18-24 years<br>2 = 25-34 years<br>3 = 35-44 years<br>4 = 45-54 years<br>5 = 55-64 years<br>6 = 65-74 years<br>7 = 75 years or older | 491 | 4.536 | 1.443 | 1 | 7 | 102 | 4.049 | 1.417 | 1 | 7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| What is the highest grade in school, or level of education that you've completed and gotten credit for? | 1 = High school or less<br>2 = Some college/technical school<br>3 = Bachelor's degree<br>4 = postgraduate work | 492 | 3.047 | 0.949 | 1 | 4 | 103 | 3.544 | 0.668 | 1 | 4 |
| What is your current annual household income? | 2 = < $25K<br>3 = 25-49,999<br>4 = 50-74,999<br>5 = 75-99,999<br>6 = 100-124,999<br>7 = 125-149,999<br>8 = 150-174,999<br>9 = 175-199,999<br>10 = >200K | 462 | 5.271 | 2.240 | 2 | 10 | 96 | 4.906 | 1.979 | 2 | 10 |

## Resident and stakeholder perceptions of ecosystem services associated with agricultural landscapes in New Hampshire

**Abstract**

Land use change associated with agriculture can result in tradeoffs in ecosystem services, such as increases in provisioning services that come at the expense of land use types that provide supporting, regulating, and cultural services. An improved understanding of how stakeholders value different land use types regarding their perceived ecosystem services, as well as the relative visual appeal of different agricultural landscape features, could assist policymakers and land use planners in decision-making related to agricultural land use in New England. We sought to survey two populations in New Hampshire, self-identified food system stakeholders (e.g., farmers, public health professionals, and technical assistance providers) and a sample from the general population, to explore how perception of the visual appeal of specific farmland use types and importance of ecosystem services specifically related to agricultural land, might differ between populations. Specifically our objectives were to explore how New Hampshire residents perceive the importance of various ecosystem services, evaluate how residents perceive the ecosystem services provided by specific agricultural landscapes and determine how those perceptions relate to the visual appeal of each landscape, and identify socio-economic factors that account for the differences between each population in terms of their landscape perception and preference. Roughly 600 residents completed the survey, including 494 individuals from the statewide sample population, and 103 food system stakeholders. From a list of seven ecosystem services, clean water was ranked as the most important across both populations, with no significant difference between populations (mean = 6.04), while food production was ranked significantly higher by the food system stakeholders (mean = 5.12 and 4.34, respectively, $p \leq$

0.001). Likewise, on a scale of most (4) to least (1) appealing, food system stakeholders ranked photorealistic visualizations of cropland higher than the statewide population (mean = 2.98 and 2.55, respectively, $p \leq 0.001$). Additionally, food system stakeholders ranked the appeal of forestland lower than the statewide population (mean = 2.20 and 2.59, respectively, $p = 0.007$). Our findings suggest that there are differences in landscape preferences and perception of ecosystem service benefits between the general population and those who consider themselves food system stakeholders. Future research is needed to determine how these differences in perception might affect land use planning and policymaking related to agricultural expansion and forestland preservation.

***Key Words***

Photorealistic visualization, agricultural expansion, public attitudes, stakeholder participation, land use change, survey

## Introduction

Interest in land use change has increased in recent years, particularly in New England, where a growing population and changing demographics are contributing to population shifts from rural to suburban and urban, and to the permanent loss of farm and forestland to development (Jeon et al., 2013; US Census Bureau, 2010-15). At the same time, New England is leading national trends for local food demand and production (USDA, 2012[b]; USDA, 2014). Regionally, the number of farms, hectares of farmland in production, and number of farmers has increased, while all have decreased nationally (USDA, 2012[c]). Together, these factors have the potential to drive land use change across the landscape and therefore the ecosystem services—the benefits that humans realize from natural systems—that these landscapes provide.

Compared nationally, New England's agricultural footprint is quite small, with over 600,000 hectares (1.55 million acres) of farmland in the region, roughly half of which is forested (USDA, 2012[c]). Additionally, challenges specific to the region including the short growing season, limited technical assistance in some areas, and the lack of infrastructure for small-scale agriculture (e.g., processing and storage facilities, and distribution channels) make maintaining a viable farm business difficult. Despite these challenges and the region's relatively small agricultural footprint, the agricultural economy in New England is substantial in several sectors (e.g., dairy in Vermont, potatoes in Maine, and horticulture in New Hampshire) (USDA, 2012[b]). There is also a growing interest in local food production, both from producers as well as consumers.

Sustained droughts in top agricultural producing states (e.g., California) due to climate change (Medellin-Azuara et al., 2015; Hanemann et al., 2016), and increasing consumer desire to know the origins of their food (Adams and Salois, 2010) are just a few of the factors influencing the desire to increase regional agricultural self-sufficiency and local food production in New England. Local food systems advocates including Food Solutions New England (FSNE) have also spurred dialog among consumers, food systems professionals, and researchers alike, with their publication of A New England Food Vision, which puts forth three scenarios for increased food production and consumption in the region (Donahue et al., 2014). While the document is not a prescribed plan for how to increase production and consumption, it details several possible strategic scenarios and has amplified attention to local food production (Grogan et al., in revision).

However, increasing agricultural production and the agricultural land base in New England would require the conversion of some forestland, particularly in New Hampshire, the second most forested state in the nation (HDRED, 2010). The existing >80% forestland in the state provides a variety of ecosystem services. According to the Millennium Ecosystem Assessment, ecosystem services include four categories: supporting (e.g., nutrient cycling and soil organic matter formation), provisioning (e.g., food, fiber, and fuel production), regulating (e.g., water purification and carbon storage), and cultural services (e.g., space for recreation and research). Ecosystems associated with both rural and urban environments provide (or have the capacity to provide) each of these services to varying degrees depending on the quality and quantity of the different types of land cover and land use present across the landscape.

The expansion of agriculture in New Hampshire would likely involve tradeoffs between food production and other ecosystem services; the type and extent of ecosystem services tradeoffs will partly depend upon where on the landscape the expansion occurs (Power, 2010; Hale et al., 2014). Tradeoffs in ecosystem services will also depend on the degree to which New Hampshire's residents support the expansion of local agriculture, as changes in the landscape, and thus ecosystem services, become more apparent. It has become more common for stakeholders to be involved in land management decision-making (Cowling et al., 2008), with an increasing number of land use assessments including stakeholder perceptions of ecosystem services (Seppelt et al., 2011). And yet, how different stakeholder groups perceive ecosystem services can be influenced by social factors, including livelihood, which can in turn affect land management decisions (McNally et al., 2016; Cebrian-Piqueras et al., 2017). At the same time, stakeholder perceptions of the visual appeal of a landscape can also influence land use policy and management (Dockerty et al., 2006). Consequently, differences in land use preferences between stakeholder groups can create conflicts for land use planners and policymakers (Adams et al., 2003; McShane et al., 2011; Vira et al., 2012). Hence, an improved understanding of how stakeholders value different land use types regarding their perceived ecosystem services, as well as the relative visual appeal of different agricultural landscape features, could assist policymakers and land use planners in decision making related to agricultural land use in New England.

In this study, we designed a statewide mixed methods survey including cognitive and visual methodologies to better understand how two groups of New Hampshire residents, a sample from the general population (hereafter *public*) and a group of food system stakeholders (hereafter *stakeholders*) perceive agricultural expansion on the landscape. We investigated perception of ecosystem services and landscape preferences specifically related to agricultural land use. Our three main objectives were to: 1) explore how the public and stakeholders perceive the importance of various ecosystem services; 2) evaluate how both populations perceive the ecosystem services provided by specific agricultural landscapes and determine how those perceptions relate to the visual appeal of each landscape; and 3) identify socio-economic factors that account for the differences between each population in terms of their landscape perception and preference.

## Methods

### *Study area*

Our survey was distributed to New Hampshire residents throughout the state between June 6-29, 2016. New Hampshire is located in the Northeastern United States and covers about 2,322,895 hectares (5.74 million acres). Roughly 1.3 million residents live in the state (U.S. Census Bureau, 2014), most whom are white (93.9% compared to 77% nationally), well-educated (34.4% of residents have a bachelor's degree or higher compared to 29.3% nationally), and wealthy (average income is $65,986 compared to $53,482 nationally). Although geographically small, New Hampshire is largely rural, with a growing suburban population (57 people/km2, compared to 34 nationally) (US Census Bureau, 2015).

Over the last several decades, New Hampshire has been the fastest growing state in the Northeast, with population increasing by 2% between 1990—2014 (US Census Bureau, 2015). As a rural state, this rapid increase in population has contributed to a shift from undeveloped to developed landscapes, which has led to the permanent loss of farm and forestland (Jeon et al., 2013). At the same time, land under agricultural production has also seen modest increases (USDA, 2012[c]). Additionally, most land in the state is forested, including more than half of the land classified by the US Census of Agriculture as farmland (64% of the 191,847 hectares (474,065 acres) of farmland) (USDA, 2012[c]). Often, land that is most suitable for farming (e.g., flat, open land near sources of fresh water) is also most attractive for development, which can create conflicts for land use.

***Survey development***

Using the Tailored-Design Method (Dillman, 2014), we developed an online mixed methods survey including cognitive and visual preference methodologies. Visual preference surveys are frequently administered as a means of measuring environmental preference related to a variety of landscapes or issues (Kaplan, 1985). While visual preference methods are often applied within the land use planning sector to obtain public feedback on various landscape features (Manning and Freimund, 2004; Zabik and Prytherch, 2013), the use of this particular methodology to evaluate preference for agricultural land use change is a novel approach.

Survey participants were presented a sequence of images depicting four different farmland operations (Figure 3.1). We also included several written questions as additional exploratory factors of landscape preferences, including a suite of socio-economic questions (see supplemental materials). We combined survey responses from both the visual preference questions as well as the traditional written questions to expand our understanding of the nuances that influence landscape preferences, allowing for more informative results.

To assess resident preference for, and their perception of the ecosystem services associated with different types of farms we developed street-level images of four different agricultural landscapes. To develop these photorealistic visualizations, we purchased images from iStockPhoto LP (2016) and digitally altered various elements in Adobe Photoshop CC 2015.5. Using methods similar to those presented in Tress and Tress (2002), we created the visualizations by adding layers to one base image of a farming landscape, altering color, light, and shading, and adding/removing landscape elements. The resulting landscapes included the following: (1) forest regrowth on abandoned farmland, (2) hay fields, (3) livestock pasture, and (4) row crop production (Figure 3.1). In each of the four images, we maintained common elements (the farm buildings and skyline) and only changed the foreground production area and tree line. Using this method, we minimized variation from image to image, and reduced uncertainty in respondent preference for specific farmland uses (van Zanten et al., 2016). We asked respondents to rank the visual appeal of each image on a scale from most visually appealing to least visually appealing. We also asked respondents to rank how they perceived the environmental benefits (i.e., ecosystem services) of each landscape from having the most environmental benefits to the least environmental benefits.

While the rank method has a linear dependency among the set of ranked items, the rating method can lead to non-differentiation among responses (Alwin and Krosnick, 1988). Previous research found that the ranking method has a higher test-retest reliability and discriminate validity (Krosnick, 2000; Reynolds & Jolly, 1980), while Moors et al. (2016) found that rankings and ratings do produce results that are quite similar. We chose the rank method to avoid issues with non-differentiation, and to increase confidence in respondents' landscape preferences and perceptions. As Bradburn et al. (2014) address, the way and order in which questions are asked can influence participant response. Thus, each visualization question was randomized so that responses were presented to survey participants in a random order. Randomizing survey responses for rank questions helps to ensure that respondents are not influenced by the order in which the choices are presented (Stern et al., 2007).

In addition to the four farm landscapes, the survey also included two other visualization questions, which are described in detail in chapter 2. In that study, we included: 1) two land use change scenarios, to best show how agriculture could potentially change over time from the year 2020 to the year 2060 (Thorn et al., 2017); and 2) aerial images representing forestland conversion to agriculture. Both visual preference questions were aimed at exploring the acceptability of agricultural expansion according to survey respondents.

***Sampling methodology***

Online surveys are often a more financially accessible research methodology for researchers compared to mailing hardcopies via conventional mail (Dillmlan, 2014). However, some researchers suggest that online only surveys can introduce bias by limiting surveyed populations to those with home internet access (Sax et al., 2003). Given that 79.5% of New Hampshire residents have home internet access (compared to the national average 69.1%), and 83.5% have internet access outside the home, an electronic survey with the option to request a paper copy was an appropriate methodology given the location of this study.

To administer the survey, we employed Qualtrics Survey Research Suite (Qualtrics, Provo, UT), a user-friendly online software. To reduce response bias in our final sample population from the public, we contacted residents via conventional mail and gave them the option to request a paper version of the survey (Dillman, 2014). To reach a target of 500 completed surveys, participants were recruited via postcard mailings sent to a random population of 12,000 New Hampshire residents across the Granite State. Given the additional requirement of moving from the postcard to an electronic device with internet access to complete the survey (or making a phone call to request a paper copy), experts at the UNH Survey Center estimated a decreased response rate compared to paper mail-out surveys (5% compared to 15-20%). We sent two waves of mailings to the same 12,000 residents: the first was a simple notification to residents about the survey, the second was a reminder postcard. As suggested by Dillman et al. (2014), to incentivize participation and increase response rates, we offered the option to all participants who completed the survey to enter a drawing to win one of six, $50 gift cards.

In addition to the statewide sample population, we also included a second population of New Hampshire residents, those who self-identified as food system stakeholders. This group is potentially more likely to be engaged in local and regional policy and land use planning and decision-making related to agriculture and therefore we were interested in how their perceptions and preferences might differ from those of the public (general population). As a focus group, food systems stakeholder participants were recruited through the New Hampshire Food Alliance network. To target this population (for 100 completed surveys), we sent an email to stakeholders identified as Food Alliance partners, encouraging them to complete the survey as well as invite their food system constituents to participate. For this focus group, we included an additional survey question to ensure that respondents were food system professionals; "Which food system sector best describes where you work in your professional or civic work (check all that apply)."

One survey from the stakeholder population did not have a response to this question and therefore was discarded and excluded from all analyses.

### *Statistical analysis*

All survey questions and scales used in this study are presented in the supplemental materials. To analyze survey results, we used Stata statistical software (StataCorp, 2015). We calculated the means and standard deviations for each question. To test for differences in how each population ranked the seven ecosystem services questions, we used ordered logistic regression. We also conducted pairwise correlation comparisons on each ecosystem service question to compare results with each regression. We used this same methodology to examine various socio-economic factors as explanatory variables for each ecosystem service question. Socio-economic variables included: (1) attendance at town meeting, (2) resident location (rural, sub-urban, and/or urban), (3) number of years lived in New Hampshire, (4) household size, (5) gender, (6) age, (7) highest level of education, and (8) current annual household income.

To assess respondents' perception of visual appeal and ecosystem services of different types of farms, we followed the same steps as described above for calculating mean, standard deviation, pairwise comparisons, and ordered logistic regressions on each of the eight variables for appeal and perception of ES of the four farm landscapes. This allowed us to check between population differences, and finally to analyze how the socio-economic factors may relate to each landscape image. Lastly, we performed Wilcoxon matched-pairs signed-ranks tests to examine the relationship between each landscape pair (i.e., appeal and perceived ES of each of the four farm landscapes).

**Results**

The statewide population had a response rate of 4.44%, with 515 online and 8 paper surveys completed. After removing partially completed surveys from the 523 returned, 494 were sufficient for analysis. We did not calculate response rate for the food system stakeholder group for several reasons. First, the total population of food system stakeholders in the state is unknown. Second, the mode of recruiting (targeting NH Food Alliance network partners) did not allow us to track the total number of members invited to participate. Lastly, as a focus group (i.e., population of convenience intended to represent special interests), this population serves to highlight differences between stakeholders and the public.

There were two notable differences between our sample populations and the general New Hampshire population. Both the statewide and food system stakeholder samples were skewed toward an older, well-educated population. The statewide sample was adequately represented both geographically and by gender, while the food system stakeholder group had uneven representation by county (e.g., some counties were representative, others not), and higher female representation (68% compared to New Hampshire's population of 49.4%). Table 1 includes population statistics for New Hampshire and both survey populations.

Despite the population differences, we did not calculate probability weights for any analyses. As the food system stakeholder population is a focus group, it is not intended to be representative of New Hampshire's population, and therefore it is unnecessary to use weighting (Solon et al., 2013). The difference between the statewide sample and New Hampshire's population, particularly the education variable was substantial. To determine whether weighting was appropriate for our data set, we ran regressions on both data weighted by education, as well as un-weighted data. We found that the spread in confidence intervals was higher in the weighted data set (Appendix C), and therefore could increase uncertainty. Solon et al. (2015) found, in some instances, weighting can reduce the efficiency of estimates. We believe that the difference in confidence intervals, when weighted for education, suggests that uncertainty would increase, and weighted estimates might not accurately represent New Hampshire residents' perceptions. The results from this study should therefore, be considered within the context of our survey population.

***Importance of Ecosystem Services***

Ecosystem services questions, scale, means, and ordered logistic regression results are described in Table 3.2. Our evaluation of how respondents perceive ecosystem services on the landscape showed that, across both populations, clean water was consistently ranked as the most important ecosystem service from a list of seven different ecosystem services, including provisioning, regulating, supporting, and cultural services. All three cultural services (i.e., scenic beauty, rural character, and space for public recreation), ranked below the regulating, supporting, and provisioning services. Food production, wildlife habitat, carbon storage, and scenic beauty each differed significantly between the two sample populations.

Demographic variables influencing each ecosystem service within both populations are outlined in Table 3.3, including ordered logistic regression results. Across both populations, education was negatively correlated with food production, and age was negatively correlated with space for public recreation. For the statewide population, household income was positively correlated with space for public recreation and scenic beauty, and negatively correlated with clean water. Resident location also explained the most variation for rural character; respondents living in rural areas ranked rural character higher than those living in sub-urban and urban locations. No other predictor variables were found to be significant for the stakeholder population.

### *Visual Appeal and Ecosystem Services of Farm Landscapes*

Evaluating both the highest and lowest ranking for each visualization helps us to understand responses (i.e., distribution and relationship between variables) better than means alone. As research by Heyman and Sailors (2016) shows, partial ranking can be an effective method for obtaining aggregate order of preferences. Figure 3.2 shows the percentage of top and bottom ranks for each of the landscape visualizations (visual appeal and perceived ecosystem services). Also, evaluating the middle rankings by calculating means, gives us a better understanding of the overall appeal and perceived ecosystem services of each landscape, which shows the subtle differences between pairs of variables as well as across populations (Table 3.4). Food system stakeholders ranked the visual appeal of the crop landscape higher than did the statewide population ($z = 3.63$, $p \leq 0.001$), and the statewide population ranked the visual appeal of forest higher than did the food system stakeholder group ($z = -2.72$, $p = 0.007$).

A Wilcoxon matched-pairs signed-rank test was conducted to determine whether there was a difference in the ranking of the visual appeal and perceived ecosystem services of each farm landscape by the statewide sample population (Table 3.5). Results from that analysis indicated that there was a significant difference in how respondents ranked the visual appeal of livestock pasture from the way they ranked the perceived ecosystem services of livestock pasture, ranking the visual appeal higher than the perceived ecosystem services ($z = 11.63$, $p < .001$). For the forested landscape image, respondents ranked the appeal lower than the perceived ecosystem services ($z = -10.79$, $p \leq 0.001$). No significant difference was found between the distributions of appeal and perceived ecosystem services of hay field and row crop landscapes.

Similar to the statewide population, results from the food system stakeholder population showed that there was a significant difference in how respondents ranked the visual appeal of livestock pasture and forest from the way they ranked the perceived ecosystem services of livestock pasture and forest ($z = 6.214$, $p < .001$; and $z = -6.848$, $p \leq 0.001$ for livestock and forest, respectively). However, results for the food system stakeholders also indicated that there were significant differences between appeal of hay field and crops, and the perceived ecosystem services of hay field and crops ($z = -2.528$, $p < .012$; and $z = 3.411$, $p \leq 0.001$ for hay field and crops respectively).

Lastly, we analyzed the socio-economic explanatory factors across both populations with each of the four farm landscapes. The explanatory factors most related to the ranking of the perceived ecosystem service value of each landscape varied by landscape image and were different between the populations. Results from ordered logistic regressions, showing the significant predictor variables for each landscape within both populations, are summarized in Table 3.6.

**Discussion**

In this study, we assessed the agricultural landscape preferences and perceived importance of ecosystem services for New Hampshire residents from two populations, the general public and a food system stakeholder focus group. Additionally, we investigated the relationships between each population and the socio-economic factors that might influence their perception of ecosystem services provided by different agricultural land uses and their preference for different types of agricultural landscapes. This mixed-methods study incorporated photo-realistic visualizations as well as written questions, and was not specific to one location but generalized to agriculture across the state of New Hampshire. The results should be considered within the context of the two sample populations. Our results confirm findings of previous landscape studies and are discussed below.

### *Study limitations*

Despite higher than average access to the internet, and the use of conventional mail invitations, the additional step of getting to an electronic device with internet access could have deterred some residents from participating in the survey. Additionally, postcard recipients could have requested a paper copy, however, only 12 recipients did so, and of those only 8 were returned. While the total response rate was adequate to represent New Hampshire residents, the sample was skewed toward the well-educated, missing a large demographic of the state's population and potentially missing an alternative perspective. Also, while we strategically chose to limit the number of landscape elements that changed across the four images to reduce uncertainty in the factors influencing responses, the photorealistic visualizations are "polished" versions of working farms. They accurately reflect agricultural landscapes in New Hampshire, but the visualizations do not depict the active use of farms, including the people and equipment needed to operate a farm business, which may seem "less attractive" to some residents. Lastly, though our study helps to shed light on resident perception of agricultural expansion, it does not address why respondents found one illustration more visually appealing than another. Future research exploring this question through follow up surveys, interviews, and/or focus groups would further aid land use planners and policymakers working to balance agricultural expansion with conservation of ecosystem services.

### *Landscape preferences and perceptions*

We found that respondents ranked provisioning, supporting, and regulating services well above cultural services, which was consistent across both populations. This is a finding supported by previous research, which shows that professionals from various backgrounds (e.g., soil science, forestry, agriculture) ranked the importance of physiological needs above cultural needs (Haida et al., 2016). The regulating service of clean water was overwhelmingly chosen as the top ranked ecosystem service across both populations. Though respondents were ranking a list of ecosystem services not associated with visualizations, previous research has shown that water as a landscape feature identified in landscape visual preference studies is positively correlated with preference scores (Kaltenborn and Bjerke, 2002; Dramstad et al., 2006). In addition, the majority of respondents ranked the forest image as having the most ecosystem service potential, which can be directly related to the supporting service of providing clean water (Barnes et al., 2009).

To empirically rank the four images based on ecosystem service potential would require an ecosystem assessment, which was beyond the scope of this study. Furthermore, land management plays a large role in the ecosystem services or dis-services of a particular landscape (Carpenter et al., 2009; Koschke et al., 2013). Given the diversity in management practices of cropland, hay fields, livestock pasture, and forested areas in New Hampshire, our aim was to present generic visualizations of these different landscapes and not represent any one type of management practice. Although knowledge-based questions can be useful in better understanding stakeholder perspective regarding ecosystem services (Cebrian-Piqueras et al., 2017), without a definitive means of ranking the actual biophysical services of each landscape type, there is no basis for accurately measuring respondent knowledge. Therefore, our focus was strictly on the relationship between visual appeal and perceived ecosystem services of these landscapes.

Findings from a study evaluating how ecosystem services are valued by different stakeholder groups showed that each group prioritized the services most closely related to their livelihood (McNally et al., 2016). Our findings suggest similar bias, as the food system stakeholders ranked the importance of food provisioning significantly higher than the public. Additionally, while the perception of ecosystem services responses was not significantly different between both populations, the stakeholders ranked the visual appeal of cropland higher than forestland, while the public rated the visual appeal of forestland higher than cropland. Given their focus on the local food system, it is not surprising that this stakeholder group would find land use that supports their work more visually appealing. The differences between the two surveyed populations indicate potential conflicts for land use.

Understanding landscape perceptions of the public compared to food system stakeholders is critical to planning, development, and policy that encourages increasing agricultural land use in the state. In a related study, we found that New Hampshire residents are generally accepting of agricultural expansion on the landscape, but are less willing to live next to different types of farms than food system stakeholders (Chapter 2). Even with a sample from the statewide population that is overwhelmingly supportive of agricultural expansion, food system stakeholders still showed a greater interest in food production (as seen in their rating of the visual appeal of cropland). Recognizing these differences, particularly the statewide population's preference for forested landscapes, can help stakeholders target outreach and education efforts aimed at alleviating potential land-use conflicts.

As the long-term sustainability of agricultural operations depends both on individual farm management practices, as well as on market forces, resident (i.e., consumer) support for local agriculture plays an important role in farm viability (Erickson et al., 2011). Understanding how New Hampshire residents perceive various types of agricultural land and the ecological importance of those lands will be important to stakeholders and other local food advocates who are working to support agricultural expansion in the state (de Groot et al., 2010).

### *Conclusions & suggestions for future research*

This study compares the perceived importance of ecosystem services and agricultural landscape preferences for New Hampshire residents from two populations, the public and a food system stakeholder focus group. We found that both populations ranked provisioning, supporting, and regulating services (e.g., clean water and food production) above cultural services (e.g., space for recreation and rural character). While there was no difference in how each population ranked the perceived value of ecosystem services of each landscape, there was a clear difference in how they ranked the visual appeal of cropland and forested landscapes; the food system stakeholders preferred the cropland illustration, while the public preferred the forested landscape. This is important because forests are the dominate landscape in New Hampshire, and most of that land is privately owned. Expanding agriculture into forested areas would require buy-in from residents, and would produce socio-ecological tradeoffs. Future research quantitatively assessing the biophysical factors affecting ecosystem services would allow land use planners and local food system advocates to make more informed decisions about the type and location of future agricultural production.

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**Tables**

**Table 3.1** Socio-economic data of both survey populations (statewide sample from the general public and a focus group of food system stakeholders), as well as New Hampshire state population (for comparison). *Data source: US Census Bureau Population estimates, July 1, 2015, (V2015). Age estimated from categories 20-24 (missing 18 and 19-year-olds and therefore could be conservative)

| Variables | *% of state population | % of public | % of stakeholders |
|---|---|---|---|
| County | | | |
| *Belknap* | 4.56 | 4.86 | 9.71 |
| *Carroll* | 3.55 | 3.24 | 5.83 |
| *Cheshire* | 5.70 | 6.48 | 9.71 |
| *Coos* | 2.35 | 3.44 | 4.85 |
| *Grafton* | 6.71 | 6.88 | 18.45 |
| *Hillsborough* | 30.56 | 28.54 | 13.59 |
| *Merrimack* | 11.12 | 11.94 | 22.33 |
| *Rockingham* | 22.68 | 23.08 | 7.77 |
| *Strafford* | 9.53 | 8.91 | 6.80 |
| *Sullivan* | 3.23 | 2.63 | 0.97 |
| Education | | | |
| *High School or Less* | 37.1 | 6.50 | 1.94 |
| *Some College* | 28.6 | 23.17 | 3.88 |
| *Bachelor's Degree* | 34.4 | 29.47 | 32.04 |
| *Postgraduate work* | N/A | 40.85 | 62.14 |
| Age | | | |
| *18-44* | 31.00 | 23.22 | 36.27 |
| *45-74* | 38.00 | 70.67 | 59.80 |
| *75+* | 6.00 | 6.11 | 3.92 |
| Gender | | | |
| *Male* | 50.6 | 47.25 | 32.04 |
| *Female* | 49.4 | 52.65 | 67.96 |
| *Trans/Non-Binary* | N/A | 0.20 | 0.97 |

**Table 3.2** Ecosystem Service, mean, and standard deviation. Results from ordered logistic regression testing for between group differences include the odds ratio (OR), standard error (SE), *z* score, and *p* value. Both correlation matrices and linear regressions showed similar *p* values. Respondents were asked to "rank how important the following environmental benefits are to you, from most (7) to least (1) important." Asterisks indicate *significant at the <0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level.

| Ecosystem Service | Population | | OR | SE | z | p |
|---|---|---|---|---|---|---|
| | Statewide | Food System Stakeholders | | | | |
| Clean water | 6.07 (1.35) | 5.88 (1.47) | 0.77 | 0.158 | -1.26 | 0.207 |
| Food production | 4.34 (1.66) | 5.12 (1.42) | 2.23 | 0.445 | 4.26 | <0.001*** |
| Carbon storage | 3.47 (1.97) | 3.95 (1.97) | 1.53 | 0.294 | 2.21 | 0.027* |
| Wildlife habitat | 4.85 (1.54) | 4.50 (1.56) | 0.66 | 0.128 | -2.12 | 0.034* |
| Space for public recreation | 2.88 (1.63) | 2.60 (1.57) | 0.73 | 0.143 | -1.61 | 0.107 |
| Scenic beauty | 3.41 (1.72) | 2.87 (1.73) | 0.54 | 0.107 | -3.13 | 0.002** |
| Rural character | 3.00 (1.88) | 3.08 (1.78) | 1.15 | 0.219 | 0.73 | 0.464 |

**Table 3.3** Results from ordered logistic regressions analyze a suite of socio-economic factors and include the regression coefficient (coef.), standard error (SE), *z* score, *p* value, and 95% confidence intervals (CI). Only significant factors from correlation comparison were run in regressions (only significant factors from final regression output shown here). Asterisks indicate *significant at the <0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level.

| | | Statewide | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem Service | Predictor Variables | Coef. | SE | z | p | 95% CI | |
| Clean Water | Household income | -0.129 | 0.046 | -2.790 | 0.005** | 0.219 | 0.038 |
| Food Production | Education | -0.197 | 0.097 | -2.030 | 0.042* | 0.388 | 0.007 |
| Carbon storage | NS | - | - | - | - | - | - |
| Wildlife habitat | Age | -0.185 | 0.072 | -2.580 | 0.010* | 0.325 | 0.045 |
| Space for public recreation | Age | -0.246 | 0.070 | -3.520 | 0.000*** | 0.383 | 0.109 |
| | Household income | 0.089 | 0.043 | 2.100 | 0.036* | 0.006 | 0.173 |
| Scenic beauty | Household income | 0.124 | 0.045 | 2.760 | 0.006** | 0.036 | 0.211 |
| Rural character | Age | 0.145 | 0.070 | 2.050 | 0.040* | 0.007 | 0.283 |
| | Resident location | -0.354 | 0.128 | -2.760 | 0.006** | 0.605 | 0.102 |
| | Town Meeting | 0.399 | 0.196 | 2.030 | 0.042* | 0.014 | 0.783 |

| | | Food System Stakeholders | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem Service | Predictor Variables | Coef. | SE | z | p | 95% CI | |
| Clean Water | NS | - | - | - | - | - | - |
| Food Production | Education | -0.810 | 0.328 | -2.470 | 0.014* | 1.453 | 0.167 |
| Carbon storage | NS | - | - | - | - | - | - |
| Wildlife habitat | NS | - | - | - | - | - | - |
| Space for public recreation | Age | -0.326 | 0.163 | -2.000 | 0.045* | 0.645 | 0.007 |
| Scenic beauty | NS | - | - | - | - | - | - |
| Rural character | NS | - | - | - | - | - | - |

**Table 3.4** Pairs of means and standard deviations in parenthesis for each photorealistic visualization. Results from ordered logistic regression testing for between group differences include the odds ratio (OR), standard error (SE), *z* score, and *p* value. Both correlation matrices and linear regressions showed similar *p* values. Respondents were asked to "rank from most visually appealing/ecosystem services to least visually appealing/ecosystem services on a scale from most (4) to least (1)." Asterisks indicate *significant at the <0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level.

| Variable | Population | | OR | SE | z | p |
|---|---|---|---|---|---|---|
| | Statewide | Food System Stakeholders | | | | |
| Appeal of Livestock | 2.54 (1.09) | 2.66 (0.97) | 1.203 | 0.231 | 0.96 | 0.337 |
| ES of Livestock | 1.76 (0.99) | 1.76 (0.98) | 1.022 | 0.223 | 0.10 | 0.919 |
| Appeal of Hayfield | 2.32 (0.98) | 2.16 (0.96) | 0.729 | 0.145 | -1.59 | 0.113 |
| ES of Hayfield | 2.31 (0.85) | 2.40 (0.77) | 1.173 | 0.243 | 0.77 | 0.441 |
| Appeal of Crops | 2.55 (1.09) | 2.98 (1.06) | 2.098 | 0.428 | 3.63 | <0.001*** |
| ES of Crops | 2.58 (0.95) | 2.52 (1.03) | 0.895 | 0.188 | -0.53 | 0.597 |
| Appeal of Forest | 2.59 (1.28) | 2.20 (1.26) | 0.576 | 0.117 | -2.72 | 0.007** |
| ES of Forest | 3.35 (1.05) | 3.32 (1.10) | 1.004 | 0.239 | 0.02 | 0.985 |

**Table 3.5** Wilcoxon matched-pairs signed-ranks test results include *z* scores and *p* values testing for differences in the distribution for how landscape visualizations (Figure 1) were ranked. The null hypothesis is that both distributions (the perceived appeal of a landscape and the perceived ES importance of the same landscape) are the same. Asterisks indicate *significant at the <0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level.

| Variables | Population | |
|---|---|---|
| | Public | Stakeholders |
| Appeal of Livestock & ES of Livestock | z = 11.629, p < 0.001*** | z = 6.214, p < 0.001*** |
| Appeal of Hayfield & ES of Hayfield | z= -0.0187, p = 0.852 | z = -2.528, p = 0.012* |
| Appeal of Crops & ES of Crops | z= -0.211, p = 0.833 | z = 3.411, p < 0.001*** |
| Appeal of Forest & ES of Forest | z = -10.788, p < 0.001*** | z = -6.848, p < 0.001*** |

**Table 3.6** Results from ordered logistic regressions analyze a suite of socio-economic factors and include the regression coefficient (coef.), standard error (SE), *z* score, *p* value, and 95% confidence intervals (CI) (only significant factors shown here). Asterisks indicate *significant at the <0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level.

| | | Public | | | | | |
|---|---|---|---|---|---|---|---|
| Landscape | Predictor Variables | Coef. | SE | z | p | 95% CI | |
| Appeal of Livestock | Resident location | -0.363 | 0.143 | -2.540 | 0.011* | -0.643 | -0.083 |
| | Household income | -0.098 | 0.045 | -2.180 | 0.029* | -0.186 | -0.010 |
| ES of Livestock | NS | - | - | - | - | - | - |
| Appeal of Hay Field | Household income | 0.154 | 0.047 | 3.320 | 0.001** | 0.063 | 0.246 |
| ES of Hayfield | NS | - | - | - | - | - | - |
| Appeal of Crops | NS | - | - | - | - | - | - |
| ES of Crops | Gender | 0.382 | 0.198 | 1.930 | 0.054 | -0.006 | 0.771 |
| Appeal of Forest | Resident location | 0.359 | 0.146 | 2.460 | 0.014* | 0.072 | 0.645 |
| | Age | -0.166 | 0.076 | -2.200 | 0.028* | -0.314 | -0.018 |
| ES of Forest | NS | - | - | - | - | - | - |

| | | Stakeholders | | | | | |
|---|---|---|---|---|---|---|---|
| Landscape | Predictor Variables | Coef. | SE | z | p | 95% CI | |
| Appeal of Livestock | NS | - | - | - | - | - | - |
| ES of Livestock | NS | - | - | - | - | - | - |
| Appeal of Hay Field | Household income | -0.277 | 0.117 | -2.360 | 0.018* | -0.507 | -0.047 |
| ES of Hayfield | Resident location | -0.776 | 0.335 | -2.320 | 0.020* | -1.431 | -0.120 |
| Appeal of Crops | Resident location | 0.837 | 0.359 | 2.330 | 0.020* | 0.133 | 1.542 |
| | Years in NH | 1.103 | 0.442 | 2.500 | 0.013* | 0.237 | 1.968 |
| ES of Crops | Resident location | 0.727 | 0.330 | 2.210 | 0.027* | 0.081 | 1.373 |
| | Gender | 1.724 | 0.508 | 3.390 | 0.001** | 0.728 | 2.719 |
| Appeal of Forest | Years in NH | -0.942 | 0.437 | -2.160 | 0.031* | -1.798 | -0.086 |
| ES of Forest | Resident location | -0.880 | 0.399 | -2.200 | 0.028* | -1.663 | -0.097 |
| | Education | -0.904 | 0.450 | -2.010 | 0.045* | -1.787 | -0.022 |

**Figures**


**Figure 3.1** Images used in survey to depict four different land-uses common in New Hampshire: livestock pasture, hay field, crops, and forest. Respondents were asked to rank the "visual appeal" of the landscapes from most to least appealing. Additionally, they were asked to rank the perceived "environmental benefits" (Ecosystem Service value) of each landscape on a scale from most to least environmental benefits.

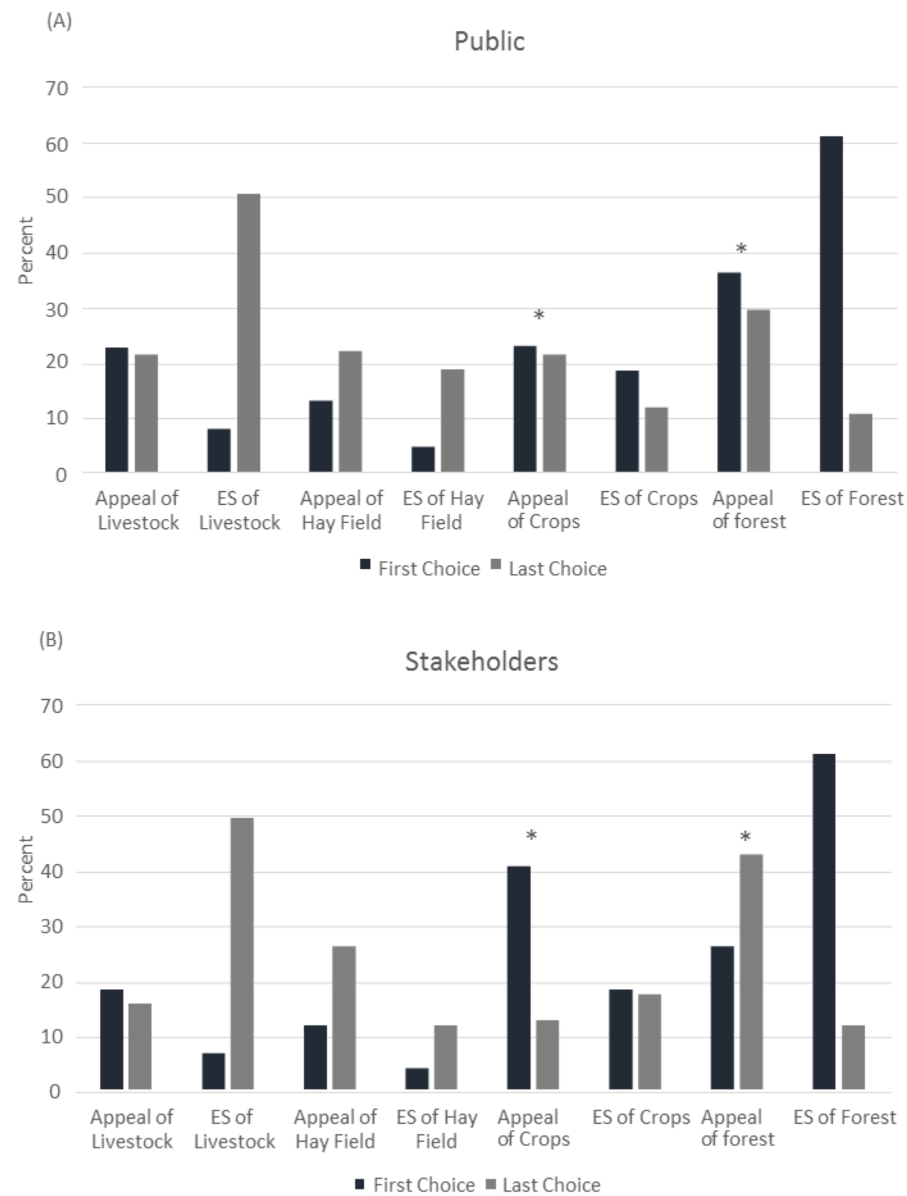


**Figure 3.2** Percentage rank for first and last choice of appeal and perceived ecosystem services of four different landscapes presented in Figure 1 (Livestock pasture, hay field, crops, and forest). Respondents from the statewide (A) and food system stakeholder (B) populations were asked to ranked the visual appeal and perceived ecosystem services of each landscape on a scale of most appealing/important (4) to least appealing/important (1). *Ordered logistic regression results show pairs are significantly different between populations (Appeal of Crops $p < 0.001$; Appeal of Forest $p = 0.007$).

**Supplemental Material**

Table S.3.1 Questions, including scoring ruberics, for each question included in this study.

| Question | Scale |
|---|---|
| Please review the above images and rank the images based on how visually appealing each landscape is to you from most to least appealing. | 4 = Most visually appealing<br>1 = Least |
| Different landscapes provide various environmental benefits. Please rank how important the following environmental benefits are to you (clean water, space for public recreation, wildlife habitat, scenic beauty, food production, carbon storage, rural character). | 7 = Most ES<br>1 = Least |
| These images represent types of land uses found in NH, which each have different impacts on the environment. This time, please rank how you perceive the environmental benefits of each landscape from most to least environmental benefits. | 4 = Most ES<br>1 = Least |
| Do you consider your place of residence to be in a rural, suburban, or urban environment? | 1 = rural environment<br>2 = Suburban environment<br>3 = Urban environment |
| How many years have you lived in NH? | 1 = < 5 years<br>2 = 5-10 years<br>3 = >10 years |
| How many people live in your household? | 1 = 1<br>2 = 2<br>3 = 3<br>4 = 4<br>5 = 5<br>6 = 6 or more |
| What is your gender? | 1 = Female<br>0 = Male |
| What is your age? | 1 = 18-24 years<br>2 = 25-34 years<br>3 = 35-44 years<br>4 = 45-54 years<br>5 = 55-64 years<br>6 = 65-74 years<br>7 = 75 years or older |

| | |
|---|---|
| What is the highest grade in school, or level of education that you've completed and gotten credit for? | 1 = High school or less<br>2 = Some college/technical school<br>3 = Bachelor's degree<br>4 = postgraduate work |
| What is your current annual HH income? | 2 = < $25K<br>3 = 25-49,999<br>4 = 50-74,999<br>5 = 75-99,999<br>6 = 100-124,999<br>7 = 125-149,999<br>8 = 150-174,999<br>9 = 175-199,999<br>10 = >200K |

## Good Intentions: Relationships between local food purchasing behavior and willingness to live next to farms


### Abstract

Previous studies have explored the drivers behind consumer behavior related to local food purchasing behavior. However, the relationship between consumers' preference for particular agricultural landscapes and their local food purchasing behavior has not been explored. We conducted a mixed methods survey including visual preference and cognitive methodologies to explore consumer behavior related to local food consumption, as well as how agricultural landscape perception—specifically resident willingness to live next to farms—is related to consumer behavior. One sample group taken from the New Hampshire state population participated in this study (n=494 completed surveys). In general, we found that most respondents were seeking (73%) and choosing to purchase locally grown food (75%) (i.e., actual behavior), while an even larger percentage would buy more locally grown food if it were available (86%) and were willing to pay more for locally grown food (79%) (i.e., intended behavior). This difference between actual and intended behavior was significant, with respondents rating their intended behavior higher than their actual consumer behavior ($z = -7.203$, $p < 0.001$). These results show that overall consumer behavior favors local food purchasing and the difference in behavior could be a result of local food availability. Additionally, structural equation modeling showed that local food purchasing behavior can be used as a predictor of willingness to live next to farms. Model results also showed that residents who support "Right-to-Farm" indicated that they would be willing to live next to farms, while household income was found to be negatively correlated with willingness to live next to farms. This paper broadens our understanding of New Hampshire residents' perception of both the production and consumption of locally grown food. Our findings propose an alternative measure of resident agricultural landscape perception that

can assist land use planners and policymakers in addressing, and potentially avoiding, land use conflict related to working farms.

***Key Words***

Landscape preference, local agriculture, New Hampshire, consumer behavior, survey, Right-to-Farm

## Introduction

As the number of farms has decreased nationally, so too has the number of people living on, or near, working farms (USDA NASS, 2012[d]). While consumers may want to purchase locally grown food, they may not want to live next to the working farms that produce that food. This disconnect between the perception of local food consumption and local food production can create potential challenges to farm viability. Despite this, local food markets are developing in cities and states throughout the country, influencing and influenced by, a renewed interest in locally grown food (Brown et al., 2014). Farmers' markets, have been shown to be a driving factor behind the growing demand for local food consumption, with a significant increase in the number of farmers' markets over the last several decades (Brown and Miller, 2008). This trend is taking shape in areas throughout the United States, and is particularly noteworthy in New Hampshire, where there has been an increase in the number of farms and farmland compared to a decrease nationally (USDA NASS, 2012[e]). Additionally, direct-to-consumer sales (i.e., transactions made directly between the farmer and a buyer) in New Hampshire are second highest in the nation (Lee, 2012).

The current literature around consumer behavior of locally grown food has focused mainly on consumer values (i.e., the drivers behind purchasing local food) (e.g., Berlin et al., 2009; Feldmann and Hamm, 2015), consumer willingness to pay more for local food (e.g., Martinez et al., 2010; Pyburn et al., 2016), and intended versus actual consumption of locally grown food (Kemp et al., 2010; Cranfield et al, 2012). Previous research has shown that when purchasing locally grown food, consumer decisions are affected more by “local” than “organic,” “quality,” “freshness,” or a number of other value claims (e.g., Roininen et al., 2006; Bond et al., 2008; Darby et al., 2008; Onozaka et al., 2016). Several studies have shown that consumers are willing to pay more for local food, and prefer local over non-local food (Adams and Salois, 2010). For example, Manalo et al. (2003) found that 62% of New Hampshire residents surveyed were willing to pay more for food grown in New Hampshire, while Pyburn et al. (2016) determined which farm products are most desired by customers. These studies are an important means of informing farmers and other agricultural professionals about how to improve farm viability, and address market challenges. However, they do not account for the potential disconnect between consumer habits and their desire to purchase locally-produced food and their willingness to live near working farms or see extensification of agriculture across the landscape (i.e., their agricultural landscape preferences).

There have been several studies exploring agricultural landscape perception, from the perceptions of climate adaptation management practices by farmers and service providers (Hurley et al., in prep) to willingness to pay for the conservation of farmland (Howley et al., 2012). Pyburn et al. (2016) found that 70% of New Hampshire respondents surveyed thought that purchasing local food was important/very important to maintain farmland. It is not clear, however, if that understanding of purchasing locally grown food to maintain farmland equates to a willingness to live next to a farm.

Direct-to-consumer sales are highest among small-scale farms (<150 acres), which is the fastest growing segment of the farming community in New Hampshire (Martinez et al., 2010;

USDA 2012b). Consequently, the number of non-farm neighbors is also increasing. As farming operations can involve noise and odor pollution, farmers need additional protection against "nuisance complaints" typically filed by non-farm neighbors. The so-called "Right-to-Farm" (RTF) legislation (New Hampshire RSA 432: Soil Conservation and Farmland Preservation - §32 to §35: "Nuisance Liability of Agricultural Operations") is intended to encourage agricultural activity in the state, and protect farmers from nuisance complaints against necessary day-to-day farm operations. If the number of farms throughout the state continues to increase, there is the potential for an increase in the number of nuisance complaints filed.

We have not found any studies that explore both consumer behavior and agricultural landscape perceptions. This study aims to address this gap in the literature by determining how landscape perception factors are related to the purchase of locally grown foods by New Hampshire residents. We conducted an exploratory analysis to better understand if consumer behavior can be used as a predictor of agricultural landscape perceptions, specifically willingness to live next to farms. Here, we assess the relationship between consumer behavior explicitly related to local food consumption and resident willingness to live next to different types of farm operations. For this study, we define local food as food grown and/or processed within the New England region. Our objectives were to: 1) assess the relationship between intended and actual purchase of local food, 2) determine if local food purchasing behavior can be used as a predictor of willingness to live next to farms, and 3) evaluate which socio-economic factors influence local food purchasing behavior among residents in New Hampshire.

**Methods**

We conducted an online, mixed methods survey using the Tailored-Design Method (Dillman, 2014). The survey was distributed via postcard solicitation between June 6-29, 2016 across the entire state of New Hampshire, reaching 12,000 residents. We included both traditional written questions, as well as several images (e.g., maps, aerial images, and photo-realistic visualizations) to better understand resident perception of potential future agricultural land use, as well as their consumer behavior related to local food consumption.

Additionally, the survey included four sections of written questions, aimed at strengthening our evaluation of landscape preferences, as well as exploring consumer behavior. The first section of questions focused on local food consumption, both actual and intended behaviors (questions and scores available in supplemental materials). The second section was aimed at resident acceptance of land use change, specifically related to forestland conversion and agricultural expansion, as well as willingness to live next to farms. The third section focused on resident support for farm-friendly regulations (i.e., policy). The last section was a set of socio-economic questions to help us understand how demographic factors may be related to landscape preferences and consumer behavior. For this study, we focus our analyses on the consumer behavior questions, as well as the policy questions. More detailed information and justification regarding the survey study area, survey development, and sampling methodology, is described in Chapter 2.

Our goal for this study was to have a survey population representative of the statewide population. However, there were several differences between the two populations, particularly in the high school or less education group. We ran regressions on both weighted and un-weighted data and found that the spread in confidence intervals was higher in the weighted data set (Appendix C). As shown by Solon et al. (2015), in some instances, weighting can reduce the efficiency of estimates. We believe that the difference in confidence intervals suggests that uncertainty would increase, and weighted estimates might not accurately represent New

Hampshire residents' perceptions. Therefore, we decided not to use weighting in our analyses for this study, and thus the results should be considered within the context of our survey population.

### *Statistical analysis*

To analyze survey results, we used Stata statistical software (StataCorp, 2015). First, we calculated the means and standard deviation for each question. To explore potential differences between actual and intended consumer purchase of locally grown food, we averaged the two questions that describe respondents' actual behavior, and the two questions that describe respondents' intended behavior (Figure 4.1). These two averages, one representative of each type of consumer behavior, were then used in a Wilcoxon matched-pairs signed-rank test.

Following a similar method to Niles et al. (2013), we also calculated a consumer score to represent respondents' consumer behavior. To calculate this score, we conducted a factor analysis with principal component factors and varimax rotation. This reduced a total of five variables to two, which loaded strongly onto one factor, and together represent the consumer score. In other words, respondents who rated questions about their actual consumer behavior as committing to purchase locally grown food clustered together on one factor. Variables loading together on the first factor with a value ≥0.40, generally acknowledged as an acceptable cut-off (Costello and Osborne, 2005), were combined to create one latent variable that best explains resident commitment to purchasing locally grown food. We then assessed the internal validity of this latent variable using Cronbach's alpha, maintaining the variables with a coefficient ≥ 0.70, which is typically accepted as the minimum cut-off for reliability (Nunnally, 1978). Questions, factor loadings, eigenvalues, and measures of reliability for each question are reported in Table 4.1.

To determine if respondents' consumer behavior can be used as a predictor of their willingness to live next to farms, we used the same methods described above, to develop a farm neighbor score. Survey responses to the seven questions, each representing a different type of farm/farm operation are described in Table 4.2. The farm neighbor score includes three of the seven farm operations, as these operations clustered together on the first factor with values >0.4, and had an alpha score ≥ 0.70. We developed a structural equation model (SEM) to explore the relationship between consumer score and farm neighbor score. SEMs are often used to evaluate unobservable concepts, or latent variables described by the causal relationships (paths) between variables (Hamilton, 2013). Previous research has developed SEMs to explore a variety of concepts within food systems research. Examples include farmer attitudes towards climate change adaptation (Niles et al., 2013), and attitudes related to sustainable food consumption (Panzone et al., 2016). This method allowed us to examine if actual purchase of locally grown food can be used as a predictor of residents' willingness to live next to farms, as well as to identify which socio-economic factors account for the differences between each population related to each latent variable.

**Results**

The survey response rate was 4.44%, with 515 online and 8 paper surveys completed. After removing partially completed surveys from the 523 returned, 494 were suitable for analysis. There were two notable differences between our sample population and the general New Hampshire population. Our sample population was skewed toward an older, well-educated resident group. However, it adequately represented the general population both geographically and by gender. Table 3 includes population statistics for New Hampshire, and the survey sample population.

***Consumer behavior: Actual versus intended***

From an initial exploratory data analysis, we found that most survey respondents were committed to purchasing locally grown food (Figure 4.2). Over 75% of respondents said that they "seek" locally grown foods when they shop, while roughly 73% said that they purposely chose locally grown over non-locally grown food (within the last three months prior to taking the survey). When asked to rate their willingness to purchase locally grown food (an intended behavior), their commitment increased (86% of respondents). To understand how consumer commitment is related to perceived value, we asked respondents to rate how willing they would be to pay more for locally grown food. The majority of respondents (79%) were willing to pay more for locally grown food (22% were willing to pay <5% more, 45% were willing to pay between 5-10% more, and 12% were willing to pay >10% more), while 7.7% were not willing to pay more. Additionally, over 10% of respondents said that they could not afford to pay more for locally grown food.

Survey responses of consumer behavior, the scale, means, and standard deviations, as well as the results of the Wilcoxon matched-pairs signed-rank tests are presented in Table 4. The analysis of respondents' actual and intended consumer behavior showed that intended behavior was consistently higher than actual consumer behavior (mean=0.84 and 0.71; compared to 0.55 and 0.53 for intended versus actual consumer behavior, respectively). We conducted a Wilcoxon test to determine whether there was a difference in the ranking of actual consumer behavior and intended behavior of residents across the survey sample population. Results from that analysis indicated that there was a significant difference in how respondents rated their actual consumer behavior from the way they rated their intended behavior, rating their actual behavior lower than their intended consumer behavior ($z = -7.203$, $p < 0.001$).

### ***Consumer behavior as a predictor of willingness to live next to farms***

We used SEM to determine if actual consumer behavior was a predictor of respondents' willingness to live next to farms. We assessed responses to eight potential demographic variables including the following: attendance at town meeting, resident location (rural, suburban, urban), number of years lived in New Hampshire, household size, gender, age, highest level of education, and current annual household income. Table 4.1 displays the scores associated with each latent variable used in the model, and Figure 4.3 reports the significant results from the model. We found that respondents' actual consumer behavior, support for "Right-to-Farm" legislation, and household income were significantly related to their farm neighbor score. Respondents who rated their consumer behavior and support for "Right-to-Farm" legislation high, had higher farm neighbor scores ($p = 0.019$, $p < 0.001$ respectively). Additionally, as household income increased, willingness to live next to farms decreased ($p = 0.001$). The SEM also indicates that gender is the driving demographic variable of actual consumer behavior, with higher consumer scores (i.e., respondents rated their actual and intended consumer behavior high) for female respondents and lower scores for male respondents ($p < 0.001$). The overall model fit was assessed by root mean squared error of approximation (RMSEA) and comparative fit index (CFI). RMSEA is an alternative to $p > chi^2$ that is generally accepted for large sample sizes (>150), and is adjusted for sample size and "strikes a balance in sensitivity with deviations in the structural model versus the measurement model" (Grace, 2006) Goodness of fit tests indicate a strong overall fit ($p > chi^2$ 0.0992, RMSEA = 0.029 and CFI = 0.986). .

## Discussion

### ***Commitment to locally grown***

There are often barriers to purchasing locally grown food, which can lead to a difference between actual and intended consumer behavior. As most small-scale farms in New Hampshire rely on some form of direct-to-consumer sales (e.g., farmers' markets, farm stands, restaurants, etc.), resident commitment to purchasing locally grown food is an important part of farm viability. As a largely rural state, local food access can be challenging for some communities, and farmers may have trouble finding market outlets. Our findings show that respondents' intentions to buy local food are higher than their actual purchase of local food, which is consistent with results from previous research (Robinson et al., 2002; Kemp et al., 2010). Respondents are interested in purchasing more locally grown food if it were available where they shop, suggesting that availability is one potential limiting factor to increasing local food consumption.

Several other studies have found that adult females tend to make up the majority of food shoppers (e.g., Zepeda et al., 2012) and that women assign greater importance to food values such as organic, U.S. grown, local, and GM-free, than men (Bellows et al., 2010). Our findings showed that gender was the most important demographic factor predicting commitment to purchase of local food. Female respondents rated their actual and intended consumer behavior higher than male respondents, which could be the result of who typically does household shopping (more women than men). Though not found to be significant predictors of local food consumption, resident location and attendance at town meetings were found to lead to differing consumer behavior. Our results suggest that rural residents are more likely to choose locally grown food supports similar findings by Weatherell et al. (2003). We did find a pattern that showed that rural residents rated their consumption of locally grown food the highest, and urban residents rated their consumption higher than sub-urban residents. Given that we know gender influences consumer behavior, it is interesting to note that the distribution of male/female respondents across the rural to urban gradient varied, with more female respondents in rural and urban locations, and more males in suburban locations. Additionally, we found that those who indicated that they attended a town meeting had higher consumer scores. Attendance at town meetings has been found to be a predictor of commitment to local land use in Vermont. For example, Bettigole et al. (2014) found attendance at town meetings to be one of the most influential socio-economic variables for predicting Vermont residents' acceptance of development in the state.

The drivers behind local food consumption are well-studied, showing that generally consumers choose locally grown food for quality, freshness, and to support the local agricultural economy (e.g., Schneider and Francis, 2003; Wolf et al., 2004), and are largely willing to pay more for locally grown food (e.g., Darby et al., 2006; Toler et al., 2008; Feldmann and Hamm, 2015). We know less, however, about how agricultural landscape perception is related to local food consumption. Using actual consumer behavior to predict willingness to live next to farms is a novel approach that we believe can inform the work of local food systems advocates in government (e.g., New Hampshire Department of Agriculture), as well as non-profits (e.g., sub-state regional food initiatives). Previous research has shown that landscape scenarios (i.e., representations of potential future land use) influence stakeholder attitudes associated with the landscape (Gantar and Golobic, 2015). Additionally, understanding landscape preferences has been demonstrated to inform the identification of land use conflict (Brown and Raymond, 2014). As the number of farm-neighbor conflicts is likely to increase with an increase in the number of farms across the state, understanding resident landscape preferences could help facilitate increasing agricultural production in the state, and alleviate potential farm neighbor conflicts. Agriculture is a valuable part of the New Hampshire landscape that can be positively or negatively affected by residents, particularly those living next to farms. The state's RTF law works to protect farmers from undue nuisance complaints, but lawsuits filed against farmers, even if unsuccessful, can be time-consuming and costly to the farmer. If the number of small farms continues to increase, it is likely that nuisance lawsuits will also increase.

In this study, we used "spreading manure" as an example of an everyday farming operation that would be covered by RTF. Most respondents (80%) support RTF, while roughly half (53%) are willing to live next to a farm that spreads manure (Figure 4.4). A similar pattern was seen with 87% of respondents willing to live next to a farm that sells farm products (such as meat, dairy, vegetables, and fruit), whereas 61% are willing to live next to a dairy farm. Though most respondents have high consumer and farm neighbor scores, the difference between those who support RTF, but are not willing to live next to a farm with odor (associated with livestock or manure), or traffic (associated with on farm sales) suggests that there is a disconnect between food production and consumption.

Understanding the relationship between local food consumption and consumers' perception of the agricultural landscape (and their willingness to live near farms) is critical to planning, development, and policy that emphasizes increasing agricultural land use in the state and supporting local farm enterprises. If people support buying local food in theory, but can't abide farms as neighbors, farmers could face numerous and costly lawsuits and nuisance complaints, which would impact their viability, and potentially, their desire to continue farming. Efforts to help understand the geographic and demographic factors that contribute to tolerance for living with agriculture in our neighborhoods will help target outreach and education efforts aimed at alleviating land-use conflicts.

***Study limitations & suggestions for future research***

Administering surveys electronically is a convenient and inexpensive method for researchers to collect large data sets. There are however, several drawbacks, including potentially limiting the sample populations surveyed. New Hampshire has higher than average in-home access to the internet (US Census Bureau, 2012), which confirmed our choice to use an online survey. Despite the high in-home internet access, and conventional mail invitations to solicit participation, the additional step of getting to an electronic device with internet access could have deterred some residents from participating in the survey. Additionally, while postcard recipients could have requested a paper copy, only 12 recipients did so (n=8 completed paper surveys). The total response rate was adequate to represent New Hampshire residents; however, the sample was skewed toward the well-educated, which may have limited the perspectives represented in our data.

As an exploratory study aimed at understanding consumer behavior related to local food and residents' agricultural landscape perceptions, our study does not address why survey respondents choose to purchase locally grown food or are willing to live next to a vegetable farm but not a dairy farm. The open-ended comments we received at the end of the survey shed some light on these questions, but future research exploring the "why" question would give a more complete picture of the New Hampshire local food consumer and resident/non-farm neighbor (Figure S.1). In Chapter 2, we describe how household income is positively correlated with the number of farms by county. Here we found that household income is negatively correlated with willingness to live next to farms. Future research could explore if farms in areas with higher home values more at risk for conflict.

In addition, future research could test the relationship between consumer behavior and landscape preferences.  We recommend research grounded in social theory, to explore local food consumption as a predictor of agricultural landscape perceptions. As a measured variable, using local food consumption data to predict agricultural landscape preferences could be a convenient tool for food systems advocates and policymakers, who are tasked with addressing the challenges associated with agricultural expansion on the landscape.

### ***Conclusions***

This study intended to test the relationship between consumer behavior and landscape preferences. Overall, we found that survey respondents, representing a sample of the New Hampshire population, are committed to supporting local agriculture through their actual and intended local food purchasing behaviors, as well as their support for farm-friendly legislation. We found a positive relationship between local food consumption and willingness to live next to farms. However, there seems to be a disconnect between their perception of local food production and consumption, as seen in ratings of willingness to live next to different types of farms. Our study indicated that while people generally support buying local food in theory, they may not tolerate those same local farms as neighbors.  Supporting local farm enterprises will require planners, developers, policy-makers, and farmers to understand more about residents' perceptions of agricultural land use and for everyone to understand more about the realities of sustaining viable farm businesses.

***Acknowledgements***

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**Tables**

**Table 4.1** Latent variables, consumer score and farm neighbor score, developed for statistical analyses, with eigenvalue, factor loadings, and measure of reliability (Cronbach's alpha). Factor loadings and alpha scores for all questions were well above generally accepted cut-off values (>0.5 and >0.7 respectively). Only questions included in determining the latent variable shown here. For a comprehensive list of questions, see supplemental material.

| Latent Variable | Question/Statement | Scale | Eigenvalue | Factor loading | Cronbach's α |
|---|---|---|---|---|---|
| Consumer Score | When you shop do you seek local foods? | | 1.612 | 0.808 | 0.65 |
| | In the past three months, have you ever made a choice to buy food grown locally rather than food grown somewhere else BECAUSE it was local food? | 1 = Yes<br>0 = IDK<br>-1 = No | | 0.804 | |
| Farm neighbor score | How willing would you be to live next door to a…<br>1) Dairy Farm<br>2) Livestock Pasture<br>3) Farm that spreads manure | 1 = Willing<br>0 = I don't know<br>-1 = Not willing | 2.87 | 0.86<br>0.80<br>0.73 | 0.793 |

**Table 4.2** Questions describing willingness to live next to different types of farms, with count, mean, and standard deviation (SD). Response scale was as follows: 1=Willing, -1=Not Willing. Means suggest that respondents more willing to live next to certain types of farms (e.g., vegetable farms, and farms with direct-to-consumer sales) than others (e.g., farms with livestock or that use pesticides). Support for Right-to-Farm (response scale: +1=Support, 0=I don't know, -1=Oppose) was high.

| Question | Count | Mean | SD |
|---|---|---|---|
| How willing are you to live next door to a… | | | |
| *Vegetable farm* | 491 | 0.939 | 0.32 |
| *Dairy farm* | 489 | 0.348 | 0.869 |
| *Livestock pasture* | 493 | 0.535 | 0.797 |
| *Farm that spreads manure* | 491 | 0.2 | 0.911 |
| *Farm that uses pesticides or other chemicals* | 491 | -0.603 | 0.705 |
| *Farm that hosts functions such as weddings and/or educational workshops* | 492 | 0.291 | 0.856 |
| *Farm that sells farm products (meat, dairy, vegetables, fruit, etc.) on site* | 493 | 0.809 | 0.526 |
| NH's Right-to-Farm Law protects farmers in conducting day-to-day operations on their land, such as the operation of machinery and spreading manure. Generally, would you say that you support or oppose the Right to Farm Law? | 492 | 0.785 | 0.44 |

**Table 4.3** Demographic variables of statewide sample population compared with New Hampshire state population. While representation was fairly reflected by county and gender, education and age were skewed toward and older, more educated residents. *Data source: US Census Bureau Population estimates, July 1, 2015, (V2015). Age estimated from categories 20-24 (missing 18 and 19-year-olds and therefore could be conservative).

| | Percent of state population | Percent of survey population |
|---|---|---|
| *County* | | |
| Belknap | 4.56 | 4.86 |
| Carroll | 3.55 | 3.24 |
| Cheshire | 5.70 | 6.48 |
| Coos | 2.35 | 3.44 |
| Grafton | 6.71 | 6.88 |
| Hillsborough | 30.56 | 28.54 |
| Merrimack | 11.12 | 11.94 |
| Rockingham | 22.68 | 23.08 |
| Strafford | 9.53 | 8.91 |
| Sullivan | 3.23 | 2.63 |
| *Resident Location (Total / Male / Female)* | | |
| Rural | - | 52.24 / 44.14 / 55.47 |
| Suburban | - | 35.98 / 52.54 / 47.46 |
| Urban | - | 11.79 / 44.83 / 55.17 |
| *Education* | | |
| High School or Less | 37.1 | 6.50 |
| Some College | 28.6 | 23.17 |
| Bachelor's Degree | 34.4 | 29.47 |
| Postgraduate work | N/A | 40.85 |
| *Age* | | |
| 18-44 | 31.00 | 23.22 |
| *45-74* | 38.00 | 70.67 |
| *75+* | 6.00 | 6.11 |
| *Gender* | | |
| Male | 49.4 | 47.25 |
| Female | 50.6 | 52.55 |
| Trans/Non-Binary | N/A | 0.20 |

**Table 4.4** Questions describing actual and intended consumer behavior, with scale, mean, and standard deviation (SD). Wilcoxon matched-pairs signed-ranks test results include z scores and p values. The null hypothesis is that both distributions are the same. Two questions about seeking and choosing locally grown food, were aimed at understanding actual consumer behavior; while two questions about a consumer's willingness to buy, and pay more for locally grown food, were designed to help us understand consumer intentions. Results from the Wilcoxon test show that respondents rated their intended behavior higher than their actual consumer behavior. Survey responses for willingness to pay were rescaled for analyses (original scoring: 1=I am not willing, 2=I am willing to pay <5%, 3=I am willing to pay 5-10%, 4= I am willing to pay >10%, 5=I don't know, and 6=I cannot afford to pay more).

| Latent Variable | Question / statement | Scale | Mean | SD | z | p |
|---|---|---|---|---|---|---|
| Actual Consumer Behavior | When you shop do you seek local foods? | 1 = Yes<br>0 = IDK<br>-1 = No | 0.552 | 0.036 | -7.203 | <0.0001 |
| | In the past three months, have you ever made a choice to buy food grown locally rather than food grown somewhere else BECAUSE it was local food? | 1 = Yes<br>0 = IDK<br>-1 = No | 0.533 | 0.036 | | |
| Intended Consumer Behavior | Would you buy more local food if it were made available where you shop? | 1 = Yes<br>0 = IDK<br>-1 = No | 0.840 | 0.019 | | |
| | Are you willing to pay more for local food, and if so how much? (yes = <5%-10% more) | 1 = Yes<br>0 = IDK / Cannot<br>-1 = No | 0.712 | 0.270 | | |

**Figures**

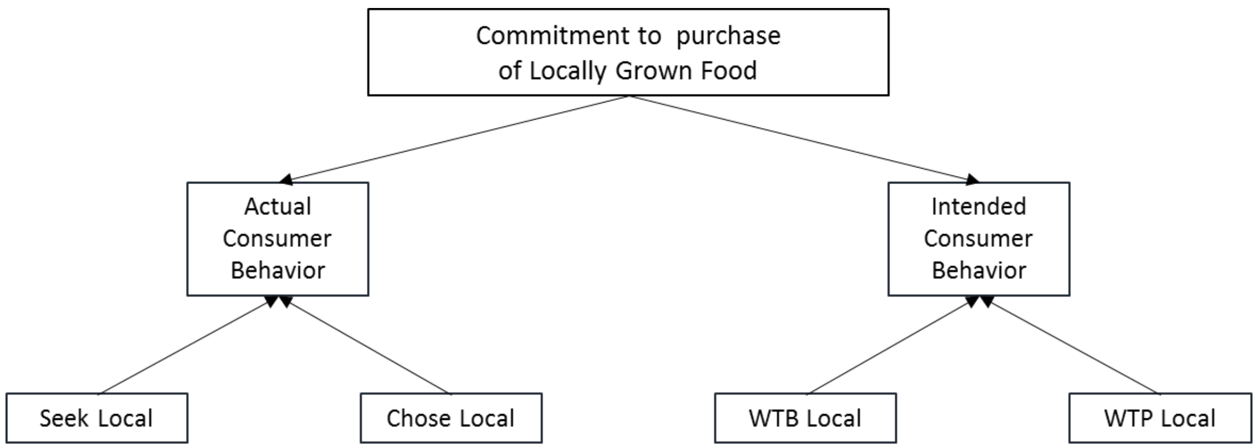


**Figure 4.1** Conceptual diagram shows four survey questions aimed at understanding actual and intended consumer behavior. The responses from these questions were scaled 1=yes/willing, 0=I don't know/I cannot afford, -1=no/not willing. Seek local and chose local were combined into one latent variable representing a consumer score and used in subsequent analyses.

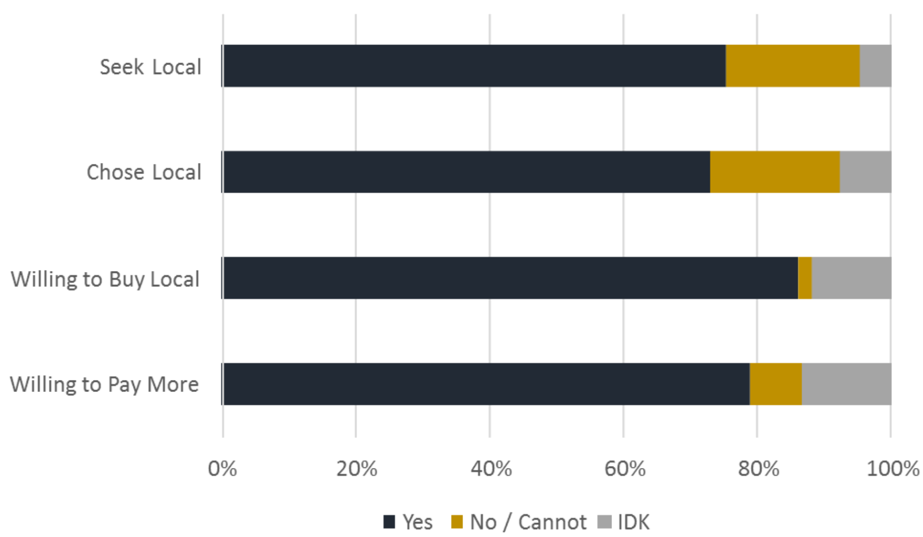


**Figure 4.2** Survey responses about actual and intended consumer behavior by percent (Yes, No, and I don't know (IDK)). The responses from seek local and choose local were aggregated to create the latent variable, consumer score, which was used in subsequent analyses. Intended commitment to purchasing locally grown food is higher than actual purchase of locally grown food.

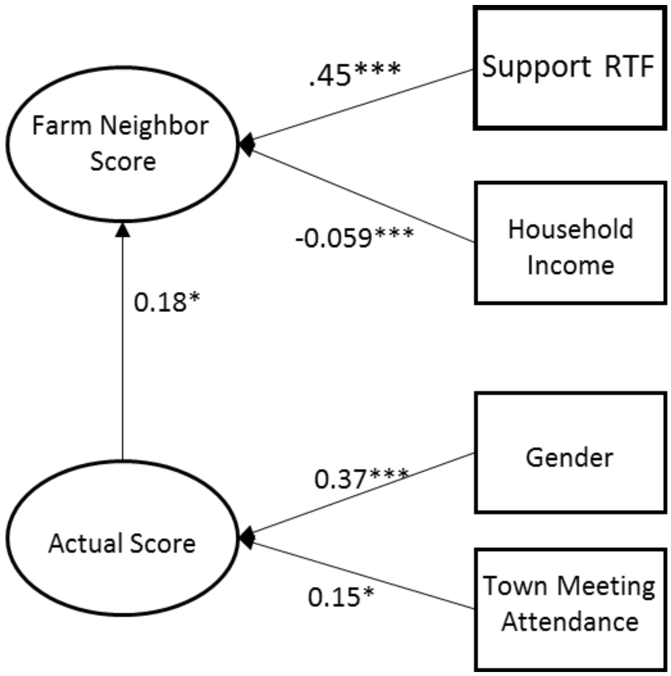


**Figure 4.3** Structural equation model results (only significant pathways are shown). Significant demographic variables shown include household income, gender, and attendance at town meetings; as well as respondents' support for New Hampshire's Right-to-Farm legislation (Support RTF). The structural equation model is shown in full in the supplemental materials. Asterisks denote significance: *significant at the 0.05 level, **significant at the <0.01 level, ***significant at the <0.001 level. Prob > chi2 = 0.0992, $R^2$=.22, root mean squared error of approximation (RMSEA = 0.029), and comparative fit index (CFI = 0.986).

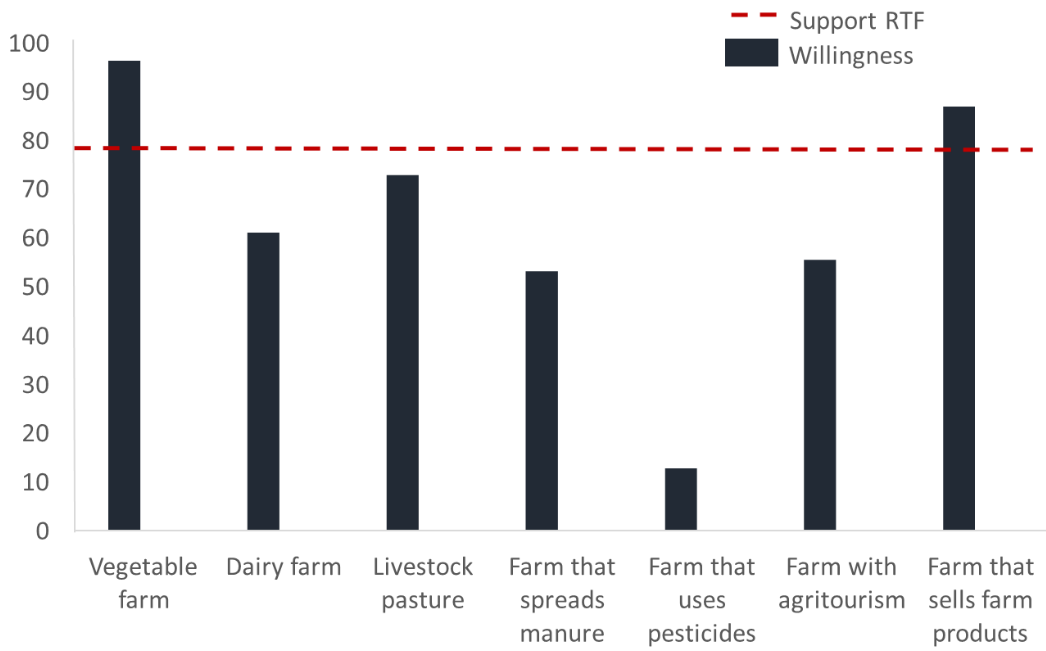


**Figure 4.4** Survey responses about willingness to live next to farms, by percent (original responses: +1=Willing, -1=Not willing, and 0=I don't know). In this figure, support for RTF law is denoted by the red dotted line. "NH's Right-to-Farm (RTF) law protects farmers in conducting day-to-day farm operations on their land, such as the operation of machinery and spreading manure. Generally, would you say that you support or oppose the RTF law?"

## Supplemental Material

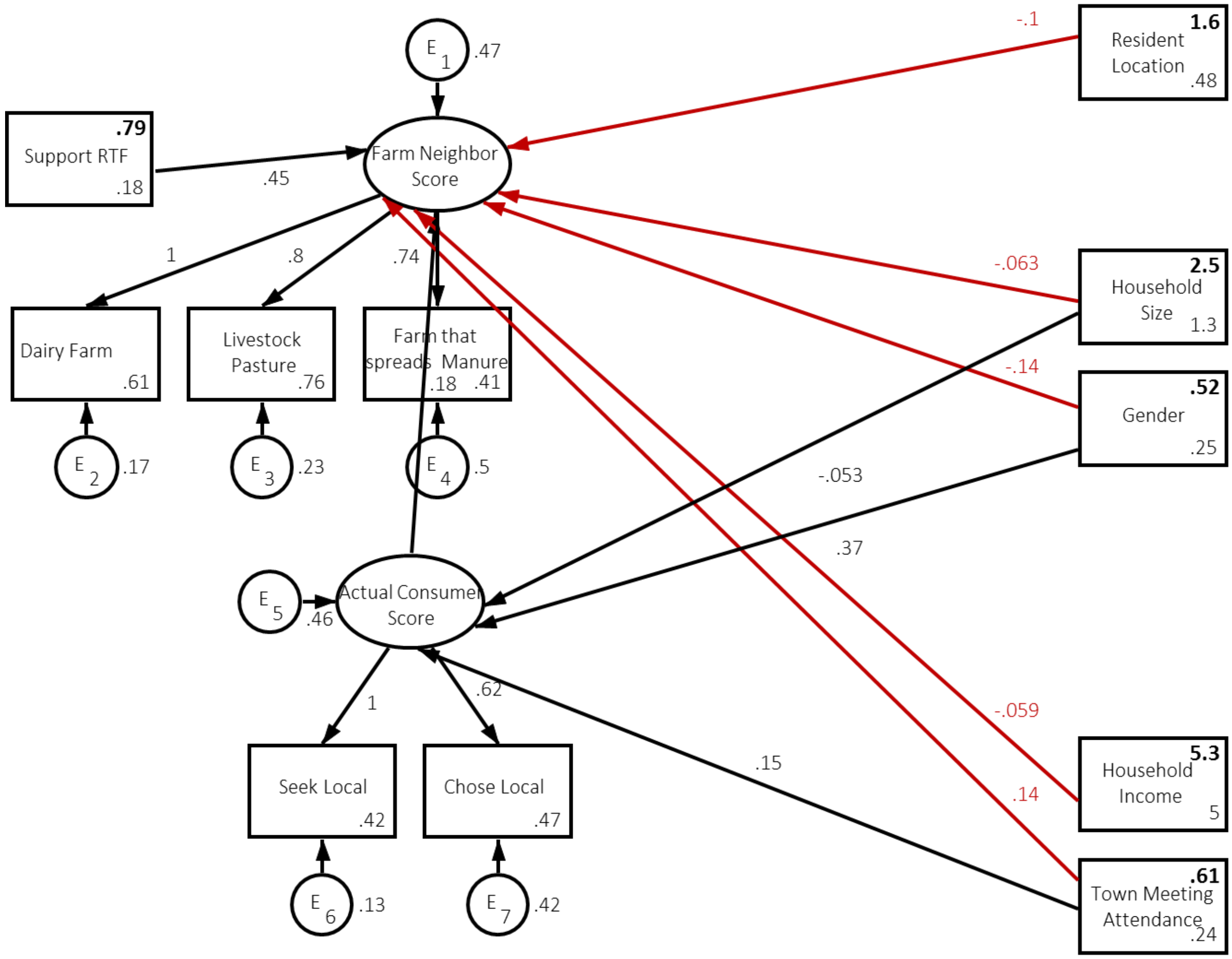


**Figure S.4.1** Full structural equation model showing all observed and latent variables in the best fit model. Prob > $chi^2$ = 0.0992, $R^2$=.22, root mean squared error of approximation (RMSEA = 0.029), and comparative fit index (CFI = 0.986). Red arrows and associated values indicate pathways between demographic variables and the *farm neighbor score*, while the black arrows and associated values indicate pathways between demographic variables and the *consumer behavior score*. Bolded values within rectangles (exogenous variables) represent the intercept (mean), while non-bolded values represent the variance.

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# APPENDICES

## APPENDIX A Institutional Review Board (IRB) Approval

University *of* New Hampshire

Research Integrity Services, Service Building
51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

11-Jan-2016

Wilhelm, Jennifer
Sustainability Institute, Nesmith Hall
170 Gates Street
Portsmouth, NH 03801

**IRB #:** 6383
**Study:** Acceptability and Perception of Agricultural Extensification in New Hampshire
**Approval Date:** 07-Jan-2016

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved the protocol for your study as Exempt as described in Title 45, Code of Federal Regulations (CFR), Part 46, Subsection 101(b). Approval is granted to conduct your study as described in your protocol.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the attached document, *Responsibilities of Directors of Research Studies Involving Human Subjects.* (This document is also available at http://unh.edu/research/irb-application-resources.) Please read this document carefully before commencing your work involving human subjects.

Upon completion of your study, please complete the enclosed Exempt Study Final Report form and return it to this office along with a report of your findings.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Director

cc: File
Smith, Richard

## APPENDIX B Survey Questions

**Q1** Consent form for participation in a research study
Title of Research Study

- Acceptability of agricultural expansion on the landscape: A visual preference study

Identity of Researchers

- My name is Jennifer Wilhelm and I am a Research Associate for the NH Food Alliance at the University of New Hampshire (UNH) Sustainability Institute, and graduate student in the Natural Resources Earth Systems Sciences Ph.D. program at UNH. I am working on this study with Dr. Richard Smith, Assistant Professor of Agroecology.

What is the purpose of this study?

- Your responses to this survey will help us understand how New Hampshire residents feel about changes to the landscape specifically related to forestland and agriculture in the state.
- We anticipate at least 600 participants to be involved with this study.
- All participants must be at least 18 years old to participate in this study.

What does your participation in this study involve?

- Your participation in this study will involve taking an online survey, including answering written questions and rating images of the landscape based on your personal preferences. Your participation in this survey is completely voluntary, and all of your responses are anonymous. The survey should take no more than 12 minutes to complete.

If you choose to participate in this study, will it cost you anything?

- You will incur no costs for participating in this study.

Will you receive any compensation for participating in this study?

- You will receive no compensation for participating in this study. You will be eligible to enter a raffle for the chance to win one of six, $50 Visa gift cards.

What are the possible risks of participating in this study?

- Risks associated with this study are unlikely. The research team will take all steps necessary to prevent the possibility of releasing any potentially sensitive information related to you.

What are the possible benefits of participating in this study?

- There are several community-level benefits including raising awareness about agriculturally-driven land use change in New Hampshire, the NH Food Alliance, and some of the benefits and challenges of agricultural expansion in the state. As a participant, you will also be exposed to potential future scenarios of agricultural expansion through images, which make the concepts more realistic and easier to conceptualize.

What options are available if you do not want to take part in this study?

- Your consent to participate in this research is entirely voluntary. Your refusal to participate will involve no prejudice, penalty or loss of benefits to which you would otherwise be entitled.

Can you withdraw from this study?

- If you consent to participate in this study, you are free to stop your participation in the study at any time without prejudice, penalty, or loss of benefits to which you would otherwise be entitled.

How will the confidentiality of your records be protected?

- We will strive to maintain the confidentiality of all data and records associated with your participation in this research.
- There are, however, rare instances when we are required to share personally-identifiable information (e.g., according to policy, contract, and/or regulation). For example, in response to a complaint about the research, officials at the University of New Hampshire, designees of the sponsor(s), and/or regulatory and oversight government agencies may access research data.

- This online survey will be conducted using UNH's License for Qualtrics Survey Research Suite (2015, Qualtrics, Provo, UT). The survey will be available online, unless you request a paper copy. The online survey will be completed on an electronic device of your choosing (personal computer, phone, iPad, etc.). Personal information about you (demographic data) will be stored with each survey, but identifiable information, including IP addresses will not be stored with the surveys. Further, any communication via the Internet poses minimal risk of a breach of confidentiality.
- Any personal information collected for the purposes of the raffle or participation in future research will be stored separately from your survey responses and thus survey responses are not identifiable to any one particular individual. Your personal information will be stored using UNH IT-approved electronic storage.

How data will be reported and used

- The results from this survey will be aggregated, analyzed, and reported both in scientific journals and NH Food Alliance publications. Additionally, the results will be shared with the NH Food Alliance stakeholders and used to inform their work.

Who to contact if you have questions about this study

- If you have any additional questions or comments about this research you can contact us (Jennifer Wilhelm or Dr. Richard Smith) to discuss them jwilhelm@wildcats.unh.edu / Richard.Smith@unh.edu. For more information about the NH Food Alliance, visit www.NHFoodAlliance.com.
- If you have questions about your rights as a research subject you can contact Julie Simpson in UNH Research Integrity Services , 603-862-2003 or Julie.simpson@unh.edu to discuss them.

**Q2** By choosing "I agree to participate," I confirm that I am at least 18 years of age, and that I consent to participate in this research study.

❍ I agree to participate

**Q3** Please enter your zip code ________________

**Q4 The first set of questions will tell us a little about your food purchasing preferences…**

**Q5** What kind of store, market, or other place do you purchase MOST of your food? Rank the top three in order from most (1) to least (3).

______ Grocery Store
______ Convenience/General Store
______ Super Store
______ Farm Stand/Farmers' Market/CSA
______ Health/Natural Food Store
______ Food Co-op
______ Other

**Q6** Do you produce some portion of food for your own/your household's consumption?

❍ Yes
❍ No

If No Is Selected, Then Skip to **Q8**

**Q7** Roughly how large is your home food production area (e.g. size of garden or farm)?

❍ 100 square feet or smaller
❍ 101-600 square feet
❍ 600 square feet or larger

**Q8** On average, about how much does your family spend on food each week (excluding restaurants)?

❍ Less than $100
❍ $100-$149
❍ $150-$199
❍ $200 or more

**Q9** For the purposes of this survey, local food is defined as food grown and/or processed within the New England region. When you shop do you seek local foods?

- ❍ Yes
- ❍ No
- ❍ I don't know

**Q10** Please estimate what percentage of the food you buy is local (average year-round).

- ❍ 0%
- ❍ 1-24%
- ❍ 25-54%
- ❍ 55-74%
- ❍ 75-100%

**Q11** Would you buy more local food if it were made available where you shop?

- ❍ Yes
- ❍ No
- ❍ I don't know

If No Is Selected, Then Skip to **Q13**

**Q12** What local food would you buy more of if available? Click on all that apply.

- ❑ Fruit
- ❑ Vegetables
- ❑ Dairy
- ❑ Meat
- ❑ Other (is there a specific food you would buy more of if it were local?) ____________________

**Q13** Are you willing to pay more for local food, and if so how much?

- ❍ I am NOT willing to pay more for local food
- ❍ I CANNOT afford to pay more for local food
- ❍ I am willing to pay less than 5% more
- ❍ I am willing to pay 5-10% more
- ❍ I am willing to pay greater than 10% more
- ❍ I don't know

**Q14** In the past three months, have you ever made a choice to buy food grown locally rather than food grown somewhere else BECAUSE it was local food?

- ❍ Yes
- ❍ No
- ❍ I don't know

**Q15** Where do you get your information about local foods?

- ❑ Farmers/growers
- ❑ The local market where I purchase food
- ❑ Friends and family
- ❑ Radio (If so, which station?) ____________________
- ❑ Evening news programs (If so, which program?) ____________________
- ❑ Newspaper (If so, which paper?) ____________________
- ❑ Other ____________________

**Q16 The next set of questions reference your perception of the New Hampshire landscape, and include both written questions as well as images…**

**Q17** Do you think that more food should be grown in New Hampshire?

- ❍ Yes
- ❍ No
- ❍ I don't know

**Q18** Are you willing to see changes to the landscape in your town, such as some forested land converted to agriculture?

- ❍ Yes
- ❍ No
- ❍ I don't know

**Q19** Do you think it is acceptable for farming to expand into some forested areas?

- ❍ Yes
- ❍ No
- ❍ I don't know

**Q20** Do you own forested land?

- ❍ Yes
- ❍ No

**Q21** If you did own forested land, would you consider converting some of it to agriculture (for instance, selling or leasing land to farmers)?

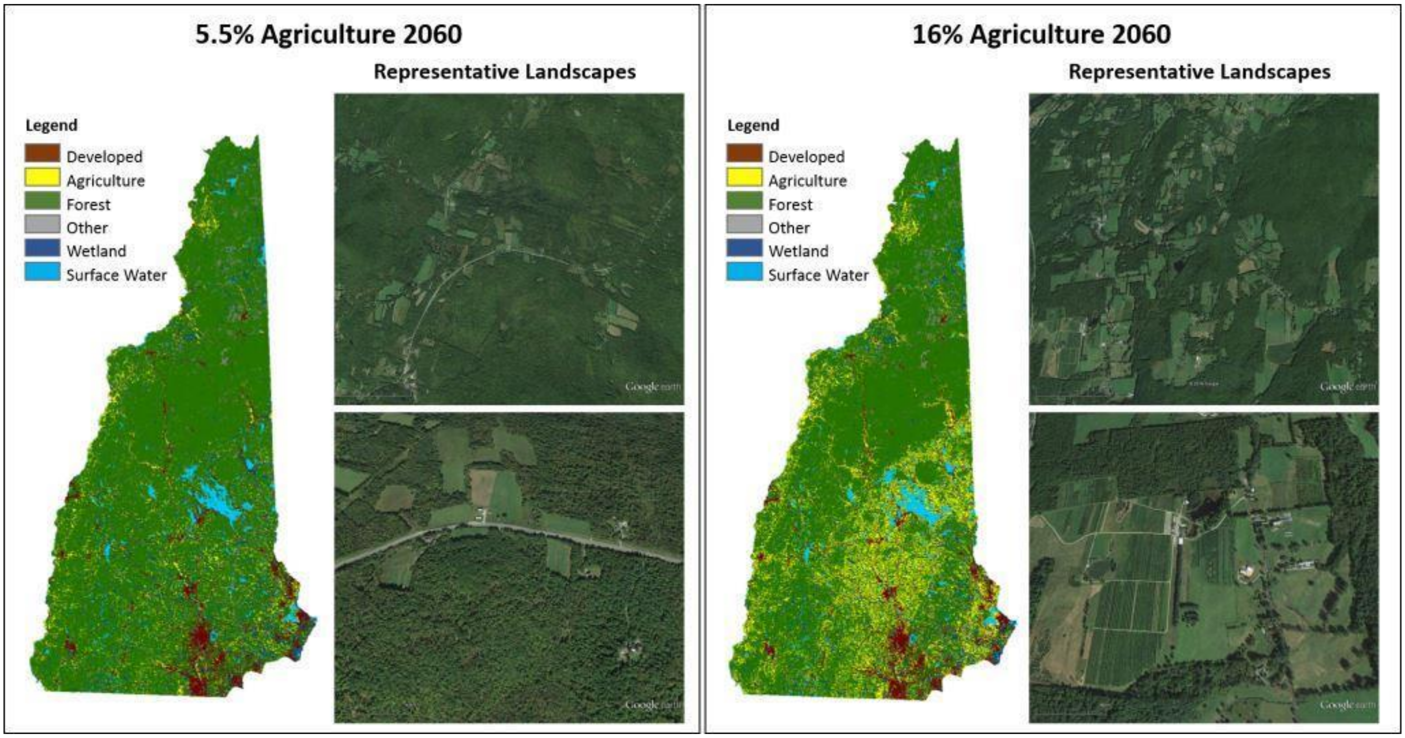
- ❍ Yes
- ❍ No
- ❍ I don't know

**Q22** How important do you feel it is to...

| | Extremely important | Very important | Moderately important | Slightly important | Not at all important | I don't know |
|---|---|---|---|---|---|---|
| Protect forestland and other natural resources | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Limit development of forested areas | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Protect agricultural lands and soil | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Limit development in agricultural areas | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

**Q23** Current agricultural land cover in New Hampshire is estimated as 5.0% of the total land area. Experts from UNH have developed different scenarios of potential future land cover changes in New Hampshire (Thorn et al., in prep). Below are two examples of what agricultural expansion might look like on the landscape by the year 2060. The first represents minimal expansion (from 5 to 5.5%) and the second represents more substantial expansion (from 5 to 16%).

**Q24**




**Q25** Please look at the two examples of agricultural expansion above. Based on your preferences, rate the acceptability of agricultural expansion represented in each. Please choose one answer for each scenario.

| | Very acceptable | Somewhat acceptable | Not very acceptable | Not at all acceptable | I don't know |
|---|---|---|---|---|---|
| 5.5% Agriculture 2060 | ❍ | ❍ | ❍ | ❍ | ❍ |
| 16% Agriculture 2060 | ❍ | ❍ | ❍ | ❍ | ❍ |

**Q26**


**Q27** Please look at the four numbered images above. Each image represents a different level of forestland converted to agriculture on a typical landscape in New Hampshire. Based on your preferences, please rate the acceptability of the amount of forestland-to-agriculture conversion represented in the images. Please choose one answer for each pair of images.

| | Very acceptable | Somewhat acceptable | Not very acceptable | Not at all acceptable | I don't know |
|---|---|---|---|---|---|
| Conversion represented from image 1 to 2 | ❍ | ❍ | ❍ | ❍ | ❍ |
| Conversion represented from image 2 to 3 | ❍ | ❍ | ❍ | ❍ | ❍ |
| Conversion represented from image 3 to 4 | ❍ | ❍ | ❍ | ❍ | ❍ |

**Q28**


**Q29** Please review the above images and rank the images based on how visually appealing each landscape is to you. Rank from most visually appealing (1) to least visually appealing (4). Click and drag each item to rank.

______ Livestock
______ Hay Field
______ Crops
______ Forest

**Q30** Different landscapes provide various environmental benefits. Please rank how important the following environmental benefits are to you, from most important (1) to least important (7). Click and drag each item to rank.

______ Clean water
______ Space for public recreation (e.g. hiking, hunting)
______ Wildlife habitat
______ Scenic beauty
______ Food production
______ Carbon storage (i.e. the capture of carbon in soil and trees where it will not enter the atmosphere as $CO2$)
______ Rural character

**Q32** Please review the above images again (**Q28**). These images represent types of land uses found in New Hampshire, which each have different impacts on the environment. This time, please rank how you perceive the environmental benefits of each landscape from most environmental benefits (1) to least environmental benefits (4). Click and drag each item to rank.

______ Livestock
______ Hay Field
______ Crops
______ Forest

**Q33 The next several questions reference how you feel about farming near where you live…**

**Q34** How close do you live to a working farm (that actively produces food for the market)?

- ❍ I live on a farm
- ❍ I live next door to a farm
- ❍ Less than 5 miles
- ❍ 5-10 miles
- ❍ Greater than 10 miles
- ❍ I don't know

**Q35** How willing would you be to live next door to a…

| | Willing | Not willing | I don't know |
|---|---|---|---|
| Vegetable farm | ❍ | ❍ | ❍ |
| Dairy farm | ❍ | ❍ | ❍ |
| Livestock pasture | ❍ | ❍ | ❍ |
| Farm that spreads manure | ❍ | ❍ | ❍ |
| Farm that uses pesticides or other chemicals | ❍ | ❍ | ❍ |
| Farm that hosts functions such as weddings and/or educational workshops | ❍ | ❍ | ❍ |
| Farm that sells farm products (meat, dairy, vegetables, fruit, etc.) on site | ❍ | ❍ | ❍ |

**Q36** How familiar are you with New Hampshire's Right-to-Farm Law?

- ❍ Very familiar
- ❍ Somewhat familiar
- ❍ Not very familiar
- ❍ Not at all familiar

**Q37** New Hampshire's Right-to-Farm Law protects farmers in conducting day-to-day farm operations on their land, such as the operation of machinery and spreading manure. Generally, would you say that you support or oppose the Right to Farm Law?

- ❍ Support
- ❍ Oppose
- ❍ I don't know

**Q38** Do you believe that more land in the state of New Hampshire should be available for farming?

- ❍ Yes
- ❍ No
- ❍ I don't know

**Q39** New Hampshire does not currently have a state-run agricultural land preservation program. Would you support or oppose the state re-establishing and funding an agricultural land preservation program to protect working farms through agricultural easements?

- ❍ Support
- ❍ Oppose
- ❍ I don't know

**Q40** Would you support or oppose changes in local zoning to allow for farmland expansion in your town (for instance, towns encouraging development closer to town centers in order to maximize land for agriculture)?
- Support
- Oppose
- I don't know

**Q41** Have you ever attended a town meeting in your town?
- Yes
- No

**Q42 This last set of questions will help us understand demographic and geographic trends...**

**Q43** Do you consider your place of residence to be in a
- Rural environment
- Suburban environment
- Urban environment

**Q44** How many years have you lived in New Hampshire?
- Less than 5 years
- 5-10 years
- 10 years or more

**Q45** How many people live in your household?
- 1
- 2
- 3
- 4
- 5
- 6 or more

**Q46** What is your gender?
- Female
- Male
- Trans / non-binary

**Q47** What is your age?
- 18-24 years
- 25-34 years
- 35-44 years
- 45-54 years
- 55-64 years
- 65-74 years
- 75 years or older

**Q48** What is the highest grade in school, or level of education that you've completed and gotten credit for?
- High school or less
- Some college/technical school
- Bachelor's degree
- Postgraduate work

**Q49** What is your current annual household income?
- Less than $25,000
- $25,000-$49,999
- $50,000-$74,999
- $75,000-$99,999
- $100,000-$124,999
- $125,000-$149,999
- $150,000-$174,999
- $175,000-$199,999
- $200,000 or more

**Q50** Please share any comments here.

**NH Food Alliance Survey Part 2**

**Q1** Thank you for your participation in this research study! You are eligible to win one of six, $50 Visa gift cards. To enter the raffle, please enter your email address and phone number. Your survey responses will remain anonymous and your contact information will be treated as confidential, following research guidelines outlined in the UNH Institutional Review Board application #6383.

- ☐ Email____________________
- ☐ Phone Number____________________

**Q2** Lastly, would you be willing to participate in future research related to this project either as part of a focus group or an individual interview?

- ☐ Yes
- ☐ No

If No Is Selected, Then Skip to **Q4**

**Q3** Please complete the four questions below. Your survey responses will remain anonymous and your contact information will be treated as confidential, following research guidelines outlined in the UNH Institutional Review Board application #6838.

- ☐ Name____________________
- ☐ Email____________________
- ☐ Phone Number____________________
- ☐ Zip Code ____________________

**Q4** Thank you for your time and participation, your feedback is instrumental to this study.

**APPENDIX C Supplemental Materials**

**Table S.1.** Acceptance of agricultural expansion (Expansion Score, Chapter 2). Eight demographic (predictor) variables included the following: resident location (reslocation), number of years lived in NH (yrsnh), household size (hhsize), gender, age, education, household income (hhincome), and attendance at town meetings (townmtg). Regression results (A) unweighted; and (B) weighted by education demographic variable.

(A) Acceptance of ag expansion score (unweighted)

| acceptscore1 | Coef. | Std. Err. | t | P>t | [95% | Conf. Interval] |
|---|---|---|---|---|---|---|
| reslocation | -0.02654 | 0.061385 | -0.43 | 0.666 | -0.14718 | 0.094094 |
| yrsnh | 0.115766 | 0.062089 | 1.86 | 0.063 | -0.00625 | 0.237787 |
| hhsize | -0.06256 | 0.040223 | -1.56 | 0.121 | -0.14161 | 0.016486 |
| gender | -0.06659 | 0.085622 | -0.78 | 0.437 | -0.23486 | 0.101683 |
| age | 0.002449 | 0.034072 | 0.07 | 0.943 | -0.06451 | 0.06941 |
| education | -0.01354 | 0.046535 | -0.29 | 0.771 | -0.105 | 0.077908 |
| hhincome | 0.019165 | 0.020765 | 0.92 | 0.357 | -0.02164 | 0.059973 |
| townmtg | 0.069259 | 0.094317 | 0.73 | 0.463 | -0.1161 | 0.254616 |
| _cons | -0.16206 | 0.314352 | -0.52 | 0.606 | -0.77985 | 0.455721 |

(B) Acceptance of ag expansion score (weighted)

| acceptscore1 | Coef. | Std. Err. | t | P>t | [95% | Conf. Interval] |
|---|---|---|---|---|---|---|
| reslocation | -0.00519 | 0.0896 | -0.06 | 0.954 | -0.18127 | 0.170887 |
| yrsnh | 0.223656 | 0.097301 | 2.3 | 0.022 | 0.032443 | 0.414868 |
| hhsize | -0.05738 | 0.066546 | -0.86 | 0.389 | -0.18816 | 0.073392 |
| gender | -0.07891 | 0.119973 | -0.66 | 0.511 | -0.31468 | 0.156861 |
| age | 0.02044 | 0.043535 | 0.47 | 0.639 | -0.06511 | 0.105995 |
| education | -0.00146 | 0.056807 | -0.03 | 0.979 | -0.1131 | 0.110176 |
| hhincome | 0.022515 | 0.025329 | 0.89 | 0.375 | -0.02726 | 0.072291 |
| townmtg | -0.01016 | 0.143357 | -0.07 | 0.944 | -0.29188 | 0.271557 |
| _cons | -0.57264 | 0.454121 | -1.26 | 0.208 | -1.46507 | 0.319781 |

**Table S.2.** Seven ecosystem services ranked by respondents: "Please rank how important the following environmental benefits are to you, from most important to least important." Ecosystem services listed included clean water (eswater), space for public recreation (esrec), wildlife habitat (eswildlife), carbon storage (escarbon), food production (esfood), scenic beauty (esscenic), and rural character (escharacter). Questions were analyzed in Chapter 3. Ordered logistic regression results (A) unweighted; and (B) weighted by education demographic variable.

Difference between populations (unweighted)

| Ecosystem Service | OR | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| eswater | 0.771529 | 0.158442 | -1.26 | 0.207 | 0.51588 | 1.153867 |
| esrec | 0.729177 | 0.142699 | -1.61 | 0.107 | 0.496883 | 1.070071 |
| eswildlife | 0.664439 | 0.128339 | -2.12 | 0.034 | 0.455032 | 0.970216 |
| escarbon | 1.52975 | 0.294497 | 2.21 | 0.027 | 1.048945 | 2.230941 |
| esfood | 2.29054 | 0.445304 | 4.26 | 0 | 1.564789 | 3.352894 |
| esscenic | 0.536232 | 0.106706 | -3.13 | 0.002 | 0.363054 | 0.792017 |
| escharacter | 1.15009 | 0.219393 | 0.73 | 0.464 | 0.791326 | 1.671508 |

(A) Difference between populations (weighted)

| Ecosystem Service | OR | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| eswater | 0.728061 | 0.171228 | -1.35 | 0.178 | 0.458733 | 1.155515 |
| esrec | 0.790219 | 0.175502 | -1.06 | 0.29 | 0.510865 | 1.222332 |
| eswildlife | 0.841921 | 0.183887 | -0.79 | 0.431 | 0.548236 | 1.292929 |
| escarbon | 1.523096 | 0.33452 | 1.92 | 0.056 | 0.98943 | 2.344606 |
| esfood | 1.762913 | 0.377068 | 2.65 | 0.008 | 1.158208 | 2.683337 |
| esscenic | 0.55411 | 0.128754 | -2.54 | 0.011 | 0.351071 | 0.874576 |
| escharacter | 1.149845 | 0.242584 | 0.66 | 0.508 | 0.759774 | 1.74018 |

**Table S.3.** Seven ecosystem services ranked by respondents: "Please rank how important the following environmental benefits are to you, from most important to least important." Ecosystem services listed included clean water (eswater), space for public recreation (esrec), wildlife habitat (eswildlife), carbon storage (escarbon), food production (esfood), scenic beauty (esscenic), and rural character (escharacter). Eight demographic (predictor) variables included the following: resident location (reslocation), number of years lived in NH (yrsnh), household size (hhsize), gender, age, education, household income (hhincome), and attendance at town meetings (townmtg). Questions were analyzed in Chapter 3. Ordered logistic regression results (A) unweighted; and (B) weighted by education demographic variable.

(A) Predictor variables (unweighted)

| (A1) eswater | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.055244 | 0.13994 | 0.39 | 0.693 | -0.21903 | 0.329521 |
| yrsnh | 0.102028 | 0.13226 | 0.77 | 0.44 | -0.1572 | 0.361253 |
| hhsize | 0.04213 | 0.091227 | 0.46 | 0.644 | -0.13667 | 0.220931 |
| gender | 0.062087 | 0.190618 | 0.33 | 0.745 | -0.31152 | 0.435692 |
| age | -0.05965 | 0.077718 | -0.77 | 0.443 | -0.21198 | 0.092669 |
| education | 0.052368 | 0.105336 | 0.5 | 0.619 | -0.15409 | 0.258822 |
| hhincome | -0.12882 | 0.046118 | -2.79 | 0.005 | -0.21921 | -0.03843 |
| townmtg | -0.04808 | 0.213638 | -0.23 | 0.822 | -0.46681 | 0.37064 |

| (A2) esfood | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.11435 | 0.129392 | -0.88 | 0.377 | -0.36796 | 0.139252 |
| yrsnh | 0.078268 | 0.128976 | 0.61 | 0.544 | -0.17452 | 0.331056 |
| hhsize | 0.035583 | 0.086319 | 0.41 | 0.68 | -0.1336 | 0.204766 |
| gender | 0.015853 | 0.179596 | 0.09 | 0.93 | -0.33615 | 0.367856 |
| age | 0.132437 | 0.070496 | 1.88 | 0.06 | -0.00573 | 0.270607 |
| education | -0.19723 | 0.097189 | -2.03 | 0.042 | -0.38772 | -0.00674 |
| hhincome | -0.07081 | 0.04375 | -1.62 | 0.106 | -0.15656 | 0.014941 |
| townmtg | -0.08832 | 0.191367 | -0.46 | 0.644 | -0.46339 | 0.286751 |

| (A3) escarbon | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.161603 | 0.127818 | 1.26 | 0.206 | -0.08892 | 0.412121 |
| yrsnh | -0.01029 | 0.127948 | -0.08 | 0.936 | -0.26107 | 0.240478 |
| hhsize | -0.01279 | 0.083396 | -0.15 | 0.878 | -0.17624 | 0.150664 |
| gender | 0.255734 | 0.176974 | 1.45 | 0.148 | -0.09113 | 0.602596 |
| age | -0.02056 | 0.070657 | -0.29 | 0.771 | -0.15904 | 0.11793 |
| education | 0.061233 | 0.095796 | 0.64 | 0.523 | -0.12652 | 0.24899 |
| hhincome | -0.04373 | 0.042377 | -1.03 | 0.302 | -0.12679 | 0.039325 |
| townmtg | 0.018193 | 0.195812 | 0.09 | 0.926 | -0.36559 | 0.401976 |

| (A4) eswildlife | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.00096 | 0.125635 | -0.01 | 0.994 | -0.2472 | 0.245276 |
| yrsnh | -0.05593 | 0.135104 | -0.41 | 0.679 | -0.32073 | 0.208866 |
| hhsize | -0.11976 | 0.083792 | -1.43 | 0.153 | -0.28398 | 0.044473 |
| gender | 0.197019 | 0.176871 | 1.11 | 0.265 | -0.14964 | 0.54368 |
| age | -0.18485 | 0.071542 | -2.58 | 0.01 | -0.32507 | -0.04463 |
| education | 0.075149 | 0.096556 | 0.78 | 0.436 | -0.1141 | 0.264395 |
| hhincome | 0.002099 | 0.043365 | 0.05 | 0.961 | -0.0829 | 0.087093 |
| townmtg | 0.053367 | 0.194128 | 0.27 | 0.783 | -0.32712 | 0.433851 |

| (A5) esscenic | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.186027 | 0.125095 | 1.49 | 0.137 | -0.05915 | 0.431209 |
| yrsnh | 0.087917 | 0.126798 | 0.69 | 0.488 | -0.1606 | 0.336437 |
| hhsize | -0.02571 | 0.080834 | -0.32 | 0.75 | -0.18414 | 0.132721 |
| gender | -0.08276 | 0.175212 | -0.47 | 0.637 | -0.42617 | 0.26065 |
| age | 0.079761 | 0.071472 | 1.12 | 0.264 | -0.06032 | 0.219844 |
| education | -0.04541 | 0.097619 | -0.47 | 0.642 | -0.23674 | 0.145918 |
| hhincome | 0.12367 | 0.044762 | 2.76 | 0.006 | 0.035938 | 0.211403 |
| townmtg | -0.31723 | 0.196952 | -1.61 | 0.107 | -0.70324 | 0.068792 |

| (A6) escharacter | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.35371 | 0.128289 | -2.76 | 0.006 | -0.60515 | -0.10227 |
| yrsnh | -0.07268 | 0.127895 | -0.57 | 0.57 | -0.32335 | 0.177988 |
| hhsize | -0.00612 | 0.082247 | -0.07 | 0.941 | -0.16733 | 0.155076 |
| gender | -0.16127 | 0.178343 | -0.9 | 0.366 | -0.51082 | 0.188274 |
| age | 0.144789 | 0.070492 | 2.05 | 0.04 | 0.006626 | 0.282951 |
| education | -0.02831 | 0.097497 | -0.29 | 0.772 | -0.2194 | 0.162784 |
| hhincome | 0.038102 | 0.042787 | 0.89 | 0.373 | -0.04576 | 0.121964 |
| townmtg | 0.398618 | 0.196244 | 2.03 | 0.042 | 0.013986 | 0.78325 |

| (A7) esrec | coef | SE | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.129304 | 0.126053 | 1.03 | 0.305 | -0.11776 | 0.376364 |
| yrsnh | -0.06426 | 0.126602 | -0.51 | 0.612 | -0.3124 | 0.183872 |
| hhsize | 0.004923 | 0.085746 | 0.06 | 0.954 | -0.16314 | 0.172983 |
| gender | -0.27587 | 0.176914 | -1.56 | 0.119 | -0.62262 | 0.070874 |
| age | -0.24605 | 0.069888 | -3.52 | 0 | -0.38303 | -0.10907 |
| education | 0.040937 | 0.096762 | 0.42 | 0.672 | -0.14871 | 0.230586 |
| hhincome | 0.089419 | 0.042528 | 2.1 | 0.036 | 0.006066 | 0.172772 |

| | | | | | | |
|---|---|---|---|---|---|---|
| townmtg | 0.070224 | 0.192886 | 0.36 | 0.716 | -0.30783 | 0.448273 |

(B)Predictor variables (weighted)

| (B1) eswater | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.08905 | 0.249477 | -0.36 | 0.721 | -0.57934 | 0.401244 |
| yrsnh | 0.150221 | 0.193844 | 0.77 | 0.439 | -0.23074 | 0.531177 |
| hhsize | -0.11617 | 0.203708 | -0.57 | 0.569 | -0.51651 | 0.284168 |
| gender | -0.18854 | 0.286287 | -0.66 | 0.511 | -0.75117 | 0.374093 |
| age | -0.16052 | 0.166132 | -0.97 | 0.334 | -0.48701 | 0.165977 |
| education | 0.195226 | 0.16772 | 1.16 | 0.245 | -0.13439 | 0.524841 |
| hhincome | -0.17917 | 0.075317 | -2.38 | 0.018 | -0.32719 | -0.03115 |
| townmtg | -0.48823 | 0.413931 | -1.18 | 0.239 | -1.30172 | 0.325254 |

| (B2) esfood | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.12271 | 0.203418 | -0.6 | 0.547 | -0.52248 | 0.277062 |
| yrsnh | 0.090711 | 0.189939 | 0.48 | 0.633 | -0.28257 | 0.463993 |
| hhsize | 0.192173 | 0.175544 | 1.09 | 0.274 | -0.15282 | 0.537164 |
| gender | -0.35919 | 0.269705 | -1.33 | 0.184 | -0.88923 | 0.170856 |
| age | 0.174874 | 0.097819 | 1.79 | 0.074 | -0.01737 | 0.367114 |
| education | -0.18589 | 0.127181 | -1.46 | 0.145 | -0.43583 | 0.064058 |
| hhincome | -0.10753 | 0.067342 | -1.6 | 0.111 | -0.23988 | 0.024811 |
| townmtg | -0.01709 | 0.277174 | -0.06 | 0.951 | -0.56182 | 0.527632 |

| (B3) escarbon | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.01193 | 0.234811 | 0.05 | 0.96 | -0.44954 | 0.473399 |
| yrsnh | 0.006557 | 0.117628 | 0.06 | 0.956 | -0.22461 | 0.237728 |
| hhsize | -0.01862 | 0.201832 | -0.09 | 0.927 | -0.41528 | 0.378033 |
| gender | 0.341167 | 0.286384 | 1.19 | 0.234 | -0.22166 | 0.90399 |
| age | -0.06241 | 0.135502 | -0.46 | 0.645 | -0.3287 | 0.203893 |
| education | 0.068028 | 0.12007 | 0.57 | 0.571 | -0.16794 | 0.303997 |
| hhincome | -0.08365 | 0.064392 | -1.3 | 0.195 | -0.21019 | 0.042902 |
| townmtg | -0.2979 | 0.308596 | -0.97 | 0.335 | -0.90437 | 0.308578 |

| (B4) eswildlife | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.157394 | 0.166155 | 0.95 | 0.344 | -0.16915 | 0.483934 |
| yrsnh | 0.222361 | 0.332188 | 0.67 | 0.504 | -0.43048 | 0.8752 |
| hhsize | -0.19526 | 0.092012 | -2.12 | 0.034 | -0.37609 | -0.01443 |
| gender | -0.10332 | 0.270049 | -0.38 | 0.702 | -0.63404 | 0.427397 |

| | | | | | | |
|---|---|---|---|---|---|---|
| age | -0.18108 | 0.093871 | -1.93 | 0.054 | -0.36556 | 0.003401 |
| education | 0.274276 | 0.137379 | 2 | 0.046 | 0.004288 | 0.544264 |
| hhincome | 0.045671 | 0.065309 | 0.7 | 0.485 | -0.08268 | 0.174021 |
| townmtg | 0.07935 | 0.273834 | 0.29 | 0.772 | -0.45881 | 0.617508 |

| (B5) esscenic | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | 0.426396 | 0.222419 | 1.92 | 0.056 | -0.01072 | 0.863509 |
| yrsnh | -0.22562 | 0.209542 | -1.08 | 0.282 | -0.63742 | 0.186189 |
| hhsize | -0.00977 | 0.119096 | -0.08 | 0.935 | -0.24382 | 0.224289 |
| gender | 0.400875 | 0.329474 | 1.22 | 0.224 | -0.24663 | 1.048381 |
| age | -0.01406 | 0.12375 | -0.11 | 0.91 | -0.25726 | 0.229144 |
| education | -0.20452 | 0.158122 | -1.29 | 0.197 | -0.51527 | 0.10623 |
| hhincome | 0.143675 | 0.071928 | 2 | 0.046 | 0.002316 | 0.285033 |
| townmtg | 0.137848 | 0.373138 | 0.37 | 0.712 | -0.59547 | 0.871167 |

| (B6) escharacter | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.21047 | 0.203596 | -1.03 | 0.302 | -0.61059 | 0.18965 |
| yrsnh | 0.065589 | 0.251677 | 0.26 | 0.795 | -0.42903 | 0.560204 |
| hhsize | 0.079444 | 0.103616 | 0.77 | 0.444 | -0.12419 | 0.283078 |
| gender | -0.12136 | 0.273035 | -0.44 | 0.657 | -0.65795 | 0.415226 |
| age | 0.116705 | 0.107846 | 1.08 | 0.28 | -0.09524 | 0.328652 |
| education | -0.12543 | 0.156781 | -0.8 | 0.424 | -0.43354 | 0.182693 |
| hhincome | 0.093089 | 0.066425 | 1.4 | 0.162 | -0.03745 | 0.223631 |
| townmtg | 0.830121 | 0.314985 | 2.64 | 0.009 | 0.21109 | 1.449152 |

| (B7) esrec | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.06887 | 0.182834 | -0.38 | 0.707 | -0.42818 | 0.290453 |
| yrsnh | -0.25399 | 0.179938 | -1.41 | 0.159 | -0.60761 | 0.099639 |
| hhsize | 0.117801 | 0.167081 | 0.71 | 0.481 | -0.21056 | 0.44616 |
| gender | -0.3315 | 0.285942 | -1.16 | 0.247 | -0.89346 | 0.230453 |
| age | -0.0567 | 0.108645 | -0.52 | 0.602 | -0.27021 | 0.156821 |
| education | 0.070792 | 0.117788 | 0.6 | 0.548 | -0.16069 | 0.302277 |
| hhincome | 0.067821 | 0.061214 | 1.11 | 0.268 | -0.05248 | 0.188123 |
| townmtg | -0.26355 | 0.305002 | -0.86 | 0.388 | -0.86296 | 0.33586 |

**Table S.4.** Actual and intended consumer behavior as determined by four questions: "Do you seek local foods when you shop?" (seeklocal); "In the past three months, have you ever made a choice to buy food grown locally rather than food grown somewhere else BECAUSE it was local food?" (choselocal); "Would you buy more local food if it were made available where you shop?" (wtblocal); and "Are you willing to pay more for local food?" (wtplocal). Means and standard errors (A) unweighted; and (B) weighted by education demographic variable.

(A) Actual and intended means (unweighted)

| | Mean | Std. Err. | [95% Conf. | Interval] |
|---|---|---|---|---|
| seeklocal | 0.552632 | 0.036256 | 0.481397 | 0.623867 |
| choselocal | 0.534413 | 0.035959 | 0.463761 | 0.605065 |
| wtblocal | 0.840081 | 0.018832 | 0.803081 | 0.877081 |
| wtplocal | 0.711968 | 0.027021 | 0.658877 | 0.765059 |

(B) Actual and intended means (weighted)

| | Mean | Std. Err. | [95% Conf. | Interval] |
|---|---|---|---|---|
| seeklocal | 0.625103 | 0.045776 | 0.535163 | 0.715044 |
| choselocal | 0.562981 | 0.050226 | 0.464297 | 0.661664 |
| wtblocal | 0.866112 | 0.023355 | 0.820225 | 0.911998 |
| wtplocal | 0.655641 | 0.050439 | 0.556538 | 0.754743 |

**Table S.5.** Willingness to live next to farms (wtlivescore) was examined in chapter 4 (there referred to as the *farm neighbor score*. Eight demographic (predictor) variables included the following: resident location (reslocation), number of years lived in NH (yrsnh), household size (hhsize), gender, age, education, household income (hhincome), and attendance at town meetings (townmtg). Regression results (A) unweighted; and (B) weighted by education demographic variable.

Willingness to live next to farms (unweighted)

| wtlivescore | coef | SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.14243 | 0.057337 | -2.48 | 0.013 | -0.25511 | -0.02975 |
| yrsnh | -0.0141 | 0.057994 | -0.24 | 0.808 | -0.12807 | 0.099878 |
| hhsize | -0.05224 | 0.03757 | -1.39 | 0.165 | -0.12607 | 0.021598 |
| gender | -0.0858 | 0.079976 | -1.07 | 0.284 | -0.24298 | 0.07137 |
| age | 0.037991 | 0.031825 | 1.19 | 0.233 | -0.02455 | 0.100535 |
| education | -0.01078 | 0.043466 | -0.25 | 0.804 | -0.0962 | 0.074645 |
| hhincome | -0.05844 | 0.019396 | -3.01 | 0.003 | -0.09655 | -0.02032 |
| townmtg | 0.179079 | 0.088097 | 2.03 | 0.043 | 0.005946 | 0.352213 |
| _cons | 0.532315 | 0.293622 | 1.81 | 0.071 | -0.04473 | 1.109359 |

Willingness to live next to farms (weighted)

| wtlivescore | coef | Linearized SE | t | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| reslocation | -0.09892 | 0.083267 | -1.19 | 0.235 | -0.26256 | 0.064712 |
| yrsnh | -0.05375 | 0.053596 | -1 | 0.316 | -0.15907 | 0.051579 |
| hhsize | -0.04758 | 0.04501 | -1.06 | 0.291 | -0.13604 | 0.040869 |
| gender | 0.031795 | 0.122217 | 0.26 | 0.795 | -0.20838 | 0.271971 |
| age | 0.07261 | 0.042393 | 1.71 | 0.087 | -0.0107 | 0.155919 |
| education | -0.0845 | 0.053483 | -1.58 | 0.115 | -0.1896 | 0.020606 |
| hhincome | -0.02675 | 0.024537 | -1.09 | 0.276 | -0.07497 | 0.021465 |
| townmtg | 0.203805 | 0.136035 | 1.5 | 0.135 | -0.06353 | 0.471136 |
| _cons | 0.381903 | 0.288009 | 1.33 | 0.185 | -0.18408 | 0.94789 |


**Figure S.1.** Word cloud represents coded themes from 187 comments left in open-ended question at the close of the survey (“Please feel free to leave any additional comments here.”). The size of the words is related to the number of times each theme was mentioned (i.e., the larger the words, the more frequently the theme was mentioned).