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Identifying barriers and motivators for adoption of multifunctional perennial cropping systems by landowners in the Upper Sangamon River Watershed, Illinois

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Abstract The demand on agriculture to meet food security goals and mitigate environmental impacts requires multifunctional land-use strategies. Considering both farmer motivations and rural development needs, one option is to transition marginal farmland to perennial crops. In this study, we considered the potential for Multifunctional Perennial Cropping Systems (MPCs) that would simultaneously provide production and ecosystem service benefits. We examined adoption potential of MPCs on marginal farmland through an agricultural landowner survey in the Upper Sangamon River Watershed in Illinois, USA. We identified adoption preferences among landowners in conjunction with socio-demographic characteristics that would facilitate targeted implementation. Hierarchical cluster analysis and discriminant analysis identified landowner categories and key factors affecting adoption potential. Landowner age, appreciation for plant diversity, and future farm management involvement were the strongest predictors of potential MPCs adoption. The landowner categories identified within the survey data, supplemented with focus group discussions, suggested a high adoption potential farmer profile as a young, educated landowner with known marginal land they would consider converting to MPCs for improved soil and water quality conservation.

Keywords Multifunctional cropping systems · Survey · Adoption · Hierarchical cluster analysis

Introduction

In order for agriculture to provide food, fiber, and fuel products to the growing population, landowners require strategic land management plans (Foley et al. 2011). The 2012 USDA agricultural census reported 127 million hectares (ha) of harvested farmland (USDA NASS 2012). However 24.68 million ha of this land is unsuitable for conventional row crop production due to low productivity caused by issues such as soil erosion, proximity to ecologically sensitive areas, and topography (Cai et al. 2011; Gelfand et al. 2013). Marginal land that is unproductive for row crops may be better suited for multifunctional land-use strategies. Alternative management systems using adaptive agricultural practices can improve production and sustainability in the face of climate change and environmental mitigation pressure (Nair et al.

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2010; Foley et al. 2011). A range of alternative systems and practices have been proposed, including agroforestry (Jose 2009; Malézieux 2012; Batáry et al. 2015).

Multifunctional Perennial Cropping Systems (MPCs) are an example of agroforestry practices designed to achieve regulating services of vegetative buffers and other conservation habitats (Schaefer et al. 1987; de Snoo and de Wit 1998; Maisonneuve and Rioux 2001) and production goals for woody crops (Smith et al. 2011). MPCs provide several options for marginal land management, and they can be designed to accommodate labor and investment limitations (Strong and Jacobson 2006). Despite the wide range of benefits and income diversification, adoption of perennial or agroforestry practices has been low (Pattanayak et al. 2003; Trozzo et al. 2014). For example, less than 1% of farms in the Upper Sangamon River Watershed (USRW) counties report income from harvestable perennials (USDA NASS 2012). Further research on preferences for marginal land management and information routes for new practices is needed to ensure MPCs adoption success (Barbieri and Valdivia 2010; Trozzo et al. 2014; Varble et al. 2016).

Previous research has emphasized the cultural influences that affect farmland adoption behavior with respect to social (e.g., neighbors, family, tenancy) and political trends (e.g., mandates, management policies), as well as personal motivations (e.g., ecosystem service valuation) (Pattanayak et al. 2003; Villamil et al. 2008; DeDecker et al. 2014). Demographic and economic traits, in connection with cultural values, are used to create typologies, or categories of landowners and farmers, that represent the heterogeneity of characteristics related to conservation behavior (Daloğlu et al. 2014) and agroforestry interest (Strong and Jacobson 2006; Barbieri and Valdivia 2010). The development of categories is a valuable targeting strategy for outreach efforts by predicting potential adopters of new practices (Pattanayak et al. 2003; Valdivia et al. 2012; Daloğlu et al. 2014). In agricultural regions with high land tenancy rates, the role of landowners in the farm management process is complex, and the viability of harvestable agroforestry systems, like MPCs, requires more exploration. We aimed to explore landowner preferences for ecosystem services and perennial production systems in conjunction with socio-demographic information to categorize landowners. We hypothesized that the needs of landowners regarding the motivators and barriers for adoption would vary depending on socio-demographic characteristics such as age and land tenancy.

Materials and methods

The Upper Sangamon River Watershed (USRW)

The USRW is located in Central Illinois and drains approximately 3000 square kilometers of land (ISWS 2015). The watershed is located in the Corn Belt, an intensively cropped region of the United States (Nickerson et al. 2012) (Fig. 1). In 2015, 16,124 ha of corn and 13,512 ha of soybean were grown in the USRW, making up 79% of the 80% agricultural land in the watershed. The other major land uses were 10% developed areas and 9% grassland and forest (USDA NASS 2015). The watershed consists of portions of eight counties: Champaign, Christian, DeWitt, Ford, Macon, McClean, Piatt, and Sangamon. According to the USDA Agriculture Census, 6866 farms operate in the counties, and the average farm size was 190 ha (USDA NASS 2012). Farm size trends are consistent with those in the Corn Belt, where commercial farms dominate (Daloğlu et al. 2014). Macon and Piatt counties are the two counties with land area falling primarily within the watershed boundary. In order to make comparisons between the survey sample and data from the USDA Agriculture Census (which mainly reports using political boundaries rather than watershed), data collection and comparison prioritized Macon and Piatt County (ISWS 2015). Both counties have similar demographic and farmland characteristics and are representative of the counties that make up the USRW, according to Agriculture Census data (USDA NASS 2012).

Soil in the USRW consists primarily of silt loam and silty clay loam with high organic matter and a hardpan subsoil layer that requires tile drainage to prevent ponding of water and to allow cultivation of annual row crops such as corn and soybean. The majority of the USRW is underlain with tile drainage systems, and combined with fertilizer applications common with conventional agriculture, waterways are prone to high nutrient concentrations. The nutrient runoff levels in the USRW are higher than surrounding

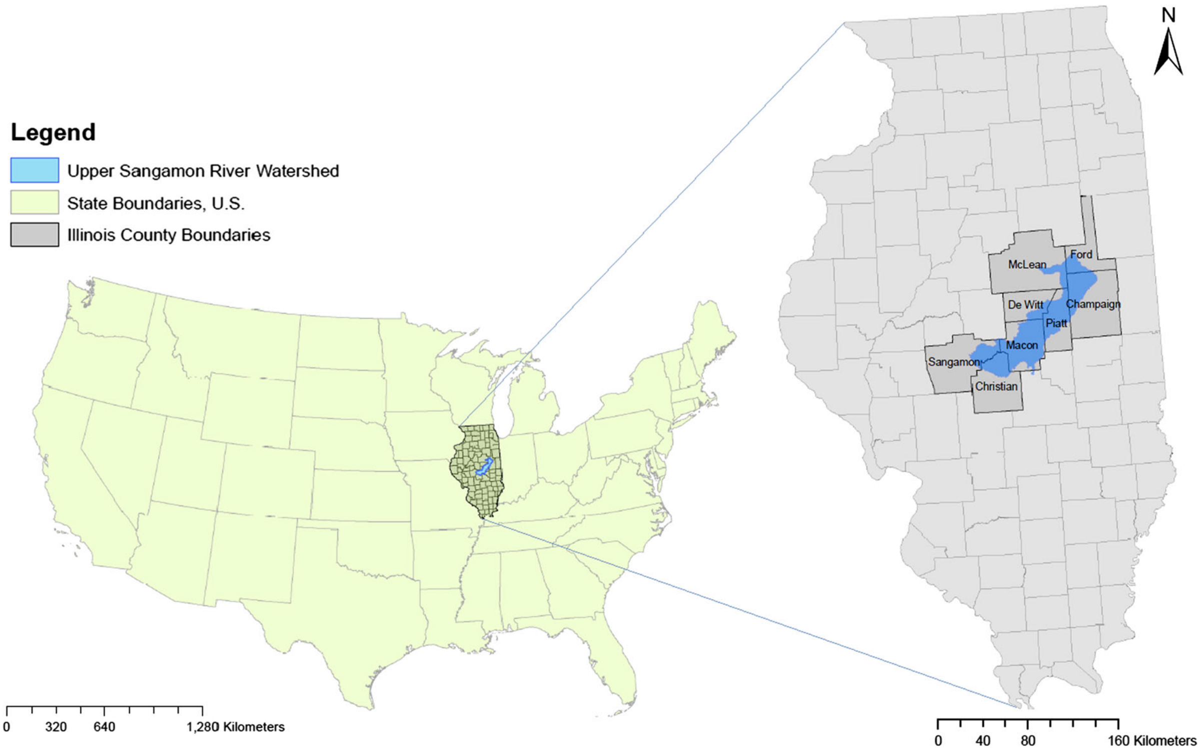

Fig. 1 Map of the Upper Sangamon River Watershed and its counties

watersheds, and non-point source pollution, typically from agriculture, is 1.84–2.76 nitrate-N kg/ha/year and 0.09–0.18 phosphorus kg/ha/year (Anbe 2004). The elevated levels have led to concerns with cropland management, especially in Macon County where Lake Decatur has consistently exceeded the Illinois Environmental Protection Agency drinking water standard of 10 mg/L of nitrate-N (Keefer et al. 2011). As a result of these issues, local and state government entities are exploring and promoting alternative agricultural systems such as MPCs for appropriate mitigation.

Data collection

The survey instrument investigated landowner barriers and motivators for implementing new cropping systems and explored the viability of MPCs, specifically on marginal land. The target population was agricultural landowners whose property was located in the USRW. County assessor's offices provided addresses of the 1500 agricultural landowners in the watershed, excluding land trusts and bank landowners. The self-administered mail and online survey was developed and administered following the guidelines outlined by Dillman et al. (2009). A selection of farmers participating in an agroforestry case study program (Savanna Institute 2016) volunteered to test the survey materials for validity. Survey data collection occurred from February 2015 to April 2015. An initial letter sent to landowners introduced them to the MPCs project and invited them to participate in the survey. The survey packet with return envelope was mailed the following week. Farmers had the option to complete the survey online at https://cropland.wufoo.com/forms/farm-survey/. A follow-up postcard was mailed 3 weeks later reminding non-responders to complete the survey by April 30th. A second method to recruit more respondents was a flyer in the February 2015 Farm Week for Macon and Piatt County that invited additional survey participants. Agricultural landowners are more likely to complete a survey if it is associated with familiar agricultural businesses and information sources (Pennings et al. 2002).

The format of the survey included four sections. The first section contained multiple choice and fill-in-the-blank questions on marginal land acreage and type. Likert scale questions measured preferences for seven types of MPC systems and valuation of ten ecosystem services. Likert questions were rated on a scale of 1–5, with lower scores indicating lower preferences. The second section contained questions on information routes, incentives, and agronomy-related needs to explore the motivators for or against adoption of new cropping systems. Also included was a series of questions on leasing arrangement preferences because land tenancy has been shown to be an important factor when deciding land management (Soule et al. 2000; Petrzelka and Armstrong 2015; Varble et al. 2016). There are two basic forms of farmland leases. Crop share is an arrangement in which the payment to the landowner from the renter is a share of the physical output, and cash rent has a fixed monetary sum as payment for the use of the land (Allen and Lueck 2008). The third section matched the USDA Agriculture Census format and gathered demographic information. The final section contained open-ended questions that provided respondents the opportunity to give unstructured thoughts on issues related to MPCs adoption. These responses were not included in the statistical analysis.

Focus groups

Focus groups were held in October 2015 following the initial review of survey data to gain greater insight into landowner and stakeholder attitudes towards new cropping systems. The focus groups allowed for unrestricted discussion of several topics identified as important by the survey: government funded agricultural programs, tenant/landowner relationships, and decision-aid tools such as precision agriculture. Focus groups were conducted at the Macon County Illinois Extension office and the Piatt County Farm Bureau office. The first focus group had five landowners, one Extension Specialist, and one non-governmental organization member. The focus group included a demonstration using the online tool EnviroAtlas from the Environmental Protection Agency (Pickard et al. 2015). Mapping tools were hypothesized to be an adoption decision-aide and landowner interest, and aptitude using a web-based mapping tool was tested. The second focus group consisted of one landowner and three non-governmental organization members. Discussions were audio recorded and transcribed. The focus group protocol and summary of discussion followed the guidelines given in focus group interviewing by Krueger and Casey (2015) in the Handbook of Practical Program Evaluation.

Survey data and analysis

Survey results were compiled into a Microsoft Excel database for data cleaning and exploration. Summary statistics describing the MPCs survey sample are presented in Table 1. Data were analyzed using statistical analysis Systems software, version 9.4 (SAS Institute, Inc. 2013) using two complementary multivariate statistical methods. First, a discriminant analysis reduced the survey data to a subset of variables most important for determining whether a respondent (observation), was a high (population 1) or low (population 2) potential adopter. To do so, the analysis requires each observation's population to be known. In the survey, respondents were explicitly asked whether they would convert land to MPCs. If they answered "yes", they were considered the "high potential adopter" population, and if they answered "no" they were the "low potential adopter" population. The discriminant analysis used the survey dataset with population one and two and created a model to predict the population of each observation. N-fold cross-validation was applied for forming the discriminant rule using Fisher's approach. Stepwise selection maximized parsimony for determining adoption potential by identifying the variables that produced the highest F score through ANCOVA, where the significance level for entry was 0.3, and the significance level for staying was 0.15.

Next, a hierarchical cluster analysis (HCA) explored underlying constructs in the survey data to identify distinct agricultural landowner categories based on measures of ecosystem service valuation, preferences for perennial cropping systems, and motivations for adoption. HCA took into account the similarity of survey respondent answers without knowledge of preset population groups. Ward's minimum variance method was used to determine clusters, because it limits over-connected clusters or compacted clusters.

The HCA procedure started with each respondent as a single cluster, and then hierarchical grouping reduced the number of clusters iteratively while maximizing their similarity based on the measured characteristics of survey responses. This outcome was achieved by reducing the number of clusters in an order that caused least impairment of the between cluster sum of squares (BSS). Cluster number was

Table 1 Comparison of demographic characteristics and farmland between MPCs respondents and the principal operators in the USRW counties or the Illinois population (USDA NASS 2012)

MPCs variablen	n	Value	USDA census	n	Value
Sample population (count)		120	Population (count)		10062
Age (years)	96			n = 6866	
Mean		63.0			58.6
SE		1.3			–
Distribution (%)	97			n = 6866	
<44 years		11.5			14.9
45–54 years		8.3			21.7
55–64 years		34.4			30.7
>65 years		45.8			32.7
Gender (%)	98			n = 10062	
Male		83.7			78.2
Female		16.3			21.8
Farming as occupation (%)	98			n = 6866	
Primary		42.9			55
Secondary		57.1			45
Farm size owned (ha)	93		Acres operated* (ha)	n = 3536	
Mean		83.8			46.8
SE		10.0			–
Distribution (%)			Distribution* (%)		
<49		31.2			44.8
50–179		33.3			17.1
180–499		24.7			14.7
500–999		8.6			10.9
>1000		2.2			12.6

* Reporting of NASS data in parallel format and at county level not available; Illinois statewide data for acres operated in place of acres owned (USDA NASS 2012)

chosen based on the BSS, R-squared value, and averaged values of characteristics for each cluster. An additional discriminant and stepwise analysis was conducted on the resulting clusters to provide a subset of key variables to assess for significant differences between clusters. ANOVA tests were used for continuous data, including Likert scale questions treated as interval data, and Chi-square tests were used for categorical data. Landowner categories were evaluated for adoption potential of MPCs based on the number of high and low potential adopters in each group and divided into high, medium, and low.

Results and discussion

Demographics and MPCs potential

Of the 1305 surveys sent, a total of 120 were returned or submitted online, for a response rate of 9.2%. Out of the total sample pool, 21 were returned less than 50% complete, giving a refusal rate of 17.5%, with 99 responding for a final response rate of 7.6%. The survey target audience were agricultural landowners, and considering that the USRW has a high land tenancy rate, with 60% of agricultural land rented or leased (USDA NASS 2012), it is a convenience sample. Because comparable data were available through the USDA Agricultural Census, we were able to measure how representative our sample was of the actual USRW population. The demographic data from the survey results showed similar trends to the Agriculture Census data (Table 1). The survey sample matches the trend of the increasing age of farm operators; those older than 65 were 46% of the USRW sample population, whereas statewide for Illinois they made up 18.1% (USDA NASS 2012). Regarding land tenancy, about half of the survey respondents lease land to others, with an average 81.6% of land owned being leased out (n = 48).

MPCs may first be adopted on marginal cropland, and a majority of respondents stated that they have some portion of marginal land (62.5%, n = 96), reporting an average of 7 ha (SD = 6.1, n = 52). The most popular use for marginal land was enrollment in conservation programs, with 35% of marginal landowners (n = 60) having 16 ha enrolled (SD = 29.2, n = 20). Approximately one third of the respondents said they would convert their marginal land to MPCs, an average of 13.2 ha (SD = 35.4, n = 32), indicating marginal land as a motivator for MPCs adoption. Respondents also gave their preferences for types of MPCs systems, and bioenergy received the most positive response (n = 84) (Fig. 2).

There was a significant difference between respondents that said 'yes' to converting to MPCs based on their land leasing arrangement, with landowners leasing a low proportion of their land out being more likely convert marginal cropland to MPCs ($P = 0.01$). The landowners' land tenancy status and its affect on their land management style was highlighted in the open-ended portion of the survey. When asked how they felt about their current farming practices, several respondents clarified that they were non-operators, or did not make farm management decisions. They offered answers such as "I cash rent [to others] all land and do not personally have any farming practices" and referred instead to their tenant's practices. Another barrier for MPCs adoption was lack of information, as landowners reported information as the incentive needed most for them to consider MPCs adoption. Regarding farming concerns, landowners most often sought information from agricultural seed and chemical suppliers.

Valuation of ecosystem services

The highest ranked ecosystem services were soil (89.2%) and water quality (81.7%) (n = 93) (Fig. 3). When asked how the environment influences farming decisions, a representative response of landowners was: "we work to maintain healthy fields and implement waterways and other erosion controls where needed." Agricultural run-off and soil loss were often reported important 85.9% (n = 92), and many respondents indicated improvement of soil management and water quality as motivators to try MPCs. Landowners indicated they try to maximize profits by managing soil health with well-timed inputs and system management (e.g., soil tests, hydrology management, crop rotation). Landowners also showed concern about tenants managing soil health and fertility, such as minimizing soil erosion with tillage methods (conservation tillage, minimum tillage, or no till). The overall awareness and valuation of ecosystem services shown by respondents indicates proper land management as a motivation for landowners and opportunity for multifunctional land-use strategies.

Focus groups

The consensus by focus group participants was that MPCs had potential, but two major barriers exist. To support the production of MPCs crops, developed markets and infrastructure are needed, including a labor force willing to learn and manage MPC systems. Participants expressed agreement that educating the next generation of farmers about MPCs could create that labor force. Major concerns about governmental

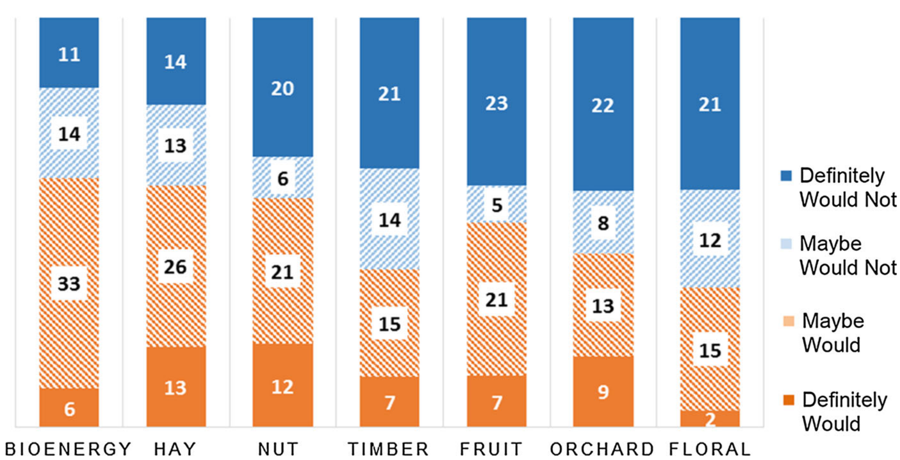

Fig. 2 The likelihood respondents would participate in various MPCs (average n = 87)

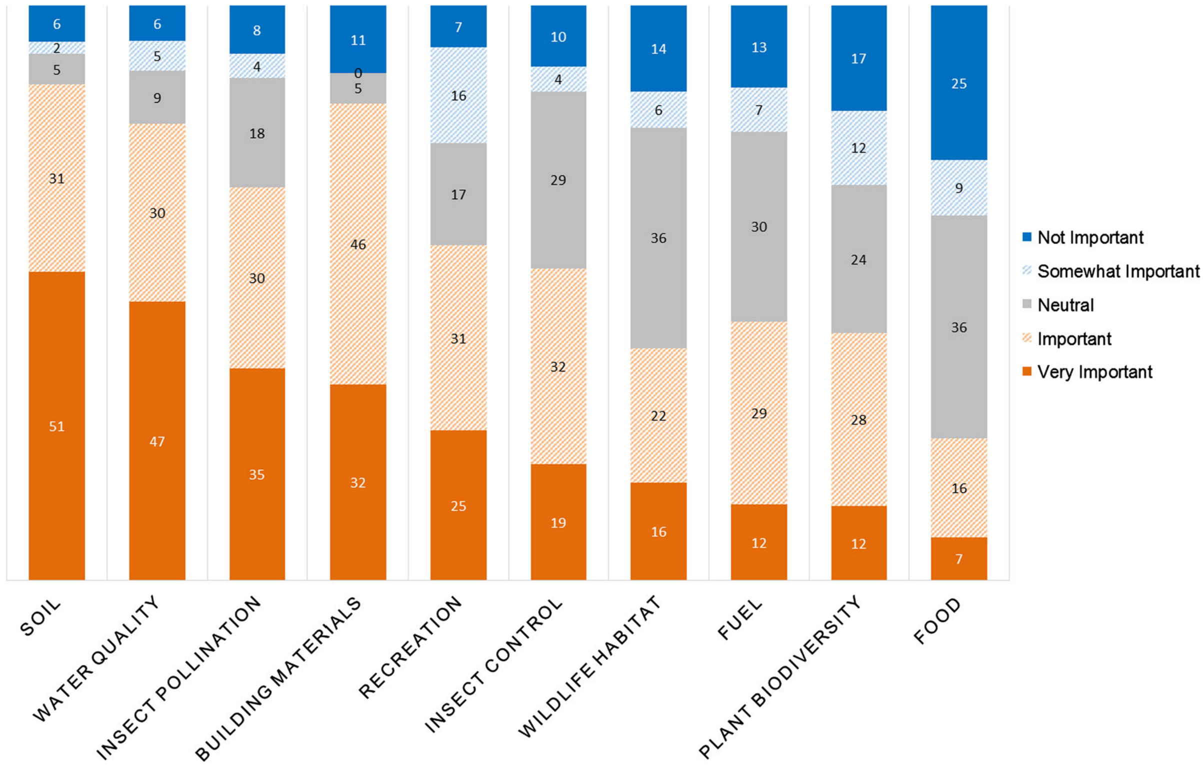

Fig. 3 The valuation of various ecosystem services by MPCs survey respondents from not important to very important (average n = 96)

regulations were voiced, and both farmer operators and NGO representatives agreed that new cropping systems could be used to comply with mitigation mandates and policies (Anbe 2004; EPA 2015).

Multivariate analysis

Multivariate analysis explored the underlying characteristics of the survey sample for landowner categories, using discriminant analysis and HCA to determine landowner characteristics that would best identify high potential adopters of MPCs. The discriminant function correctly classified potential adopters 69% and non-potential adopters 88% of the time. The survey questions most important for predicting adoption potential were: future involvement in farm management decisions, willingness to sublease portion of land to a MPCs farmer, willingness to plant harvestable perennial crops once a government conservation program contract was over, likelihood of enrolling in a government conservation program if products could be harvested from it, and valuation of plant diversity conservation on farmland.

The HCA resulted in six distinct clusters with an R-squared of 0.80 (Fig. 4). The six clusters represent landowner categories identified in the USRW, and each category was interpreted based on average values for variables and was considered for high or low adoption potential (Table 2). Conclusions on significant differences between clusters were made using ANOVAs for continuous and Likert scale data and Chi-square tests for categorical data (Table 3). Greatest parsimony may have been found with four clusters (Fig. 4), however, more information was lost as the characteristics of respondents were averaged within fewer clusters, and a reduction from six to four clusters resulted in a higher BSS and diminished R-squared. Six clusters achieved the goal of classifying respondents into both statistically strong clusters and practical categories to describe the USRW agricultural landowners.

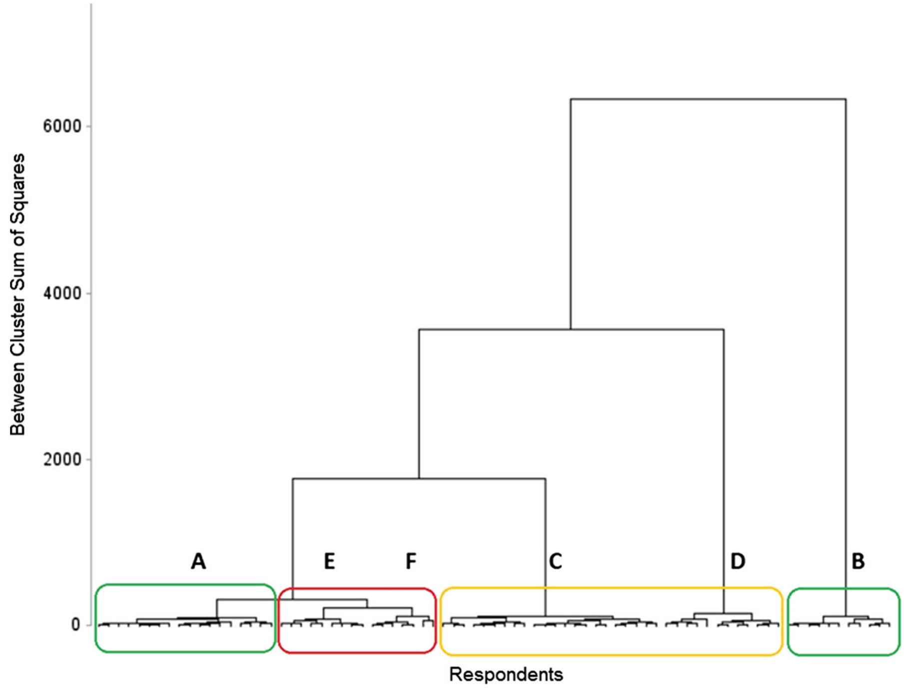

Fig. 4 Dendrogram of the hierarchical cluster analysis showing individual respondents in 6 unique clusters (*letters A–F*) (R-squared = 0.80). Dendrogram branch lengths are proportional to the distances between points and clusters when they are combined. The clusters represent the landowner categories identified by responses to the survey instrument. The categories fell along a continuum of high (*A*, *B*), medium (*C*, *D*), and low (*E*, *F*) adoption potential for MPCs

Landowner categories

The HCA excluded respondents with missing data (not including optional and text response questions), resulting in 79 successfully clustered respondents.

Educated networkers Cluster A comprised 22.8% (n = 18) of the sample and contained the majority of high potential adopters. Cluster A will be referred to as "Educated Networkers" (EN). Landowners in cluster A reported the highest average education levels with 14 respondents having a bachelor's degree or higher. members of cluster A were most likely to report farming as their secondary occupation (86.7%), and most interested in working with neighbors and selling farm products locally. EN were most willing to use a perennial cropping system if their neighbor was, and they would be most interested in joining a cooperative agreement for creating a connected network of MPCs. EN highly rated the importance of ecosystem services. Environmental awareness was highlighted in a respondent comment about his farming management as "too chemical rich… I am a career physician concerned by urea rates in [my] county." Another respondent also had chemical use concerns: "resistant weeds are the 800 pound gorilla in the room…land diversification will be necessary and critical." EN were most interested in nut perennial cropping systems, were willing to wait the longest for a perennial crop harvest, and they most highly valued the need for a well-established market for perennial crop products.

Young innovators Cluster B contained 13.9% (n = 11) of the sample, and 72.7% of them were identified as high potential adopters. Cluster B had the youngest average age for the landowner at 39 years old, and they indicated the greatest interest in perennial cropping systems. Cluster B will be discussed as the "Young Innovators" (YI). YI was the only cluster to indicate high involvement in decision-making for both current and future farm management. They reported high marginal and conservation land area, and they scored highest for interest in hay and bioenergy MPCs. This result highlights an opportunity for introducing perennial grasses for marginal land management and yield. One YI commented, "I'm interested in diversified crop mixes that take some of the burden away from row crops to cover [farming operation] costs."

Small conventional Cluster C was the largest group, comprising 27.8% (n = 22) of the sample, and 63.6% of cluster C were classified as high potential adopters. Landowners in this cluster had the smallest average farms size at 78.9 ha. Cluster C will be referred to as

Table 2 Categories of landowners and comparisons between their demographic and economic characteristics

Name	Educated	Young	Small conventional	Large conventional	Money motivated	Hands-off	n	Statistical values	
Category	A	B	C	D	E	F			
Potential	High	High	Medium	Medium	Low	Low			
n	18	11	22	12	9	7			
Gender (count)							79	$X^2 = 1.1428$	p = 0.2851
Male	16	11	19	9	6	7			
Female	2	0	3	3	3	0			
Age: average (SD)	64.2 (2.1)	39.3 (3.6)	54.9 (2.3)	80.7 (3.7)	70.9 (1.8)	65.4 (2.7)	79	F = 297.88	p = <0.0001[a]
Count distribution									
<44 years	0	11	0	0	0	0			
45–54 years	0	0	8	0	0	0			
55–64 years	9	0	14	0	0	3			
>65 years	9	0	0	12	9	4			
Has off-farm income (count)	10	4	11	8	5	4	79	$X^2 = 0.3741$	p = 0.5408
Owned hectares: average (SD)	75.4 (100.8)	260.2 (590.8)	78.7 (108.4)	334.9 (279.5)	76.1 (40.1)	98.8 (64.2)	79	F= 1.10	p = 0.3659
Count distribution									
<49 ha	7	4	9	2	0	0			
50–179 ha	6	1	6	3	6	3			
180–499 ha	4	4	4	5	3	4			
500–999 ha	1	1	3	1	0	0			
>1000 ha	0	1	0	1	0	0	79	F = 0.73	p = 0.6008
Marginal hectares							49	F = 1.15	p = 0.3468
Average (SD)	7.4 (9.5)	31.5 (69.2)	9.6 (10.8)	8.2 (4.4)	9.0 (10.6)	39.8 (49.9)			
n	12	8	15	7	3	3			
Conservation hectares							18	F = 3.82	p = 0.0265[b]
Average (SD)	10.0 (12.7)	40.2 (52.8)	2.8 (2.5)	0.4 (0.6)	5.3 (4.0)	-			
n	5	3	5	2	2	1			
Hectares leased to others							78	F = 1.44	p = 0.2216
Average (SD)	34.6 (63.8)	242.6 (597)	42.7 (97.2)	60.0 (55.8)	48.5 (43.0)	18.5 (34.0)			
n	18	11	22	12	8	7			

[a] Pairwise shows that all clusters are different except A and F

[b] Pairwise shows cluster F different than Cluster C and D

the "Small Conventional" (SC) cluster due to the emphasis among its members on a strong conventional farming identity. The SC landowners reported high involvement in management of their cropland, highlighted by their preference for crop share leasing arrangements, which bases the income received by the landowner on the yield produced by the land. Thus the landowner has a higher stake in the land management decisions (Soule et al. 2000). Water quality and agricultural run-off was a motivator for this group to

Table 3 Categories of landowners and comparisons between their preferences, ecosystem service (ES) valuation, and interest in various MPCs

Name	Educated	Young	Small conventional	Large conventional	Money motivated	Hands-off	N	Statistical values	
Potential	High	High	Medium	Medium	Low	Low			
Category	A	B	C	D	E	F			
n	18	11	22	12	9	7			
Hectares willing to convert to MPCs						32	32	F = 0.67	p = 0.618
Average(SD)	8.5 (12.0)	33.0 (74.7)	6.9 (6.3)	6.8(6.2)	8.3 (8.3)	–			
n	11	7	8	4	2	0			
Interest in various MPCs[a]	2.8	3.4	2.5	2.2	2.0	1.2	79	F = 4.75	p = 0.0008[b]
Insect control ES valuation[a]	4.3	3.9	3.6	4.3	4.1	3.1	79	F = 3.00	p = 0.0161[c]
Biodiversity ES valuation[a]	3.5	3.7	3.1	2.8	3.8	2.9	94	F = 1.53	p = 0.19
Plant ES valuation[a]	4.0	3.5	3.0	2.6	3.2	1.6	79	F = 5.92	p = 0.0001[d]
Willingness to plant MPCs after CRP contract[a]	3.2	3.3	3.1	3.0	2.4	1.4	79	F = 3.45	p = 0.0074[e]
Willingness to do CRP if harvestable[a]	4.1	3.9	3.6	3.6	3.1	1.9	79	F = 5.51	p = 0.0002[e]
Willingness to participate in perennial network[a]	3.7	3.0	3.2	3.2	3.1	2.3	79	F = 3.02	p = 0.0157[c]
Future involvement in farm management[a]	4.3	4.4	4.0	3.6	3.0	2.0	79	F = 6.12	p = <0.0001[e]

[a] Measured using five-point Likert scale question

[b] Pairwise shows cluster B different from E, and cluster F from A, B, and C

[c] Pairwise only shows differences between A and F

[d] Pairwise shows clusters A and D are different, and cluster F from A, B, C, and E

[e] Pairwise only shows cluster F different from A, B, C, and D

try MPCs, with the majority of their marginal land classified as riparian zones.

Large conventional Cluster D contained 15.2% (n = 12) of the sample and exhibited moderate potential for MPCs adoption, with high potential adopters making up half of the cluster. They had the oldest average age at 82 years. The strong conventional farming identity and larger relative acreage to SC was also a characteristic of Cluster D, thus it is named "Large Conventional" (LC). The valuation of ecosystem services by LC reflected a strong conventional mindset, where soil and insect control were scored highest and all other ecosystem services were scored as relatively unimportant. As one landowner expressed, "environmental concerns are important, but many environmental plans go too far and are unrealistic." An adoption challenge with the LC are their low reported acreage of marginal and conservation land. With larger farms, these landowners could utilize precision agriculture data to show where perennial cropping systems would be most needed.

Money motivated Cluster E comprised 11.4% (n = 9) of the sample. Less than half the respondents in this cluster were high potential adopters. Cluster E is considered "Money Motivated" (MM), because the most defining characteristic of this group was the land tenancy arrangements. Two-thirds of respondents in this group were most likely to prefer cash rent, an arrangement where the landowner receives a fixed rent payment irrespective of crop yield. All MM preferred long-term lease contracts, with about half leasing out 100% of their farmland, and about half relying on off-farm income. MM had generally positive valuation for ecosystem services, and the majority were uninterested in perennial cropping systems.

Hands-off Cluster F was the smallest group comprising 8.9% (n = 7) of the sample, and all respondents were classified as low potential adopters. Cluster F will be "Hands-off" (HO) due to their preference for cropping systems with low labor and time requirements. Members of HO reported the lowest scores for ecosystem services valuation and low willingness to work with neighbors and to network in the rural community. When asked about selling to local markets, respondents indicated they were "not willing due to age and time needed" and "not willing, too labor intensive." HO landowners were not willing to wait more than 1 year for a crop to be harvested, and had the lowest interest in perennial cropping systems. Their ties to annual systems was highlighted in the income data, where 71% of HO reported 90–100% of their income was from corn soy production.

Diversity in the USRW related to age, land tenancy, and farm size

The high number of landowner categories identified by the HCA implies a diversity of attitudes across sociodemographic characteristics. For example, age played a significant role in classifying attitudes towards MPCs for nearly all categories (Fig. 5), as seen in previous research (Strong and Jacobson 2006; Arbuckle et al. 2009). Focus group discussions also served to verify important motivators and barriers for MPCs adoption.

Land tenancy influences adoption of new practices (Soule et al. 2000; Daloğlu et al. 2014; Varble et al. 2016), and this factor was generally shown to be an adoption barrier for MPCs. The survey found that 35% of respondents rented out 90% or more of the land they owned (n = 99), and seven respondents reported they are not the farmer of the property. This result suggests these are absentee landowners, or non-operators that own but do not permanently reside on their farmland. One respondent, from Educated Networkers, commented: "Cropping decisions are made by the tenants, and are conventional corn and beans. I realize that's probably not optimal for the land, but 'everybody's doing it', and I feel like I should give the tenants freedom to farm their way." The types of leasing arrangements were also found to affect adoption potential. Cash rent incentivizes greater tenant effort in managing the farm operation but also incentivizes overuse of the land. Landowners with crop share lease arrangements are more invested in the success of the farm operation than those with cash rent (Allen and Lueck 1995; Soule et al. 2000; Fukunaga and Huffman 2009). The values of landowners preferring crop share lease arrangements could be compatible with MPCs.

Another demonstration of land tenancy that affects landowner adoption preferences is information and experience with the new land practice. Greater knowledge of a system is not always correlated with higher adoption rates. In a comparison of attitudes of absentee landowners versus operators, absentee landowners have more positive attitudes towards conservation practices, potentially due to naivety regarding management requirements (Nassauer et al. 2011; Daloğlu et al. 2014). In this regard, information is the limiting factor for increasing adoption rates of absentee landowners. The need for information incentives by the MPCs survey respondents reiterates information availability as agroforestry adoption barrier (Strong and Jacobson 2006; Barbieri and Valdivia 2010; Villamil et al. 2012).

Another factor that has previously been identified as relevant for the implementation or extent of agroforestry is farm size (Lovell et al. 2010; Trozzo et al. 2014). While there was no significant difference in farm size between the USRW landowner categories, the non-response bias where fewer landowners of large farm sizes responded to the survey infers that small and medium sized farms have greater interest in MPCs. In the U.S., small farms less than 72.8 ha, make up 20% of agricultural land area and 85% of the number of farms (USDA NASS 2012). Small farms are also the recipients of most government conservation payments (Hoppe et al. 2010). Survey respondents and focus group participants indicated harvesting land enrolled in government conservation programs as an adoption motivator. If conservation land was planted with perennial crops that take multiple years to establish, the planting could fulfill the conservation needs while providing additional crop products once the contract was over (3–15 years). Focus group discussions concluded that converting conservation

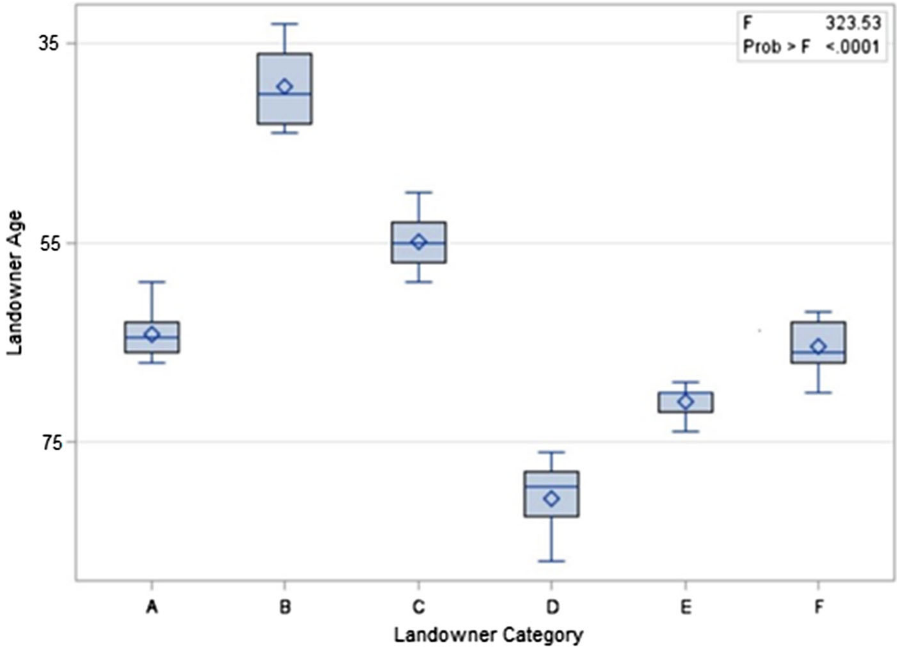

Fig. 5 Boxplots for the age of survey respondents for each landowner category

land to MPCs is a viable land management option once conservation contracts expire. Due to the large number of small farms and their contribution to rural communities, practices such as MPCs that introduce local products and diversify farm operations can facilitate rural development (Alavalapati et al. 2004; Rosset and Martínez-Torres 2012; Liebman et al. 2013). There is potential for this to occur in the USRW, as the majority of focus group participants and the educated networkers category indicated willingness to sell their farm products to local markets.

Limitations

The survey results provide valuable information to target landowners for MPCs adoption, however, the generalizability of the results are somewhat limited by non-response bias. The survey respondent dataset did not capture the full scope of landowners in the USRW, under-sampling large farms. While 12% of Illinois farms are greater than 404.7 ha, only 2.2% of MPCs respondents' farms were of that size (Table 1). The non-response bias from large farm landowners could be due to the characteristic of mailed and mixed mode surveys to receive higher response from those interested in the survey topic (Dillman et al. 2009). The overall low response of the survey could be attributed to this as well because surveys were mailed to the owners of the agricultural land. Due to 60% of the USRW farmland being leased, the landowner may not be a non-operator (Petrzelka and Armstrong 2015; USDA NASS 2012).

Research implications

The agricultural landowner categories can be used to prioritize implementation efforts for agroforestry and MPCs through information tools and outreach. Efforts can prioritize landowners that match the high potential adopter profile and then make use of the identified motivators and barriers of MPCs adoption. The high potential adoption landowners are generally of a younger age and a higher education level. They highly value the conservation of plant diversity on their farmland and have high valuation of soil and water ecosystem services. Natural resource professionals or conservation organizations could reach out to the landowners with environmental motivations to present MPCs as a practice to enhance ecosystem services (Malézieux 2012). High adoption potential also exists where landowners are highly involved in farm management decisions and have known marginal land area. A conclusion made by focus group participants was that in cases where landowners do not report marginal areas, an information tool such as precision agriculture could help them identify marginal land.

Connecting with the conventional farming identity categories for MPCs implementation may be a challenge because it is a characteristic found to negatively influence agroforestry adoption with absentee landowners (Arbuckle et al. 2009). However, one motivation identified for the small conventional and large conventional categories is mitigation of agricultural runoff, a function provided by perennial systems (Lee et al. 2003). This motivation may originate from government policies related to the environmental impacts of agricultural practices (Anbe 2004; EPA 2015). Focus group participants also came to this conclusion. One farmer said: "I would choose to do it [mandated practice] now while I had the choice, before the government gets involved." A major socioeconomic barrier was identified in landowners that prioritize financial and economic characteristics of a cropping system, such as those in money motivated and hands-off categories, because they are less likely to adopt agroforestry (Arbuckle et al. 2009). The adoption potential may remain low for these landowners until the infrastructure and market to support MPCs products is developed.

Conclusions

In this study, we sought to identify how farmer sociodemographics and attitudes influence willingness to implement new land-use systems and conservation practices, specifically for marginal land management. The high number of landowner categories identified in the USRW indicated a diversity of landowner types, each with socio-economic barriers and motivators pertaining to age and land tenancy status. Landowners with high adoption potential are motivated by improving ecosystem services on their land, whether in soil and water quality conservation or increasing biodiversity. Governmental policy and regulation pressures also provide motivation for MPCs adoption, as well as known marginal cropland area. Barriers are the lack of strong economic incentives, information and experience for MPCs, and an established market for MPCs.

The traits of landowners and farmers found to be most important for MPCs adoption potential match previous findings. Behavior and implementation studies are needed next to investigate adoption methods for new land practices. We need to determine which methods result in adoption success and test outreach on identified key groups, such as absentee landowners (Petrzelka et al. 2014). The next step for MPCs research is to work with individual landowners identified from the high potential adopter categories to develop custom MPCs for their property. Interviews will explore participant design preferences, adoption behaviors, and decision making throughout the innovation-decision process. Areas of opportunity for MPCs in the USRW will be identified, utilizing marginal land area mapping and an economic analysis for a MPCs market.

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References

Alavalapati JR, Shrestha RK, Stainback GA, Matta JR (2004) Agroforestry development: an environmental economic perspective. Agrofor Syst 61:299–310

Allen DW, Lueck D (1995) Risk preferences and the economics of contracts. Am Econ Rev 85:447–451

Allen DW, Lueck D (2008) Agricultural contracts. In: Handbook of New Institutional Economics. Springer, pp 465–490

Anbe DT (2004) Nutrient reduction strategy. Ill EPA 44:671–719

Arbuckle JG, Valdivia C, Raedeke A et al (2009) Non-operator landowner interest in agroforestry practices in two Missouri watersheds. Agrofor Syst 75:73–82. doi:10.1007/s10457-008-9131-8

Barbieri C, Valdivia C (2010) Recreational multifunctionality and its implications for agroforestry diffusion. Agrofor Syst 79:5–18. doi:10.1007/s10457-009-9269-z

Batáry P, Dicks LV, Kleijn D, Sutherland WJ (2015) The role of agri-environment schemes in conservation and environmental management: european agri-environment schemes. Conserv Biol 29:1006–1016. doi:10.1111/cobi.12536

Cai X, Zhang X, Wang D (2011) Land availability for biofuel production. Environ Sci Technol 45:334–339. doi:10.1021/es103338e

Daloğlu I, Nassauer JI, Riolo RL, Scavia D (2014) Development of a farmer typology of agricultural conservation behavior in the American Corn Belt. Agric Syst 129:93–102. doi:10.1016/j.agsy.2014.05.007

de Snoo GR, de Wit PJ (1998) Buffer zones for reducing pesticide drift to ditches and risks to aquatic organisms. Ecotoxicol Environ Saf 41:112–118

DeDecker JJ, Masiunas JB, Davis AS, Flint CG (2014) Weed management practice selection among Midwest U.S. organic growers. Weed Sci 62:520–531. doi:10.1614/WS-D-13-00138.1

Dillman DA, SMYTH JD, Christian LM (2008). Internet, Mail, and Mixed-mode surveys. The tailored Design Method. 3rd edn. John Wiley & Sons

EPA, Department of Defense (2015) Clean water rule: definition of "Waters of the United States" 80(124), pp. 37054–37127. Federal Register. https://www.gpo.gov/fdsys/pkg/FR-2015-06-29/pdf/2015-13435.pdf

Foley JA, Ramankutty N, Brauman KA et al (2011) Solutions for a cultivated planet. Nature 478:337–342. doi:10.1038/nature10452

Fukunaga K, Huffman WE (2009) The role of risk and transaction costs in contract design: evidence from farmland lease contracts in U.S. agriculture. Am J Agric Econ 91:237–249. doi:10.1111/j.1467-8276.2008.01164.x

Gelfand I, Sahajpal R, Zhang X et al (2013) Sustainable bioenergy production from marginal lands in the US Midwest. Nature 493:514–517. doi:10.1038/nature11811

Hoppe RA, Banker DE (2010) Structure and finances of U.S. farms: family farm report, in EIB-66, E.R.S. U.S. Department of Agriculture, Editor

Illinois State Water Survey (ISWS) (2015) Discovery report: upper sangamon watershed, 07130006. http://www.illinoisfloodmaps.org/DFIRMpdf/discovery/uppersangamon/UpperSangamonDiscoveryReport.pdf

Jose S (2009) Agroforestry for ecosystem services and environmental benefits: an overview. Agrofor Syst 76:1–10. doi:10.1007/s10457-009-9229-7

Keefer L, Bauer E (2011) Upper Sangamon River Watershed monitoring data for the USEPA targeted watershed study: 2005–2008. http://www.isws.uiuc.edu/pubdoc/CR/ISWSCR2011-03.pdf

Krueger RA, Casey MA (2015) Focus Group Interviewing. In: Newcomer KE, Hatry HP, Wholey JS (eds) Handbook of practical program evaluation, 4th edn. Wiley, Hoboken. doi:10.1002/9781119171386.fmatte

Lee KH, Isenhart TM, Schultz RC (2003) Sediment and nutrient removal in an established multi-species riparian buffer. J Soil Water Conserv 58:1–8

Liebman M, Helmers MJ, Schulte LA, Chase CA (2013) Using biodiversity to link agricultural productivity with environmental quality: results from three field experiments in Iowa. Renew Agric Food Syst 28:115–128. doi:10.1017/S1742170512000300

Lovell ST, DeSantis S, Nathan CA et al (2010) Integrating agroecology and landscape multifunctionality in Vermont: an evolving framework to evaluate the design of agroecosystems. Agric Syst 103:327–341. doi:10.1016/j.agsy.2010.03.003

Maisonneuve C, Rioux S (2001) Importance of riparian habitats for small mammal and herpetofaunal communities in agricultural landscapes of southern Québec. Agric Ecosyst Environ 83:165–175

Malézieux E (2012) Designing cropping systems from nature. Agron Sustain Dev 32:15–29. doi:10.1007/s13593-011-0027-z

Nair PKR, Nair VD, Kumar BM, Showalter JM (2010) Carbon sequestration in agroforestry systems. Adv Agron 108:237–307

Nassauer JI, Dowdell JA, Wang Z et al (2011) Iowa farmers' responses to transformative scenarios for Corn Belt agriculture. J Soil Water Conserv 66:18A–24A. doi:10.2489/jswc.66.1.18A

Nickerson CJ, Morehart M, Kuethe T et al (2012) Trends in US farmland values and ownership. US Department of Agriculture, Economic Research Service, Wasington

Pattanayak SK, Mercer DE, Sills E, Yang J-C (2003) Taking stock of agroforestry adoption studies. Agrofor Syst 57:173–186

Pennings JM, Irwin SH, Good DL (2002) Surveying farmers: a case study. Rev Agric Econ 24:266–277

Petrzelka P (2014) Absentee Landlords and Agriculture. In: Thompson PB, Kaplan DM (eds) Encyclopedia of Food and Agricultural Ethics. Springer, Netherlands, Dordrecht

Petrzelka P, Armstrong A (2015) Absentee landowners of agricultural land: influences upon land management decision making and information usage. J Soil Water Conserv 70:303–312. doi:10.2489/jswc.70.5.303

Pickard BR, Daniel J, Mehaffey M, Jackson LE, Neale A (2015) EnviroAtlas: a new geospatial tool to foster ecosystem services science and resource management. Ecosyst Serv 14:45–55

Rosset PM, Martínez-Torres ME (2012) Rural social movements and agroecology: context, theory, and process. Ecol Soc. doi:10.5751/ES-05000-170317

SAS Institute Inc (2013) Base SAS® 9.4 procedures guide: statistical procedures, 2nd edn. SAS Institute Inc., Cary

Savanna Institute (2016) Case study program. 501(c)(3) nonprofit organization. http://www.savannainstitute.org/

Schaefer PR, Dronen S, Erickson D (1987) Windbreaks: a plains legacy in decline. J Soil Water Conserv 42:237–238

Smith DJ, Schulman C, Curent D, Easter KW (2011) Willingness of landowners to supply perennial energy crops. Agricultural and Applied Economics Association Meeting, Pittsburgh

Soule MJ, Tegene A, Wiebe KD (2000) Land tenure and the adoption of conservation practices. Am J Agric Econ 82:993–1005

Strong N, Jacobson MG (2006) A case for consumer-driven extension programming: agroforestry adoption potential in Pennsylvania. Agrofor Syst 68:43–52. doi:10.1007/s10457-006-0002-x

Trozzo KE, Munsell JF, Chamberlain JL (2014) Landowner interest in multifunctional agroforestry riparian buffers. Agrofor Syst 88:619–629. doi:10.1007/s10457-014-9678-5

USDA National Agricultural Statistics Service (2012) County profiles: Illinois. Quick Stats. Ag Census Web Maps. USDA-NASS, Washington, DC. https://www.agcensus.usda.gov/

USDA National Agricultural Statistics Service (2015) Cropland data layer. USDA-NASS, Washington, DC. https://nassgeodata.gmu.edu/CropScape/. Accessed 6 Aug 2016

Valdivia C, Barbieri C, Gold MA (2012) Between forestry and farming: policy and environmental implications of the barriers to agroforestry adoption. Can J Agric Econ 60:155–175. doi:10.1111/j.1744-7976.2012.01248.x

Varble S, Secchi S, Druschke CG (2016) An examination of growing trends in land tenure and conservation practice adoption: results from a farmer survey in Iowa. Environ Manag 57:318–330. doi:10.1007/s00267-015-0619-5

Villamil MB, Silvis AH, Bollero GA (2008) Potential miscanthus' adoption in Illinois: information needs and preferred information channels. Biomass Bioenergy 32:1338–1348. doi:10.1016/j.biombioe.2008.04.002

Villamil MB, Alexander M, Silvis AH, Gray ME (2012) Producer perceptions and information needs regarding their adoption of bioenergy crops. Renew Sustain Energy Rev 16:3604–3612. doi:10.1016/j.rser.2012.03.033