

## Ecological worldview, agricultural or natural resource-based activities, and geography affect perceived importance of ecosystem services

C.B. Wardropper<sup>a,b,\*</sup>, A.S. Mase<sup>b,c</sup>, J. Qiu<sup>d</sup>, P. Kohl<sup>e</sup>, E.G. Booth<sup>f</sup>, A.R. Rissman<sup>b</sup>

<sup>a</sup> University of Idaho, Department of Natural Resources and Society, 875 Perimeter Dr. MS 1139, Moscow, ID 83844-1139, United States

<sup>b</sup> University of Wisconsin-Madison, Department of Forest and Wildlife Ecology, 1630 Linden Drive, Madison, WI 53706, United States

<sup>c</sup> University of Wisconsin-Madison Environmental Resources Center, 445 Henry Mall, Room 202, Madison, WI 53706, United States

<sup>d</sup> University of Florida, School of Forest Resources and Conservation, Fort Lauderdale Research and Education Center, 3205 College Ave, Davie, FL, 33314, United States

<sup>e</sup> Nicholson School of Communication and Media, University of Central Florida, 12405 Aquarius Agora Dr. Orlando, FL, 32816-1344, United States

<sup>f</sup> University of Wisconsin-Madison, Department of Agronomy, 1575 Linden Drive, Madison, WI, 53706, United States

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### ABSTRACT

Understanding public perceptions of the importance of ecosystem services (ES) is crucial for the development and communication of sustainable management and policies. Yet public perspectives on ES and their sociocultural and geographic patterns are not well understood. This study asks: Which ES are perceived as more or less important by the general public?; Which ES are considered most similar when the public are asked to evaluate the importance of specific water, agricultural and natural resources ES?; And, what individual and geographic factors are associated with perceived importance of different ES? We conducted a survey of residents in an urban and agricultural watershed in the U.S. Upper Midwest (n = 1136). This study asked respondents about a wider range of ES than is typical, and examines how ecological worldviews influence the perceived importance of ES. Respondents rated regional provision of drinking and surface water quality, clean lakes and rivers for wildlife, and a reliable supply of drinking and surface water most important. Those with a stronger ecological worldview tended to rate natural areas and processes as more important and agricultural products as less important than respondents with a more anthropocentric worldview. Perceived importance of various ES was also predicted by other individual-level factors relating to livelihood, outdoor recreation, and proximity to lakes, forests and agriculture. For example, respondents with livelihoods dependent on agriculture rated agricultural products and rural character highly. These findings bolster the case for more context-specific assessments of public importance ratings for environmental benefits to inform planning and management.

### 1. Introduction

Many scholars and practitioners have adopted an ecosystem services (ES) framework to demonstrate and assess environmental benefits for humans and the regulating services that support benefit provision. According to proponents of this approach, direct and indirect ES support human wellbeing at many scales and in a variety of landscapes (Boyd & Banzhaf, 2007; Costanza et al., 2014; de Groot, Wilson, & Boumans, 2002). There are increasing calls in the scientific literature to develop comprehensive ES assessment frameworks that integrate biophysical, socio-cultural, and monetary values (Tallis & Polasky, 2009; de Groot, Fisher et al., 2010; Martín-López, Gómez-Baggethun, García-Llorente, & Montes, 2014; Torralba, Fagerholm, Hartel, Moreno, & Plieninger, 2018). Yet most of the focus has been on measurement of individual ES, with less attention given to how the broader public understands and values different types

of ecosystem services in relation to one another (Turner et al., 2016). Furthermore, there has been little work using theoretically grounded individual and landscape factors to predict the plural values ascribed to ES. This study uses survey data from an urban and agricultural watershed in the U.S. Upper Midwest to first assess ES through the lens of their perceived importance on a regional scale. Second, this study relates ratings of ES importance to a psychologically stable predictor of ecological worldview, measured by the New Ecological Paradigm (NEP), and to a suite of other variables including location of respondents' residences on the landscape and respondents' resource use for recreation or their livelihood. Our study contributes to ES and natural resource management literatures by leveraging these psychological, activity, and geographic variables to improve understanding of why resource users ascribe subjective values to different ES. We argue that engaging more deeply with individual predictor variables is crucial for the development of salient policies and the goal of providing benefits

\* Corresponding author at: University of Idaho, Department of Natural Resources and Society, 875 Perimeter Dr. MS 1139, Moscow, ID 83844-1139, United States.  
E-mail address: [cwardropper@uidaho.edu](mailto:cwardropper@uidaho.edu) (C.B. Wardropper)

to all people, not just to those with greater advocacy capacity (Rissman, Kohl, & Wardropper, 2017).

Since the concept of ecosystem services became widely used in the scientific literature in the 1990s (Costanza et al., 1998; Daily, 1997; de Groot, 1992), research has become increasingly sophisticated with respect to addressing the ways in which nature contributes to people. ES have become prominent in arguments for ecosystem protection by representing the (often monetary) values of the goods and services provided by ecosystems that fulfill human needs and contribute to well-being (Fisher, Turner, & Morling, 2008). One early effort to assess and quantify ES is the Millennium Ecosystem Assessment (MA). The MA identifies the following ES categories, which are commonly used by ecologists and economists, among others: (1) provisioning services, such as food and water; (2) regulating services, such as purification or cooling of water or air; (3) cultural services, such as recreation and aesthetic appreciation; and (4) supporting services, such as nutrient and water cycling and primary production (Millennium Ecosystem Assessment, 2005). Since the MA categories were proposed in 2005, efforts to put the concept into practice have increased rapidly (Daily & Matson, 2008; Posner, Verutes, Koh, Denu, & Ricketts, 2016), and numerous expansions and variations have been proposed. One of the most recognized, the Economics of Ecosystems and Biodiversity (TEEB) report, expanded on the MA through a meta-analysis of the monetary values of ecosystem services across biomes, and by further addressing the link between biodiversity and ES (de Groot, Fisher et al., 2010). Following the TEEB report, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012 to incorporate wider conceptualizations of values and valuation into ecosystem assessment, including the notion of “nature’s contributions to people,” which is context-specific (Díaz, Demissew, Joly, Lonsdale, Larigauderie, 2015). Many studies and uses of ES now focus on how nature benefits people directly as well as the supporting functions that enable those benefits.

The benefits of nature and ecosystem services to people are pluralistic and complex, which is reflected in the evolution of ES conceptualizations from a historic focus on economic valuation towards more inclusive methods of valuation (Van Riper et al., 2017). Indeed, environmental arenas often feature conflicts and compromises among groups with different values and interests. This characteristic can be described as value pluralism, the idea of multiple human values that may not be commensurate (O’Neill, 1997). Pluralistic values are unevenly represented by interest groups (Rosenbaum, 2013). The IPBES recommends that assessment teams tasked with conceptualizing “multiple values of nature and its benefits, including biodiversity, ecosystem functions, and services” start by identifying the range of values associated with nature (IPBES, 2015). Values can refer to principles, preferences, importance levels, and measures such as quantity (IPBES, 2015). The importance people ascribe to the benefits of nature provides a broad, non-economic framing of value; many highly important products and relations have low monetary prices (Heal, 2000). The task for policy-makers and resource managers wishing to incorporate value pluralism into decisions, then, is to elicit or predict what different resources users view as important in ecosystems, and how to address diverse importance rankings. Seeking to create a usable output that honors pluralistic values, this study illuminates the multiple ES values that exist in a particular place, and relates those values to individual and geographic characteristics that may help managers target and communicate their work.

Predicting views about, or values associated with, natural resources issues is complicated by differences in individuals’ beliefs about the natural environment and human-nature relationships (Muhar et al., 2018). However, few studies have adequately accounted for this factor in models predicting views of ES (Flint, Kunze, Muhar, Yoshida, & Penker, 2013). We address this gap by including what has become

the most popular research measure of beliefs about the natural environment in our prediction models, the NEP scale of ecological worldviews (Dunlap, 2008; Dunlap, Van Liere, Mertig, & Jones, 2000). The scale is composed of a series of statements about living in harmony with nature (biocentrism) or having mastery over nature (anthropocentrism). Our use of the NEP to predict ES values is one of the important contributions of this paper.

Our research also contributes to calls to better understand how different groups of people value and conceptualize ES in the context of their particular landscape (Bryan, Raymond, Crossman, & Macdonald, 2010; de Groot, Alkemade, Braat, Hein, Willemsen, 2010; Loomis, Ortner, Kelble, & Paterson, 2014). Our approach examines the extent to which individual worldviews, resource use, demographic characteristics, and landscape features relate to the perceived importance of ES in a mixed urban and agricultural watershed. Based on a household mail survey in Dane County, Wisconsin, USA, focused on its Yahara watershed, we investigate public perceptions of ES and predictors of relative ES importance for different respondents. Our research questions are: (Q1) Which ES are perceived as more or less important by the general public?; (Q2) Which ES are considered most similar when the public are asked to evaluate the importance of specific water, agricultural and natural resources ES?; And, (Q3) what individual and geographic factors are associated with perceived importance of different ES? (e.g., serving agricultural, recreation, cultural, or household needs)?

## 2. Literature review: Factors influencing perceived importance of ES

Human interactions with, and views of, ES are the subject of a growing body of literature. Relevant to our analysis, a number of studies examine how people group, or “bundle,” diverse types of value when asked about the importance of an ES. For example, Klain, Satterfield, and Chan (2014) conducted interviews with coastal community residents in British Columbia and found that respondents talked about cultural ecosystem services within distinct bundles - multiple ES were linked together as place and heritage ES or as artistic ES. Other studies have asked people to rate the importance of different ES. For instance, Martín-López et al. (2014) used survey data to ask about the socio-cultural importance of ES in Spain. They found that water quality was perceived as most important, while food from farming and fishing was the least important of the list of services they included. In a survey conducted by Smith and Sullivan (2014), Australian farmers consistently rated water quality protection and maintenance of soil as the most important ES for their farms. Quintas-Soriano et al. (2018) tracked the number of times an ES category was mentioned in survey data from two U.S. and one Spanish site, and found that cultural ecosystem services were the most frequently discussed across all research sites.

Our survey asked respondents to rate how important it was to them that the region provide an array of potential benefits (see more in Section 3.3: Model Variables). The survey instrument separated the benefits into two categories: agricultural and natural resources, corresponding with major land uses in the watershed. We chose ES across all four MA categories (provisioning, regulating, cultural, and supporting) in order to ensure we were in conversation with larger discussions of ES provision and value. We further chose the specific ES because of their relevance to the larger project within which this research was conducted (Carpenter et al., 2015), which modeled the trajectory of different ES under four future scenarios. These ES were also illustrative of “hotspots” and “coldspots” of multiple service delivery and policy attention (Qiu & Turner, 2013; Qiu, Wardropper, Rissman, & Turner, 2016).

This study accounts for several individual-level factors that may influence how people rate the importance of various ES provided by

their region, including ecological worldview, livelihood, outdoor activities, geography, and demographics. We were particularly interested in the relationship between NEP and different groups of ES, because we hypothesized that this sociocultural measure would be most influential in explaining the range of importance scores across ES stereotypically associated with biocentric (e.g., visiting a park) versus anthropocentric worldviews (e.g., agricultural products provision). Other independent variables were chosen as context- and issue-specific explanatory variables. We asked whether a respondent's livelihood was dependent on agriculture because many of the ES we queried in the survey were related to agricultural products, and we posited that having a personal stake in agriculture would influence perceptions. The outdoor activities included in the model – visiting a park and fishing – were chosen to be representative of activities in which a variety of people engage, that are common in our study site, and that take place in terrestrial and aquatic places. Our geographic variables – distance to water, percent adjacent agriculture, and percent adjacent forest – represented the most common natural or semi-natural landscape features providing ES with which residents might interact. Our demographic variables – gender and age – have been shown to create differences in views and interests across a range of issues, including the environment.

### 2.1. Ecological worldview

In this study, we measure ecological worldview using the revised NEP scale developed by Dunlap et al. (2000). The NEP scale taps into beliefs about nature and human relationships to the natural world that form the core of a person's belief system. Social psychologists and other researchers see these core beliefs as influencing a wide range of attitudes concerning more specific environmental and natural resource issues (Dunlap et al., 2000; Stern, Dietz, & Guagnano, 1995). Items on the NEP scale ask respondents to rate their level of agreement or disagreement with a set of 15 statements, including statements on beliefs about humans' ability to upset the balance of nature, the existence of limits to growth for human societies, and humanity's right to rule over nature (Appendix A). Given the nature of these items, we anticipated that a stronger ecological worldview would correspond with greater importance for ES associated with less instrumental ways of enjoying nature, such as visiting a park, following past studies (e.g., Van Riper & Kyle, 2014). We also expected a stronger ecological worldview to predict lower importance ratings for ES relating to agricultural products, which involve management of nature to benefit humans and is increasingly technologically driven (Marsden, 2012).

### 2.2. Agricultural livelihood

Livelihoods have been used to predict perceived ES values in previous studies (e.g., Kari & Korhonen-Kurki, 2013; Reed et al., 2015). Other studies have additionally connected agricultural livelihoods with pro-environmental behavior (Prokopy et al., 2019). Natural resource-based livelihoods create ES, such as agricultural goods, and are sustained by other ES, such as flood control and fresh water provision. Livelihoods become especially important in the context of payments for ES programs, which supplement income for those with natural resource-based livelihoods through payments to preserve certain ES (e.g., Zheng et al., 2013). Yet conservation to preserve ES can sometimes clash with immediate needs, particularly for subsistence households (Rodríguez et al., 2006), but also for agricultural households with higher incomes (Reimer, Thompson, & Prokopy, 2012). Nonetheless, we expected that reliance on agriculture for livelihood would be associated with higher importance values for the agricultural provisioning ES.

### 2.3. Outdoor recreational activities

People who engage in outdoor recreation tend to be concerned about the environment, but this varies with the activity and the environmental issue (Teisl & O'Brien, 2003). Outdoor recreationists hold a range of concerns for the environment. For instance, Daigle, Hrubec, and Ajzen (2002) found that hunting was associated with multiple benefits in the minds of people taking part in that activity, including "creating or maintaining significant relationships with family or friends," "getting exercise and staying in shape," and "feeling a sense of belonging and familiarity with nature." Thus, we might expect recreationists to view numerous benefits or services derived from nature as important. While our study did not seek to elicit behavior responses, other studies have investigated the connection between pro-environmental behavior and outdoor recreation activities. For instance, Cooper, Larson, Dayer, Stedman, and Decker (2015) found that both hunters and birdwatchers were 4–5 times more likely than non-recreationists to engage in conservation behaviors. Self-identified environmentalists tend to engage primarily in activities with little or no environmental impact, though their avoidance of activities considered extractive (e.g., hunting) or motorized is inconsistent (Wolf-Watz, Sandell, & Fredman, 2011). Thus, we did not have clear expectations as to whether fishermen would differ from park visitors in their ratings of different ES importance. Rather, we expected that participation in either of these activities would result in higher importance ratings for any of the natural areas and processes ES.

### 2.4. Geography

We included three geographic variables in our survey analysis: distance of home address to nearest water body, percent agriculture in vicinity, and percent forest in vicinity. Geographic variables are increasingly included in ES analyses (Nemec & Raudsepp-Hearne, 2013; Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013), with the recognition that views of ES are contingent on particular places. We expected that proximity to these landscape features would increase respondents' perceived importance of associated services. We were interested in respondents' distance to a water body because we anticipated that closer proximity would make people rate water for recreation and habitat more highly. The spatial relationship between watershed residents' location and their views of water services and disservices has been found in other studies; for instance, Brody, Highfield, and Peck (2005) studied the spatial clustering of perceptions of water in Texas watersheds, and found that responses of people who lived in densely populated areas and closer to a creek were more likely to cluster with similar views than those living further away and in less populated areas. We further anticipated that people living closer to both agriculture and forests would rate related ecosystem services as more important. Past studies support this assumption, including Muhamad, Okubo, Harashina, Gunawan, and Takeuchi (2014), which demonstrated that people living closer to agroforests perceived more ecosystem services provided by the landscape than those living further away.

### 2.5. Demographics

We included gender and age to control for demographic differences. Gender and age have been shown to have an effect on environmental attitudes and behaviors (Blankenberg & Alhusen, 2018; Stern, Dietz, & Kalof, 1993), though they often account for less than ten percent of variation in statistical analyses (Jones & Dunlap, 1992). Women of all ages generally have stronger environmental attitudes and behaviors than men (Zelezny, Chua, & Aldrich, 2000), which has been found to be due to socialization towards other-oriented and so-

cially-responsible behaviors. On the other hand, agricultural products can carry the valence of either industrial production, which is traditionally more male-oriented, or feeding the household, more female-oriented (Laslett & Brenner, 1989). Younger people tend to exhibit stronger environmental concern than older people (Johnson, Bowker, & Cordell, 2004). Agricultural products views depend on the type of food issues in question – providing for the family versus supporting local growers, for instance (Witzling & Shaw, 2019).

### 3. Methods

#### 3.1. Study area

The study region in south-central Wisconsin, USA, was defined as Dane County plus small areas of adjacent Rock and Columbia Counties within the Yahara Watershed (Fig. 1). The region's urban core is located primarily along the shores of the three upstream lakes of the Yahara watershed's chain of five lakes. The rest of the study region is primarily agricultural land dominated by corn, soybean, and alfalfa fields, and dairy production. The Yahara Watershed's lakes are well-studied and prominent features in the county's landscape. Dane County is also home to the Wisconsin state capital, Madison, a metropolitan area of approximately 300,000 people.

This region has experienced high-profile changes in, and tradeoffs among, ES. Nutrient runoff from dairies and other farms, as well as urban areas, has been an ongoing concern as it drives poor water quality in downstream water bodies. Agricultural runoff is the largest contributor to phosphorus pollution, which causes algae blooms every summer that are a focal point of local concern. The region has a history of efforts to reduce phosphorus in the lakes, starting as early as the 1970s (Wardropper, Chang, & Rissman, 2015). Despite these efforts, the frequency and severity of algal blooms has not declined. Over the past decade, manure production, development, and extreme rainfall events have all increased, which may have offset efforts to manage phosphorus in this region (Gillon, Booth, & Rissman, 2016; Lathrop & Carpenter, 2014). While supplies of freshwater from a high-yielding sandstone aquifer are abundant for household consumption, this groundwater pumping has led to stresses on regional lakes, streams, and wetlands due to reduced groundwater flow (Booth, Zipper, Loheide, & Kucharik, 2016).

#### 3.2. Survey instrument

Our survey asked respondents about their views related to water quantity and quality, agriculture, recreation, and climate change. We did not explicitly use the term "ecosystem services" in order to make language accessible to a general audience. We developed our survey

by first pretesting questions with regional experts from watershed and agricultural organizations, and undergraduate students ( $n = 18$ ). The pretest survey was distributed in June and July of 2015 and allowed respondents to make comments about how the survey could be improved, which we used to adjust the final survey. Some respondents also sent us survey feedback by email after taking the survey.

The survey was administered by the University of Wisconsin Survey Center from August to October of 2015. We sent the mail questionnaire to 2200 residential addresses based on a United States Postal Service address database. Our sample was randomized by household and stratified by rural and urban census blocks in order to ensure adequate representation; 60% of addresses were drawn from urban areas and 40% from rural areas, compared with the actual household composition of 88% urban and 12% rural (Census Bureau, 2010a). We conducted a four wave mailing following the Dillman tailored design method (Dillman, Smyth, & Christian, 2014), specifically, an initial survey booklet with a \$2 incentive, a reminder postcard, and a second and third mailing of the survey booklet if no response was previously received. 1136 usable surveys were returned for a response rate of 52%.

#### 3.3. Model variables

We describe the model variables below, and in Table 1, used to determine factors associated with importance scores attributed to different groups of ES.

**Ecosystem Services importance.** We asked respondents to rate the importance of 19 ES. We asked the following questions, "How important is it to you that the region provides the following agricultural benefits?" and "How important is it to you that the region provides the following natural resource benefits?" We phrased the questions in this way in order to provide specificity and avoid jargon. Response options were on a 5-point Likert scale, from 1, "Not at all Important," to 5, "Extremely Important."

**Ecological worldview.** We used the New Ecological Paradigm scale (15 items; Appendix A) developed and refined by Dunlap et al. (2000). Response options were on a 5-point Likert scale, from 1, "Strongly disagree," to 5, "Strongly agree." The NEP score was calculated using the mean of 15 items (including seven reverse-coded items). A higher score indicates a stronger ecological (or biocentric) worldview, and a lower score indicates a weaker (or anthropocentric) ecological worldview.

**Agricultural livelihood.** We asked the yes or no question, "Is your livelihood connected to or dependent on agriculture, as a farmer, manager, laborer, consultant, agronomist, or something else?"

**Recreational activities.** We asked, "How often do you participate in the following outdoor recreational activities [Visiting a park; Fishing]?" with response options being 1, "Not at all" to 5, "Very often."

**Geographic attributes.** Survey responses were geolocated using mailing addresses and the Google Maps API geocoding tool (<https://developers.google.com/maps/documentation/geocoding>). This location datapoint was then used to define the respondent on a spectrum for three geographic variables: distance to nearest water body (in meters), percent agriculture in vicinity, and percent forest in vicinity. These variables were created using the 2011 NLCD (National Land Cover Dataset) (Homer et al., 2015).

**Demographics.** Age and gender were determined through survey items. Age was measured as a continuous variable, in response to the question: "What is your age? (in years)." Our gender response options included "male," "female," and "prefer not to say."

#### 3.4. Statistical analysis

To address our first research question on the overall perceived importance of ES, we report the mean and standard error for each of

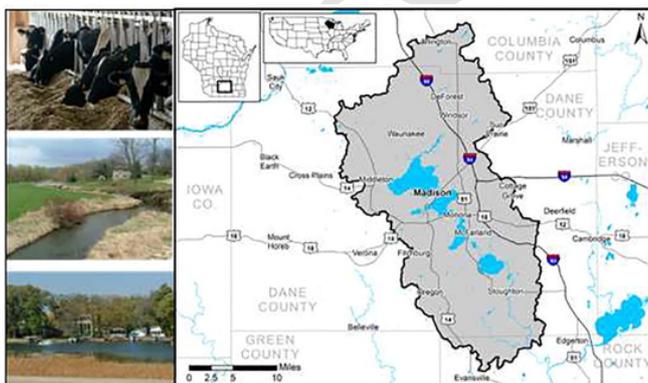


Fig. 1. The Yahara Watershed in Dane County, south central Wisconsin. This figure is adapted from the front page of the household survey mailed to 2200 residential addresses.

**Table 1**  
Variable names, data sources, and descriptive statistics. See Appendix A for full survey items with response options.

Variable	Data source and description <sup>1</sup>	Mean (S.E.)
<i>Ecosystem Services</i>		
Agricultural products	Survey. Composite score. (alpha = 0.87)	3.91 (0.02)
	Agricultural products for local consumers	4.18 (0.02)
	Agricultural products for non-local consumers	3.55 (0.03)
	Fruits and vegetables	4.17 (0.02)
	Dairy products	4.19 (0.03)
	Corn and soybeans to feed livestock	3.79 (0.03)
	Grass or pasture to feed livestock	3.99 (0.03)
	Biofuel crops	3.04 (0.04)
	Farmer livelihoods	4.31 (0.02)
<i>Natural areas and processes</i>		
	Survey. Composite score. (alpha = 0.88).	4.46 (0.02)
	Clean lakes and rivers for fish and wildlife	4.66 (0.02)
	Clean lakes and rivers for recreation	4.41 (0.02)
	Reliable water supply for lakes and rivers	4.61 (0.02)
	Forests and grasslands that remove and store carbon dioxide from the air	4.19 (0.02)
	Forests and grasslands for wildlife	4.46 (0.02)
	Forests and grasslands for recreation	4.12 (0.03)
<i>Rural character</i>		
	Survey. Composite score. (correlation = 0.59).	3.63 (0.03)
	Scenic farms	3.45 (0.03)
	Farming heritage	3.81 (0.03)
<i>Water for households</i>		
	Survey. Composite score. (correlation = 0.67).	4.82 (0.01)
	Drinking water that is clean and safe	4.89 (0.01)
	Reliable water supply for drinking, showering and laundry	4.76 (0.01)
<i>Other</i>		
	Survey. Flood control	4.18 (0.03)
<i>Worldview</i>		
New Ecological Paradigm	Survey. Composite score, mean of 15 items (see Appendix A). (alpha = 0.87).	3.6 (0.02)
<i>Livelihood and activities</i>		
Agricultural livelihood	Survey. Yes/No response.	16.5% Yes (0.01)
Park visit frequency	Survey.	3.57 (0.03)
Fishing frequency	Survey.	2.33 (0.04)
<i>Demographics</i>		
Age	Survey. Number of years response.	53.22 (0.5)
Gender	Survey. Male/female/prefer not to say response.	NA (0.02)
<i>Geography</i>		

**Table 1 (Continued)**

Variable	Data source and description <sup>1</sup>	Mean (S.E.)
Distance to water (m)	NLCD (National Land Cover Database) 2011.	1,482 (37.17)
Percent adjacent agriculture	NLCD 2011. Percent within 1-mile radius.	14.18 (0.75)
Percent adjacent forest	NLCD 2011. Percent within 1-mile radius.	29.75 (0.31)

<sup>1</sup> Survey response options on a 1–5 Likert scale, unless noted under data source.

the 19 ES presented. To answer our second research question, we performed exploratory factor analysis (EFA), following Qiu and Turner (2013), to identify the latent factors underlying the 19 items measuring perceived importance of the ES presented. EFA determines a smaller number of distinct “factors” that account for the structure of a set of correlated variables (Johnson & Wichern, 2002). A correlation matrix was calculated using ‘hcor’ function in the *polycor* package (Fox, 2016), and factor analysis was performed based on the calculated correlation matrix using the ‘fa’ function in the *psych* package (Revelle, 2018). These analyses were performed using R 3.3.3 statistical software (R Development Core Team 2007). Inspection of the scree plot and eigenvalues suggested a four-factor solution. We extracted these four orthogonal factors with varimax rotation. We report the mean of composite factors, and the Cronbach’s alpha or Pearson’s correlation for factors, as well as standard error and standard deviation in Table 1.

Using the ES factors that emerged from the EFA, we ran four multiple linear mixed effects models to examine what individual and landscape factors affect the perceived importance of different groups of ES (Q3). Any individual with missing responses for any item used in this analysis was excluded. Analyses were performed individually for each identified group of ES, with calculated factor score as the response variable. We included the respondent’s residence in an urban or rural area, as defined by the U.S. Census (Census Bureau, 2010a), as a random effect in the models in order to account for our sampling differences and potential variation between urban and rural residents. Rather than making inferences from a single best model, we used multi-model inference analysis to avoid the uncertainty of model selection (Burnham & Anderson, 2004). We used second-order AIC (i.e., AICc) corrected for small sample sizes to evaluate and rank all possible models, and created a subset of models within 2 AICc units of the best model for model averaging. We presented the model-averaged coefficient estimates as well as the importance (i.e., the sum of the model weights within the set that included that variable) for each predictor variable as the final model outputs. All predictor variables were standardized prior to analyses. Heterogeneity of residuals, normality of errors, and multicollinearity among predictor variables indicated by variance inflation factors (VIFs) were assessed for the full models; no violations were detected. All statistical analyses were performed in the R 3.3.3 statistical software.

#### 4. Results

Our sample of respondents was mostly representative of the regional population, with a somewhat higher response rate from older, White and male people compared to median county population statistics. Our respondents had a median age of 55, are 88.8% White, and 43.4% female, while Dane County had a median age of 34.4, 84.7% White, and 50.5% female as of 2010 (Census Bureau, 2010b). A majority of survey respondents were residents of the region for 20 years or longer.

The ES given the highest mean importance by respondents were clean drinking water, water supply for households, and clean lakes

and rivers for fish and wildlife. Of lowest importance were biofuel crops, scenic farms, and agricultural products for non-local markets. All ES were rated at least “somewhat important” on average.

Our 19 ES factored into four groups, which we call *Water for Households*, *Natural Areas and Processes*, *Agricultural Products*, and *Rural Character* (Fig. 2). Flood control did not factor into a group, and it was excluded from subsequent analyses. There is a clear difference between agricultural and non-agricultural ES in our groups. We show our ES by MA category as a means of comparison with a widely-used classification system. The *Rural Character* group includes only cultural ecosystem services from the MA. The MA’s provisioning services are split into two groups: *Agricultural Products* and *Water for Households*. The *Natural Areas and Processes* group includes services from three out of four MA categories.

Models for each of our four ES factor groups reveal differences across factors associated with the perceived importance of different types of ES (Fig. 3). Ecological worldview (i.e., NEP score) was significant and negatively related to the importance of *Agricultural Products*, though not significant for *Rural Character*, while ecological worldview was positively related to the importance of *Natural Areas and Processes*, but not significant for *Water for Households*.

Having an agriculture-based livelihood was significant and positively related to higher *Agricultural Products* and *Rural Character* importance. Agricultural livelihood was not significant in relation to the importance of *Natural Areas and Processes* or *Water for Households*. Visiting a park and fishing were split in relation to the associated importance respondents gave to *Agricultural Products*: fishing was positively associated with *Agricultural Products* importance and visiting a park was negatively associated with *Agricultural Products* importance ratings. Visiting a park was significant and positively associated with higher *Rural Character* importance ratings, while fishing was not significant. Fishing and park visitation were both positively associated with higher *Natural Areas and Processes* importance ratings, though not significant for *Water for Households*.

Geographic variables were not significant in most models, with a few exceptions. Percent adjacent agriculture was positively associated with *Rural Character* importance, but there was no significant relationship for *Agricultural Products*. There was no significant relationship between distance to water and *Agricultural Products* or *Rural Character* ES importance. *Natural Areas and Processes* and *Water for Households*’ ES importance were not significantly associated with geographic variables except that distance to water was negatively associated with *Nat-*

*ural Areas and Processes* importance. Demographic differences were significant with respect to gender for the *Agricultural Products* and *Rural Character* models: females rated the importance of these ES higher than males. Older respondents were more likely to rate *Agricultural Products* higher.

### 5. Discussion

This study offers insight into how different people value the many ES provided by their regional landscape. We found pluralistic values that suggest some areas of tension among groups, but also many areas of agreement and even consensus on the importance of clean drinking water. One of the unique contributions of this study is the investigation into the relationship between ecological worldview and the importance attributed to a range of ES provided across a spectrum of land covers and land uses, from forests to agricultural fields to urban lakes. We found that ecological worldview was positively related to the importance of *Natural Areas and Processes*, while we found a negative association between ecological worldview and a heterogeneous group of *Agricultural Products* ES, a relationship that has received little attention in the ES literature. Results from our research support the argument that no single value typology for ES will be sufficient for all contexts, research needs, and applications (Fisher & Turner, 2008; La Notte et al., 2017).

We found that the high importance given to several ES, particularly *Water for Households* ES, cut across worldviews and demographics. The four ES given highest importance by our respondents were clean drinking water, reliable water supply for household uses, clean water in lakes and rivers for fish and wildlife, and reliable water supply in lakes and rivers. As a service that is used daily, generated locally from groundwater pumping, and visible in lakes and rivers, water quality and supply are highly valued across the U.S. and globally, and an important focus of environmental policy (Rosenbaum, 2013). Pollution of drinking water and lakes or rivers were the top two environmental concerns of U.S. residents each year in the past decade (Organization, 2016). Water is often listed first among resource benefits on conservation ballot initiatives due to its cross-cutting popularity and high ratings in polls (such as the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act or Minnesota’s Clean Water, Land and Legacy Amendment) (McQueen & McMahon, 2003). The cross-cutting nature of values for water was documented in several classic ES case studies such as perceptions of ES in upstate New York’

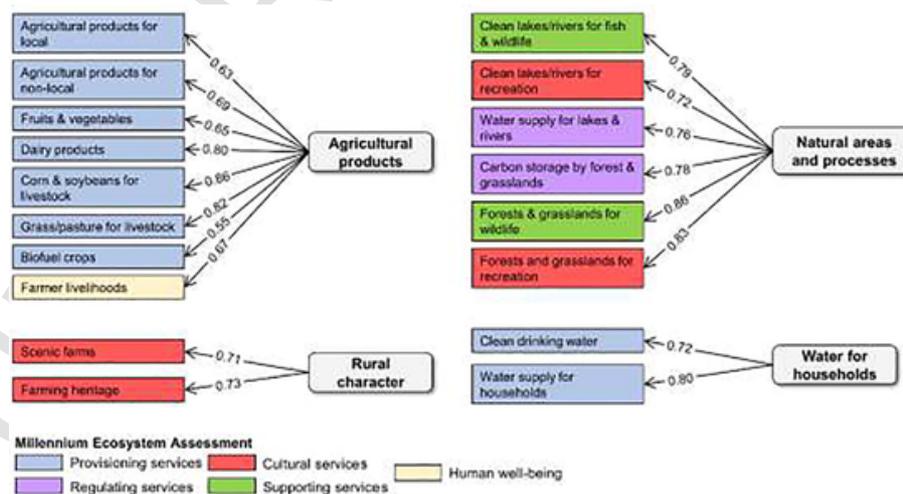


Fig. 2. Exploratory factor analysis based on ES importance ratings. Respondents’ importance ratings of ES are grouped into four categories: *Agricultural Products*, *Natural Areas and Processes*, *Rural Character*, and *Water for Households*. Numbers on each arrow are loadings on each orthogonal factor. Color-coding represents the ES classification from the MA as one means of comparison with another grouping of individual ES.

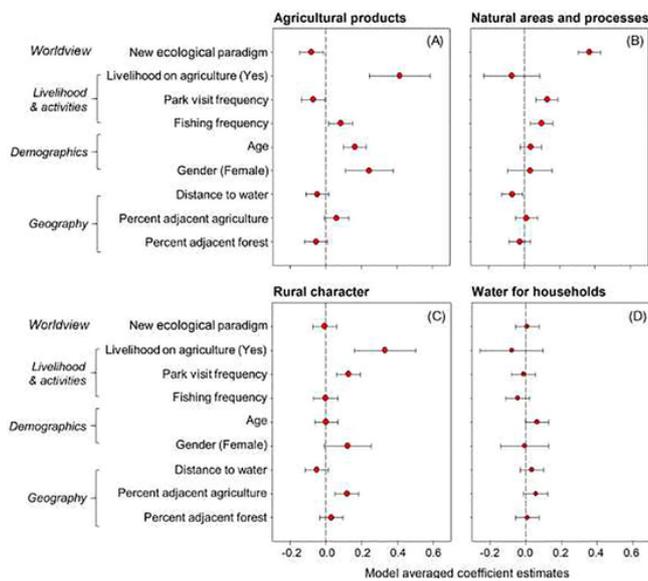


Fig. 3. Model-averaged coefficient estimates (b) for effects of respondents' worldview, livelihood & activities, geographic variables, and demographics, and on their perceptions of four categories of ecosystem services. The bar around the mean indicates 95% confidence intervals (CI). The variables are significantly different from zero when its 95% CI do not bracket zero.

s Catskills and provision of a clean water supply for New York City (Heal, 2000).

We found that carbon storage in forests and grasslands was in the top five most important services. This finding is somewhat surprising, as carbon sequestration is a slow process with low visibility and little immediate, concrete impact on peoples' everyday lives compared with water for household services (de Groot et al., 2010). Furthermore, a number of studies have documented the relatively low value the public tends to put on regulating and supporting ES such as carbon storage (e.g., Bryan et al., 2010; Klain & Chan, 2012). This finding may be influenced by concerns over climate change and a desire to increase carbon mitigation.

Farmer livelihoods were given the highest importance of all food and agriculture issues. Dairy farming is common in the region, is deeply entrenched as an identity in the "dairy state," and is also highly rated among agricultural items in our survey responses. Interestingly, residents rated fruits and vegetables highest among crop-related ES, although these crops are uncommon in the region (<0.5% of land cover, NLCD 2011). Grass-based pasture (<1% of land cover) and corn or soybean production (~35% of land cover) hold lower importance for our respondents (NLCD 2011). Biofuels production was rated the lowest of the agricultural items in our survey, even while other agricultural ES were given high importance. This finding suggests a potential disconnect with plans to dramatically increase biofuel production across the U.S. and in the Midwest in particular (Biomass Research and Development. (2013) (2013, 2013).

Individual and landscape variables explained a small amount of the variance in ES models. The variable with the most explanatory power across models was ecological worldview, which reflects orientations toward the environment. Our finding of a positive relationship between biocentric worldviews and *Natural Areas and Processes* ES importance is in line with other studies focused on natural areas (Van Riper & Kyle, 2014). The association between anthropocentric worldviews and higher *Agricultural Products* importance makes sense given that the dominant paradigm in agriculture is human domination of resources through technological innovation (Marsden, 2012). Our group of agricultural ES included products intended for local markets and

those sometimes associated with sustainability, such as biofuels. Yet these ES grouped together and were all negatively associated with NEP, suggesting a strong association of agricultural production with an anthropocentric worldview. Having a livelihood associated with agriculture had significant explanatory power for the importance of *Agricultural Products* and *Rural Character*, which reflects past findings in other places (Reed et al., 2015). With respect to recreational activities, we found that respondents who participate in fishing and park visitation have significantly higher *Natural Areas and Processes* importance scores, which we expected. Frequent engagement with certain benefits of nature can thus increase the importance attributed to those benefits. Interestingly, park visits were also associated with higher *Rural Character* scores, which is a cross-over variable, since *Rural Character* is composed of farm-related ES. This finding could be somewhat unique to our study area, as there are several large county and state parks outside of the city that are surrounded by agricultural operations, thus increasing the association between the two.

Geographic and demographic variables shed light on both locally- and globally-relevant phenomena influencing perceptions of ES. Our finding that distance to water is negatively associated with *Natural Areas and Processes* importance makes sense in our study area, where most urban residents live closer to water bodies than rural residents. This finding can be understood in that environmental concern can sometimes be higher among urban populations (Tremblay & Dunlap, 1978) – though not always (Huddart-Kennedy, Beckley, McFarlane, & Nadeau, 2009). Our finding that female respondents attributed higher importance to *Agricultural Products* ES than men was somewhat surprising, especially given no significant gender differences in the three other models. Past studies have found gender differences in ecological worldview (Zelezny et al., 2000), but we did not find this difference in our study. The higher importance given to agricultural products by women may be explained in part by women's traditional role as primary food decision-makers for their households, particularly among those women in our study region interested in buying local food (Witzling & Shaw, 2019).

### 5.1. Implications

This study has important implications for managers, policy-makers, and other decision-makers. First, we found high importance ratings for a variety of agricultural and natural resources ES that cut across demographics, worldview, and geography. Tradeoffs between water quality and agricultural production are well documented and widely discussed, yet both continue to be very important to residents (Gillon et al., 2016). Our findings could help to facilitate productive conversations about addressing tradeoffs by highlighting commonalities in values across watershed residents. Agreement is important to restate since so much of the focus in the media and political discourse is on conflict. Second, recognizing the central role that ecological worldview plays in peoples' ecosystem values can help resource managers or advocacy organizations more effectively frame messaging to promote or conserve certain ES. For example, in our study watershed, language that emphasizes human-centered outcomes from increasing agricultural production or preserving farmland would resonate with the people who care most about these ES. Third, our study is specific to our study area, and understanding the range of values in different types of ES will be important for representing pluralistic values in that county. However, a value typology in a different county or different country will look different. We suggest that in order to incorporate wider conceptualizations of values and valuation into ecosystem assessment, including the notion of "nature's contributions to people," it is necessary to conduct context-specific studies that take worldviews into account.

## CRedit authorship contribution statement

**C.B. Wardropper:** Conceptualization, Writing - original draft, Writing - review & editing, Visualization. **A.S. Mase:** Conceptualization, Methodology, Investigation, Writing - review & editing. **J. Qiu:** Conceptualization, Formal analysis, Visualization, Writing - review & editing. **P. Kohl:** Conceptualization, Investigation, Writing - review & editing. **E.G. Booth:** Conceptualization, Writing - review & editing. **A.R. Rissman:** Conceptualization, Writing - review & editing, Resources, Supervision, Funding acquisition.

## Uncited references

Millennium Ecosystem Assessment, 2005.

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