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The Food-Water-Energy Nexus and Household Behavior: An Oregon Case Study

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Abstract

The food-water-energy (FWE) nexus is by definition a 'wicked problem' in that potential solutions in one sector may inadvertently create perverse effects in another such as a reduction of available water for energy or food production. Extant and projected demand for FWE creates an intertwined problem of supply and demand and new policy considerations for managing the nexus. This study examines the FWE behaviors of Oregon households using survey data gathered in 2017. Findings suggest that a majority of all sampled households have engaged in sustainable food, energy and water behaviors in the last five years, with rural households less likely to participate in such activities when compared to urban households. Education, environmental values—as measured by the New Ecological Paradigm—and environmental efficacy were also found to be significant predictors of both individual FWE behaviors as well as behaviors in the FWE nexus. The study concludes with some policy recommendations for encouraging sustainable public FWE nexus behaviors.

Keywords: FWE Nexus; rural-urban residency; new ecological paradigm; environmental efficacy; sustainable household behavior

1.0 Introduction

Recent attention on the integrated nature of food, water, and energy (FWE) has resulted in a focus on the nexus, or the point where actions in one sector impacts the others. While there is no set definition of the FWE nexus, the Food and Agriculture Organization defines the nexus as "a conceptual approach to better understand and systematically analyze the interactions between the natural environment and human activities, and to work towards a more coordinated management and use of natural resources across sectors and scales" (2014, p. 3). Attention on the FWE nexus has raised significant concerns about creating policies that address both individual sectors of the nexus and the integrated nature of food, water, and energy. Prior research on the nexus has primarily focused on large-scale management, while very few studies have examined smaller scale nexus issues, particularly at the household level. This focus was driven, in large part, by systems practitioners hoping to address the lack of land for food, water scarcity, and the ecological impacts of energy production collectively in order to address nexus concerns. However, with increasing demand for resources, it is imperative that households contribute to the conservation of collective resources, and time to understand to what degree households are already engaging in FWE nexus behaviors.

Previous research into household behaviors regarding food, water, and energy consumption have primarily been examined as individual actions, without exploring if there is nexus consistency (Portney et al., 2018). This is in part because research into food, water, and energy conservation individually does not reveal consistent predictors for conservation behavior. For example environmental concern is not a strong predictor of reducing food waste (Lyndhurst, 2007; Quested, Marsh, Stunell, & Parry, 2013; Watson & Meah, 2013), but is for home water conservation (Glig & Barr, 2006; Trumbo & O'Keefe, 2001; Willis, Stewart, Panuwatwanich, Willimas, & Hollingsworth, 2011; Wolters, 2014). The paucity of research into household FWE environmental behaviors suggests that there is still much to gain from examining this sector and, specifically, how and whether individuals make nexus connections in their conservation behaviors. Understandably, individuals can have a significant impact on food, water, and energy use, particularly when actions are considered in aggregate with other households. In countries like the U.S., where personal consumption levels are already significantly higher than in lower income countries, the continued rise in population growth and income levels in conjunction with climate change will further stress existing resources to meet both needs and demands.

The purpose of this research is to examine to what degree Oregonians engage in FWE behaviors and whether there are differences in engagement based on sociodemographic factors and urban or rural residency. In addition, this paper explores the participation in conservation of food, water, and energy independently, then as a nexus. Specifically, we assess whether people who engage in one behavior are more likely to engage in the others. Further, this research tests whether the values, beliefs, norms (VBN) theory (Stern, 2000; Stern, Dietz, Abel, Guagnano & Kalof, 1999) provides a robust explanation for individuals' engaging in sustainable FWE as stand alone issues, whether those relationships are consistent across sectors, and if the explanations hold for a combination of behaviors within the nexus. The study concludes with policy recommendations to engage the public in sustainable FEW nexus behaviors.

1.1 Literature Review

Prior research on household use and conservation on FWE has focused on both the motivations and behaviors related to conservation. Research on demographic correlates of food waste have found that being older (Hannibal & Vedlitz, 2018) and having fewer people in the home were related to less food waste (Stancu, Haugaard, & Lahteenmaki, 2016; Visschers, Wickli & Siegrist, 2016), as was lower income (Stancu et al., 2016; Hannibal & Vedlitz, 2018). Women have been found to waste more food than men (Visschers et al., 2016), which may be related to the responsibilities placed on them for shopping, meal preparation and child care. In one study, parents, but primarily mothers, discussed the "importance of purchasing a variety of foods perceived to be healthy and nourishing, even if it meant food going to waste" (Graham-Rowe, Jessop, and Sparks, 2014, p. 19). In contrast, Hannibal and Vedlitz (2018) found that women are more concerned about food waste.

Furthermore, among the top reasons for concern about food waste at the household level is the economic impact—waste of money—(Lyndhurst, 2007; Quested et al., 2013), general thrift—low cost-low demand on time—(Watson & Meah, 2013), and guilt about wasting food (Lyndhurst, 2007; Quested et al., 2013). Although food waste is directly related to environmental issues (e.g., water and energy waste, use of farmland, etc.), environmental concern has not been found to be a strong correlate on avoidance of food waste (Lyndhurst, 2007; Quested et al., 2013; Watson & Meah, 2013). However, a study by Hannibal and Vedlitz (2018) found that people who expressed concern for the environment displayed higher levels of concern pertaining to food waste. Inconsistencies suggest that this distinction has important policy implications as it shows a lack of connectivity between food waste and environmentalism. It is possible, then, that individuals—even those who might practice environmental behaviors in other ways—do not overtly perceive food waste as an environmental issue and therefore environmental values would not necessarily be a precursor to food waste prevention behaviors. Alternatively, if people perceive food waste to be an environmental issue, then those who are concerned for the environment may extend this concern to a reduction of food waste.

Households practicing water conservation, like those who are concerned about food waste, often do so because of cost—reduced water to save money—(Corral-Verdugo, Frias-Armenta, Perez-Urias, Orduna-Cabrera, & Espinoza-Gallego, 2002; Grafton, Ward, & Kompas, 2011). However, environmental concern has been shown to shape individual attitudes and behaviors related to water use (Glig & Barr, 2006; Trumbo & O'Keefe, 2001; Willis et al., 2011; Wolters, 2014). In addition, research reveals that a sense of efficacy of an action having an immediate positive impact (Kortenkamp & Moore, 2006), awareness of local impact (Gregory & Di Leo, 2003), and trust that other households and industries are also reducing their water use (Jorgensen, Graymore, & O'Toole, 2009) are important for individuals to change their behavior.

Attempts at identifying sociodemographic correlates of water conservation behaviors has met with mixed results. Prior research suggests that older cohorts (Olli, Grendstad, & Wolleback, 2001; Wolters, 2014) and households with higher income levels (Trumbo & O'Keefe, 2001; Wolters, 2014) are more likely to engage in residential water conservation. Income as a predictive variable is a bit more complex with some studies finding that it is lower income groups that are more likely to conserve water (De Oliver, 1999). However, income is difficult to isolate as a correlate of water conservation because there are several factors to consider like water pricing (metered or well water), discretionary use (outside water for lawns, gardens, pools, etc.), water efficient technology in the home, and household size. It is important to note that performing water conservation behaviors happens for a variety of reasons, including economic concerns, social desirability, time commitment, and so forth, in addition to or separate from environmental concern. It is unsurprising then that there is a lack of consistent demographic predictors for water conservation behaviors due to the innumerable motivations and/or disincentives.

Household energy conservation, like water conservation, occurs for a myriad of motivational reasons including environmental concern (Mills & Schleich, 2012; Steg, Dreijerink, & Abrahamse, 2005), moral obligation (Steg et al., 2005), and economic reasons (Crosbie & Baker, 2010; Mills & Schleich, 2012). However, energy use is also related to household constructs and sociodemographics. Increased energy use in the home is associated with owning a larger house and having a higher income (Abrahamse & Steg, 2009), while households with young children (Mills & Schleich, 2012; O'Neill & Chen, 2002) and fewer occupants (O'Neill & Chen, 2002) use less energy. In terms of energy conservation, households with young children (Mills & Schleich, 2012) and people with higher levels of education (Mills & Schleich, 2012) are more likely to adopt energy efficient technologies. On the other hand, older people are more likely to conserve energy than younger cohorts (Barr, Gilg, & Ford, 2005).

Another consideration that will be investigated in this study concerns the location of households in the state. Previous studies conducted in Oregon have found significant urban-rural differences in political and environmental values that may impact FWE behaviors (Pierce & Steel, 2017; Wolters, 2014; Clucas, Henkels, & Steel, 2011; Hibbard, Seltzer, Weber, & Emshoff, 2011). For example, Clucas et al. (2011) found that urban Oregonians are far more likely to have environmental values that are more 'biocentric' in orientation or values that "elevates the value of all natural organisms, species, and ecosystems to center stage" (2011, p.123). Alternatively, rural Oregonians are likely to have more 'anthropocentric' orientations or values that center on "a human-oriented view of nature in which human needs and wants are given priority" (2011, p. 123). Rural Oregon is more politically conservative and Republican while urban Oregon is more politically liberal and Democratic (Clucas et al., 2011). Because values and ideological orientations can impact how people perceive certain issues and information (Wolters & Steel, 2018), it may be that rural residents in a state like Oregon may be less receptive to FWE conservation issues when compared to urban residents. On the other hand rural residents have less access to the amenities that urban residents have such as close proximity to grocery stores, dependable water supplies and energy sources (Hibbard, Seltzer, Weber, & Emshoff, 2011), which may impact their FWE behaviors. Therefore, this study is also designed to investigate rural vs. urban household participation in FWE behaviors.

1.2 Values-Beliefs-Norms (VBN) Theory

Several social-psychological theories have been utilized to explore the relationship of values, beliefs and attitudes to environmental behaviors such as Fishbein and Ajzen's (1975) theory of reasoned action, which examines how the strength of a behavioral intension can predict behavioral actions. Theories exploring environmental behavior primarily examine the characteristics of individuals—including values, sociodemographics, ideology, knowledge, concern, and so forth—in an attempt to understand what characteristics are antecedent to environmental behavior.

The VBN theory is a cognitive theory that suggests that individuals will engage in activities consistent with their values when they believe their actions can impact the outcome and feel compelled to act based on their values. The VBN theory has been used to explain environmental behaviors as an outcropping of values that can be measured by the New Ecological Paradigm (NEP) scale (Dunlap, Van Liere, Mertig, & Jones, 2000). The NEP has been successfully utilized as a scale to assess environmental values as indicators of a broader endorsement of a worldview that is ecologically centered (Dunlap et al., 2000; Lundmark, 2007). These pro-environmental values provide the basis for action when individuals are aware of environmental problems and feel their actions can positively impact the outcome.

Another component to environmental behavior—and the VBN—is efficacy. An individual with strong levels of self-efficacy, or a person's perceived behavioral control, are more likely to engage in environmental behaviors compared to people who feel their actions are insignificant (Sawitri, Hadiyanto, & Hadi, 2015). Personal efficacy has been correlated to beliefs about climate change (Heath & Gifford, 2006) as well as a personal responsibility to act in an environmentally sustainable manner (Kellstedt, Zahran, & Vedlitz, 2008).

2.0 Methods

2.1 An Oregon Case Study

The state of Oregon, like much of the western United States, is no exception to the impacts of climate change and population growth on food, water, and energy. Oregon's population continues to grow by about 1.6% per year, a rate that puts Oregon the ninth fastest growing state (Frazier, 2016) and on track to have a 40% increase in population by 2050 (Oregon Water Resources Department, 2015). Concomitantly, climate change has led to a reduction of snowpack, an earlier spring snowmelt, and subsequently less available water during the summer months (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). The loss of available water affects both energy and food production. Hydroelectric power supplies about 68% of electricity to Oregon (U.S. Energy Information Administration, n.d.), however hydroelectric power faces reliability concerns as the impacts of climate change continue to alter both the availability and timing of water reducing the predictability of hydroelectric generation (Oregon Department of Energy, n.d.). Water is also critical to Oregon's agricultural industry that accounts for about 85% of water use in the state (Oregon Water Resources Department, 2015). With Oregon agriculture providing $8.25 billion to the state economy each year (Oregonfresh, 2011), Oregon's increasing need for water will likely adversely impact food and energy production in the state, which consequently will affect the states revenue from agriculture.

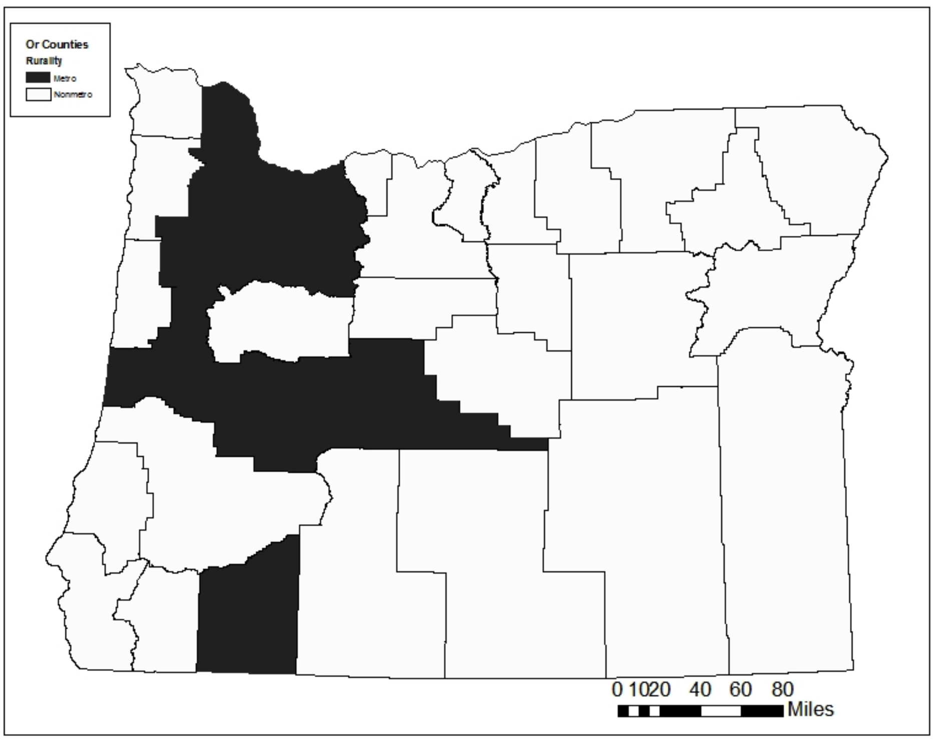
Almost 24% of the total energy use in Oregon is residential (U.S. Energy Information Administration, n.d.). Residents powering everything from clothes dryers to cars put a heavy reliance on readily available energy. While the State has committed to achieve 50% renewable energy by 2040 (Oregon Department of Energy, n.d.), increasing energy demand for a growing population combined with exacerbated climate impacts from carbon intensive energy suggests that the timeline does little to improve overall reduction of energy use.

2.2 Methodology

This research is focused on the attitudes and behaviors of Oregonians related to FWE conservation efforts. Since few studies of household FWE nexus questions exist, we draw many of our questions from the Irish Lifestyle Survey first conducted in Ireland in 2011. The purpose of the Irish survey was to explore people's attitudes and behavior regarding household consumption in the context of sustainable lifestyles (Lavelle & Fahy, 2014), and thus incorporated questions in food-water-energy—with modified language for a U.S. context. The Oregon survey draws from many of the same questions related to sustainable household consumption, and potential variables influencing environmental behaviors.

As discussed above, because previous studies conducted in Oregon on similar topics found significant urban–rural differences in political and environmental values and behaviors, half of the sample was selected from metro counties and the other half from non-metro counties (see Figure 1). Counties are classified as 'metropolitan' if they contain an urbanized area of at least 50,000, or are adjacent to such a county and linked to it through significant commuting flows. All other counties are classified as non-metro in this study. While the U.S. Census definition of metro and non-metro counties is not necessarily the best proxy for rural versus urban households, in Oregon it does provide a fairly good, but not perfect job, of capturing rural versus urban households (Martin & Weber, 2011; Weber, Crandell, & Etuk, 2014).

Figure 1. Oregon metro and nonmetro counties.



Source: (Wolters & Hubbard, 2014)

Participants were selected using a random household sample provided by a national sampling company. Random address-based sampling using the U.S. Postal Service's Computerized Delivery Sequence file was used to generate 2,493 valid residential addresses from metro and non-metro counties—1,256 metro and 1,237 non-metro.[1] The reason for this sample size was to generate at least 500 responses each from

[1] According to the U.S. Census, Oregon's nonmetropolitan counties include: Baker, Clatsop, Coos, Crook, Curry, Douglas, Gilliam, Grant, Harney, Hood River, Jefferson, Klamath, Lake, Lincoln, Malheur, Morrow, Sherman, Tillamook, Umatilla, Union, Wallowa, Wasco, and Wheeler. Metropolitan counties include: Benton, Clackamas, Columbia, Deschutes, Jackson, Josephine, Lane, Linn, Marion, Multnomah, Polk, Washington and Yamhill.

metro and nonmetro counties (confidence level at 95% at plus or minus 4.3 for confidence interval for 3.3 million Oregonians 18 plus years). The Computerized Digital Sequence includes over 135 million residential addresses, which covers nearly all households in the U.S. A modified version of Dillman's Tailored Design Method (2007) was used in questionnaire format with a multi-wave mail survey implemented during the winter of 2017. Survey respondents were first notified by postcard of the survey then sent the survey two weeks later. Non-survey respondents were then sent a second reminder survey.

The response rate for the metropolitan county sample was 43.3% (544 surveys returned) and for the non-metropolitan sample it was 43.1% (533 surveys returned). For this study we compare 2010 U.S. Census data with survey respondents to determine the demographic representativeness of the respondents (see Table 1). Because only respondents 18 years of age and older were eligible to participate, only data for 18 years of age and older are included in the U.S. Census data. When comparing survey response data with the 2010 U.S. census data, we find that survey respondents are slightly older, slightly more affluent, and slightly more educated than U.S. Census estimates, which is typical of survey respondents (Messer, Edwards, & Dillman, 2012). The percent of female respondents is almost identical to the census estimates for the combined samples.

Table 1: *Survey Response Bias*

	Survey Respondents	**2010 U.S. Census**
Mean Age (18 and older)	53.4	49.5
Average Household Income	$35,000–74,999 range	$49,260
Gender (18 and older)	48.5% Male	48.4% Male
	51.5% Female	51.6% Female
Associates Degree or Higher	36.4%	35.0%

Source: U.S. 2010 American Community Survey Public Use Microdata Sample

2.3 Analyses

Three questions were included in the survey as dependent variables to determine if respondents participated in FWE conservation behaviors. For the food behavior question, respondents were asked the following: "Do you feel that you often buy more food than needed when shopping', with possible responses of 'yes', 'no', and 'don't know.'" Those who responded 'no' are seen as individuals who engage in more sustainable food behaviors. Table 2 provides frequencies for this question showing 63.1% of metro county respondents reporting that they "do not buy more food than needed" compared to 49.9 percent of non-metro respondents ($p = .000$). While we do not know for sure why there is a difference, it might be that households in metro counties are located closer to grocery stores and therefore do not have a need to buy and store food and other goods.

The question included in the survey to assess water consumption behavior asked households if they have "cut down on water use over the last five years?" Metro households were more likely to respond that they have cut down on water use over the last five years when compared to non-metro households (see Table 2). Over 63% of metro households reported reducing water use compared to 48.2% of non-metro households (p = .000).

Table 2: *Self-reported Food, Water, and Energy Behaviors*

	Metro Counties	**Non-metro Counties**	**Total**
Do you feel that you often buy more food than needed when shopping?			
a. Yes	34.3%	47.1%	40.7%
b. No	63.1%	49.9%	56.5%
c. Don't know	2.6%	3.0%	2.8%
N =	539	531	1,070
Chi-square =	19.085		
Significance =	.000		
Has your household cut down on water use over the last five years?			
a. Yes	63.3%	48.2%	55.8%
b. No	29.3%	44.3%	36.8%
c. Don't Know	7.4%	7.5%	7.5%
N =	539	533	1,072
Chi-square =	27.208		
Significance =	.000		
Has your household taken steps to reduce energy in the last five years?			
a. Yes	79.2%	78.4%	78.8%
b. No	18.9%	16.2%	17.6%
c. Don't Know	1.8%	5.5%	3.6%
N =	544	532	1,076
Chi-square =	10.884		
Significance =	.004		

Energy consumption behavior was assessed similarly to water use. Respondents were asked if their household had "taken steps to reduce energy in the last five years?" The results are very similar for both metro and non-metro households with 79.2% of metro respondents and 78.4% of non-metro respondents indicating they had taken steps to reduce energy use over the last five years.

Because we are interested in seeing if the relationships found for one component of the nexus are similar for FWE as a nexus, we constructed an additional dependent variable as the FWE nexus Food+water+energy 1= Do not buy more food than needed, and reduced water and energy use over five years, 0= Else.

The frequencies displayed in Table 3 provide percentages of respondents that have engaged in the FWE nexus variables, and reveal consistency in the relationship of residential location to behaviors. For the food+water+energy variable 36.4% of metro residents and 23.6% of non-metro residents engaged in all three behaviors. Similar to the results displayed in Table 2, metro respondents are much more likely than non-metro respondents to engage in combinations of FWE behaviors. However, as discussed previously, we cannot determine from this study if people think strategically in their FWE behaviors, however knowing what singular and collective nexus behaviors people engage in and the determinants of those combinations may lead to more optimal policies and outreach in the future.

Table 3. *Frequencies for Food+Water+Energy Nexus Behaviors*

Food+Water+Energy Nexus			
	Metro Counties	***Non-metro Counties***	***Total Sample***
Nexus Engagement	36.4%	23.6%	30.1%
Other	63.6%	76.4%	69.9%
N =	539	531	1,070

As discussed above, participation in FWE behaviors can be affected by a variety factors including, but not limited to, demographic factors, location of residence, environmental values, and environmental efficacy. Our primary independent variables will be residential location (metro–non-metro), environmental concern, and environmental efficacy (see Table 4).

The indicator to assess environmental values is based on survey participants' responses to six items drawn from a revised NEP index (Dunlap et al., 2000). Each item asks respondents to give a reaction on a five-point scale, ranging from 1 = strongly disagree to 5 = strongly agree. The NEP is a environmental values scale that measures environmental attitudes and may be the most cited and employed measure in the social science study of the environment, and one of the most in all of social science in the past three decades (Lundmark, 2007). The following six statements have been used in many previous studies and are used in this study (see Pierce & Steel, 2017):

1. The balance of nature is very delicate and easily upset by human activities.
2. Humans have the right to modify the natural environment to suit their needs.
3. We are approaching the limit of people the earth can support.
4. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
5. Plants and animals have as much right as humans to exist.
6. Humans were meant to rule over the rest of nature.

Table 4. *Control and Independent Variables*

Variable Name:	**Variable Description:**	**Mean (s.d.)**
Age	*Respondent Age in Years* [Range: 18 to 91 years]	53.44 (15.90) n=1,075
Gender	*Dummy Variable for Respondent Gender* 1= female, 0= male	.51 n=1,074
Education	*Formal Educational Attainment* 1=Grade School to 8=Postgraduate/Professional Degree (e.g., MA, JD, etc.)	4.81 (1.45) n=1,069
Income	*Annual income before taxes (2016)* 1=Less than $10,000 to 10=$200,000 or more	5.63 (2.00) n=1,059
Nonmetro	*Dummy Variable for Metro vs. Nonmetro Residence* 1= Nonmetro county, 0= Metro county	.49 n=1,077
NEP	*New Ecological Paradigm Index* 6=Dominant Social Paradigm to 30=New Ecological Paradigm (Cronbach's alpha=.830)	21.58 (5.51) n=1,049
Efficacy	*Environmental Efficacy Index* 4=Low Level of Efficacy to 20=High level of Efficacy (Conbach's alpha=.811)	13.84 (3.88) n=1,062

After reverse recoding of items 2, 4, and 6, the responses also were summed across all six items to produce an overall index, possible scores on which ranged from six to 30, with low scores indicating more human centered—human domination of nature—values and higher scores indicating more pro-ecological—nature for nature's sake—values. The scale has a Cronbach's alpha of .830 indicating that respondents were relatively consistent in their responses. Table 4 shows that the mean score for respondents is 21.58, which is skewed somewhat toward biocentric values versus anthropocentric values, not a surprising score for a Democratic, more environmentally oriented state like Oregon (Pierce & Steel, 2017).

The measure of environmental efficacy used in the survey was based on Bandura's (2006) guide for developing self-efficacy scales. Respondents were asked their level of disagreement or agreement to four items using a five-point scale, ranging from 1 = strongly disagree to 5 = strongly agree. The items provided in the survey were:

- I feel that my own personal behavior can bring about positive environmental change.
- I would be willing to accept cuts in my standard of living, if it helped to protect the environment.
- I would be willing to support higher taxes, if it helped to protect the environment.
- I would be willing to sacrifice some personal comforts in order to conserve resources.

The four items were summed for a scale with a range of four to 20, with lower scores indicating lower levels of environmental efficacy and higher scores indicating higher levels of efficacy. The mean score for the scale is 13.84 with a Cronbach's alpha of .811.

The demographic–control variables included in the multivariate analyses are displayed in Table 4 and include age in years, gender, formal educational attainment, and income. As was discussed in the previous methods section, the average age for the combined metro and non-metro samples is 53.44, which is a little older than 2010 U.S. Census estimates. Women comprise 51% of respondents and educational attainment and the average income category are similar to census estimates. We also include a dummy variable for place of residence with 1=non-metro counties and 0=metro counties.

Dichotomous dependent variables were developed for the multivariate analyses given the categorical nature of the self-reported behavior questions for FWE in Table 2. For the logistic regression models presented in Table 5 each variable is coded 1 for a behavior that pays attention to conservation—do not buy more food, cut down water use over 5 years, reduced energy use over 5 years—and 0 otherwise. Two models are provided for each behavior with the first model only including the NEP and efficacy variables and the second model with all of the independent variables.

Chi-square results for all six models are statistically significant, indicating a relatively good fit overall. For the three models with just Nonmetro, NEP and Efficacy included, all variables have a statistically significant impact indicating that urban respondents with higher levels of support for the NEP and who feel they can make a difference through their own behaviors are significantly more likely than rural respondents with lower NEP support and lower levels of efficacy to engage in food, water and energy conservation efforts.

Turning now to the models with the control variables, we find that, other things being equal, non-metro residents were significantly less likely to engage in sustainable food behaviors—that is, they are more likely to buy more food than they need—when compared to metro households. Non-metro residents were also significantly less likely to say that they have engaged in reducing water use in the last five years. While less likely to also engage in reducing energy than metro-residents, the differences between the two groups is not statistically significant.

With respect to environmental values, the NEP variable was statistically significant and positive for all three models. As expected, those with higher NEP scores—more pro-environmental in their beliefs—are more likely to report that they do not buy more food than needed, to cut down on water use over the last five years, and to reduce energy use over the last five years when compared to those with lower NEP scores. While this finding is not surprising, it does replicate previous research on attitude-behavior consistency with environmental issues and supports the VBN theory discussed previously (e.g., Steel, 1996; Wolters, 2014).

The final independent variable included in each model is the environmental efficacy scale, which has a positive and statistically significant effect in all three models. Those respondents with higher levels of efficacy were significantly more likely than those with lower levels of efficacy to not buy more food than necessary, to have reduced water consumption over the last five years, and to reduce energy use over the last five years. Similar to the impact of the NEP, these results reinforce the idea that those who feel they can have a positive environmental impact by engaging in certain behaviors are more likely to follow through with actual behavior with FWE.

When examining the impact of the demographic variables, age and gender do not have a statistically significant impact in any model. However, education level does have a positive and significant effect for both the water and energy models. Respondents with higher levels of education are more likely to have reduced water and energy use over the last five years. Income level has a significant effect in only the water model, and the coefficient is negative meaning that lower income levels are significantly more likely to have reduced water use over the last five years.

The final analysis conducted examines the impact of the independent variables on an additive food+water+energy variable previously discussed (see Table 3), and combination of other nexus behaviors such as food+water, food+energy, and water+energy. The range of values for the first variable is 0=engaged in none of the FWE behaviors to 3=engaged in all three behaviors. For the next three variables the range of nexus behaviors are 0=engaged in neither behavior to 2=engaged in both behaviors. Multinomial logistic regression are used to analyze each of the nexus variables (see Table 6) with the chi-square statistic significant at the .000 level for each model indicating that all models are a good fit.

The results of the FWE nexus model illustrate some differences from the single models run for individual behaviors. While age was not related to FWE behaviors individually, we find that it does help predict behavior cumulatively. Older individuals are significantly less like to engage in multiple conservation behaviors than younger individuals. Similar to the individual models, residence location, the NEP and efficacy all have statistically significant effects on the FWE nexus behaviors. Specifically, metro county respondents, those with higher NEP and efficacy scores are more likely to engage in multiple FWE behaviors.

For the three additional models of nexus behaviors, we find that the control variables age, education, and income all have a statistically significant impact for the food+water model. Older, more highly educated and more affluent respondents were significantly more likely to engage in food and water conservation behaviors when compared to younger, lower educated and lower income households. Gender and nonmetro did not have an impact, however the NEP and efficacy both had positive and significant impacts on food+water conservation behaviors. For the food+energy nexus dependent variable, the only control variable that had a statistically significant impact on food and water conservation behaviors was education, with the more highly educated more likely to engage in conservation behaviors when compared to respondents with lower levels of formal education. As with the previous models in Table 5 and Table 6, both the NEP and efficacy variables had a statistically and positive impact on food and enegy nexus behaviors.

Table 5. *Logistic Regression Estimates for Food, Water and Energy Behavior*[a]

	Food *Coefficient (SE)*	**Food** *Coefficient (SE)*	**Water** *Coefficient (SE)*	**Water** *Coefficient (SE)*	**Energy** *Coefficient (SE)*	**Energy** *Coefficient (SE)*
Age		-.002 (.005)		.000 (.006)		-.003 (.007)
Gender		-.037 (.170)		-.034 (.201)		-.012 (.220)
Education		.097 (.063)		.200** (.074)		.294*** (.082)
Income		-.018 (.045)		-.140** (.053)		.045 (.059)
Nonmetro	-.140** (.050)	-.142** (.051)	-.112** (.049)	-.115** (.048)	.198 (.190)	-.269 (.225)
NEP	.170*** (.015)	.171*** (.020)	.070*** (.016)	.0752** (.025)	.130*** (.024)	.138*** (.031)
Efficacy	.125*** (.022)	.127*** (.028)	.108*** (.023)	.107*** (.031)	.152*** (.031)	.158*** (.037)
Chi-Square=	80.75	81.02***	36.75***	52.101**	78.663***	124.574***
N=	1,049	1,014	1,049	1,021	1,049	1,015

[a] ***Food models*** 1= Do not buy more food, 0= Else; ***Water models*** 1= "Yes," cut down water use over 5 years, 0= Else; ***Energy models*** 1= "Yes," reduced energy use over 5 years, 0= Else.

*$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

The final model presented in Table 6 concerns water+energy nexus behaviors. Gender was the only control variable with a statistically significant and negative impact, with females less likely to engage in water+energy nexus behaviors when compared to males. The nonmetro variable was also negative and statistically significant indicating that metro respondents were more likely to engage in water and energy nexus behaviors when compared to nonmetro households. For the final 2 variables, only the NEP has a statistically significant impact, with those respondents with higher support for the NEP more likely to engage in water and energy conservation nexus behaviors than those with lower scores.

Table 6. *Multinomial Logistic Regression Estimates for FWE Nexus Behaviors*[ab]

	Food+Water+Energy *Coefficient (SE)*	**Food+Water** *Coefficient (SE)*	**Food+Energy** *Coefficient (SE)*	**Water+Energy** *Coefficient (SE)*
Age	-.010* (.005)	.010* (.005)	.007 (.005)	.004 (.004)
Gender	.058 (.165)	.005) (.156)	.278 (.149)	-.313* (.143)
Education	.289*** (.063)	.243*** (.059)	.268*** (.056)	.084 (.054)
Income	.063 (.045)	.098* (.043)	.014 (.040)	-.029 (.038)
Nonmetro	-.116*** (.021)	.191 (.157)	-.263 (.151)	-.285* (.145)
NEP	.061** (.020)	.063*** (.018)	.070*** (.017)	.055*** (.016)
Efficacy	.087*** (.026)	.110*** (.025)	.144*** (.024)	.004 (.022)
Chi-Square=	268.555***	261.290***	255.811***	112.413***
N=	1,011	1,042	1,045	1,042

[a]Range is 0=engaged in no FWE behaviors to 3=engaged in all 3 behaviors.
[b]Range is 0=engaged in no behaviors to 2=engaged in 2 behaviors.
*$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

3.0 Discussion, Limitations, and Conclusions

Individual decisions regarding consumption of FWE involve complex mental processes that can be bound by deeply rooted values and norms and constrained by more practical choices based on values, convenience, and access. While certain sociodemographic variables were determined to be predictive of conservation of FWE, the NEP and efficacy scales were associated with all three conservation activities, individually and in concert. People who positively identify with the NEP, exhibiting a pro-environmental worldview, tend to ‘consistently’ align their behavior with their ecological values (van der Werff, Steg, & Keizer, 2013). Similarly, people exhibiting high levels of personal efficacy, feeling their behavior can have a positive environmental impact, are also more likely to exhibit conservation behaviors such as recycling (Tabernero & Hernández, 2011) as well intrinsically motivate individuals to engage in environmentally friendly behaviors (Tabernero & Hernández, 2012). As we would expect, our results regarding both the NEP and Efficacy scales to predict environmental behaviors were consistent with prior research.

Apart from the NEP and efficacy, residency stood out as a variable influencing food purchasing. Specifically, people living in non-metro areas are more likely to buy more food than needed. For food behavior, this could be the result of limited access to larger supermarkets—thus increasing purchasing while available—and potentially the distance non-metro residents must travel to attain food. Many studies have explored the 'food deserts' of rural areas that increases the time, and often money, needed to acquire food (Morton & Blanchard, 2007). Potentially, the greater the distance to grocery shopping, the more likely non-metro residents would over-purchase food items to ensure that they have food on hand. One drawback of our study is that we did not ask about types of food purchasing. It is important to recognize that while non-metro residents may purchase more food than necessary, the type of food is equally important in terms of overall food waste. If metro residents purchase more carbon intensive food items, like red meat and dairy, while non-metro residents purchase less carbon intensive food—like produce—then metro shoppers have an overall greater food footprint regardless of waste.

The variables most likely to influence water conservation related to higher levels of education, lower income, and living in urban areas. Prior research on the sociodemographic predictors of water conservation is inconclusive. While some studies suggest older cohorts (Olli, 2001; Wolters, 2014) and people with higher levels of income (Trumbo & O'Keefe, 2001; Wolters, 2014) are more likely to conserve, these variables were not predictive in our research. Instead, we find an inverse relationship between income and water conservation, which is consistent with research conducted by De Oliver (1999). The negative relationship between income and water conservation is curious considering that prior research suggest the opposite relationship to be predictive. There are, of course, many factors that could influence this finding, notwithstanding that increased income is generally associated with larger houses, more property, and so forth, where water use is more proportional to household and property size. Further, water pricing could act as a disincentive for water use, (e.g., if water use is correlated with higher prices the cost of water may outweigh the benefits of use) leading to more conservation in the home.

Our finding of a positive relationship between education and water conservation is consistent with prior research where environmental conservation is associated with higher levels of education (Hines, Hungerford, & Tomera, 1987) and specific to water conservation (Gilg & Barr, 2006). Further, level of education was positively related to energy reduction behaviors. Again, this is consistent with prior research correlating increased education to conservation behaviors and studies finding that higher level of education correspond specifically to less home energy use (Poortinga, Steg, & Vlek, 2004).

Lastly, residency was correlated with water conservation in Oregon. A recent study determined that over the last several decades urban areas are increasing water efficiency and conservation, while rural areas are actually becoming less water efficient across the U.S. (Sankarasubramanian, et al., 2017). Sankarasubramanian et al. (2017) find that this is the result of increased technology and infrastructure in urban areas that may impact residents' awareness of water consumption. Another mitigating factor may be the impact of the 2015 drought, where many urban centers were asked to voluntarily conserve water, or in some cases face fines for discretionary water use. Both the experience of the drought as well as the impacts on individual household water use may have established new water use behaviors for conservation.

Of the sociodemographic, value and efficacy variables tested pertaining to the FWE nexus components, age, education, income, metro–non-metro residence, the NEP and efficacy scales were significantly related to environmental behaviors. What the overall takeaway from these findings suggests is that certain determinants of behavior align with other environmental behaviors. Therefore, even if people do not strategically engage in behaviors in one sector with the explicit recognition of impacts to other sectors of the nexus, the propensity to engage in environmental behaviors suggests a broader cognition of environmental issues.

Both the NEP and efficacy results help support the VBN theory where values combined with a sense of personal efficacy influence behaviors. The NEP and efficacy variables were consistent indicators of individual actions and nexus behaviors. Therefore, we find that the VBN theory accurately reflects how personal environmental values, combined with a belief that individual actions can positively affect environmental outcomes results in engaging in FWE conservation behaviors.

From a policy perspective, household resource conservation might need to be ‘nudged’ along, meaning creating policies that encourage people to make more environmentally friendly choices by making more FWE conservation default options (Zaval & Cornwell, 2016). For example, in 2015 the city of Seattle created a new law making it illegal to put food or food waste into trashcans. The city provides household bins for food and yard waste, and anyone putting food waste into their trash bin will be fined. The concept behind this is to change the default behavior toward one that is more ecologically friendly, and could impact both how much food is wasted and how it is disposed. By combing education with policy ‘nudges’ it is possible to achieve environmentally desirable behaviors in the FWE nexus.

The only other consistent antecedent to FWE behaviors is education, suggesting that the more aware people are of nexus issues, the more likely they will engage in conservation behaviors related to the nexus. For example, people who believe that their individual actions are impactful may engage in behavior they believe is having a positive environmental effect, when in fact other actions would be more meaningful. Therefore, education should expressly convey economic or ecological benefits that are the more impactful, that is, in terms of energy a focus on efficiency rather than curtailment (Gardner & Stern, 2010). Further, education should focus on specific actions individuals can take and clearly illustrate the environmental impact of each action.

There were several limitations to our survey. Specifically, we used one question each for the dependent variables of FWE to establish consumption. Future research should focus on questions that can clarify consumption and conservation efforts by asking respondents to identify what specific behaviors they engage in—such as food choices like a vegetarian or vegan diet or water conservation like use of rain barrels, and so forth. Understanding more comprehensively what conservation behaviors households engage in can provide clarity into the potential reasons behind their responses—for example, if someone composts, generates their own electricity, and so forth, this would impact their responses. In addition, understanding the source of their food, water and energy is also important. A household that draws water from a private well may not see water conservation as significant versus someone paying for water delivery. Further, attempts to clearly identify other variables that can impact both willingness and ability to engage in conservation of FWE—for example, income, access, urban-rural residency, and so forth—is critical to understanding engagement in FWE conservation behaviors.

In addition, a multi-method research approach could offer more in-depth analysis into personal environmental behaviors, specifically integrating interviews into the research. Larson, Stedman, Cooper and Decker (2015) find that relying on self-reported personal environmental behaviors alone is often unreliable and does not allow for an understanding of behavior that may be less frequent, but environmentally significant. The authors recognize that this paper presents a snapshot providing broad insights into FWE conservation in the home. A more detailed research project could delve more deeply into trade-offs, constraints and behaviors.

To date, we are aware of only one other public FWE nexus survey (Portney et al., 2017), and one focused on food waste and FWE awareness (Hannibal & Vedlitz, 2018), with neither study focusing on rural-urban differences. Results from the Portney et al. (2018) survey found that "people who are aware of any one nexus are highly likely to be aware of the others, suggesting that there is probably an underlying nexus cognition construct" (p. 18). However, they also find that there is "considerable variation in the extent to which people make the connections between water and energy, water and food, and food and energy" (Portney et al., 2018, p. 18). Hannibal and Vedlitz (2018) found that nexus awareness heightened concern over food waste, and led to higher levels of policies to reduce food waste. The findings from both surveys suggest that education about the interconnectivity of the nexus is critical in establishing that behavior in one sector of the nexus may impact other nexus components. This would also hopefully address any 'moral licensing' wherein "resource conservation in one area may make people more wasteful elsewhere" (Tiefenbeck, Staake, Roth, & Sachs, 2013, p. 160). While challenging, in order to capitalize on individuals' behavior having an impact on conservation of FWE resources, it is imperative that education is provided or default environmentally desirable behaviors are encouraged to have meaningful results.

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