Applied Geography 43 (2013) 45–55

Contents lists available at SciVerse ScienceDirect

Applied Geography

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

Preferences of Wyoming residents for siting of energy and residential development

Amy Pocewicz [a,*], Max Nielsen-Pincus [b]

[a] The Nature Conservancy, Wyoming Chapter, 258 Main St., Suite 200, Lander, WY 82520, USA
[b] Department of Environmental Science and Management, Portland State University, Portland, OR 97207, USA

Keywords:
Geographic discounting
Public participation GIS
Energy development
Residential development
NIMBY

A B S T R A C T

Many communities are challenged with balancing growing demands for energy and residential development with the protection of places having cultural or biological importance. Incorporating the preferences and values of local residents early in decision-making processes through public participation GIS (PPGIS) data may help to limit land use conflicts. We used a PPGIS dataset from three counties in Wyoming to determine 1) if there are spatial relationships among mapped cultural or biological values and preferences for new energy or residential development that indicate compatibility or conflict and 2) if there is evidence of geographic discounting or a not-in-my-backyard (NIMBY) pattern associated with development preferences. We found strong overlap, or compatibility, between mapped cultural and biological values and little or no overlap among mapped biological or cultural values and energy development siting preferences. These relationships could identify opportunities for conservation initiatives and inform siting of new developments. Where people live influenced their mapping patterns. Participants mapped perceived positive environmental conditions closer to home than negative conditions, demonstrating geographic discounting. We observed NIMBYism for wind development, as participants mapped wind preferences further from their homes than where development is anticipated. We also observed NIMBYism for residential development, but at a reduced spatial discounting rate compared to wind development. Participants mapped their preferences for oil and gas development further from home than existing or anticipated wells but tended to place them near a large oil and gas field, which may reflect a preference for concentrated development, rather than NIMBYism. We noted distinct preferences for contrasting values in different locations, and this consistency among participants shows that PPGIS datasets have potential to communicate a useful collective vision to inform development siting.

Introduction

Many communities in the western United States are challenged with balancing growing demands for energy and residential development with the protection of other important cultural and biological values. These challenges stem from the West's abundant energy resources (Copeland, Pocewicz, & Kiesecker, 2011), along with natural amenities that have attracted many new residents (Frentz, Farmer, Guldin, & Smith, 2004; Hansen et al., 2002; Radeloff et al., 2010). Between 1990 and 2007, development of oil and natural gas doubled in the Intermountain West (Naugle et al., 2011), and similar increases are expected in the next 20 years (Copeland, Doherty, Naugle, Pocewicz, & Kiesecker, 2009). Many of the new wind farms needed to meet U.S. renewable energy goals are also being constructed in this region (US Department of Energy 2008). Energy development brings economic benefits, including jobs, but new energy and residential development can also reduce open space, increase the costs for community services (Coupal, McLeod, & Taylor, 2002) and have impacts on recreational activities, wildlife habitat (Hansen et al., 2005; Maestas, Knight, & Gilgert, 2003; Naugle et al., 2011; Sawyer, Kauffman, & Nielson, 2009), water quality (Entrekin, Evans-White, Johnson, & Hagenbuch, 2011; Frost & Mailloux, 2011; Lohse & Merenlender, 2009), and agriculture (Gosnell, Haggerty, & Travis, 2006; Nielsen-Pincus et al., 2010). Conflicts over land use often arise due to the potential impacts of development on other resources that communities value (Bengston, Fletcher, & Nelson, 2004). Incorporating the preferences and values of local residents early in the land use

* Corresponding author. Tel.: +1 307 335 2131; fax: +1 307 332 2974.
E-mail addresses: apocewicz@tnc.org (A. Pocewicz), maxn@uoregon.edu (M. Nielsen-Pincus).

http://dx.doi.org/10.1016/j.apgeog.2013.06.006

decision-making process may help to reduce conflicts over land use change.

Public participation GIS (PPGIS) captures community preferences and values in a spatially-explicit way, which can support and empower public participation in land use planning, natural resource management, and policy development (Sieber, 2006). In PPGIS, individual participants identify locations that represent where they feel certain values are most important, their preferences for where specific land uses or activities should occur, or other preferences or knowledge associated with places. PPGIS has been used for many applications (Brown, 2005), including planning for forests and national parks (Beverly, Uto, Wilkes, & Bothwell, 2008; Brown & Reed, 2009; Brown & Weber, 2011; Clement & Cheng, 2010), identifying places with conservation or wilderness value (Brown & Alessa, 2005; Zhu, Pfueller, Whitelaw, & Winter, 2010) and determining siting preferences for residential or tourism development (Brown, 2006; Nielsen-Pincus et al., 2010). PPGIS has also been applied to understand perceptions related to climate change (Raymond & Brown, 2011) and ecosystem services (Brown, Montag, & Lyon, 2012; Raymond et al., 2009; Sherrouse, Clement, & Semmens, 2011).

Identifying the spatial agreement or disagreement among different types of values or preferences mapped by communities could be valuable to inform land-use decisions. PPGIS participants often place multiple values or preferences in the same locations, and these relationships can be used to understand which values or land uses may be perceived as compatible (Brown, 2006; Brown & Reed, 2012; Zhu et al., 2010). Relationships among mapped values can also be used to identify places having high potential for land use conflicts (Brown & Donovan, 2013; Brown & Reed, 2012; Nielsen-Pincus, 2011). A commonly-used typology of mapped values (Brown, 2005) clustered spatially into two groups, representing socioeconomic quality (e.g. economic values) or personal/environmental quality (e.g. aesthetics, biodiversity), and biological and economic values avoided each other spatially in three counties in the northwestern US (Nielsen-Pincus, 2011). Places where socioeconomic and personal or environmental values did overlap were identified as places having high potential for conflict over resource management (Nielsen-Pincus, 2011). These types of relationships have not previously been investigated with respect to energy development siting preferences.

Where people live may influence how they assign values and preferences across landscapes. Geographic discounting theory suggests that people prefer to be close to what they like or consider "good" and follow predictable patterns in willingness to pay to maintain distance between themselves and what they dislike (Hannon, 1994; Norton & Hannon, 1997). Geographic discounting is an expression of the spatial preferences for consumption of market or non-market goods over space, and is generally found to vary inversely with distance from an individual's reference location (Kozak, Land, Shaikh, & Wang, 2011; Perrings & Hannon, 2001). Some evidence of geographic discounting has been observed with PPGIS data. Mapped environmental values were clustered around communities, with values associated with direct uses located closer to communities than those associated with indirect uses (Brown et al., 2002) and different mapping patterns were observed for participants who lived in different towns (Alessa, Kliskey, & Brown, 2008). However, these studies did not ask participants to locate positive ("good") and negative ("bad") evaluations of the landscape, or where potentially impactful land use changes should occur. A specific case of geographic discounting is the not-in-my-backyard (NIMBY) effect sometimes associated with development. NIMBY refers to the motivation local residents have to avoid locally undesirable land uses (Dear, 1992). NIMBYism has been observed during the siting of wind energy facilities, where people living closest to wind farms in the U.S. had the lowest support for or most negative attitudes about the developments (Jacquet, 2012; Swofford & Slattery, 2010; Thayer & Freeman, 1987). The inverse of this pattern has been observed in Europe (Devine-Wright, 2005). All of these previous studies have used the fixed location of existing development and measured how attitudes about the existing development changed for people at living at varying distances from it. In contrast, PPGIS allows the location of the participants to be fixed, and they can be asked where they would like to see future development. This seemingly small difference may be of importance for planners who often have to navigate the future rather than evaluate the past or present. Possible NIMBY effects associated with energy development have not been previously investigated using PPGIS data.

In this study we used a PPGIS dataset from Wyoming to further investigate the utility of PPGIS data to inform land use decision making, particularly the siting of energy and residential development. Community preferences for where new energy development should be located have not been included previously in similar PPGIS analyzes and could be useful to inform siting of widespread and increasing energy development in the western U.S. and globally. We applied a typology of values representative of land use issues in the western U.S. First, we tested whether there are spatial relationships among mapped cultural, biological, and economic values, perceived positive and negative biological conditions, and preferences for future energy and residential development that indicate compatibility or conflict. Second, we tested for evidence of geographic discounting based on the distance from participants' homes at which perceived positive or negative conditions were mapped. Finally, we tested for evidence of a NIMBY pattern associated with preferred siting for oil and gas, wind energy, or residential development. If a NIMBY pattern were present, we would expect development preferences to be mapped further from participants' homes than existing or potential developments of that type. Additionally, we would expect development preferences to be mapped further from participants' homes when attitudes about the type of development are negative. To help explain mapping patterns, we also evaluated how well mapped development preferences corresponded with locations of existing and anticipated development.

Methods

Study area

We surveyed residents of Albany, Carbon, and Sweetwater counties in Wyoming, USA (59,000 km^2; Fig. 1). This is a mostly rural area, having a combined population of 96,000 (http://2010.census.gov/2010census). The majority of this population lives in the cities of Green River, Laramie, Rock Springs and Rawlins. These counties were selected because of ongoing and anticipated changes related to energy development that are leading to conflicts between economic development and protection of places important for wildlife or for cultural reasons. Extraction of oil and gas has traditionally been important to the local economy here, and in recent years, wind energy development has increased rapidly. Mining for coal and trona (source of sodium bicarbonate) also occurs here. Agriculture, which is dominated by ranching rather than crop fields in our study area, is also an important part of the local economy and cultural identity. Ranches provide habitat for a number of important species of fish and wildlife and often serve as an important recreational asset for hunting and fishing. While some areas have been affected by energy resource (oil, gas, wind) infrastructure, much of this landscape remains intact and provides important habitat for wildlife species such as the greater sage-

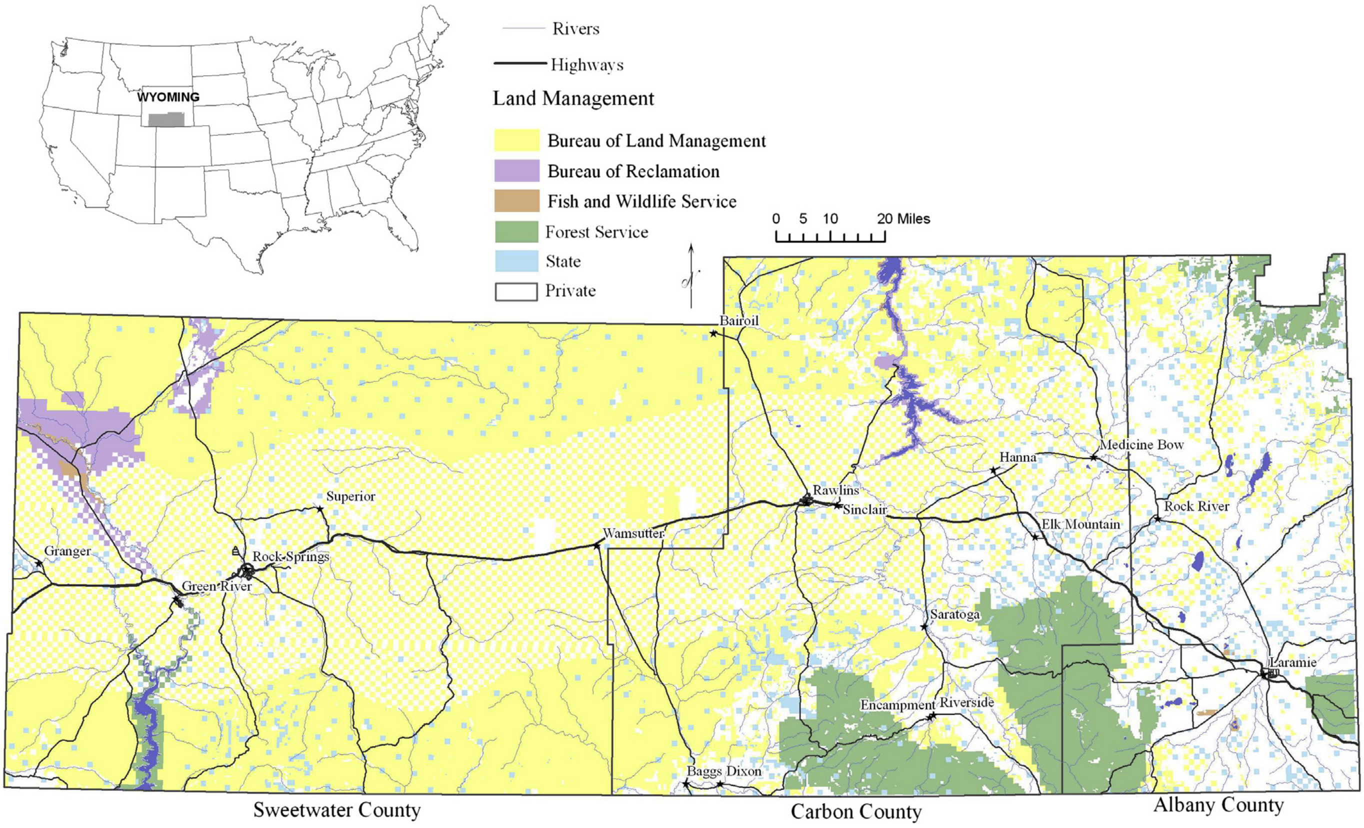

Fig. 1. The three-county study area in southern Wyoming, displayed in similar format to the paper map used by survey participants.

grouse (*Centrocercus urophasianus*), pronghorn antelope (*Antilocarpa americana*) and mule deer (*Odocoileus hemionus*). Seventy-five percent of the land in these counties has native sagebrush or shrubland habitat. Another 11% of the land is forested, primarily at higher elevations, and the remainder is grassland, wetland, and urban areas. Two major rivers, the Green and North Platte, flow through the study area. The majority of the lands here are publicly managed (61%), primarily by the Bureau of Land Management (77%) and Forest Service (12%) (Fig. 1).

Data collection

Data were collected using an Internet-based survey, and invitees were provided the option to complete a paper survey, to avoid excluding people lacking convenient Internet access. Invitation letters were mailed to 2000 randomly-selected residents of the three counties in March 2010, and reminders were mailed after two and four weeks. The survey included a mapping exercise and a questionnaire with questions related to demographics, Internet use, knowledge about and perceived importance of attributes included in the mapping exercise, and attitudes regarding wind energy development. For the mapping exercise, participants were asked to place map markers for 16 attributes representing cultural, biological, and economic values, perceived positive and negative biological conditions, and development siting preferences (Table 1). Energy development preferences included in the survey were limited to wind and oil and gas development, because these resources are widespread with many siting options. Mining also occurs within the study area, but large mines are located in only a few locations and typically have limited siting options. The Internet-based survey used a Google® Maps interface, allowing participants to zoom, pan and view the maps in multiple views. Paper maps displayed terrain, land tenure, major roads, streams and rivers, towns and place names (Fig. 1), and participants were provided with stickers to represent each map attribute.

We completed a non-response survey to identify potential response bias. Phone interviews were completed with 45 non-participants that included a subset of survey questions related to education level and the importance and knowledge of mapped attributes. Additionally, we compared participant gender and employment status with census data and compared participant ages with those obtained from online telephone directory estimates for non-participants ($n = 432$). We tested for differences between participants and non-participants with Chi-square or Fisher's tests for proportional data and *t*-tests or Wilcoxon rank sum tests for continuous data ($\alpha = 0.05$), using SAS 9.3 (SAS Institute, Cary, North Carolina).

Data analysis

Spatial relationships among values, conditions, and development preferences

We measured the spatial overlap or dispersion among pairs of eight categories of mapped attributes: cultural, biological or economic values, perceived positive or negative biological conditions, and preferences for the siting of oil and gas, wind energy, or residential development. The cultural, biological and condition categories each combined multiple mapped attributes (Table 1). We generated hotspot polygons to highlight the areas of greatest importance from the point data using the kernel density method (Silverman, 1986) at a 4 km^2 spatial resolution, which corresponded with the area represented by a map sticker (see Appendix 1 for details). We used hotspot polygons that were created separately for each attribute to retain the unique spatial patterns of each

Table 1
Descriptions of the attributes that participants were invited to map, grouped into categories representing cultural, biological, and economic values and perceived positive and negative biological conditions. The numbers of mapped points are shown in parentheses.

Mapped attribute/category	Attribute descriptions from survey
Cultural values (2293)	
Recreation (838)	It is important to maintain outdoor recreation opportunities in these places.
Agriculture (501)	It is important to maintain working farms and ranches in these places.
Open space (494)	It is important to maintain wide open spaces and scenic views in these places.
Family traditions (244)	These places are important to the traditions and history of my family.
Special places (216)	Use these stickers to identify places that are special to you.
Biological values (1066)	
Habitat protection (596)	It is important to protect fish and wildlife habitat in these places.
Water (470)	These places are important sources of water.
Economic values (336)	
Economic	These places are important because of the economic opportunities they provide.
Positive condition (930)	
Good land condition (210)	Lands in these places are in good condition. For example, there is little soil erosion, plenty of native vegetation, and good resources to support wildlife or livestock.
Abundant wildlife (452)	There are abundant wildlife populations in these places, such as large herds of antelope and deer and large numbers of birds and fish.
Good water resource (268)	These streams, rivers, and lakes are in good condition. There is plentiful and good quality water for fish, wildlife, agriculture, and people.
Negative condition (378)	
Water shortage (222)	There is not enough water in these places to keep up with demand for its use.
Poor land condition (156)	Lands in these places are in poor condition. For example, there are problems with soil erosion and weeds, and resources are lacking to support wildlife or livestock.
Development preferences	
Wind development (406)	If new wind energy farms are built in these counties, these are the places where I would prefer that development to occur.
Residential development (316)	If new homes are built in these counties, these are the places where I would prefer that development to occur.
Oil/gas development (284)	If new oil and gas wells are drilled in these counties, these are the places where I would prefer that development to occur.

attribute, and we merged the individual hotspot maps for the cultural, biological and condition categories.

We used two methods to measure the spatial agreement between each pair of polygon hotspots. The first method, the Jaccard coefficient, included only areas of hotspot presence. The second method, the phi correlation coefficient, measured the overlap of the two categories relative to the full extent of the study area. The Jaccard coefficient measures percent spatial overlap, calculated as the number of pixels shared by two hotspot maps divided by the sum of the number of additional pixels for both maps, multiplied by 100 (van Jaarsveld et al., 1998). The phi coefficient is a variation of the Pearson correlation coefficient that is used for binary data, and the statistical significance of the relationship can be evaluated using the chi-square statistic (Chedzoy, 2006; Zhu et al., 2010). We calculated the phi coefficient for the 28 combinations of paired value categories, using data from a 2×2 contingency table. We calculated chi-square and Bonferroni-corrected *p*-values for each pair ($\alpha = 0.0018$).

Geographic discounting and NIMBYism

We tested for a difference in the mean distances between participants' homes and their mapped points for perceived positive versus negative biological conditions, to determine whether there was evidence of geographic discounting. For comparison, we also included the mapped cultural, biological, and economic values and development preferences. Most participants reside in towns, and conditions might vary in distance from an individual's home simply because they are associated with population centers. Thus, we also measured the distances between towns and mapped positive and negative condition points. We used Tukey–Kramer multiple comparison tests ($\alpha = 0.05$) in SAS 9.3 to test for differences in distances to homes or towns among the categories of mapped attributes. Street address locations were available for 79% of participants, and for the remaining rural participants, home locations were assigned to the small town associated with their post office box address.

We tested for differences in the mean distances between participants' homes and their mapped preferences for wind or oil and gas development, as compared with locations of existing and projected development, using Tukey–Kramer multiple comparison tests ($\alpha = 0.05$). Existing energy development was represented by locations of wind turbines (O'Donnell & Fancher, 2010) or producing oil or gas wells (Wyoming Oil and Gas Conservation Commission, May 2010) that were in place at the time of the 2010 survey. Projected energy development was represented by 20-year projections (2010–2030) based on predicted development probability surfaces that were populated with published projections of expected numbers of wells or turbines (Copeland et al., 2013). Oil and gas wells are widely distributed throughout the study area, but because most wells are concentrated in a few fields, we also measured distances to the largest field located near Wamsutter, Wyoming.

Additionally, for wind development, we tested whether the distance between home and mapped preferences was correlated with participants' attitudes regarding wind development. We focused on wind development because it is relatively new to the study area, as compared with oil and gas development. We asked three survey questions related to attitudes and perceptions about wind development. Each question used a 5-point Likert-scale that represented a range of positive to negative outcomes related to wind development for: economic sustainability of family farms and ranches, ability to access public lands for recreation, and effects on wildlife populations. There was consistency among responses to the three questions (Cronbach's alpha = 0.72), so responses were averaged across each participant to obtain a development attitude score. Each score was classified as positive, negative, or neutral. Positive and negative scores had the strongest within-respondent consistency and represented clear preferences. We compared the average distance between participants' homes and mapped wind development preferences for participants with positive versus negative attitudes about wind development, using a *t*-test in SAS 9.3.

We measured how each participant mapped residential development preferences with respect to their residence location. We counted how often their mapped preferences occurred within 5-km of their town of residence and how often their preferences occurred either within this residence town or a neighboring town, i.e. their neighborhood. We buffered towns by 5 km to account for mapping error and the coarse scale of the maps, which did not define town boundaries.

Finally, we evaluated how well mapped preferences corresponded with existing and projected development locations. We tested for clustering or dispersion among mapped preferences and existing or projected oil and gas or wind development using the bivariate K-function in the R (R Development Core Team, 2013) SPATSTAT package (Baddeley & Turner, 2005). The bivariate K-function uses the expected number of points in a given class (e.g., mapped wind preference points) occurring within a given radius of another class of points (e.g., existing wind turbines) to describe whether the point patterns of the two classes are spatially independent or correlated (Lotwick & Silverman, 1982). We tested the observed values against an expected completely random spatial distribution using a Monte Carlo approach with 999 iterations to simulate a confidence envelope ($\alpha = 0.001$) around Besag's −L function values (Besag & Diggle, 1977). Besag's-L standardizes the $K(r)$ statistic so that $L(r) > 0$ indicates spatial clustering, $L(r) < 0$ indicates dispersion, and $L(r) = 0$ represents the expected random spatial arrangement (Besag, 1977). We specified the search radius in 2-km increments up to one-third of the size of the study area, and applied Ripley's isotropic correction for edge effects (Ripley, 1977).

For residential development, we used chi-square tests ($\alpha = 0.05$) in SAS 9.3 to test for differences in the proportions of existing residential development (housing structures) and mapped preferences occurring within 5 km of town boundaries. Numbers of housing units (households) were obtained from the 2010 US Census for each census block, and we adjusted these for multiple-household units, to represent residential structures. We mapped the structures by randomly assigning the corresponding number of structures within the private land portion of each census block.

Results

Survey participation

Approximately 10% of 1961 deliverable surveys were completed. The mapping activity was completed by 198 participants (99 via the Internet, 99 via paper maps), and 191 participants completed the questionnaire. Participants placed a total of 6009 map markers for the attributes of interest. Participants who used paper maps placed more markers than those who used Internet maps, but there was no spatial bias associated with survey mode (Pocewicz, Nielsen-Pincus, Brown, & Schnitzer, 2012). Participants were distributed equally among the three counties, and 75% of participants lived in one of four major towns – Green River, Laramie, Rawlins, or Rock Springs – which is consistent with the population distribution. There was no difference in age, employment status, or in the proportion of people with a high school degree among participants and non-participants; however, a greater proportion of survey participants had a 4-year college degree. The importance of working farms and ranches, fish and wildlife habitat, and availability of water did not differ between participants and non-participants, but economic opportunities were more important to non-participants. Participants had greater self-described knowledge concerning wind development and fish and wildlife habitat than did non-participants. Further details on the non-response survey findings are provided in related reports (Pocewicz et al., 2012; Pocewicz, Schnitzer, & Nielsen-Pincus, 2010).

Spatial relationships among values, conditions, and development preferences

The spatial overlap between mapped biological and cultural values, perceived positive biological conditions and cultural values, perceived positive biological conditions and biological values, and economic values and preferences for residential development was high (Fig. 2). Overlap was at least 60% when considering only hotspot extent, and there were phi correlations of at least 0.50 when considering the entire study area extent (Table 2). There was a negative spatial relationship, or dispersion, between cultural values and preferences for oil/gas development, biological values and preferences for oil/gas development, and positive biological conditions and preferences for wind development (Table 2, Fig. 2). Wind development also had no or negative overlap with biological values, and low overlap with cultural values. Residential development had low overlap with biological and cultural values, but higher than that observed for energy development. There was moderate overlap between mapped preferences for wind and residential development and almost no overlap between preferences for wind and oil and gas development (Table 2).

Geographic discounting and NIMBYism

Participants mapped perceived positive biological conditions closer to their homes, on average, than negative biological conditions (Fig. 3). This pattern was not confounded with the location of towns, as we found no difference between the distances of positive versus negative conditions from towns. The map attributes that participants placed closest to their homes were cultural and biological values, positive biological conditions, and preferences for wind and residential development. Economic values, negative biological conditions, and preferences for oil and gas development were mapped furthest from participants' homes (Fig. 3).

The distance between participants' homes and their mapped preferences for wind development versus the distance from their homes to existing turbines did not differ (Fig. 4a). However, projected turbines were located much closer to their homes than their mapped preferences (Fig. 4a). There were well-distributed attitudes toward wind development among participants who mapped wind preferences, with 32% negative, 20% neutral, and 48% positive, and this distribution was the same among participants who did not map wind preferences. Participants presenting a negative attitude toward wind development tended to map their preferences for wind development further from their homes (98.7 km, standard error 11.3, $n = 32$) than those who presented a positive attitude toward the development (78.5 km, standard error 8.1, $n = 49$), but these distances were not significantly different ($p = 0.14$). Mapped preferences for wind development were strongly correlated with locations of existing and projected wind turbines based on visual analysis of maps (Fig. 5a) and the bivariate-K analysis, which showed very strong and statistically significant clustering.

Mapped preferences for oil and gas development were located much further from participants' homes than either existing or projected oil and gas wells (Fig. 4b). The largest oil and gas field was also closer to homes on average than mapped preferences, but the difference in distance was smaller (Fig. 4b). Mapped preferences for oil and gas development were strongly correlated with locations of existing and projected wells, based on visual analysis of maps (Fig. 5b) and the bivariate-K analysis, which showed very strong and statistically significant clustering. The majority of mapped oil and gas preferences clustered near the large field development near Wamsutter (Fig. 5b).

Only 27% of residential development preferences were mapped within the same town in which the participant lived in or near (81% of participants lived within towns). However, this increased to 70% when neighboring towns or rural areas near the participants' residences were included. Preferences for residential development were mapped within 5-km of incorporated towns 78% of the time, which is significantly less than the 88% of existing housing that occurs here.

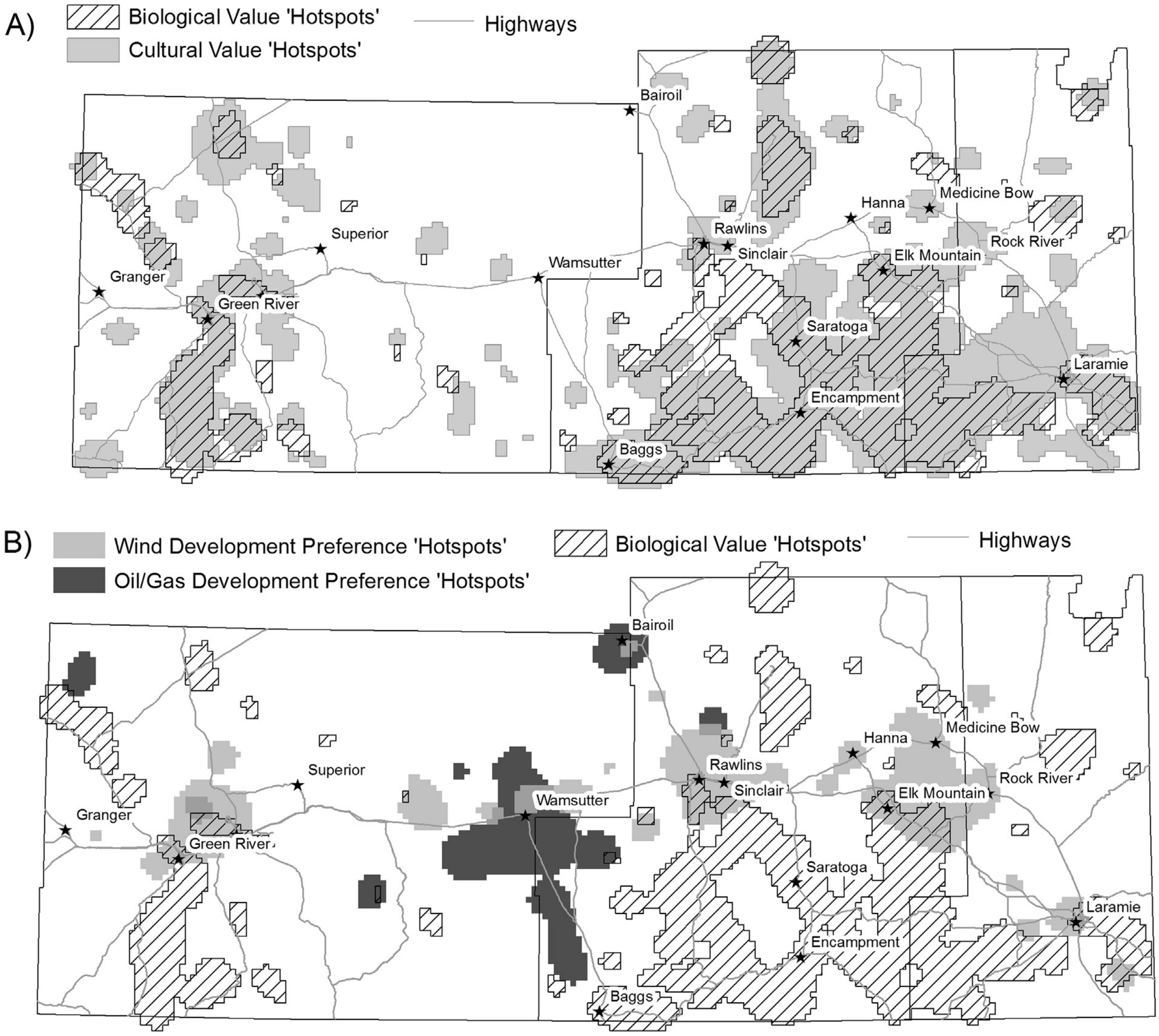

Fig. 2. Comparison of spatial locations of survey participants' mapped preferences for A) biological and cultural values and B) biological values and preferences for the siting of wind or oil and gas development. 'Hotspot' polygons were created from individual mapped points through a kernel density analysis.

Discussion

Spatial relationships among values, conditions, and development preferences

The strong overlap between mapped cultural and biological values was striking and suggests that these two beliefs about the landscape are perceived as compatible. Only 24% of biological hotspot extent fell outside the extent of cultural hotspots, and possibly biological values were identified here because participants were familiar with the same places through their agricultural, recreational, or other activities. In contrast, the lack of overlap between economic values or development preferences and either cultural or biological values suggests that these values are perceived as conflicting. This pattern is not surprising, as spatial avoidance has been observed previously between mapped economic and biological values (Nielsen-Pincus, 2011) and between residential development and biological diversity values (Brown,

Table 2
Overlap between pairs of hotspot polygons representing different categories of mapped attributes. Jaccard percent overlap is shown, followed by phi correlation coefficients in parentheses. All relationships were statistically significant ($\alpha = 0.0018$) except those labeled ns. Negative phi coefficients indicate dispersion.

	Cultural	Biological	Economic	Positive	Negative	Oil/gas	Wind
Biological	76 (0.50)						
Economic	11 (0.12)	8 (0.06)					
Positive	62 (0.50)	85 (0.57)	4 (−0.03)				
Negative	4 (0.13)	5 (0.12)	10 (0.18)	6 (0.14)			
Oil/gas	1 (−0.12)	0 (−0.10)	12 (0.14)	0 (0.08)	7 (0.11)		
Wind	12 (0.4)	6 (0.01^{ns})	26 (0.29)	3 (−0.06)	3 (0.05)	4 (0.02^{ns})	
Residential	17 (0.24)	12 (0.14)	82 (0.60)	7 (0.04)	11 (0.19)	4 (0.02^{ns})	31 (0.34)

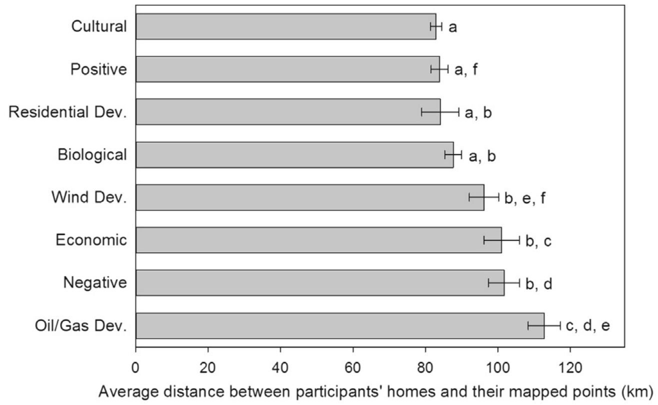

Fig. 3. Bars represent the average distances from participants' homes to eight categories of mapped points, including cultural, biological, and economic values, positive and negative conditions, and siting preferences for residential, wind and oil and gas development. Error bars represent standard error. Letters indicate results of Tukey tests, where categories sharing the same letter are not significantly different.

2006). We observed distinct preferences for certain values in certain places, while land use conflicts might be anticipated if the opposite were true; for example, if half of participants had mapped a particular area as biologically important while the other half mapped their development preferences there. This consistency among participants shows that PPGIS datasets have potential to communicate a useful collective community vision.

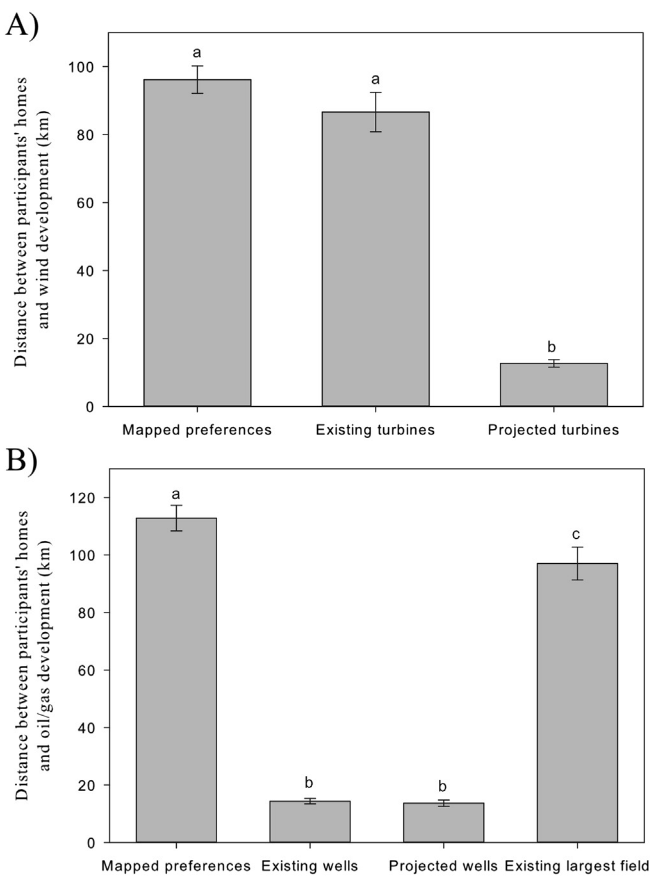

Fig. 4. The bars represent the average distances between participant's homes and A) mapped wind development preferences, existing wind turbines, or projected wind turbines and B) mapped oil and gas development preferences, existing oil/gas wells, or projected oil/gas wells. Error bars represent standard error. Letters indicate results of Tukey HSD tests, within each development type. Two categories sharing the same letter are not significantly different.

PPGIS datasets summarizing community values and preferences are a potential tool to provide community input to inform federal land management plans for multiple use (Brown & Donovan, 2013; Brown & Reed, 2009; Clement & Cheng, 2010) and may also be useful to counties, states, or federal management agencies creating comprehensive plans for or reviewing proposals for energy or other development. Developers may also benefit from consulting PPGIS datasets, in addition to datasets describing resource potential or environmental limitations, to understand in advance of investing in a project where a community may be more supportive or where a project may face opposition (Pasqualetti, 2011; Wolsink, 2007). Our results showed that participants mapped their preferences for new energy development in locations coinciding with the presence of the energy resources, which further highlights the relevance of these datasets for planning applications. Often, large investments in development have been made before opportunities are provided for community input, and some costs and conflicts might be avoided by considering cultural values as part of an initial screening process (Bohn & Lant, 2009). PPGIS datasets showing where communities support new development might be used alongside datasets representing biological, cultural, and other values to highlight those places where development may proceed more efficiently or where incentives might be offered for development. This concept has been previously demonstrated for biological features through the identification of opportunities for wind development to occur on disturbed lands or those having low wildlife value (Fargione, Kiesecker, Slaats, & Olimb, 2012; Kiesecker et al., 2011).

The strong relationship between mapped cultural and biological values highlights an opportunity for conservation initiatives. There may be greater public support for conservation in places that are culturally valued, in addition to having biological importance (Donovan et al., 2009). Places participants identified as biologically important may not coincide entirely with places identified as biologically important through scientific assessments, but there is typically considerable concurrence (Brown, Smith, Alessa, & Kliskey, 2004; Donovan et al., 2009). Personal connections to these culturally-valued places could lead to increased support for conservation there. Place attachment has been linked to support for conservation planning (Walker & Ryan, 2008) and interest in conservation easements (Farmer, Knapp, Meretsky, Chancellor, & Fischer, 2011). Generally, there is increasing awareness that for conservation to succeed, it must be relevant to and resonate with people (Kareiva & Marvier, 2007; Mascia et al., 2003). Mapped cultural data could help to identify potential allies for conservation in biologically-important areas that are also important culturally (e.g., agricultural community, hunters, historical preservation groups), as well as where more engagement or education may be needed to increase support for conservation in biologically-important areas of little cultural value (Bryan, Raymond, Crossman, & King, 2011).

The datasets presented here represent a random sample of residents from these three counties. Our non-response survey showed that these participants provide a reasonable representation of the demographics and values of all study area residents. However, participants were more educated than the general populations of these counties and also described themselves as being more knowledgeable about the issues presented in the survey. The survey's salience to more knowledgeable segments is unsurprising given the effort required to complete a PPGIS mapping activity. Mapped results may better represent the perspectives of those who are more likely to be involved in energy, development, or natural resource planning than the general public. One important potential

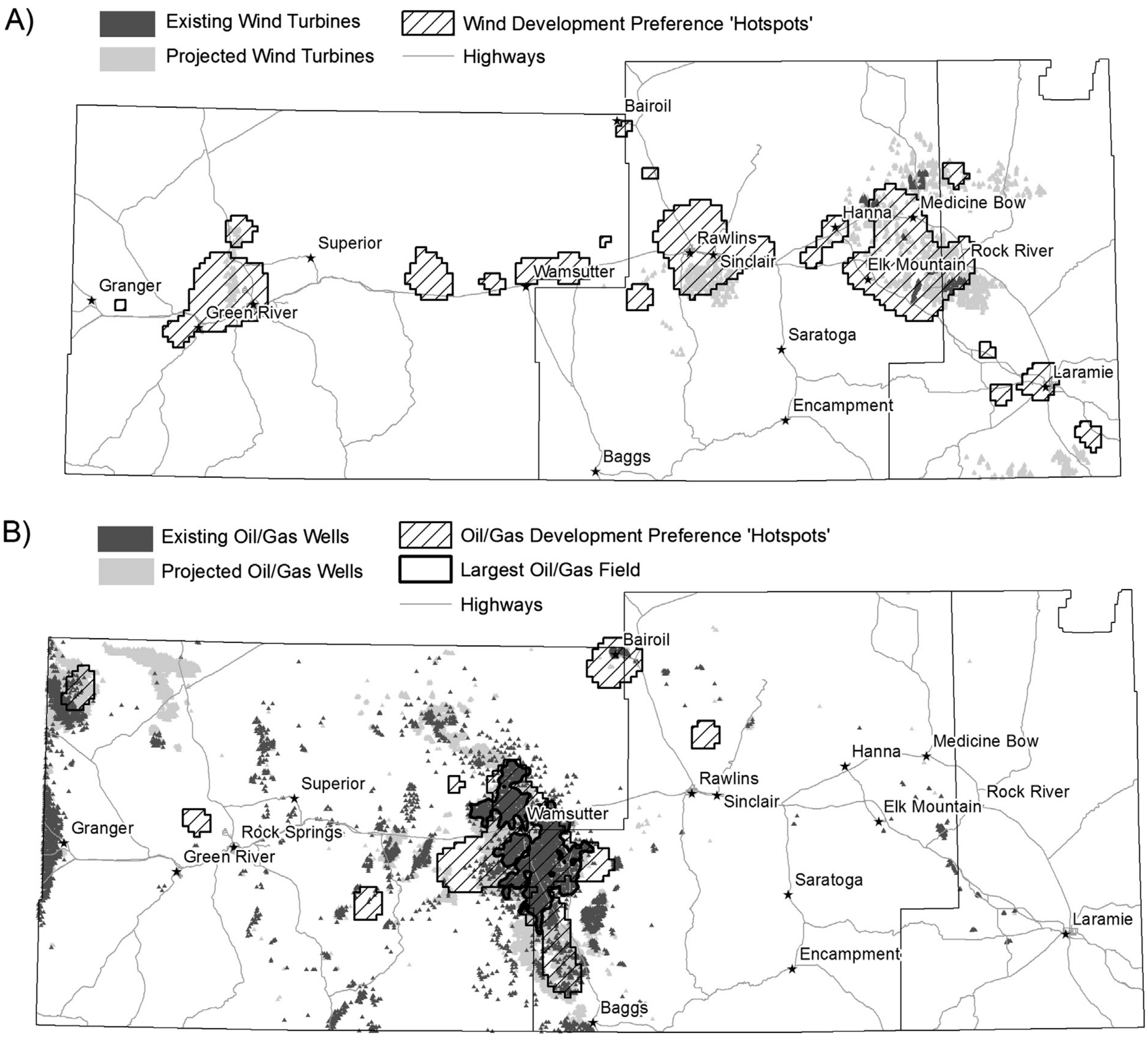

Fig. 5. Comparison of spatial locations among survey participants' mapped preferences for development, locations where development already existed at the time of the survey, and locations where future development is expected based on modeling projections, for A) wind development and B) oil and gas development. 'Hotspot' polygons were created from individual mapped points through a kernel density analysis.

bias is that economic opportunities were more important to non-participants than participants, suggesting that economic values and development preferences may be underrepresented in the survey. Capturing this bias in our data collection could potentially strengthen our conclusions, as we found that people with positive attitudes toward wind development opportunities had a tendency to map their preferences for those opportunities closer to their homes.

Geographic discounting and NIMBYism

Similar to the time value of money so prevalent in the field of economics, Hannon (1994) suggests that people discount their preferences spatially too – that is, we prefer positive features to be located close in space and negative features be located further away. Although geographic discounting is more commonly investigated economically (Perrings & Hannon, 2001), social value mapping also provides evidence of geographic discounting and helps to explain why some people exhibit NIMBY attitudes for certain land uses. Participants mapped perceived positive environmental conditions closer to their homes than negative conditions, supporting the notion that people exhibit a preference to be near to the positive and far from the negative. This is similar to the findings reported in other studies about the influence of spatial locations on environmental values (Brody, Highfield, & Alston, 2004; Brown et al., 2002), which generally find that environmental valuation is related to distance, even though different types of values may exhibit different relationships with distance.

Geographic discounting may also help to explain why some participants mapped their preferences for wind development closer to home than existing wind development, while others mapped them further away. Positive attitudes toward wind development were associated with closer, on average, preferences for wind development, suggesting that participants' positive attitudes increased the spatial discount rate leading to closer preferences. People who expressed negative attitudes toward wind development decreased the spatial discount rate, leading to preferences that, on average, were farther away. It would be valuable to investigate this through additional PPGIS studies, as we had a small sample size and this tendency was not statistically significant. The differences between those participants who expressed negative versus positive attitudes toward wind development may be explained by the NIMBY phenomenon whereby people want to avoid or oppose locally undesirable land uses (Dear, 1992). Participants placed their preferences for wind development close to where it currently exists or is expected, but these preferences were mapped further from home than where development is projected, which may be indicative of NIMBYism. Projected turbines are more widespread than existing turbines, so tended to be closer, on average, to participants' homes.

Evidence of NIMBYism related to wind development was most apparent among participants from Albany County. Albany County participants mapped their wind development preferences the furthest from home – 104 km on average, as compared with 76 and 80 km for Carbon and Sweetwater counties, respectively. This is not consistent with county-level patterns in existing and projected wind developments. Albany County has 20% of existing wind turbines and is projected to have 38% of the new turbines that are anticipated across the three counties. In contrast, Sweetwater County currently has no wind turbines and is projected to have only 7% of new turbines, yet Sweetwater participants placed most of their preference points for wind within their own county, while Albany participants did the opposite. Albany County differs in two ways from the other two counties that may help to explain this pattern. First, Albany participants lived closer to existing wind turbines, on average within 47 km, than participants from Carbon (73 km) and Sweetwater counties (102 km). Previous studies in Texas and Pennsylvania have found that people living closest to wind farms tend to be least supportive of the developments (Jacquet, 2012; Swofford & Slattery, 2010). Second, Albany County does not have the long history with oil and gas and mining industries that Carbon and Sweetwater counties do, and Albany County's wind farms were recently constructed. Industrial legacies have been found to lead to greater support for new industrial developments of different types in those communities (van der Horst, 2007). Employment history with the energy industry has also been linked to more positive attitudes toward wind and natural gas development (Jacquet, 2012), and due to the longer history of oil and gas development, we expect that participants from Carbon and Sweetwater County would be more likely to have a direct or familial employment association with an extractive industry than participants from Albany County.

At first glance, it would appear that there also may be a NIMBY pattern related to oil and gas development, because participants mapped oil and gas preferences further from their homes than the locations of existing or projected wells. However, individual wells are scattered across the study area and there is a high likelihood that any participant may have a well within 10 or 20 km of their home. Instead of identifying areas near these individual wells as preferred for development, participants tended to map their preferences for oil and gas development in the vicinity of the largest oil and gas field. This result suggests that participants were mapping their preferences close to where they had seen most development occur previously, or that they prefer for development to be concentrated or confined. Our findings were similar to those of Jacquet (2012), who found no correlation between attitudes toward natural gas development and proximity to wells, possibly related to an even distribution of wells across their study area.

Most participants placed their residential development preferences within their neighborhood of nearby communities, and thus there was less evidence for NIMBYism around residential development than for wind energy development. Of the 30% of preferences not placed close to home within these neighborhoods, 66% were placed in the largest towns of Laramie, Rock Springs, Green River, and Rawlins. However, with exception of Laramie, these urban areas are also associated with oil and gas and mining industries, and 61% of the outside-neighborhood points were mapped in urban or rural areas (including Wamsutter and Sinclair) where energy development is prevalent. Only 12% of outside-neighborhood points were mapped in the small towns of Encampment, Saratoga, and Centennial and might be associated with natural amenities and vacation homes. These findings suggest a reduced spatial discounting rate for residential development than for wind energy development and a preference for new residential development that is relatively close to home, in urban areas, or in communities that have been associated with extractive industries. Urban areas and communities associated with extractive industries are places that have typically experienced residential growth in the past in Wyoming. The general pattern of residential development preferences being located near existing cities or towns is consistent with patterns observed in past studies including mapping of this preference (Brown, 2006; Nielsen-Pincus et al., 2010). However, in our study the mapped preferences also demonstrated an interest in more development outside of towns than what occurs currently. This reflects a trend toward rural, exurban development that has been occurring in Wyoming and throughout the western US (Brown, Johnson, Loveland, & Theobald, 2005; Gude, Hansen, Rasker, & Maxwell, 2006; Hulme et al., 2009). These residential development preferences could be useful for informing county zoning or comprehensive plans and examining tradeoffs among residential development and other land uses (Brown, 2006; Nielsen-Pincus et al., 2010).

Conclusion

Demands on lands for multiple uses, including energy development, are anticipated to continue increasing in the western United States and throughout the world. As this occurs, land use conflicts will undoubtedly continue. PPGIS could be useful to identify locations where compatibility with or conflict over certain land uses may occur and could be an effective mechanism for engaging the public in land use decision making. We found strong agreement between mapped cultural and biological values, but a lack of overlap between these cultural and biological values and preferences for siting of new energy development. These findings could identify opportunities for conservation initiatives and provide useful information to governments, agencies or companies planning new developments. Where people live influenced how they mapped their values and preferences across the landscape. Our mapping data provided evidence of geographic discounting, as perceived positive environmental conditions were mapped closer to home than negative conditions. We also observed NIMBYism related to wind energy and residential development.

Acknowledgments

We are grateful to the Wyoming residents who shared their time for this survey. We thank Greg Brown and Jeremy Murray for designing and hosting the Internet survey, Diana Hulme and Russ Schnitzer for collaboration in designing and administering the survey, Dot Newton for assistance with survey data and non-response surveys, Jeffrey Evans for advice on spatial statistics methods, and Greg Brown, Graham McGaffin and Wayde Morse for their insightful comments on an earlier version of this article. We also thank the two anonymous reviewers whose suggestions greatly improved this article.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.apgeog.2013.06.006.

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