Science
Education

A "Sense of Place" in Public Participation in Scientific Research

BENJAMIN K. HAYWOOD
Department of Geography, University of South Carolina, Columbia, SC 29208, USA

ABSTRACT: Public participation in scientific research (PPSR) within the natural sciences has been demonstrated as an effective strategy to expand cognitive knowledge and understanding of ecology, with implications regarding individual perspectives, attitudes, and behaviors about the environment and feelings about the personal relevance of science. Yet the development of PPSR outcomes, the processes through which they form, and the settings where they are shaped are still not fully understood. Because most PPSR takes place and is grounded in specific sites and socioecological contexts, the relationships among PPSR participants and the places in which they explore, collect, and gather information are central to the PPSR experience. Nonetheless, a dearth of empirical research on the interactions between people and places in PPSR highlights a promising area of future scholarship. Drawing from theoretical traditions within geography and environmental psychology, this article contends that PPSR experiences and outcomes both influence and are influenced by a "sense of place." Highlighting the significance of people–place relationships in PPSR via a place-based window, this article calls for efforts that bridge multiple academic communities to open innovative avenues for understanding natural science PPSR experiences, the cognitive, conative, and affective outcomes of such encounters, and the dynamics of human–environment interactions.   © 2013 Wiley Periodicals, Inc. *Sci Ed* **98:**64–83, 2014

INTRODUCTION

Natural science communities have often used information provided by ordinary citizens to inform and expand analysis and research efforts (Dickinson & Bonney, 2012; Dickinson, Zuckerberg, & Bonter, 2010). As ecological research has grown in complexity and scale

Correspondence to: Benjamin K. Haywood; e-mail: haywoodb@email.sc.edu

throughout the past century, efforts to include community members in research have multiplied in recognition of the valuable role citizens can play in collecting, submitting, and analyzing ecological data over large spatial and temporal scales (Conrad & Hilchey, 2011; Cooper, Dickinson, Phillips, & Bonney, 2007; Dickinson, Zuckerberg, & Bonter, 2010). A host of traditions exist today that have emerged to encourage public participation in the scientific research process. In this context, the basic procedures involved in monitoring and analyzing natural phenomenon are used as platforms to unite scientists, communities, and stakeholders across scales, help frame socially legitimate indicators of environmental problems, and advance locally relevant and practical conservation goals and strategies (Couvet, Jiguet, Julliard, Levrel, and Teyssedre, 2008; Danielson, Burgess, & Balmford, 2005).

Acknowledging the convergence and synergies that exist among these varied strategies, scholars have recently advocated the use of an integrated umbrella term called public participation in scientific research (PPSR) to facilitate more collaborative research and practice among this broad collection of participatory traditions (Shirk et al., 2012). Although each individual PPSR initiative may stress some aspects over others, four overarching goals extend across multiple PPSR projects. These include expanding the scope and scale of scientific research (Couvet et al., 2008; Devictor, Whittaker, & Beltrame, 2010; Greenwood, 2007; Lee, Quinn, & Duke, 2006; Schmeller et al., 2008), enhancing science knowledge and understanding via interactive learning experiences for "nonscientists" (Bell, Lewenstein, Shouse, & Feder, 2009; Bonney et al., 2009a, 2009b; Brossard, Lewenstein, & Bonney, 2005; Conrad & Hilchey, 2011; Jordan, Gray, Howe, Brooks, & Ehrenfeld, 2011; Trumbull, Bonney, Bascom, & Cabral, 2000), increasing environmental stewardship (Dickinson & Bonney, 2012; Marshall, Kleine, & Dean, 2012; Wolf, Blahna, Brinkley, & Romolini, 2013), and developing more democratic and inclusive science research and policy processes (Mejlgaard & Stares, 2010; Powell & Colin, 2008; Rowe & Frewer, 2004; Wilderman, Barron, & Imgrund, 2004; Wooden, 2006). Such goals have emerged from a variety of theoretical traditions advancing PPSR efforts. These include those stemming from large-scale ecological research, the public understanding of science and technology tradition, largely focused on science outreach and research expansion (Bauer, Allum, & Miller, 2007; Lewenstein, 1992), and those from the public engagement in science tradition, focused more on challenging the dominance of the scientific "elite" by opening up the research and policy process to be more responsive to socially negotiated needs and interests (Mejlgaard & Stares, 2010).

A large amount of literature on PPSR has focused on evaluating the validity and reliability of data collected by volunteers (Dickinson et al., 2010; Lee et al., 2006; Lepczyk, 2005; Schmeller et al., 2008; Wintle, Runge, & Bekessey, 2010). Research within this tradition is considered an evaluation of the *external value* of PPSR projects (Lawrence, 2006), treating PPSR data as a public good (Dickinson & Bonney, 2012). Simultaneously, a community of research exists on the *internal value* of PPSR projects in the form of participant outcomes (Lawrence, 2006), specifically as it relates to educational effects (Bonney et al., 2009a, 2009b). Although most all natural science PPSR takes place and is grounded in specific sites imbued with meaning (Goodchild, 2007), neither of these research traditions have extensively interrogated the affective interactions and relationships among volunteer participants and the *places* in which they explore and collect ecological information via such programs. To address this critical contextual dimension, this article argues that the geographic concept of "sense of place" is an empirically underrepresented, yet theoretically well-established entry point to explore how PPSR participants make connections between embodied experiences, thoughts, ideas, interactions, and behaviors and how participant characteristics and positions can influence these experiences. Examining the role of sense of place in the meaning making of PPSR experiences can reveal information about how

individuals connect to and perceive the environment, cultivate relationships with other humans and nonhumans, and develop perceptions, values, and attitudes about human–environment interactions. Such information has broad potential to influence not only the educational and stewardship outcomes of PPSR but the quality of research outcomes as well.

PUBLIC PARTICIPATION IN SCIENTIFIC RESEARCH: A HETEROGENEOUS PRACTICE

PPSR programs within the natural sciences have changed dramatically over the past several centuries. Whereas some of the earliest PPSR projects (generally referenced as citizen science) in the early 19th century were largely reserved for the privileged or elite, the practice today is much more inclusive and open (Silvertown, 2009). At a basic level, PPSR involves collaborations between professional or "expert" scientists and members of the public ("amateurs") who are directly involved in a scientific research project. Such projects range from those focused more on environmental justice like "participatory action research" to efforts intended for science outreach or literacy (Shirk et al., 2012). Bonney et al. (2009a, p. 15) note that most PPSR projects in the natural sciences involve a "scientific question or environmental issue that is best addressed by analyzing large amounts of data that are collected across a wide area, or over a long period of time" by citizen volunteers. Nonetheless, PPSR programs vary widely with regard to the structure and organization of the program, the topic of interest or question(s) being investigated, and the goals and objectives of program leaders and project participants. While this article is concerned primarily with the experiences of participants engaged in one of the most common forms of PPSR—in situ programs within the areas of natural science—it is important to note that rich opportunities exist for research on sense of place among other forms of PPSR, including those that take place virtually (Nov, Arazy, & Anderson, 2011; Rotman et al., 2012).

Public and Personal PPSR Outcomes

There is a strong cohort of researchers who have documented the valuable public, external contributions of PPSR (Bonney et al., 2009b; Foster-Smith & Evans, 2003; Harvey, 2006; Newman, Buesching, & Macdonald, 2003; Szabo, Vesk, Baxter, & Possingham, 2010). Couvet et al. (2008) offer three areas in which PPSR has improved scientific knowledge and public decision-making processes. The first, and most apparent, involves improvements in the massive efforts to monitor and understand biodiversity and other natural phenomenon at multiple scales across the globe. Second, programs help frame socially legitimate indicators of environmental problems and thus help to "democratize" research and policy processes. Because indicators must be widely accepted and easily understood to gain traction in the broader public arena, the involvement of "amateur" scientists can enhance the transparency and inclusivity of environmental monitoring efforts (Couvet et al., 2008). Finally, projects help decision makers build scenarios and compare the effects of proposed policies or procedures to address environmental concerns. In the context of adaptive learning, PPSR can expand the audience and reach of potential projects and help identify a broader range of human responses to potential threats or policies.

The value of PPSR as an effective tool to advance complex natural science research and expand involvement in research and policy processes is established. Within the past decade, however, a growing body of literature has emerged to study the multidimensional impacts of PPSR on the *participants* involved in the process. Table 1 includes an overview of some of the more salient assertions about citizen-science participant benefits. Such research is

TABLE 1
Claims About Citizen Science Participant Benefits

Citizen Science Participant Benefit	Citation
Enhanced science knowledge and literacy (e.g., knowledge of science content, science applications, risks and benefits of science, and familiarity with scientific technology)	Braschler, Mahood, Karenyi, Gaston, and Chown (2010), *Brewer (2002), *Danielsen et al. (2005); Devictoret al. (2010), *Evans et al. (2005), *Fernandez-Gimenez, Ballard, & Sturtevant (2008), *Jordan et al. (2011), Krasny and Bonney (2005), and Sullivan et al. (2009)
Enhanced understanding of the scientific process and method	Bonney (2004), Bonney and Dhondt (1997), Braschler et al. (2010), Devictor et al. (2010), Sullivan et al. (2009), and *Trumbull, Bonney, and Grudens-Schuck (2005)
Improved access to science information (e.g., one-on-one interaction with scientists, access to real-time information about local scientific variables)	*Fernandez-Gimenez et al. (2008) and Sullivan et al. (2009)
Increases in scientific thinking (e.g., ability to formulate a problem based on observation, develop hypotheses, design a study, and interpret findings)	*Kountoupes and Oberhauser (2008) and *Trumbull et al. (2000)
Improved ability to interpret scientific information (e.g., critical thinking skills, understanding basic analytic measurements)	Bonney (2007)and Braschler et al. (2010)
Strengthened connections between people, nature, and place (e.g., place attachment and concern, establishment of community monitoring networks or advocacy groups)	*Devictor et al. (2010), *Evans et al. (2005), *Fernandez-Gimenez et al. (2008), and *Overdevest et al. (2004)
Science demystified (e.g., reducing the "intimidation factor" of science, correcting perceptions of science as too complex or complicated, enhancing comfort and appreciation for science)	Devictor et al. (2010)and *Kountoupes and Oberhauser (2008)
Empowering participants and increasing self-efficacy (e.g., belief in one's ability to tackle scientific problems and questions, reach valid conclusions, and devise appropriate solutions)	*Danielsen et al. (2005), Lawrence (2006), and Wilderman, Barron, and Imgrund (2004)
Increases in community-building, social capital, social learning, and trust (e.g., science as a tool to enhance networks, strengthen mutual learning, and increase social capital among diverse groups)	Bell et al. (2009), *Danielsen et al. (2005), *Fernandez-Gimenez et al. (2008), *Overdevest et al. (2004), *Roth and Lee (2002), and Wilderman et al. (2004)
Changes in attitudes, norms, and values (e.g., about the environment, about science, about institutions)	*Danielsen et al. (2005), *Ellis and Waterton (2004), *Fernandez-Gimenez et al. (2008), *Jordan et al. (2011), and *Melchior and Bailis (2003)

Studies that have empirically tested outcome hypotheses and reported results are noted with an asterisk.

notoriously difficult as the effects of PPSR project variables on specific outcomes are a challenge to measure or isolate given the range of influences that may mediate these outcomes (e.g., preexisting beliefs, attitudes, and knowledge; motivation to participate; project content and experience; and training) (Phillips, Bonney, & Shirk, 2012).

Although claims about the benefits of PPSR participation are highlighted here, it is worth noting that some study results are mixed. For example, some studies on PPSR outcomes have failed to demonstrate statistically significant changes in attitudes toward science and the environment (Brossard et al., 2005), behaviors (Jordan et al., 2011), or knowledge about science concepts or the scientific process (Brossard et al., 2005; Jordan et al., 2011; Moss, Abrams, & Kull, 1998; Overdevest, Orr, & Stepenuck, 2004). Several study authors have attributed this lack of change to the fact that the projects evaluated in these studies primarily involved participants collecting data, with little or no opportunity to critically reflect on the science content or process. In addition, research on learning in informal settings like museums has demonstrated that participant outcomes are temporal in nature, meaning they are best understood when measured over time and not captured well in static assessments of cognitive knowledge (Falk, 2004; Rennie & Johnson, 2004). These studies also highlight that the context in which an individual engages in informal science research has substantial implications for the long-term impacts of such engagement (Burns, O'Connor, & Stocklmayer, 2003; Rennie & Johnson, 2004). Although a participant may be able to recite a set of scientific facts immediately following engagement, other contextual factors (e.g., whether or not the experience was positive, the connections that were made between other actors or concepts) have substantial influence over future cognitive-behavioral outcomes. As such, while rigorous efforts like those reviewed above to measure participant outcomes are critical, so too is a better understanding of the interactions between PPSR participants and the places in which they engage, and the connections that provide the literal foundation for program outcomes and mediate program experiences. I argue that further research is needed regarding the factors that influence sense of place and the characteristics of place meaning among PPSR participants to inform the development of a more holistic conceptual model of PPSR experiences.

GEOGRAPHY AND THE CONCEPT OF PLACE

The North American naturalist Leopold (1949) once wrote that places must be experienced via sensory connection to fully understand them. Later, Carson (1965) noted that effective interactions with natural phenomena provide the foundation for our thoughts, attitudes, and behaviors about the physical landscape. The field of geography has a long history of research on human experience, awareness, and meaning as it relates to relationships with space, place, and the environment. As a whole, the discipline has a tradition of scholarship on the "lived experiences" of humans within specific socioecological contexts (Allen, 2004; Casey, 1993; Hubbard, Kitchin, Bartley, & Fuller, 2002). The phenomenological geographers Relph (1976) and Tuan (1975, 1977) first inspired a tradition of "place-based" scholarship that has since expanded into many allied disciplines. In contrast to the notion of space, once seen as an open and fixed plane on which objects and activities were located, Tuan asserts that place is much more particular, linked to life histories, social processes, and individual experiences. Specifically, race, age, gender, sexuality, and spiritual orientation have all been highlighted as factors which influence understanding of place (Brace, Bailey, & Harvey, 2006; Hidalgo & Hernandez, 2001; Kruger & Jakes, 2003; Lane, 2002).

Agnew and Duncan (1989) have observed that place scholarship within the field of geography generally assumes one of three conceptualizations of place: place as location, as locale, and as phenomenological event. As location, place is treated as an object that

is distributed among other objects on a flat spatial plane, often used alongside spatial-chorological approaches like spatial statistics. Among geographers most interested in the humanistic nature of geographic experience, place is utilized as locale, or the background stage on which social interactions take place. While these two conceptualizations utilize place in distinct ways, they both assume a clear separation among the physical characteristics of place and human cultures and social interactions. The third conceptualization of place noted by Agnew and Duncan (1989) regards place as a phenomenological event, an intersubjective interaction among places themselves and the humans that intermingle with them. This third approach to place has a deep history in the field of human geography (Cloke & Johnston, 2005; Massey, 2005) with roots in the writings of scholars like Martin Heidegger and Maurice Merleau-Ponty (Patterson & Williams, 2005). Such a relational lens is highlighted by others in allied fields like architecture, where scholar Pallasmaa (2005) reminds us that experiences of place involve complex sensual interactions. Pallasmaa avers that it is our sense of a place (its smell, touch, color, or sound) that allows us to remember it. Pallasmaa manages to construct the body as a first-order site in which each of us experiences the world—all our ideas about place and space can be traced back to our bodily interactions in physical sites. Whether it is self and the body, home and the family, society and public processes, or structures and buildings, the places where all of these senses collide capture the "multivocal" and "multilocal" aspects of life (Rodman, 1992).

Many nature–society geographers have highlighted that relational approaches to place must be firmly grounded in the material networks which hold them together (Anderson & Harrison, 2010; Murdoch, 1998, 2006). Accordingly, approaches like actor network theory (ANT) are frequently employed to ground relational concepts of place and meaning making in interconnected systems of nodes and networks (Murdoch, 1998, 2006). ANT allows the exploration of place as a multifaceted and multidimensional human–environmental phenomenon and expands place-based analysis to include other nonhuman elements that are part of interactive networks. A number of studies have utilized such theory to guide exploration of human–environment interactions. Mordue (2009, p. 549) uses ANT in his research of angling networks to demonstrate how fishing is shaped both by the social construction of the activity as well as "multisensorial interactions with nature." Campbell (2008), in his study about the geography of avian feeding habits, reveals that intraspecies interactions between humans and birds can have equal, if not greater, bearing on the behavior of birds and humans instead of interspecies interactions. And according to Bonta (2010), there is no better line of inquiry into the experience of birding than the field of geography. Indeed, he muses "few human endeavors exist in which place is as important, in itself, as it is in birding" (p. 150). Bonta contends that birding is, by nature, geographically charged; that it is a three-way encounter between self, bird, and landscape. Through the lens of "hybrid" geographies like these, geographic scholars utilize spaces and places as entry points to call forth and wrestle with the multifaceted dimensions of being in and experiencing the world. Such perspectives interrogate the ontological dimension of place, an aspect Karrow and Fazio (2010) have called "place-as-being," a dimension these authors argue has been widely overlooked within a science education context. A number of more recent theories within the subdiscipline of resource geography have attempted to "rematerialize" nature–society scholarship (Bakker & Bridge, 2006; Jackson, 2000; Stedman, 2003a). In particular, practices of "new ecosystem management" (part of the new ecological paradigm in the 1990s) have assumed a material-semiotic (Haraway, 1991) approach to resource management, expanding resource management strategies beyond those squarely concerned with economic or ecological considerations to include the cultural, social, and spiritual meaning attached to resources and landscapes (Williams & Carr, 1993).

The political geographer Soja (1999) has advanced a salient theoretical schematic of human experience of place that assumes the third conceptualization of place highlighted by Agnew and Duncan (1989), that of a phenomenological event. Soja's model posits three separate "spaces" of being. "Firstspace," or "perceived space," represents our empirical experiences with phenomena that appear to represent objective reality (p. 265). "Secondspace," or "conceived space," is our subjective interpretation of the world and items in it (p. 266). However, Soja also presents a "thirdspace," or "lived space," as an integrated area opened up in the margins of the other two where spaces are both "real and imagined" (pp. 267–271). Such thirdspaces are places where connections, networks, and new concepts are formed among the empirical firstspaces and conceptual secondspaces of individual existence. Altogether, Soja contends these spaces constitute "the trialectics of spatiality," not a combination of all three into one, but a "hybridity" of place, each aspect influenced and interacting with the other. PPSR experiences might also be viewed in such a fashion, conceived as experiences that bridge firstspaces of empirical investigation and secondspaces of interpretive understanding to bear hybrid thirdspaces of experiencing the world. The landscapes involved in PPSR investigation and the actors therein play fundamental roles in shaping firstspace experiences. At the same time, the conceived secondspaces of PPSR participants shape the lenses in which the landscape is explored and sensed. Current research on PPSR outcomes and experiences has little to say about these fundamental interactions in place. A focus on the material-semiotic dimension of place succeeds at collapsing binary walls among empirical senses and cognitive processes and helps elucidate the interactions among the two, interactions that lead to what geographers often refer to as a "sense of place" (Jorgensen & Stedman, 2001).

Sense of Place

Although the concept of sense of place has been used inconsistently among various academic disciplines (Devine-Wright & Clayton, 2010; Manzo, 2003), it can be described broadly as "an experiential process created by the setting, combined with what a person brings to it" (Steele, 1981, p. 9). In this sense, place is understood as a concrete site where the physical environment, the self, and sociopolitical processes overlap, known as the tripartite model of place (Scannell & Gifford, 2010). Along these lines, Karrow and Fazio (2010) have suggested that place involves "natural, cultural, and ontological" components. In particular, alongside the physical and sociocultural dimensions of place, these authors advocate for more attention to the ontological dimension of place that inspires a "psychology of awe" (Karrow & Fazio, 2010). As noted above, geographic phenomenologists like Tuan (1975) have studied individual and collective sense of place by examining the "lived experiences" of everyday, even mundane, place-based interactions (Bachelard, 1969; Relph, 1985; Seamon, 1982, 1984). Such interactions between humans and the physical places in which they engage are informed by individual histories and experiences, leading to an organic and relational sensory landscape (Jorgensen & Stedman, 2001). Conceptually speaking, sense-of-place theory includes two principal aspects, place attachment and place meaning, each with related subcomponents (Stedman, 2003b).

Place Attachment

The environmental psychologists Altman and Low (1992) define place attachment as an affective bond between people and places, enveloping different human and nonhuman actors and social relationships. Place attachment broadly encompasses aspects of identity, physical or social dependence, and emotional connection to specific aspects of the physical

environment or other creatures that share such space. The amount, intensity, and duration of experiences in a place (often called residence length) has been correlated with changes in sense of place (Semken, Freeman, Watts, Neakrase, Dial, & Baker, 2009) and has consistently predicted levels of place attachment (Lewicka, 2011). Although various scholars have compartmentalized place attachment into smaller subcomponents, I will utilize the four-dimensional conceptualization of place attachment outlined by Ramkissoon, Weiler, and Smith (2012) to provide just one example of the how the various components of place attachment might be utilized to expand knowledge and understanding of the numerous purported outcomes of PPSR programs. Ramkissoon et al. (2012) have suggested that place attachment includes the subcomponents of place identity, place dependence, place affect, and place social bonding, all dimensions which these authors contend are linked to what they call "proenvironmental behaviors," although admittedly to various degrees and via mechanisms not fully understood. I will review each below, while providing both examples of how such aspects might directly link to or influence the PPSR outcomes highlighted in Table 1 and important questions about these relationships.

Place identity (a concept coined by Proshansky, 1978) refers to the degree to which place is included in perceptions of individual or collective identity. Feeling that a place is a part of you is just one element that contributes to place attachment. Assuming that the identities and values of people are indeed informed by places they judge significant, then it follows that peoples' bonds with important sites will influence their engagement in those places. Such engagement might take the form of efforts to maintain or protect the sites, respond to threats or changes within them, or interact with them in a specific way (Pretty, Chipuer, & Bramston, 2003). In this sense, it is reasonable to assume that the degree to which one identifies with a place may have some bearing on the sense of responsibility felt for that place, an aspect that may influence broader advocacy or further civic engagement behaviors and outcomes (like those demonstrated in Stedman, 2002), and may spur community-initiated efforts that enhance feelings of empowerment or self-efficacy among those involved. Indeed, many place-based environmental education pedagogies embrace the objective of increasing local environmental action as a guiding tenet (Semken & Brandt, 2010). Furthermore, as a place becomes more intimately entwined with the identities of PPSR participants who have engaged with that place via a particular "scientific" lens, specific habits of mind that foster scientific thinking and interpretation may become a more "natural" part of the way in which volunteers view themselves. The role that place attachment plays in the development of a sense of scientific identity is an area open for study.

Place dependence, on the other hand, refers to functional connections humans have to a setting and the degree to which a place meets day-to-day needs (Schreyer, Jacob, & White, 1981). The more a person connects or identifies with a place, the more likely (although not always) that person is to develop a dependence on that place for meeting his/her spiritual, social, or ecological well-being. Although Ramkissoon et al. (2012) discuss this concept largely in regard to a reliance on the physical characteristics of a place to meet a need (e.g., dependency on a local reservoir to provide drinking water), I argue such dependence may also be psychosocial. Because higher levels of place dependence have been associated with increased place loyalty (Yuksel, Yuksel, & Bilim, 2010), it is sensible to question the relationship between place dependence among PPSR participants and the nature and level of scientific knowledge and literacy about the specific ecological community to which participants become more dependent. In other words, do PPSR participants who become more dependent on a place also become more scientifically knowledgeable about that place? This is both with respect to knowledge about local natural history and more global scientific concepts. Might higher levels of place dependence influence the degree of scientific literacy participants demonstrate about an area? If so, might the confidence gained from enhanced

scientific knowledge of a local ecosystem also reduce the mystical sense of scientific research, demystifying the practice?

A third dimension of place attachment includes *place affect,* which Ramkissoon et al. (2012) characterize as specific emotional bonds that form between person and place. Although Ramkissoon et al. (2012) conceptualize affect solely as emotional connection in their characterization of place attachment, others like Rose, Degen, and Basdas (2010) separate the notion of affect, or the "precognitive" inherent nature of a place (Tuan, 1975), from emotion (internal personal reaction to a place). As feelings of connection grow between person and place, sentiments associated with that place increase as well. Although research has demonstrated links between affective connection to wilderness places and changes in environmental attitudes and behaviors within environmental education settings (Pooley & O'Conner, 2000), little work has been done to consider these relationships within PPSR environments. In particular, because PPSR efforts are generally built around specific scientific protocols and procedures, a reasonable hypothesis might consider whether or not an increase in an emotional bond with place not only influences attitudes about the environment but also attitudes, norms, and values in regard to science and scientific research. Furthermore, how might these sentimental connections with place impact overall sense of trust among participants of both professional scientists and the field of science as a whole, or, as Semken and Brandt (2010) have noted, perhaps even lack of trust in conflict situations?

Finally, *place social bonding* concerns the degree of attachment to place that results because of interpersonal social bonding in places. As ties develop between individuals that interact within specific places, the sense of belonging or community that ensues may become associated with a particular setting. The setting thus becomes an integral component of that communal relationship and can lead to an increased sense of shared place attachment. One might expect such bonds that form in place to foster enhanced community building and social capacity, along with elevated levels of social learning and confidence in collective action. As with place affect, this subcomponent of place attachment may be significant with regard to the desired PPSR outcomes of increased trust among participants and professional scientists. As individual bonds over specific places and social networks are developed, those communal relationships reinforced by place attachment may also increase access and sharing of scientific information, another supposed PPSR outcome. The components of place attachment outlined by Ramkissoon et al. (2012) above are provided here as an example of the utility of the concept in regard to research on PPSR outcomes. However, it is worth noting that other conceptualizations of the concept exist (see Trentelman [2009] for a thorough review of scholarship on place), many of which are sure to provide additional relevant insight.

Place Meaning

Often treated as distinct from place attachment, the second major aspect of the sense of place concept is place meaning, which refers to the ascribed symbolic meanings between people and places. Place meaning is negotiated from heterogeneous life positions, while being mediated by culture, politics, and the physical environment (Nassauer, 1995). Although place attachment and meaning are commensurate aspects of an overall sense of place, they are not identical concepts. Manzo (2005) has demonstrated that even though multiple individuals may share similar levels of attachment, feelings, or relationships with a place, the meanings associated with that place can be quite diverse and can encompass both positive and negative dimensions. Place attachment therefore reflects the emotional intensity and nature of attraction to places, whereas place meaning exposes the reasons for such an

attraction, although the interrelationships between the two concepts should not be over-looked (Wynveen, Kyle, & Sutton, 2012). A focus on place meaning has the potential to contribute a nuanced understanding of how people in PPSR programs connect with environmental settings, negotiate environmental values and attitudes, and conceptualize "natural resources." As I have argued here, the sense of place concept is a conceptually robust theoretical lens through which to interrogate the connections, interactions, and meaning making between people and places, a central aspect of all in situ PPSR experiences. While many vigorous efforts have examined the relationships between PPSR experiences and educational or personal outcomes like those reviewed above, few critically feature place as a mediator in or contributor to these relationships. The concept of place provides a holistic entry point to interrogate the sociopolitical, cultural, psychological, *and* physical/environmental actors involved in PPSR experiences and may shed new light on some of the "big questions" within the field.

ADVANCING "BIG QUESTIONS" WITHIN PPSR THEORY AND PRACTICE VIA SENSE OF PLACE RESEARCH

Focusing on the processes and actors involved in the meaning making associated with PPSR sites has the potential to contribute to the development of new conceptual frameworks that help make sense of complex PPSR experiences and outcomes for volunteers. As demonstrated in the preceding section, sense-of-place inquiry provides promise for expanding understanding of PPSR outcomes by including an often neglected dimension of participation, the material-semiotic relationships between people and place. Research findings, key themes, and lessons learned within this vein will be of interest to those who are involved in participatory research and policy processes as well as those who manage and develop specific PPSR programs. In addition, scholars who focus on geographic or environmental education, informal learning, or place-based therapies may benefit from this type of analysis (Kudryavtsev, Stedman, & Krasney, 2012). Four broad areas in which major questions have been raised in PPSR scholarship are outlined below to highlight future research directions that present particular promise for sense of place exploration.

Participant Motivation and Retention

Bonney et al. (2009a) have noted that there is a need for "significant research into motivations for members of the public to understand and participate in [scientific] research" (p. 48). Although Measham and Barnett (2008) have suggested that place attachment is one of several central motivating factors for environmental volunteers, we still do not know to what extent this factor may motivate participants across a variety of PPSR programs or settings which are not always connected to environmental concerns directly. How does place attachment inform motivation to engage in PPSR? Does the level of motivation inspired by place attachment vary by geographic location, participant characteristics, or program format (e.g., in situ or online)? Recent evidence reveals that volunteer motivation is rarely static, demonstrating a temporal dimension that can change throughout participation (Clary & Snyder, 1999; Rotman et al., 2012). Accordingly, it is important to know whether attachment to place also changes as participants engage in PPSR over time. Although sense of place and place attachment is certainly not the only factor that influences volunteer motivation, the research reviewed in this article suggests it may be a significant one. Researchers will need to explore more fully how time engaged in the project, level of engagement in the project, and life position (i.e., age, gender, race, sexual, and spiritual orientation) influences the sense of place among participants. Of particular relevance to practitioners will be

the identification of "best practices" in regard to the cultivation of a rich sense of place within PPSR as well as those place-based aspects that contribute to participant satisfaction and commitment to the program. Are there programmatic elements, for example, that might help facilitate a deeper connection to place among participants, or strategies that appear to be more effective under particular program parameters like duration of project or participant audience? Perhaps it is even possible to create innovative partnerships between groups that demonstrate a preexisting attachment to place and PPSR efforts designed to expand knowledge of that place. Such inquiry might make significant contributions to efforts to increase PPSR participation and science literacy, specifically among individuals from minority and traditionally underrepresented groups (Georgia, Neale, Van Horne, & Malcom, 2001; Hobbs & White, 2012).

Expanding Inquiry on Concepts of Nature, Environmental Attitudes, and Behaviors

Pitkanen, Puhakka, and Sawatzky (2011) have documented the bidirectional relationship between sense of place and concepts of nature, noting that place meanings and attachment are both informed by and inform individual and collective definitions of "nature" and the norms that influence nature–society interactions. Several studies have concluded that sense of place can influence broader feelings of "connectedness to nature," affective bonds which develop between individuals and their own conceptualization of "nature" in ways that are quite personal (Brugger, Kaiser, & Roczen, 2011; Mayer & Frantz, 2004; Schultz & Tabanico, 2007). These affective connections influence not only the attachment and meaning of specific places but also broader ideas about environmental responsibility and concern (Shultz, 2001). As noted earlier, several studies have demonstrated a correlation between place attachment and "environmentally responsible behaviors" (Kyle, Mowen, & Tarrant, 2004; Stedman, 2002; Uzzell, Pol, & Badenas, 2002; Vaske & Kobrin, 2001) as well as increased learning (Semken & Butler-Freeman, 2008). The absence of connections among people and place can lead to a relationship "deficit" with the natural world, with purported broad behavioral consequences (Louv, 2005). Podeschi and Howington (2011) have argued that people need to know about the places in which they live, feel a connection to those places, and be engaged in managing those places. Similar sentiments have been expressed for decades within the "place-based education" movement, centered on a pedagogy designed to facilitate "essential links between a person and her place" among a "rootless" society (Sobel, 2005, p. ii). PPSR presents a unique opportunity for those kinds of connections to occur, but the practice would benefit from thinking more critically about how and when these relationships form and what dimensions are most influential. Traditional measures of scientific knowledge (literacy) and skills of PPSR participants, while of critical importance, are not likely to fully explain or predict PPSR outcomes with regard to environmental attitudes and behaviors because cognitive, conative (behavioral), and affective dimensions collectively inform these aspects (Aiken, 2002). Research on sense of place in PPSR may again shed much light on the interactional relationships between PPSR experiences in particular places and attitudinal or behavioral outcomes.

Such inquiry would build on an already rich body of scholarship around the cognitive-behavioral consequences of differences in human sociocultural perspectives of nature and nature–society interactions (Anderson, 2010; Bakker & Bridge, 2006; Bang, Medin, & Atran, 2007; Kellert, 1993; Williams & Patterson, 1996). This research suggests that such differences have implications for science education and literacy as well. Bang et al. (2007) have argued that traditional science education often misses the boat when it comes to effectively engaging nonmajority cultural groups because many of these approaches fail to

consider the diversity of ecological frameworks various communities use to understand and interact with the environment. Research on the interactions between concepts of place, place attachment and meaning, nature, and science among PPSR participants will have much to contribute to scholarship around nature–society interactions and science education. How do diverse ecological frameworks conceptualize place and place attachment? Can PPSR programs change perceptions and beliefs about human–environment relationships? From a science or environmental education vantage point, are specific PPSR practices or programs more effective at engaging one type of ecological framework over the other? An expansive research opportunity exists within PPRS scholarship when it comes to sociocultural influences on place perception, methods and pathways to connect with place, and place meaning-making processes.

Enhancing Local Empowerment, Advocacy, and Community Action

As noted in Table 1, some PPSR initiatives have been linked with increased feelings of community empowerment and personal self-efficacy in regard to the ability to investigate and mitigate environmental concerns on a local level (Danielsen et al. 2005; Lawrence, 2006; Wilderman et al., 2004). Although multiple factors are likely at play, how does sense of place and place connection influence such outcomes? Does place attachment, for example, increase the willingness of participants to utilize data collected via PPSR programs to autonomously advocate for environmental policy or management changes? From an environmental psychology context, evidence suggests that people can be more protective of and concerned about spaces imbued with meaning (Podeschi & Howington, 2011; Williams & Vaske, 2003). As such, affective ties to places may motivate people to be better informed about the relationships between environmental health and community well-being and may lead to the advancement of ecojustice concerns regarding the fair distribution of environmental benefits and burdens (Adams, Ibrahim, & Lim 2010). But questions still remain regarding what aspects of place elicit personal response and connection and how those elements shape the type or degree of community action that develops. Do participants feel more confident in their ability to protect sea turtle nests than they do at mitigating the water quality of a local stream, for example? If so, what biogeographic or sociopolitical elements serve as facilitating or constraining factors? Furthermore, uncertainties remain regarding what components of significant places (e.g., natural, cultural, or ontological) most often elicit concerted action among those most closely attached. Could further inquiry identify differences among these responses based on the level or type of connection felt by participants? From a science in society perspective, how do such actions make use of scientific research or "data?"

PPSR Research Process, Efficacy, and Impacts

Sense of place research within PPSR demonstrates promise to go beyond contributions to practical program management or the education and stewardship objectives of science and environmental education. Asking place-based research questions might also contribute to enhancements of the scientific procedures that underpin all PPSR research. As Goodchild (2007) has noted, despite the massive growth in technology that can aid in the survey and analysis of biogeographic information, the "human sensory system" is still one of the best tools available for the study and investigation of the natural world. Even with the sophisticated technology available today, most data on species-level occurrence still must be gathered by humans (Kelling, 2008). Investigations into sense of place among PPSR participants may reveal strategies in which to enhance the accuracy and precision of

volunteer-collected data as researchers explore how participants "tune-in," sense, perceive, and process the intricacies of the environment around them. Of even greater interest to those involved in research on the history of science and technology studies may be how the unique sense of place of PPSR participants is molding, shaping, and influencing the scientific knowledge that is produced in participatory science programs. Research might also contribute to efforts to integrate traditional ecological knowledge (TEK) into conventional science knowledge paradigms. Elbroch et al. (2011) have already begun the work of integrating TEK into PPSR research protocols and infrastructure, but further research will need to explore how ecological knowledge of place is formed and interpreted among groups indigenous to an area to better inform integration efforts. Given the magnitude and complexity of current day environmental challenges, the need for wide-scale, efficient, and collaborative programs to evaluate environmental phenomena, test hypotheses, and develop applied policies and management practices is evident. Investigating the ways in which PPSR participants connect to, interact with, monitor, and alter places can provide helpful insight into the types of research questions best suited for PPSR programs, biases that can emerge among participants and how they might be overcome, and methods to enhance the ecological assessments that take place.

EXPANDING SENSE OF PLACE EXPLORATION

With new PPSR programs emerging en masse across diverse fields of scientific inquiry, the growth of the practice is outpacing understanding and systematic evaluation of the impacts of PPSR participation on volunteers (Bonney et al., 2009a; Dickinson et al., 2010; Phillips et al., 2012). To help close this knowledge gap, I have argued that a focus on place-based interactions and sense of place provides a foundation for a deeper understanding of the affective bonds which develop between individuals and places in PPSR programs to shed light on critical questions about PPSR impacts and outcomes. Not only will this enhanced understanding provide opportunities to improve PPSR practice and impact, but it also has enormous potential to inform key concerns and questions about scientific literacy, as well as the theories and tenets of science and environmental education.

Fortunately, methodological traditions within sense of place scholarship afford a host of robust tools which with PPSR practitioners or researchers might expand research on people–place relationships in PPSR and subsequent outcomes. Evaluating outcomes and testing specific programmatic impacts is an established habit within most PPSR projects given the accountability required of many of these programs by external funding sources. Utilizing existing sense of place research tools alongside established PPSR assessment practices may initiate novel metrics with which to understanding the relationships between people, place, and program outcomes.

Historically, place meaning and place attachment have been measured using opposing methodological approaches (Kudryavtsev et al., 2012). Place meaning more frequently is gauged using qualitative investigatory strategies, underscoring the highly variable and context-specific nature of psycho–social–ecological meaning (Davenport & Anderson, 2005). In contrast, place attachment is often measured quantitatively for nomothetic purposes, by using scales in which individuals indicate degree of attachment using common numerical intervals (Halpenny, 2010). Such an approach can provide useful information regarding intensity of attachment, but is typically not able to explore, in depth, the details of such attachment, such as why, how, and via what processes attachment forms. Quantitative scales of place attachment, while valuable for establishing broad-scale trends and changes (Semken & Butler-Freeman, 2008), often overlook the specific objective and subjective attributes and social systems in which attachment is cultivated and are

generally not able to consider what aspects of the setting people attach to and the active role of those items in that relationship. As Lewicka (2011, p. 209) has noted, places are "qualitative totalities of a complex nature" and thus involve contingent and unique experiences and interpretations that resist broad and analytically derived generalizations. Furthermore, generalizations about PPSR experiences cab be problematic as the task of accounting for multiple—often overlapping—participant and programmatic variables confounds investigation.

Lewicka (2011) and Kudryavtsev et al. (2012) have provided a thorough and detailed review of both quantitative and qualitative methods in sense of place scholarship, an effort I will not duplicate here. These include quantitative approaches that rely on unidimensional or multidimensional scales of place attachment, as well as qualitative approaches that include both verbal and pictographic measures of place connection and meaning (Lewicka, 2011, pp. 219–222). Others are devising new techniques, like Everett and Barrett's (2012) "guided tour" strategy to deepen the way we study the pathways through which intimate relationships between people and place form and develop. Mixed methods approaches that draw from both quantitative and qualitative traditions have also been utilized to explore sense of place relationships (Devine-Wright & Howes, 2010; Morrell & Jin Bee Tan, 2009), although disagreement exists regarding the philosophical validity of mixing methodological paradigms to study place (Beckley, Stedman, Wallace, & Ambard, 2007; Williams & Patterson, 2007). Haywood and Besley (2013) have recently outlined a set of "integrated indicators" of successful program outcomes in participatory science that, while not specifically designed to interrogate sense of place, integrate existing indicators that draw from Karrow and Fazio's (2010) natural, cultural, and ontological dimensions of place.

Given the range of existing techniques available to study the concept of sense of place and the comfort many PPSR administrators have with program assessment and research, I argue that the benefits of exploring sense of place components among PPSR participants far outweigh any potential initial cost associated with updating or expanding research questions, protocols, or evaluation procedures. Even expanding assessment of PPSR outcomes to include one dimension of sense of place might provide a useful start to consider this essential component of participatory science experiences. For program managers, this might be accomplished initially by allowing PPSR participants to document their "favorite" aspects of their study site(s) using photo elicitation or free-write strategies during annual program evaluation procedures. For researchers, exploration of the role of place in PPSR experiences might begin by adding basic measures of place attachment to research metrics, to track changes over time or document the nature of such attachment. These cursory suggestions are not provided to imply that the complexity of people–place interactions and their impact on cognitive or behavioral outcomes can be identified and categorized with the addition of a few basic survey questions. Instead, they are included to encourage program managers and scholars to consider those dimensions of sense of place that may be more relevant to program or research objectives and contexts and to begin exploring with program participants the role such aspects play in dynamic PPSR systems.

CONCLUSIONS: FAR-REACHING CONTRIBUTIONS

Bridging scholarship within the fields of environmental and geographic education, environmental psychology, and human and environmental geography, expanding the PPSR research agenda to include inquiry on sense of place is particularly pertinent and timely given the extensive socioecological challenges of the twenty-first century. These challenges necessitate relevant, responsive, and sound scientific research and policy that accounts for the heterogeneous social contexts in which science is developed and enacted. As such,

research within this vein has the potential to contribute to each of the major overarching goals of PPSR projects (increasing the scope of research, scientific literacy, environmental stewardship, and the transparency and responsiveness of science).

In addition to the value of this research for those engaged in communities of science education and participatory engagement, this research will provide wide-ranging insight regarding the highly social and negotiated process of human–environment interactions by opening up new discoveries regarding phenomenological sense of place. As such, it follows a strong emphasis within cultural and political ecology on the social and contested nature of human–environment relationships (Peet, Robbins, & Watts, 2010; Robbins, 2004; Zimmerer, 2007). Questions regarding how and why physical space is valued, who and what it is used for, and how it should be managed will likely reveal important clues about the sociopolitical influences that shape sense of place. Similarly, attention to "positionality" (McCleery, 2008) within PPSR place-based research obliges questions regarding who participates in PPSR, how they identify with place, what narratives inform such identities, and, just as importantly, who is not participating in those experiences. Information obtained from this analysis will further understanding of why certain groups or individuals choose to participate in PPSR.

Probing questions about sense of place, the processes involved in place connection and attachment, the values associated with place meaning, and the hybrid human and nonhuman networks that glue such aspects together has great promise for enhancing understanding of the novel forms of scientific inquiry and policy taking shape in the twenty-first century. Accordingly, this article has positioned sense of place scholarship as an appropriate entrée into the complex and dynamic world of PPSR program impacts and outcomes, while highlighting how such inquiry might inform questions within science and environmental education theory and practice. Four broad-spectrum research directions have been provided to suggest salient research questions and avenues for future inquiry to enrich and enliven areas of synthesis and connection among strands of complementary research grounded in both sociocultural and physical dimensions of human–environment interactions. It is the belief of the present author that capitalizing on such synergies will advance scholarship around place and science education while also elevating the impact and effectiveness of the growing practice of participatory science.

REFERENCES

Adams, J., Ibrahim, S., & Lim, M. (2010). Invoking the ontological realm of place: A dialogic response. Cultural Studies and Environmentalism, 3, 215–228.

Agnew, J., & Duncan, J. (Eds.). (1989). The power of place: Bringing together geographical and sociological imaginations. Boston: Unwin Hyman.

Aiken, L. (2002). Attitudes and related psychosocial constructs: Theories, assessment, and research. Thousand Oaks, CA: Sage.

Allen, C. (2004). Merleau-Ponty's phenomenology and the body-in-space encounters of visually impaired children. Environment and Planning D: Society and Space, 22, 719–735.

Altman, I., & Low, S. (Eds.). (1992). Place attachment. Human behaviour and environment: Advances in theory and research, Vol. 12. New York: Plenum.

Anderson, J. (2010). The place of nature. In Anderson, J. (Ed.), Understanding cultural geography: Places and traces. Oxford, England: Routledge.

Anderson, B., & Harrison, P. (Eds.). (2010). Taking-place: Non-representational theories and geography. Burlington, VT: Ashgate.

Bachelard, G. (1969). The poetics of space (M. Jolas, Trans.). Boston: Beacon Press.

Bakker, K., & Bridge, G. (2006). Material worlds? Resource geographies and the "matter of nature." Progress in Human Geography, 30(1), 5–27.

Bang, M., Medin, D., & Atran, S. (2007). Cultural mosaics and mental models of nature. Proceedings of the National Academy of Sciences, 104(35), 13868–13874.

Bauer, W., Allum, N., & Miller, S. (2007). What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. Public Understanding of Science, 16, 79–95.

Beckley, T., Stedman, R., Wallace, S., & Ambard, M. (2007). Snapshots of what matters most: Using resident-employed photography to articulate attachment to place. Society and Natural Resources, 20, 913–923.

Bell, P., Lewenstein, B., Shouse, A., & Feder, M. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. Washington, DC: National Research Council of the National Academies.

Bonney, R. (2004). Understanding the process of research. In D. Chittenden, G. Farmelo, & B. Lewenstein, (Eds.), (Creating connections: museums and public understanding of current research. Walnut Creek, CA: Altamira Press.

Bonney, R. (2007). Citizen science at the Cornell Lab of Ornithology. In R. Yager & D. Falk (Eds.), (Exemplary science in informal education settings: Standards-based success stories. Arlington, VA: NSTA Press.

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., & Wilderman, C. (2009a). Public participation in scientific research: defining the field and assessing its potential for informal science education. A CAISE Inquiry Group Report. Washington, DC: Center for Advancement of Informal Science Education (CAISE).

Bonney, R., Cooper, C., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K., & Shirk, J. (2009b). Citizen science: A developing tool for expanding science knowledge and scientific literacy. BioScience, 59(11), 977–984.

Bonney, R., & Dhondt, A. (1997). Project FeederWatch. In K. Cohen (Ed.), Internet links to science education: Student scientist partnerships. New York: Plenum Press.

Bonta, M. (2010). Ornithophilia: Thoughts on geography in birding. Geographical Review, 2, 139–151.

Brace, C., Bailey, A., & Harvey, D. (2006). Religion, place and space: A framework for investigating historical geographies of religious identities and communities. Progress in Human Geography, 30(1), 28–43.

Braschler, B., Mahood, K., Karenyi, N., Gaston, K., & Chown, S. (2010). Realizing a synergy between research and education: How participation in ant monitoring helps raise biodiversity awareness in a resource-poor country. Journal of Insect Conservation, 14, 19–30.

Brewer, C. (2002). Outreach and partnership programs for conservation education where endangered species conservation and research occur. Conservation Biology, 16(1), 4–6.

Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. International Journal of Science Education, 27(9), 1099–1121.

Brugger, A., Kaiser, F., & Roczen, N. (2011). Connectedness to nature, inclusion of nature, environmental identity, and implicit association with nature. European Psychologist, 16(4), 324–333.

Burns, T., O'Conner, D., & Stocklmayer, S. (2003). Science communication: A contemporary definition. Public Understanding of Science, 12, 183–202.

Campbell, M. (2008). An animal geography of avian feeding habits in Peterborough, Ontario. Area, 40(4), 472–480.

Carson, R. (1965). The sense of wonder. New York: Harper & Row.

Casey, E. (1993). Getting back into place. Bloomington: Indiana University Press.

Clary, E., & Snyder, M. (1999). The motivations to volunteer: Theoretical and practical considerations. Current Directions in Psychological Science, 8(5), 156–159.

Cloke, P., & Johnston, R. (2005). Spaces of geographic thought: Deconstructing human geography's binaries. London: Sage.

Conrad, C., & Hilchey, K. (2011). A review of citizen science and community-based environmental monitoring: Issues and opportunities. Environmental Monitoring and Assessment, 176, 273–291.

Cooper, C., Dickinson, J., Phillips, T., & Bonney, R. (2007). Citizen science as a tool for conservation in residential ecosystems. Ecology and Society, 12(2), 11 [online].

Couvet, D., Jiguet, F., Julliard, R., Levrel, H., & Teyssedre, A. (2008). Enhancing citizen contributions to biodiversity science and public policy. Interdisciplinary Science Reviews, 33(1), 95–103.

Davenport, M. A., & Anderson, D. H. (2005). Getting from sense of place to place-based management: An interpretive investigation of place meaning and perceptions of landscape change. Society and Natural Resources, 18(7), 625–641.

Danielsen, F., Burgess, N., & Balmford, A. (2005). Monitoring matters: Examining the potential of locally-based approaches. Biodiversity and Conservation, 14, 2507–2542.

Devictor, V., Whittaker, R., & Beltrame, C. (2010). Beyond scarcity: Citizen science programmes as useful tools for conservation biogeography. Diversity and Distributions, 16, 354–362.

Devine-Wright, P., & Clayton, S. (2010). Introduction to the special issue: Place, identity and environmental behavior. Journal of Environmental Psychology, 30(3), 267–270.

Devine-Wright, P., & Howes, Y. (2010). Disruption to place attachment and the protection of restorative environ-ments: A wind energy study. Journal of Environmental Psychology, 30, 271–280.

Dickinson, J., & Bonney, R. (Eds.). (2012). Citizen science: Public participation in environmental research. Ithaca, NY: Comstock.

Dickinson, J., Zuckerberg, B., & Bonter, D. (2010). Citizen science as an ecological research tool: Challenges and benefits. Annual Review of Ecology, Evolution, and Systematics, 41, 149–172.

Elbroch, M., Mwampamba, T., Santos, M., Zylberberg, M., Liebenberg, L., Minye, J., Mosser, C., & Reddy, E. (2011). The value, limitations, and challenges of employing local experts in conservation research. Conservation Biology, 25, 1195–1202.

Ellis, R., & Waterton, C. (2004). Environmental citizenship in the making: The participation of volunteer naturalists in UK biological recording and biodiversity policy. Science and Public Policy, 31, 95–105.

Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsen, L., & Marra, P. (2005). The Neighborhood Nestwatch Program: Participant outcomes of a citizen-science ecological research project. Conservation Biology, 19(3), 589–594.

Everett, M., & Barrett, M. (2012). "Guided tour": A method for deepening the relational quality in narrative research. Qualitative Research Journal, 12(1), 32–46.

Falk, J. (2004). The director's cut: Toward an improved understanding of learning from museums. Science Education, 88, S83–S96.

Fernandez-Gimenez, M., Ballard, H., & Sturtevant, V. (2008). Adaptive management and social learning in collaborative and community-based monitoring: A Study of five community-based forestry organizations in the western USA. Ecology and Society, 13(2), 4 [online].

Foster-Smith, J., & Evans, S. (2003). The value of marine ecological data collected by volunteers. Biological Conservation, 113, 199–213.

Georgia, Y., Neale, D., Van Horne, V., & Malcom, S. (2001). In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by under-represented minorities. Washington, DC: American Association for the Advancement of Science. Retrieved February 11, 2013, from http://ehrweb.aaas.org/mge/Reports/Report1/AGEP/.

Goodchild, M. (2007). Citizens as sensors: The world of volunteered geography. GeoJournal, 69, 211–221.

Greenwood, J. (2007). Citizens, science and bird conservation. Journal of Ornithology, 148, S77–S124.

Halpenny, E. (2010). Pro-environmental behaviors and park visitors: The effect of place attachment. Journal of Environmental Psychology, 30, 409–421.

Haraway, D. (1991). A cyborg manifesto: Science, technology and socialist feminism in the late twentieth century. In D. Haraway, (Ed.), Simians, cyborgs and women: The Reinvention of nature. London: Free Association Books.

Harvey, K. (2006). Monitoring change: Citizen science and international environmental treaty-making. In W. Moomaw & L. Susskind, (Eds.), (Papers on international environmental negotiation: Ensuring a sustainable future. Cambridge, MA: Harvard University Press.

Haywood, B., & Besley, J. (2013). Education, outreach, and inclusive engagement: Towards integrated indicators of successful program outcomes in participatory science. Public Understanding of Science. doi:10.1177/0963662513494560. Available online July 25, 2013.

Hidalgo, M., & Hernandez, B. (2001). Place attachment: Conceptual and empirical questions. Journal of Envi-ronmental Psychology, 21, 273–281.

Hobbs, S., & White, P. (2012). Motivations and barriers in relation to community participation in biodiversity recording. Journal for Nature Conservation, 20(6), 364–373.

Hubbard P., Kitchin, R., Bartley, B., & Fuller, D. (2002). Thinking geographically: Space, theory and contemporary geography. London: Continuum.

Jackson, P. (2000). "Rematerializing" social and cultural geography. Social and Cultural Geography, 1(1), 9–14.

Jordan, R., Gray, S., Howe, D., Brooks, W., & Ehrenfeld, J. (2011). Knowledge gain and behavioral change in citizen science programs. Conservation Biology, 25(6), 1148–1154.

Jorgensen, B., & Stedman, R. (2001). Sense of place as an attitude: Lakeshore owners attitudes toward their properties. Journal of Environmental Psychology, 21, 233–248.

Karrow, D., & Fazio, X. (2010). Educating-within-place: Care, citizen science, and ecojustice. In D. Tippins, M. Mueller, M. van Eijck, & J. Adams (Eds.), Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems, (Chap. 16, pp. 193–214). New York: Springer.

Kellert, S. (1993). The biological basis for human values of nature. In S. Kellert & E. O. Wilson (Eds.), The biophillia hypothesis (Chap. 2, pp. 42–72). Washington, DC: Island Press.

Kelling, S. (2008). Significance of organism observations: Data discovery and access in biodiversity research. Report for the Global Biodiversity Information Facility, Copenhagen, Denmark.

Kountoupes, D., & Oberhauser, K. (2008). Citizen science and youth audiences: Educational outcomes of the monarch larva monitoring project. Journal of Community Engagement and Scholarship, 1(1), 10–20.

Krasny, M., & Bonney, R. (2005). Scientific research and education collaboration. In E. Johnson & M. Mappin (Eds.), Environmental education and advocacy: Changing perspectives of ecology and education. Cambridge, England: Cambridge University Press.

Kruger, L., & Jakes, P. (2003). The importance of place: Advances in science and application. Forest Science, 49(6), 819–821.

Kudryavtsev, A., Stedman, R., & Krasney, M. (2012). Sense of place in environmental education. Environmental Education Research, 18(2), 229–250.

Kyle, G., Mowen, A., & Tarrant, M. (2004). Linking place preferences with place meaning: An examination of the relationship between place motivation and place attachment. Journal of Environmental Psychology, 24, 439–454.

Lane, B. (2002). Landscapes of the sacred: Geography and narrative in American spirituality. Baltimore, MD: Johns Hopkins University Press.

Lawrence, A. (2006). No personal motive? Volunteers, biodiversity and the false dichotomies of participation. Ethics, Place and Environment, 9, 279–298.

Lee, T., Quinn, M., & Duke, D. (2006). Citizen, science, highways, and wildlife; using a Web-based GIS to engage citizens in collecting wildlife information. Ecology and Society, 11(1), 11.

Leopold, A. (1949). A Sand County almanac and sketches here and there. New York: Oxford University Press.

Lepczyk, C. (2005). Integrating published data and citizen science to describe bird diversity across a landscape. Journal of Applied Ecology, 42, 672–677.

Lewenstein, B. (1992). The meaning of "public understanding of science" in the United States after World War II. Public Understanding of Science, 1, 45–68.

Lewicka, M. (2011). Place attachment: How far have we come in the last 40 years? Journal of Environmental Psychology, 31(3), 207–230.

Louv, R. (2005). Last child in the woods: Saving our children from nature-deficit disorder. New York: Algonquin Books.

Manzo, L. (2003). Beyond house and haven: Toward a revisioning of emotional relationships with places. Journal of Environmental Psychology, 23(1), 47–61.

Manzo, L. (2005). For better or worse: Exploring multiple dimensions of place meaning. Journal of Environmental Psychology, 25(1), 67–86.

Marshall, N., Kleine, D., & Dean, A. (2012). CoralWatch: Education, monitoring, and sustainability through citizen science. Frontiers in Ecology and the Environment, 10(6), SI332–SI334.

Massey, D. (2005). For space. London: Sage.

Mayer, F., & Frantz, C. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. Journal of Environmental Psychology, 24, 503–515.

McCleery, A. (2008). So many Glasgows: From "personality of place" to "positionality in space and time." Scottish Geography Journal, 120(1–2), 3–18.

Measham, T., & Barnett, G. (2008). Environmental volunteering: Motivations, modes and outcomes. Australian Geographer, 39(4), 537–552.

Mejlgaard, N., & Stares, S. (2010). Participation and competence as joint components in a cross-national analysis of scientific citizenship. Public Understanding of Science, 19(5), 545–561.

Melchior, A., & Bailis, L. (2003). 2001–2002 earth force evaluation: Program implementation and impacts. Waltham, MA: Center for Youth and Communities, Heller Graduate School, Brandeis University.

Mordue, T. (2009). Angling in modernity: A tour through society, nature and embodied passion. Current Issues in Tourism, 12(5–6), 529–552.

Morrell, L., & Jin Bee Tan, R. (2009). Validating for use and interpretation: A mixed methods contribution illustrated. Journal of Mixed Methods Research, 3(3), 242–264.

Moss, D., Abrams, E., & Kull, J. (1998). Can we be scientists too? Secondary student perceptions of scientific research from a project-based classroom. Journal of Science Education and Technology, 7(2), 149–161.

Murdoch, J. (1998). The spaces of actor-network theory. Geoforum, 29(4), 357–374.

Murdoch, J. (2006). Post-structuralist geography: A guide to relational space. London: Sage.

Nassauer, J. (1995). Culture and changing landscape structure. Landscape Ecology, 10(4), 229–237.

Newman, C., Buesching, C., & Macdonald, D. (2003). Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation. Biological Conservation, 113, 189–197.

Nov, O., Arazy, O., & Anderson, D. (2011). Dusting for science: Motivation and participation of digital citizen science volunteers. Presented at Proceedings of the 2011 iConference, pp. 68–74.

Overdevest, C., Orr, C., & Stepenuck, K. (2004). Volunteer stream monitoring and local participation in natural resource issues. Human Ecology Review, 11(2), 177–185.

Pallasmaa, J. (2005). The eyes of the skin: Architecture and the senses. West Sussex, England: Wiley.

Patterson, M., & Williams, D. (2005). Maintaining research traditions on place: Diversity of thought and scientific progress. Journal of Environmental Psychology, 25, 361–380.

Peet, R., Robbins, P., & Watts, M. (Eds.). (2010). Global political ecology. Oxford, England: Routledge.

Phillips, T., Bonney, R., & Shirk, J. (2012). What is our impact? In J. Dickinson & R. Bonney (Eds.), Citizen science: Public participation in environmental research (pp. 82–95). Ithaca, NY: Comstock.

Pitkanen, K., Puhakka, R., & Sawatzky, M. (2011). The role of nature in place meanings and practices of cottage owners in northern environments. Norwegian Journal of Geography, 65, 175–187.

Podeschi, C., & Howington, E. (2011). Place, sprawl, and concern about development and the environment. Sociological Spectrum, 31(4), 419–443.

Pooley, J. A., & O'Conner, M. (2000). Environmental education and attitudes. Environment and Behavior, 32, 711–723.

Powell, M., & Colin, M. (2008). Meaningful citizen engagement in science and technology: What would it really take? Science Communication, 30, 126.

Pretty, G., Chipuer, H., & Bramston, P. (2003). Sense of place amongst adolescents and adults in two rural Australian towns: The discriminating features of place attachment, sense of community and place dependence in relation to place identity. Journal of Environmental Psychology, 23, 273–287.

Proshansky, H. (1978). The self and the city. Environment and Behavior, 10(2), 147–169.

Ramkissoon, H., Weiler, B., & Smith, L. (2012). Place attachment and pro-environmental behavior in national parks: The development of a conceptual framework. Journal of Sustainable Tourism, 20(2), 257–276.

Relph, E. (1976). Place and placelessness. London: Pion Limited.

Relph, E. (1985). Geographical experiences and being-in-the-world. In D. Seamon & R. Mugerauer (Eds.), (Dwelling, place and environment: Towards a phenomenology of person and world (pp. 15–31). New York: Columbia University Press.

Rennie, L., & Johnston, D. (2004). The nature of learning and its implications for research on learning from museums. Science Education, 88, S4–S16.

Robbins, P. (2004). Political ecology: A critical introduction. Malden, MA: Blackwell.

Rodman, M. (1992). Empowering place: Multilocality and multivocality. American Anthropologist, 94(3), 640–656.

Rose, G., Degen, M., & Basdas, B. (2010). More on "big things": Building events and feelings. Transactions of the Institute of British Geographers, 35, 334–349.

Roth, W., & Lee, S. (2002). Scientific literacy as collective praxis. Public Understanding of Science, 11, 33–56.

Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., et al. (2012). Dynamic changes in motivation in collaborative citizen Science projects. Presented at Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work, pp. 217–226.

Rowe, G., & Frewer, L. (2004). Evaluating public participation exercises: A research agenda. Science, Technology, & Human Values, 29(4), 512–556.

Scannell, L., & Gifford, R. (2010). Defining place attachment: A tripartite organizing framework. Journal of Environmental Psychology, 30, 1–10.

Schmeller, D., Henry, P., Julliard, R., Gruber, B., Clobert, J., Dziock, F., et al. (2008). Advantages of volunteer-based biodiversity monitoring in Europe. Conservation Biology, 23(7), 307–316.

Schreyer, R., Jacob, G., & White, R. (1981). Environmental meaning as a determinant of spatial behavior in recreation. In J. Frazier & B. Epstein (Eds.), Proceedings of the Applied Geography Conferences (Vol. 4, 294–300). Kent, OH: Applied Geography Conferences, Inc.

Schultz, P. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. Journal of Environmental Psychology, 21, 327–339.

Schultz, P., & Tabanico, J. (2007). Self, identity, and the natural environment: Exploring implicit connections with nature. Journal of Applied Social Psychology, 37(6), 1219–1247.

Seamon, D. (1982). The phenomenological contribution to environmental psychology. Journal of Environmental Psychology, 2, 119–140.

Seamon, D. (1984). Emotional experience of the environment. American Behavioral Scientist, 27, 757–770.

Semken, S., & Brandt, E. (2010). Implications of sense of place and place-based education for ecological integrity and cultural sustainability in diverse places. In D. Tippins, M. Mueller, M. van Eijck, & J. Adams (Eds.), Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems (pp. 193–214). New York: Springer.

Semken, S., & Butler-Freeman, C. (2008). Sense of place in the practice and assessment of place-based science teaching. Science Education, 92, 1042–1057.

Semken, S., Freeman, C. B., Watts, N. B., Neakrase, J. J., Dial, R. E., & Baker, D. R. (2009). Factors that influence sense of place as a learning outcome and assessment measure of place-based

geoscience teaching. Electronic Journal of Science Education, 13(2). Retrieved February 13, 2013, from http://ejse.southwestern.edu/article/view/7803.

Shirk, J., Ballard, H., Wilderman, C., Phillips, T., Wiggins, A., Jordan, R., et al. (2012). Public participation in scientific research: A framework for deliberate design. Ecology and Society, 17(2), 29.

Silvertown, J. (2009). A new dawn for citizen science. Trends in Ecology and Evolution, 24(9), 467–470.

Sobel, D. (2005). Place-based education: Connecting classrooms and communities. Great Barrington, MA: The Orion Society.

Soja, E. (1999). Thirdspace: Expanding the scope of the geographical imagination. In D. Massey, J. Allen, & P. Sarre, (Eds.), (Human geography today (pp. 260–277). Malden, MA: Blackwell.

Stedman, R. (2002). Toward a social psychology of place: Predicting behavior from place-based cognitions, attitude and identity. Environment and Behavior, 34(5), 561–581.

Stedman, R. (2003a). Sense of place and forest science: Toward a program of quantitative research. Forest Science, 49, 822–829.

Stedman, R. (2003b). Is it really just a social construction? The contribution of the physical environment to sense of place. Society & Natural Resources. An International Journal, 16(8), 671–68.

Steele, F. (1981). The sense of place. Boston: CBI Publishing.

Sullivan, B., Wood, C., Iliff, M., Bonney, R., Fink, D., & Kelling, S. (2009). eBird: A citizen-based bird observation network in the biological sciences. Biological Conservation, 142, 2282–2292.

Szabo, J., Vesk, P., Baxter, P., & Possingham, H. (2010). Regional avian species declines estimated from volunteer-collected long-term data using list length analysis. Ecological Applications, 20(8), 2157–2169.

Trentelman, C. K. (2009). Place attachment and community attachment: A primer grounded in the lived experience of a community sociologist. Society and Natural Resources, 22, 191–210.

Trumbull, D., Bonney, R., Bascom, D., & Cabral, A. (2000). Thinking scientifically during participation in a citizen-science project. Science Education, 84, 265–275.

Trumbull, D., Bonney, R., & Grudens-Schuck, N. (2005). Developing materials to promote inquiry: Lessons learned. Science Education, 89, 879–900.

Tuan, Y-F. (1975). Place: An experiential perspective. Geographical Review, 65, 151–165.

Tuan, Y-F. (1977). Space and place: The perspective of experience. Minneapolis: The University of Minnesota Press.

Uzzell, D., Pol, E., & Badenas, D. (2002). Place identification, social cohesion, and environmental sustainability. Environment and Behavior, 34, 26.

Vaske, J., & Kobrin, K. (2001). Place attachment and environmentally responsible behavior. Journal of Environmental Education, 32(4), 16–21.

Wilderman, C., Barron, A., & Imgrund, L. (2004). Top down or bottom up? ALLARM's experience with two operational models for community science. In Proceedings of the 4th National Monitoring Conference. Chattanooga, TN: National Water Quality Monitoring Council. Accessed February 17, 2013, at http://acwi.gov/monitoring/conference/2004/proceedings_contents/13_titlepages/posters/poster_235.pdf.

Williams, D., & Carr, D. (1993). The sociocultural meaning of outdoor recreation places. In A. Ewert, D. Chavez, & A. Magill (Eds.), Culture, conflict and communication in the wildland-urban interface (pp. 209–219). Boulder, CO: Westview Press.

Williams, D., & Patterson, M. (1996). Environmental meaning and ecosystem management: Perspective from environmental psychology and human geography. Society and Natural Resources, 9(5), 507–521.

Williams, D., & Patterson, M. (2007). Snapshots of what, exactly? A comment on methodological experimentation and conceptual foundations in place research. Society and Natural Resources, 20, 931–937.

Williams, D., & Vaske, J. (2003). The measurement of place attachment: validity and generalizability of a psychometric approach. Forest Science, 49, 830–840.

Wintle, B., Runge, M., & Bekessey, S. (2010). Allocating monitoring effort in the face of unknown Unknowns. Ecology Letters, 13, 1325–1337.

Wolf, K., Blahna, D., Brinkley, W., & Romolini, M. (2013). Environmental stewardship footprint research: Linking human agency and ecosystem health in the Puget Sound region. Urban Ecosystems, 16(1), SI13–SI32.

Wooden, R. (2006). The principles of public engagement: At the nexus of science, public policy influence, and education. Social Research, 73(3), 1057–1063.

Wynveen, C., Kyle, G., & Sutton, S. (2012). Natural area visitors' place meaning and place attachment ascribed to a marine setting. Journal of Environmental Psychology, 32, 287–296.

Yuksel, A., Yuksel, F., & Bilim, Y. (2010). Destination attachment: Effects on customer satisfaction and cognitive, affective and connative loyalty. Tourism Management, 31, 274–284.

Zimmerer, K. (2007). Cultural ecology and political ecology in the "environmental borderlands": Exploring the expanded connectivities within geography. Progress in Human Geography, 31, 22.