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REVIEW

Exploring dynamism of cultural ecosystems services through a review of environmental education research

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Abstract The field of cultural ecosystem services (CES) explores the non-material benefits that ecosystems provide to people. Human perceptions and valuations change, for many reasons and in many ways; research on CES, however, rarely accounts for this dynamism. In an almost entirely separate academic world, research on environmental education (EE) explores how EE programming affects peoples' attitudes and values toward the natural world. In this review of 119 EE research publications, we explore whether CES (and the adjacent concept of relational values) can be dynamic. We approach this via two lines of inquiry that explore whether EE may instigate this change. First, we investigate whether the EE community measures (and tries to affect) CES-related outcomes. Second, we ask: Has EE research detected changes in CES-related outcomes? We find the EE programs measure many CES outcomes (e.g., aesthetic appreciation, social connectedness), and that in most cases studies observe increases in these outcomes after EE experiences.

Keywords Change · Measurement · Relational values · Social-ecological systems

INTRODUCTION

Change is central to the ecosystem services (ES) framework. ES research explores the services that "flow" from different ecosystems, and in many applications of the framework, this information is used to predict how ES will change based on changes in land use. The role of the ES framework as a decision-making aid relies on the idea of change: widely used scenario-based tools demonstrate how changing (or not changing) a landscape in various ways will affect ES flows. ES frameworks recognize deep social-ecological connections; an ecosystem *process,* for instance, is not a *service* unless social conditions lead people to demand it (Geijzendorffer et al. 2017) and articulate that demand in particular ways (Ernstson 2013). Yet despite that recognition of social-ecological connections, nearly all attention to change in the ES framework focuses on ecosystem change—that is, changes in "service flows" that result from changes in ecosystems. A recent priority-setting paper for the ES field lists deepening understanding of the dynamics of ES, with a strong focus on biophysical drivers, as a top priority (Rieb et al. 2017). This attention to ecological change is logical, since the ES framework initially grew out of, and is still firmly rooted in, ecology. Yet social change may also be critical to understanding ES and the social-ecological systems in which they are embedded. Perceived benefits or values of a given ecosystem can change; in some situations ecosystems do not change, but the features that are considered services, or how those services are valued, do.

The realm of ES where this dynamism may be most relevant is cultural ecosystem services (CES) and the adjacent concept of relational values. We define CES, following Chan et al. (2012a, b), as "ecosystems' contribution to the nonmaterial benefits (e.g., experiences, capabilities) that arise from human–ecosystem relationships" (ibid., p. 9). Relational values, in turn, "are not present in things but derivative of relationships and responsibilities to them," and they include "core values, such as justice, care, virtue, and reciprocity" (Chan et al. 2016, pp. 1462–1463). The notion of relational values was proposed in response to a combination of emerging empirical findings about CES and fundamental criticisms of the ES framework. An example empirical finding suggesting the relevance of relational values is that many

people in diverse places, when asked to speak about non-material benefits from nature, mention reciprocal relationships such as kinship with non-humans (Gould et al. 2015). An example of a fundamental criticism of CES is that the one-way "service" metaphor is inadequate to describe the complexity of human interaction with ecosystems (Raymond et al. 2013).

A hypothetical example may be helpful here. A local riverbank is considered "overgrown," and members of a community do not think much about it. Then the city implements an educational initiative related to the riparian area, and people learn about the interesting array of plants and animals there. People now attend more to, and spend more time in, the area (e.g., people take walks there, and local school science classes take field trips there). The bank begins to figure more into their communal identity. A place that before provided few to no CES or relational values now provides an array of them, not because of a change in the ecosystem, but because of a change in the social system. Of course, the two will change together, as described by SES theory—e.g., greater awareness might lead to more trails, which will facilitate further access—but in this hypothetical example, ecological changes were far less dramatic than social changes.

This paper explores the core idea that CES and relational values from a given ecosystem, in a given state, can be dynamic. We focus primarily on CES, but briefly explore the dynamism of relational values as well. It seems fairly straightforward that CES change, yet this phenomenon is hardly discussed in scholarly treatment of the issue. One goal of this paper is to begin that discussion in the ES field. A second goal relates to mechanisms. An important and obvious follow-up to this idea of CES dynamism is the question: *why* do CES change? The answer to this question likely involves a complex array of social phenomena and their interactions with biophysical phenomena. In this paper, we explore one specific reason that CES might change: environmental education initiatives.

Background on environmental education, cultural ecosystem services, and possible links between them

Environmental education (EE) has numerous and varied goals, and can be defined in numerous ways. We rely on the definition of EE as "a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment" (EPA 2017). EE is considered to have five main components: awareness and sensitivity; knowledge and understanding; concern and motivation; skills; and participation (UNESCO 1977). This list of components of EE opens the door to our discussion of how EE might lead to changes in CES. Tidball and Krasny (2011) suggest that EE, through engagement with other initiatives, may foster ecosystem services in general; our analysis explores whether that may be true for CES specifically. Many of these components of EE are related to changing how people experience, perceive, or access CES. The process of "exploring environmental issues" to increase awareness and sensitivity, for instance, may have a frequent core component of changing the way people relate to the environment (e.g., they become more aware and observant of their surroundings, and thus find more beauty in them). This then changes the environment's ability to improve their well-being—i.e., the new interaction created an ecosystem service that provides an aesthetic benefit. That newly developed chain of events (attend to environment differently, find more beauty, increase in well-being) exemplifies the concept of ES.

Our work addresses the central question outlined above: Can the CES (and relational values) associated with a given ecosystem be dynamic? We approach this by considering EE as the possible instigator of change, and ask two more specific questions. First, we investigate whether the EE community is measuring (and trying to affect) CES. Specifically, we ask, "Are CES related to the outcomes of EE; if so, what CES-related outcomes does EE measure?" Second, if the answer to the first question is affirmative, we ask, "Has EE research detected increases in CES-related outcomes?"

This paper builds on two nascent areas: existing work at the EE–ES intersection, and treatment of dynamism in CES. This paper sits at the little-studied intersection of the EE and ES fields. The work that does exist at that intersection tends to address the fact that education can increase understanding of ES generally (e.g., Wiborn 2013). Such approaches typically entail a focus on the material ES (provisioning, regulating, supporting), with the goal of facilitating learning specifically about those material ES. One paper that addresses both EE and ES focuses on education as a CES—that is, the fact that ecosystems can aid learning about ecological and biophysical principles—rather than on education as a mechanism to enhancing or developing a suite of CES (Mocior and Kruse 2016). Our approach, of focusing on how EE may aim to, and succeed in, modifying how people experience CES, is unique.

Just as the intersection of EE and ES, and particularly EE and CES, is little studied, recognition of the dynamism of the CES associated with a given ecosystem, in a given state, is rare. Relatively few CES-related initiatives have explicitly acknowledged that CES change as a result of primarily social, rather than ecological, changes. (A note on terminology: from here onward, we use the term "CES dynamism" to refer to CES change that results from primarily social forces, which is the focus of this paper). One instance is found in the United Kingdom's National

Ecosystem Assessment; its chapter on Cultural Ecosystem Services states:

> We attempt to develop an interpretive framework for examining cultural services that reflects our understanding of culture as a dynamic and transformative process involving the enormous range of social communications and social practices that enfold nature, places and landscapes into everyday life. How might this interpretive approach contribute to a science- and economics-based assessment of ecosystem services? (Church et al. 2011, p. 643).

In another instance, an investigation conducted in Singapore analyzed changes in CES associated with the country's mangrove forests over multiple decades. To determine historical CES, the study examined historical photographs and archived oral histories; to determine present-day CES, it used social media and a survey (Thiagarajah et al. 2015). A more general approach that incorporates dynamism is evident in studies that posit that CES might be best characterized as processes rather than services. As one of these papers describes, "focusing on services as fixed outcomes, rather than processes, prevents the concept from remaining open to local actors' dynamic changes in valuation" (Pröpper and Haupts 2014, p. 28). Although other scholars do not deny that CES may change, they do not explicitly discuss, not to mention measure, their dynamism.

We hope that this investigation will be helpful to both the EE and ES fields. For scholars and practitioners in the ES field, an understanding of whether research demonstrates changes in CES-related constructs is important, and could open the door to a potentially large new arena of allowing for and accommodating this dynamism in ES analyses. Further, understanding *how* EE researchers measure CES-related outcomes may offer a trove of suggestions for creative characterization of those elusive phenomena. For people in the EE field, this paper suggests a novel possible framing of EE programs: as modifiers of how people experience CES. Given the ample discussion of the role that CES play in encouraging conservation support and action (e.g., Daniel et al. 2012; Plieninger et al. 2013), this angle could inform and motivate EE work in new ways.

MATERIALS AND METHODS

Creation of article database

Given that we sought to understand whether CES may change, specifically as a result of EE, we conducted a literature review of existing manuscripts from the field of EE. We examined these manuscripts to determine whether EE initiatives attempted to influence outcomes that could be interpreted, or labeled, as CES, and if so, whether the studies observed changes in these outcomes. We sought a representative sample of peer-reviewed articles that measure EE outcomes. As we began our literature review, we found a recent review of EE program evaluation with the guiding question: "What do we measure and what have we learned?" (Stern et al. 2014). We began building our article database with the Stern et al. sample and updated their list (adding articles published between 2010 and 2016) using a variant of their methods.

Stern et al. used a multi-step system to select 66 articles (published between 1990 and 2010). Their methods centered around examining the Tables of Contents of six major environmental education peer-reviewed journals: *The Journal of Environmental Education; Environmental Education Research; Applied Environmental Education and Communication; International Research in Geographical and Environmental Education*; *Australian Journal of Environmental Education; and the Canadian Journal of Environmental Education*. They also conducted keyword searches, for "Environmental Education" AND "evaluation," searched known repositories of EE research, and examined works cited for possible additional articles (see Stern et al. (2014) for details). They then ensured that articles that they added to their database met four characteristics, including that programs worked with children under the age of 18 and that "at least one element of knowledge, awareness, skills, attitudes, intentions, or behavior was empirically measured, either qualitatively or quantitatively, following participants' exposure to the program" (Stern et al. 2014, p. 584). Our goal was a sample of articles that addressed outcomes of awareness, attitudes, intentions, and/or enjoyment, as they were most relevant to CES. All 66 of the Stern articles met these criteria, so we included all of them in our database.

To ensure that our sample of articles was current, we used a subset of Stern et al.'s selection criteria to add articles published between 2011 and 2016. A subset of their criteria was appropriate because our aims differ from theirs. We aim to explore general occurrence of CES-related measures in EE outcomes, not to holistically portray how evaluation is proceeding in the EE field. We reviewed the Tables of Contents of the six primary EE journals that Stern et al. used (see above) that met the central criterion listed above from the Stern et al. study, but modified for our more specific CES-related purpose: that the study measured outcomes related to awareness, attitudes, intentions, and/or enjoyment. Using this method, we added 53 articles to our database.

Reviewing CES-related EE outcomes and their measurement

Two researchers had extensive, iterative discussions to determine how EE outcomes overlap with CES. This began with the decision to include only articles that Stern et al. had categorized as addressing outcomes of awareness, attitudes, intention, and enjoyment. It continued with decisions about how to assign EE outcomes to CES-related categories. In a first stage of this process, we listed all measured outcomes that might be relevant to CES, verbatim as discussed in each study. In a second step, we grouped these outcomes into CES-related categories. In a final step, we refined this list, culling some outcomes that were too tangential to CES to be included in the present analysis. See Table 1 for the final list.

We undertook a systematic process to characterize and describe techniques used to measure these CES-related EE outcomes. First, we collected verbatim descriptions of measurement techniques for each study, and examined them jointly. This led to a second step of lifting out specific survey items (in the case of quantitative work) and interview items or writing prompts (in the case of qualitative work) used to analyze each outcome. Finally, we examined the set of measurement tools used for each CES. We present our results of measurement items organized by CES.

Coding for changes in cultural ecosystem services

Two researchers worked together to code for observed changes in CES-related outcomes. We followed Stern et al.'s system for ranking a change in EE outcomes. Within this system, 0 = no change or (the rare instances of) negative change in the outcome, 1 = mixed results for the outcome, and 2 = positive change in the outcome. Our process for rating was as follows: One researcher summarized the outcomes for each article, and then both researchers used those summaries to independently assign rankings following Stern et al.'s system above. The researchers then compared their rankings and evaluated areas of disagreement by returning to the original manuscripts. In all cases, after returning to the original manuscripts the two easily agreed on the most appropriate ranking.

Note on language used in this paper

We would be remiss if we did not address distinctions between services, benefits, and values (Fisher et al. 2009). This is an important discussion in ES generally, and becomes particularly complex for CES. We use the term CES as a shorthand that we perceive will be widely recognized. Yet the EE outcomes we focus on would not be considered services in the ES framework; they would, instead, be considered benefits and/or the values associated with those benefits. We will not go into detail on these distinctions, as multiple other works have treated the issue in detail (Chan et al. 2012a, b). We have used the term CES-related outcomes to denote the distinction, and further explore the implications of the fact that the outcomes are benefits and values in the final section of the paper.

We also wish to clarify a distinction between EE and education as a CES. In typologies of CES, education is often listed; the category encompasses how ecosystems aid learning about ecology and ecological principles. This "education as a CES"—i.e., an ecosystem helping someone to learn about itself or the principles that govern it—is distinct from (though related to) the field of EE. EE has a broader scope, with a focus on creating educated citizens equipped to respond to changing conditions. This paper explores how EE can increase access to CES. One of those CES is education about the natural world.

Lastly, in the remainder of this paper, we use phrasing such as "studies found increases in education as a CES." Technically, the proper phrasing would be "studies found increases in outcomes that we coded as education as a CES." In other words, no EE studies articulated their outcomes as increases in CES. Rather, they articulated outcome(s) that we identified as a particular CES benefit or relational value. We use the terms from our coding (e.g., "studies found increases in education as a CES") for brevity and ease of reading.

RESULTS

Our results show that many EE researchers measure constructs that are closely related to CES, using a variety of methods. Our analysis indicates these constructs fall into two categories: CES benefits (i.e., benefits associated with CES established in the literature) and relational values. We also find that when researchers measure CES benefits and relational values, they often (in over 60% of cases for all concepts) detect increases after EE programs.

The authors of the 119 manuscripts in our sample measured and often found increases in six CES benefits and three relational values. We discuss each of these CES benefits and relational values, summarize the changes found (see Figs. 1 and 2), and provide examples of manuscripts that document increases after EE programming. We additionally provide examples of methods that researchers used to measure changes in CES benefits and relational values, in an effort to supply future researchers with a menu of possible approaches for documenting the dynamic nature of these constructs (see Table 1).

Table 1 Selection of measurement methods used in studies in our sample

Construct	Method	Item
CES Benefits		
Appreciation of aesthetics	Survey with student participants (Bogner 1999)	Survey questions about aesthetics (with Likert scale responses):
		I would really enjoy sitting at the edge of a pond watching dragonflies in flight
		Grass and weeds growing between pavement stones really looks untidy
		I prefer a well-cared for lawn to a wild meadow where flowers grow in an unordered way
	Pre/post open-ended assessments with participants (Hadzigeorgiou et al. 2011)	Researchers asked open-ended questions about the value of trees and why they are important
Artistic inspiration	Observations of participant behavior (Baumgartner and Zabin 2008)	Researchers watched participants create a mural and took note of what the participants were inspired to depict in the mural
Education as a CES	Interview with participants and non-participants (Basile 2000)	Questions assessing ecological knowledge:
		What is a habitat?
		What makes a good habitat?
		What would make a good home for the baby bird?
	In-depth interviews with participants (Ruiz-Mallen et al. 2009)	Interview questions to assess Education as a CES:
		What do you think about the environmental education experience conducted in your community?
		What ecological knowledge did you gain through participation in the program?
Identity	In-depth interviews (D'Amato and Krasny 2011)	Interview questions related to identity:
		Would you describe yourself as an environmentalist before the trip?
		Would you describe yourself as an environmentalist after the trip?
	Qualitative document analysis (Jagger 2014)	Researchers collected participants' writing, letters, and poetry.
Recreation and enjoyment	Pre/post survey (Hinds 2011)	Likert scale questions related to recreation and enjoyment:
		I really enjoy nature
		I like places where there are lots of different plants and trees
		I feel good when I'm close to nature,
		Walking in the woods is a waste of time
	Survey instrument (Schneller et al. 2015)	Likert-style survey questions that address Recreation and Enjoyment:
		I feel good in the silence of nature
		I would really enjoy visiting an oasis in the desert to watch birds in flight
		I like to go on trips to nature, for example to the beach, the mountains, or the desert
	Pre/post survey (Powers 2004)	Multiple choice question that addresses Recreation and Enjoyment:
		Choose your favorite free time activity
		Watching TV
		Exploring nature
		Playing sports
		Other
Social connectedness	Observation of participant behavior (Mayer-Smith et al. 2010)	Observations about who students developed relationships with as a result of the EE programming, as well as observations about the characteristics of those new relationships
	Pre/post survey (Hinds 2011)	Likert scale survey questions related to social connectedness:
		I enjoy being part of a group
		I really like the company of the people around me
		I like being alone
		I try to avoid other people
		I make friends easily
		I tend to keep people at a distance

Table 1 continued

Construct	Method	Item
Relational values		
Attitudes about the natural world	Pre/post survey (Bodzin 2008)	Survey questions adapted from Leeming et al.'s (1995) Children's Environmental Attitude and Knowledge Scale (CHEAKS), which includes 36 questions that measure attitudes toward environmental issues
	Questionnaire (Cummins and Snively 2000)	Multiple choice question that addresses attitudes toward the natural world:
		Some species of whales are not near extinction. What should be done about hunting these kinds of whales?
		A. Hunting whales should be allowed because it provides people with food, clothing, and money
		B. Hunting whales should not be allowed because whales are beautiful and intelligent
		C. It is alright to kill a certain number of these kinds of whales as long as plenty are left
		D. Hunting whales should not be allowed because whales are part of the food chain
	Survey instrument administered to participants (Dettmann-Easler and Pease 1999)	Likert scale questions:
		Animals should be hunted for food, never for just sport
		It's okay to catch fish for eating, but not just for fun
		Dressing up elephants to do circus tricks is mean
		Because coyotes eat rabbits they should be shot
		Because hawks kill small rodents they should be shot
		All poisonous snakes like rattlesnakes should be killed
		Most wild animals are dangerous to people
		I throw rocks at wild animals (for example, birds)
		Hunting big animals like deer and putting their antlers on the wall is okay
Connection to nature	Pre/post survey (Liefländer et al. 2013)	Survey questions based on Schultz (2002) *Inclusion of Nature in Self (INS) Scale* that addressed Connection to Nature:
		How interconnected are you with nature?
		Choose the picture which best describes your relationship to nature
	Survey administered to participants (Cachelin et al. 2009)	Fill-in-the-blank questions related to Connection to Nature:
		The place I just visited made me feel …
		If I could tell my best friend one thing about this place I would say …
		I might go back to this place because …
Responsibility	Semi-structured interview (Schneller 2008)	Self-report questions, which focused on if the EE programming made students feel a greater sense of responsibility:
		Do you think the course experiences augmented your environmental consciousness?
		If yes, how so?
	Pre/post surveys (Stern et al. 2008)	Likert-style questions about responsibility:
		I (will) turn the lights out when I leave a room
		I am (will be) careful not to waste food
		I am (will be) careful not to waste water
	Pre/post surveys (Siemer and Knuth 2001)	Five-point Likert scale questions that address responsibility:
		I feel like my actions have a direct effect on the environment
		Trying to protect the environment is my responsibility
		I think about how my actions may harm the environment

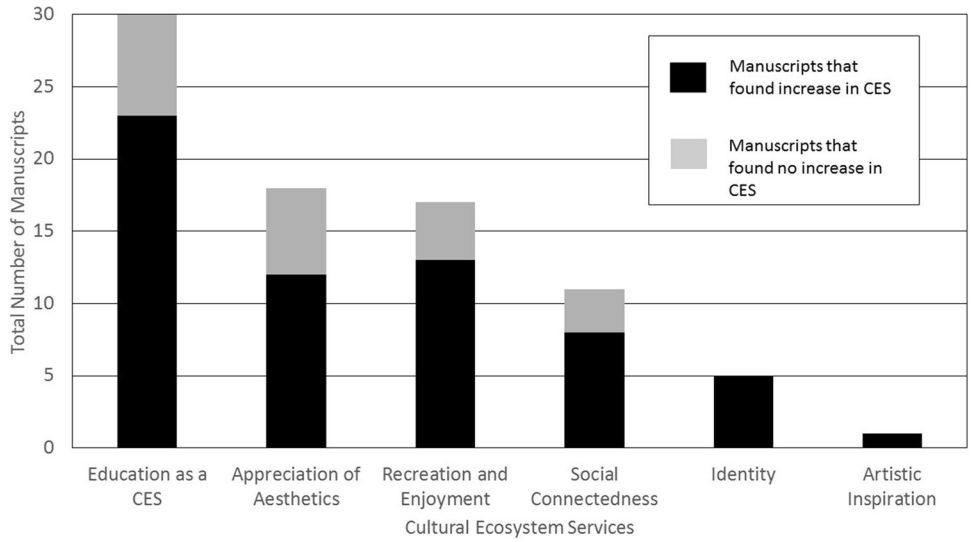

Fig. 1 Number of manuscripts in our sample that addressed each outcome coded as a cultural ecosystem service. Shading denotes the proportion of studies that found increases in each outcome

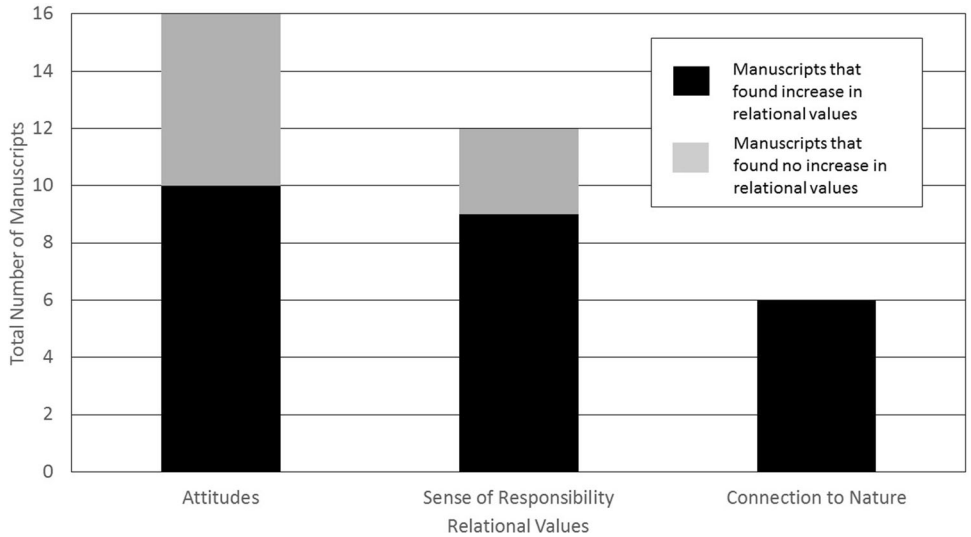

Fig. 2 Number of manuscripts in our sample that addressed each outcome coded as a relational value. Shading denotes the proportion of studies that found increases in each outcome

Education as a CES

As described above, in CES typologies, education encompasses ecosystems' role in helping people to learn specifically about the natural world and ecological principles. In total, 30 studies (25% of our sample) attempted to measure concepts that fit this description. Of these, 77% presented findings that suggested increases in education as a CES, 13% suggested mixed results, and 10% suggested no change or a decrease in education as a CES.

For the majority (77%) of papers addressing education as a CES, results suggest that being outside in an ecosystem enhanced students' learning about that ecosystem. One study of a permaculture-based EE program found that learning outdoors enhanced understanding of permaculture in ways that being inside would not have; one participant explained, "'When we went down to the garden. That was really memorable'" (Lebo and Eames 2015, p. 51). Another study found that students were excited by learning outdoors; one student reported appreciating "'the chance to experience important things, instead of sitting in a class filling your head with information and no understanding'" (Russell 2000, p. 295).

Aesthetics

In the CES literature, aesthetics refers to individuals' appreciation of aesthetic aspects of nature or ecological phenomena. In total, 18 studies (15% of our sample) investigated concepts related to aesthetics. Of these, 67% presented findings that suggested positive increase in aesthetics, 33% had mixed results, and none suggested no change or a decrease in aesthetics.

The majority (67%) of studies that addressed aesthetics found that appreciation of aesthetics increased after environmental education. One study of an EE program, for example, found that participants expressed greater appreciation of the beauty of trees after an EE program (Hadzigeorgiou et al. 2011). As part of data collection, the authors asked participants to draw pictures before and after the EE program. They found that, "Most children's drawings [after the EE program] were about trees protecting us from wind, flooding, heat and about trees making our town beautiful (i.e., gardens, parks, streets)" (Hadzigeorgiou et al. 2011, p. 528). Another study similarly reported that participants' appreciation of natural beauty increased after EE programming; as one example, one participant stated: "'[It] inspired me to appreciate [the] beauty of nature and the environment more…'" (Curtis et al. 2013, p. 190).

Recreation and/or enjoyment

In the CES context, recreation and/or enjoyment refers to individuals' demonstrated enjoyment of recreation-related activities or of nature in general. In total, 17 studies (14% of our sample) assessed outcomes related to recreation and/or enjoyment. All of these studies either found positive increases in recreation and enjoyment (76%) or mixed results (23%); none found no change or a decrease in recreation and/or enjoyment.

Seventy-six percent of the papers that examined recreation and enjoyment demonstrate a positive increase after environmental education programming. One study, for example, found increases in student enjoyment of nature following the program (Bogner 1999; see Table 1); it concludes that "adolescents' preferences towards the environment and nature usage may be influenced by extracurricular educational approaches" (Bogner 1999, 1180). In another study, researchers uncovered an increase in students' enjoyment of recreation (specifically hiking) after their EE experience. One interviewee indicated this: "'Probably the hike was the most fun because we got out to a few different sites and different areas and we learned about forest fires and it was neat!'" (Knapp and Benton 2006, p. 172).

Social connectedness

Social connectedness refers to interacting and forming bonds (of various intensities) with other people. In total, 11 studies (9% of our sample) examined concepts related to social connectedness. Of these, 73% found a positive increase in social connectedness, 27% found mixed results, and none found no change or a decrease in social connectedness.

The majority (73%) of papers that examined social connectedness document a positive increase after the EE programming they studied. For example, one study found that program participants expressed the, "importance of being in a tight-knit, supportive community that helped individuals as they undertook challenges, set high standards for environmental behavior, and facilitated learning in the outdoors" (D'Amato and Krasny 2011, p. 243). A second study similarly found increases in social connectedness after an EE program (Mayer-Smith et al. 2010; see Table 1). They describe social tolerance emerging through the intergenerational learning facilitated by their program: "the universal hugs and tears and small tokens of appreciation exchanged between children and adults on final farm days for all our schools provided clear evidence that culture and socio-economic status mattered little to the participants in our project" (ibid., p. 115).

Identity

Identity refers to a sense of one's self and affiliations with particular communities. With respect to CES, identity can involve many types of intricate relationships with the non-human world—for example, a livelihood (e.g., a fisherman whose identity is intertwined with the sea); a particular passion or concern (e.g., someone who dedicates time or money to advocacy for wildlife conservation); or a general orientation (e.g., seeing oneself as "an environmentalist"). In total, 5 studies (4% of our sample) assessed outcomes related to Identity. Of these, 100% found positive increase in Identity.

All of the papers that investigated concepts related to identity found increases after EE programming. One study reported that students' identities as environmentalists increased after the EE program; one student interviewee explicitly mentioned change: "'I understand the environment more now, so I feel more like an environmentalist'" (Schneller et al. 2015, p. 263). Another study describes an EE teacher who gives her students T-shirts that identify them as "EcoLeaders" in an effort "influence how students see themselves, and thus how they see their role in their urban communities and their relation to environmental or natural elements in the city." This teacher also expressed "what she hopes to hear from students: 'I can do something

and be successful. I enjoy myself in nature, and maybe I might want to do something like this in the future'" (Russ et al. 2015, p. 83). The study's analysis of student narratives of their experience indicates that those goals were largely achieved; one student's narrative, for instance, "demonstrates that her identity became defined in relation to the Bronx's environment, her urban environmental education program, as well as her connections to Bronx environmental leaders" (Russ et al. 2015, p. 85).

Artistic inspiration

Artistic inspiration, in the CES realm, indicates the phenomenon of inspiration from the natural world to create art. Only one paper (less than 1% of our sample) investigated concepts related to artistic inspiration. It found a positive change. In that study, researchers investigated a semester-long EE program focused on intertidal biodiversity. One of the program's activities was painting a mural, and the researchers found that even though participants had "no guidelines or restrictions [for painting the mural], 10% of the 2003 cohort and 33% of the 2004 cohort painted organisms that they had been studying on the mural (an exciting result considering that these paintings included tunicates, sea cucumbers and algae, generally not considered to be the most charismatic or glamorous of marine creatures)" (Baumgartner and Zabin 2008, p. 105).

Relational values

We also coded for concepts not typically included in CES typologies, but which fit well with the concept of relational values. As discussed in the introduction, many scholars feel that relational values are closely related to CES, and may help to more accurately portray the non-material aspects of human–ecosystem relationships. We provide examples of three outcomes assessed by the studies in our sample that can be considered relational values, and we apply the same analysis to determine whether these values have changed following EE programming.

Attitudes toward ecosystems and "environmental" attitudes

Our category of attitudes toward ecosystems and "environmental" attitudes includes outcomes related to individuals' outlook and opinions about aspects of the environment or environmental issues. Because the term "attitudes," so broadly used in the social sciences, is particularly complicated, we coded to this category studies that identified themselves as addressing attitudes. In total, 16 studies (13% of our sample) targeted concepts related to attitudes. Of these, 75% found positive increase in attitudes toward ecosystems, 25% found mixed results, and none found no change or a decrease in attitudes toward the natural world.

The majority (75%) of papers that examined environmental attitudes found increases after EE programming. In one example, researchers found a statistically significant increase in positive environmental attitudes as defined by the researchers (e.g., "Hunting and fishing are important environmental activities"; "Government should regulate the use of land to protect wildlife habitat") after students' participation in an environmental science course (Bradley et al. 1999). A second study found a positive increase in pro-environmental perceptions (e.g., higher ratings of items such as "I try to to tell others that nature is important") among participants in an EE program (Johnson and Manoli 2008).

Responsibility

Responsibility refers to individuals' awareness of their role in caring for the natural world. In total, 12 studies (10% of our sample) examined concepts related to responsibility. Of these, 100% found positive increases in responsibility.

All of the papers that looked at responsibility demonstrate increases after EE programming. For example, one study found that participants' sense of responsibility increased after the program they studied (Schneller 2008). One interviewee said, "I have more appreciation. When we go on trips, me and my friends, we always take our garbage with us and put it in bags which we didn't do before" (ibid, p. 298). A second control-impact study that investigated the effects of a science-based EE program focused on a schoolyard pond found an increase in students' sense of ownership of the pond: "the science club students [as opposed to students in the control group] displayed a sense of ownership of the pond and began referring to it as 'our pond'" (Bodzin 2008, 52). The participating students also displayed an increased sense of stewardship toward the pond and increased motivation "to undertake constructive actions to help clean up the pond" (ibid., p. 54).

Connection to nature

Connection to nature refers to feelings of identification with nature and closeness to it. In total, 7 studies (6% of our sample) investigated concepts related to Connection to Nature. Of these, 86% found positive increase in connection to nature, 14% (i.e., 1 study) found mixed results, and none found no change or a decrease in connection to nature.

Most of the papers that examined connections to nature found a positive increase after EE programming. For example, one study found that participants' connection to

nature increased significantly ($p = 0.01$) after the EE program (Stern et al. 2008). In a second study, researchers found a statistically significant increase in participants' connection to nature after EE programming (Theimer and Ernst 2012).

Measurement

Our review demonstrated that EE researchers employ a wide range of epistemological approaches and methods to document changes in CES. Because some papers did not detail every interview question asked or the precise nature of every observation made, we cannot create a comprehensive list of specific measurement approaches and tools. However, we can summarize the general trends we observed (see next paragraph) and provide representative examples of some of the most replicable approaches (see Table 1), such that future researchers interested in measuring CES might adopt some of these strategies.

Studies drew from diverse epistemologies, including investigations based in phenomenological approaches that allowed for organic emergence of findings, positivist approaches that sought to test hypotheses, and several others. Data collection methods included surveys, interviews, in-person and video observations, and collection of students' work, including written reflections, artwork, and other assignments. Some studies used control groups while others did not; many studies, but not all, collected data before and after an EE program. We have included examples of these and other techniques in Table 1.

DISCUSSION

We analyzed over 100 articles from the EE field, with three goals: to understand if EE researchers address CES (our first research question); to review the diversity of forms of measurement used (a follow-up to our first question); and to understand whether or not the studies detected changes in those CES-related outcomes (our second research question). We found that these studies created and employed a wide variety of techniques for characterizing CES-related outcomes; the techniques span epistemological and methodological orientations, and include validated scales and open-ended observational protocols. We also found that the majority of these studies detected positive changes in CES-related outcomes.

We hope that this paper, which demonstrates the synergy between the concept of CES and many of EE's goals, is thought-provoking and useful for at least two groups. EE audiences may be interested in considering CES as a communication, and possibly evaluation, tool. The list of types of CES could be considered as one framing of desired outcomes of EE. ES audiences, on the other hand, may find it important to add to their framing the idea that CES are dynamic even when an ecosystem is relatively unchanged. That is, this paper provides evidence of a second kind of dynamism from the type typically discussed in the ES field. It discusses changes in services, benefits, and values that may be largely independent of ecosystem change. The ES community, in working to incorporate this concept, may appreciate the evidence provided here—both its systematically drawn conclusions of various CES changing, and the many examples of techniques for detecting both CES and their dynamism.

Those many examples of techniques are useful to collect and curate because EE outcomes and CES share a fundamental challenge: measuring, and more broadly characterizing, them is notoriously difficult. Meaningful measurement is a central challenge of social science in general. Given that challenge, sharing methods and ideas seems useful. In this paper, we provide a repository of measurement tools used by EE researchers that are relevant to CES work. This may be helpful to CES researchers seeking new tools, and also to EE practitioners looking for collections of characterization techniques that are validated (or otherwise tested). For EE researchers wishing to couch their research in ES terms, the collection here provides ample fodder for research with a CES framing.

Another possible angle on the relevance of these findings relates to repeated claims that CES, because they are the ES that are most detectable, accessible, and understandable to many people, will be most connected to support for conservation, and perhaps environmental protection more generally (Daniel et al. 2012). This paper demonstrates that EE can change CES-related phenomena. If the argument about the importance of CES is accurate, then EE can increase people's awareness of, access to, and benefits from CES in ways that may lead to increased support for conservation. This may encourage increased support for EE from the conservation community.

Connections to CES scholarly work

This paper relates to two central threads in scholarly conversation of CES: epistemological variation, and the relational values concept.

The EE and CES fields are both diverse and multi-disciplinary; one predictable result of this ideological diversity is wide epistemological, and therefore methodological, variation within each field. Both EE and CES scholars have extolled the importance and benefits of this diversity (e.g., Milcu et al. 2013; Stevenson et al. 2013). A common claim is that the use of multiple approaches allows for a deeper, richer understanding of nuance. Yet this variation also leads, in both fields, to substantial confusion and

complexity. One underlying distinction that impacts nearly all scholarly work relates to epistemological stances on human values and perceptions: how much are they "truths" out there to be measured, and how much are they contextually dependent and mutually developed (Raymond et al. 2014)? The idea of change is present in these two epistemological stances, but it manifests differently. There is nuance in the distinction; conceptions of values do not always fall onto the ends of the spectrum named above (i.e., values and perceptions as "truths" that can be discovered, versus as contextually dependent and mutually developed). Scholars in both the EE and CES fields operate with a diversity of understandings. A series of efforts to understand CES in the United Kingdom, for instance, employ both surveys that "measure" values and perceptions, and also interactive workshops that facilitate discussion on, and in many cases, development of "shared values" (Kenter et al. 2016).

The second thread that this paper can inform is the idea of relational values. The concept of relational values resonates with the ethos of many EE programs, which might describe a primary goal as modifying participants' relationships with the non-human world. No one has yet proposed a typology of relational values of ecosystems (although Fish et al. (2016) provide a valuable first step). Yet many proposed relational values have been—with different names and different framings—targets of EE programming. The present study offers support for the importance of the relational values concept, because many of the EE studies in our sample characterized outcomes that have obvious relevance to the non-material ways that ecosystems benefit people, but which do not fit neatly into the CES framework. Connection to nature is an obvious instance of this: a connection is better conceptualized as a relationship, not a benefit. Responsibility, as another example, is often central to relational values (see the definition above). The issue that this paper raises for CES—that they can be dynamic—is just as relevant for relational values. The measurement techniques used in EE could also be informative for developing measures of relational values.

LIMITATIONS

One limitation involves the ease with which methods from different approaches can be succinctly captured and conveyed. Specifically, interpretivist and constructivist approaches sometimes do not even use the language of outcomes (instead focusing on, for instance, processes); these studies thus rarely report measurement items. As one example, one study investigated a project called "Environmental Education through Filmmaking" using a version of grounded theory; the study described what was observed during, and after, the project, but measured no a priori outcomes and thus no specific measurement items (Harness and Drossman 2011). This type of study, and it close cousins, will be under-represented especially in our collection of measures (Table 1).

An even more fundamental issue concerns the types of measures used in the studies in our sample. Both EE and CES scholars have questioned the appropriate unit of analysis for research in their fields; many argue that for phenomena that are profoundly social and collective in nature, measuring only at the level of the individual is inadequate (Stevenson et al. 2013). Social capital—a topic of CES research that has its own sub-field in the broader social sciences—provides an example. Foundational work in social capital demonstrates that social capital is built, maintained, and lost at both individual and community levels (Bourdieu 1980; Coleman 1988). There is, however, no universal consensus about which unit of measurement is best (Narayan and Cassidy 2001; Adam and Rončević 2003). Relatedly, much environmental education research—including the vast majority of the studies in our sample—uses the individual as the unit of analysis. Yet environmental education researchers increasingly discuss how although environmental education often focuses on changing individual knowledge, attitudes, and behavior, meaningful environmental action involves communities, systems, and interactions. These researchers suggest that both practice and research must address this more "ecological" and collective reality (Tidball and Krasny 2011; Krasny et al. 2015). General consensus, both in the two fields mentioned and more broadly, is that both approaches yield insight. Some researchers tend to focus on individuals as units of analysis, while others treat social units as such. This debate over whether to measure at the individual or community level is relevant to most CES benefits and relational values, since most have some collective element. Our assumption is that both approaches are informative for many CES; we thus suggest that future work attends to both.

Our presentation of changes after EE programming also confronts the issue of publication bias. One of our three categories of ranking results, "no change or negative change," is highly subject to publication bias, or the "file drawer problem," in which studies, showing no significant results, are not published (Rosenthal 1979). This bias, and its probable manifestation in our sample (or rather, in what is missing from our sample), means that our findings are skewed toward detecting changes in CES that result from EE programming. We are not highly concerned about this issue for two reasons. First, the "file drawer problem" affects all review papers that summarize published studies. Second, even if this were a concerning or unique source of

bias, it does not affect the primary message of our findings, which is not *how often* EE leads to changes in CES, but simply that it *can* lead to changes.

Perhaps the most problematic limitation is with a fundamental tenet of our claims that EE describes changes in how nature benefits people. A primary issue with the changes observed is that they are a result of a program. We do not know if it was the program or the ecosystem in which the program took place, or more likely their combination, that led to those changes. Examining the outcomes of EE programs to determine whether the outcomes depended primarily on the ecosystem in which the program took place, versus on the program itself—the type of teaching, the fellow students, the content taught—was beyond the scope of the articles we reviewed.

FUTURE RESEARCH

This study opens a door to a range of enticing research topics. We envision at least five areas of future study (see Table 2). These topics include connections to environmental behavior; effects of engagement with CES on the success of EE; whether the field of CES suggests new potential outcomes of EE; relationships between characteristics of EE programs and particular changes in CES; measuring "slippery outcomes"; and of course, a central question arising from this paper: how do we study CES when they change?

One question involves connections between EE, CES, and pro-environmental behavior. EE aims to create more informed, active citizens, and in many cases one goal of this increase in awareness and engagement is to affect environmental behavior (UNESCO 1977). Many EE programs do succeed in changing some aspects of behavior (Stern et al. 2014), and the mechanisms underlying that change are the focus of a vibrant field of study (Heimlich and Ardoin 2008). At the same time, it seems logical that CES might be connected to behavior; when a place is important to our spiritual fulfillment or identity, for instance, we may be inclined to protect it (e.g., Jorgensen and Stedman 2001). That relationship between CES and behavior, however, is understudied. Our immersion in the two literatures led us to wonder: Are changes in (perceptions of) CES a *mechanism* through which EE leads to behavior change? Might CES be a lens or framework to add to the toolbox of studying influences on environmental behavior?

A closely related question expands beyond the behavioral goals of EE to include its goals related to engagement, attitudes, and values (UNESCO 1977). We suggest that CES could provide one framing for questions about what helps EE to achieve those goals. One way to ask these questions could be: Do outcomes of EE programs that focus on CES (and related constructs) differ from programs with other foci? If so, how? One component of exploring this question could be to consider which CES-related outcomes are not, based on our findings, currently much of a focus in EE, but could potentially be added. In other words, are there CES that are "missing" from EE outcomes? Although there exists no one standard typology of CES, there is a set of roughly 10 CES that occur in 3 or more typologies. These include, in order of decreasing commonality of inclusion: Spirituality, Recreation, Aesthetic, Artistic, Cultural heritage, Education, Social capital/relations, Sense of place, Existence Value, Knowledge systems, Cultural diversity, and Identity (Gould and Lincoln 2017). The articles we investigated for this paper addressed many of these common CES, but not spirituality, cultural heritage, existence value, knowledge systems, and cultural diversity. This finding may offer suggestions to EE; perhaps programs should focus more on, and assess outcomes related to, these alternative constructs. The idea of highlighting diverse knowledge systems is particularly interesting, as most EE programs we analyzed did not focus on recognizing the importance of diverse views of and perspectives on nature. Two notable exceptions were Ballantyne and Packer (2009) and Jagger (2014).

Our work examined if EE papers reported changes in CES and how those changes were measured. We did not, however, examine aspects of EE programs that lead to particular changes in CES, and questions remain about specific characteristics of EE programs that may be associated with specific changes in CES. Results from work addressing these questions could help to guide EE programming, particularly for programs that seek to promote conservation ethics increase by increasing access to CES. Such research could also attempt to distinguish between changes in CES that result from interaction with ecosystems, those that result solely from educational content or approach, and those that result from both the ecosystem and education programming together. Understanding the

Table 2 Future research questions. This list is not exhaustive, and each question we present has numerous sub-questions

General areas for future exploration
Are changes in (perceptions of) CES related to behavior?
Do outcomes of EE programs that focus on CES differ from those that do not focus on CES? If so, how?
Which characteristics of EE programs lead to which changes in CES?
How can EE and CES research work together to develop new ways to measure slippery concepts?
How can ES scholars measure CES, given that they are dynamic?

relationships between CES, ecosystems, and learning may be an important frontier of CES research.

Many CES scholars emphasize the importance of characterizing and incorporating a meaningful array of CES—of expanding beyond the more easily measured, and thus more commonly measured, recreational, and aesthetic benefits. This expansion has important implications for issues of equity and inclusion, due to close ties between often highlighted forms of outdoor recreation (e.g., hiking) and a particular relationship with nature (i.e., a relationship that is stereotypically associated with more urban, White, middle-class, and male populations) (Sténs et al. 2016). Although researchers in the CES field have identified many creative methods of characterizing varied forms of human–nature relationships (Chan et al. 2012a, b), EE research may offer further methods. The focus of EE extends well beyond recreation; target outcomes can include (in addition the CES-related outcomes identified above) mindfulness, critical thinking, hope, curiosity, and wonder (Ardoin et al. 2015). These "slippery" outcomes can be "challenging to characterize" and "difficult to directly observe" (Ardoin et al. 2015, p. 43). The EE field offers additional suggestions of how to proceed in capturing these other more difficult to grasp benefits.

Perhaps the most striking question arising from this work is also the most obvious. The ES field, as mentioned above, deals integrally with changes in values and benefits that result from ecosystem change. How can this field incorporate CES when they can change independent from ecosystem change? This is far from an insurmountable task, and we hope the methods and concepts herein provide a starting point.

CONCLUSIONS

The concept of CES is well known for presenting challenges to analysis and implementation (Satz et al. 2013). This paper's results further complicate that analysis and implementation. We recognize the additional challenges presented, but addressing them may be unavoidable.

The dynamism of the CES associated with a given ecosystem, in a given state, may be crucial, and it is largely absent in the literature. Within the current context, wherein the ES framework increasingly shapes discourse related to both management and policy, it is important that representations of ES are as accurate and thorough as possible. If a meaningful aspect of the framework is lacking, we need to figure out how to include it. Incorporating dynamism is a task not unique to CES. Many (if not most or all) scholarly fields are tasked with addressing dynamic phenomena. As one example, scholars of collaborative land management must consider the dynamic nature of relationships and trust between stakeholder groups (Wondolleck and Yaffee 2000). To treat these relationships as static would risk incomplete findings about collaboration, so too with CES; to treat them as static risks incomplete analysis of their roles and functions. An important step forward for the ES community may be to look to other fields for strategies to incorporate dynamic phenomena in diverse, creative ways.

Although the ES community now most frequently conceptualizes change as "changes in ecosystems change CES," we suggest an alternate and complementary framing, one consistent with work in EE: that "changes in social or cognitive phenomena can change CES." This idea of CES as a moving target certainly does not simplify environmental management. Yet understanding the reality of this important component of the ES framework may be crucial to developing policies that are holistic, forward-looking, and feasible.

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