Andrachuk, M., and D. Armitage. 2015. Understanding social-ecological change and transformation through community perceptions of system identity. *Ecology and Society* 20(4):26. http://dx.doi.org/10.5751/ES-07759-200426

Research

Understanding social-ecological change and transformation through community perceptions of system identity

Mark Andrachuk [1,2] *and Derek Armitage* [1,2]

ABSTRACT. We developed an empirical approach to consider social-ecological system change and transformation by drawing on resource users' knowledge and perceptions. We applied this approach in the Cau Hai lagoon, a coastal area dominated by small-scale fisheries in central Vietnam. Nine focus groups with more than 70 fishers were used to gather information about key social-ecological system elements and interactions, historical social-ecological dynamics, and possible thresholds between distinct social-ecological system identities. The patterns of change in livelihoods and resource exploitation in the Cau Hai lagoon are similar to those seen in other coastal lagoon and small-scale fishery contexts. Our findings show some promise for the use of local knowledge and the perceptions of resource user communities to understand and characterize social-ecological transformations. Importantly, however, we also demonstrate how social-ecological transformations are complicated processes driven by many factors beyond the control of any singular individual or group. We argue that (1) the occurrence of social-ecological transformations can result in either positive or negative outcomes and (2) that we need to direct our thinking away from drawing tidy conclusions about if and when social-ecological transformations take place. Our research also encourages scholars to carefully consider how we frame the benefits of participatory, community-based governance initiatives. Importantly, we need to examine the ways that governance initiatives will be beneficial for some people and detrimental for others, and we need to be fully aware of locally contested interests and acknowledge competing priorities for fisheries management and human well-being. Community-oriented assessments informed by resilience thinking can help to open up questions about economic, political, cultural, and environmental aspects of undesirable path dependencies and traps.

Key Words: *aquaculture; environmental change; governance; local knowledge systems; perceptions; resilience; small scale fisheries; social-ecological transformations*

INTRODUCTION

The concept of transformations provides an enticing language for interdisciplinary environmental change and resource management scholars (e.g., Gelcich et al. 2010, O'Brien 2012). However, we need to be careful about the labels we place on the types of changes taking place in social-ecological systems (SESs; see Blaikie 1989). In resilience literature, transformations have been defined as processes that involve fundamental reorganization of SES structures, properties, and controls (Biggs et al. 2010, Chapin et al. 2010). We explore some questions that are often overlooked in transformations literature: How can we empirically know if a transformation has occurred? What types of empirical evidence are used to support conclusions about the occurrence of transformations? How are efforts to know when a transformation has occurred influenced by who is making the determination? These subjective dimensions of transformations research bring attention to the ways that people perceive SESs (e.g., system boundaries, feedback) and how these perceptions influence what we think of as real or potential transformations.

In this paper, we outline an approach for conceptualizing and perceiving transformations that works around some of the challenges of measuring resilience and transformations. Our approach draws on fishers' perceptions of system identity to consider long-term SES change (Cumming et al. 2005, Robinson and Berkes 2010). We apply this approach in the Cau Hai lagoon in central Vietnam to reflect on the ways that local fishery-based livelihoods both contribute to and are impacted by a social-ecological transformation.

Making sense of social-ecological transformations

Researchers are bringing diverse foci, scales, and meanings to transformations research. O'Brien and Synga (2013) describe several recent strands of literature broadly concerned with SES transformations or socio-technical transitions, which they refer to as transformational adaptation, transformations to sustainability, transforming behaviors, and social transformations. These strands of literature are at times complementary and at times contradictory. Consistent among uses of transformations is the suggestion that an object or process of interest converts from one form or function to another. Transformations have alternatively been positioned as a deliberate, anticipatory response to environmental change (e.g., Nelson et al. 2007, Kates et al. 2012), a process of shifting toward sustainability (e.g., Geels 2002, Frantzeskaki et al. 2012), a concept to potentially help confront power imbalances and sources of vulnerability (e.g., Pelling 2011, O'Brien 2012), or as an SES phenomena associated with the loss of resilience (e.g., Folke et al. 2010, Walker et al. 2010).

Strunz (2012) has argued that conceptual vagueness can be an asset for enabling interdisciplinary communication and allowing for creativity in problem solving. Despite conceptual and empirical ambiguity in the literature, we can see the overlap and interplay among uses of transformations. The trade-off is that inconsistent conceptualizations can lead to confusion and communication breakdowns, false inferences about real-world problems, and subsequently, challenges for application in management (Brand and Jax 2007, Strunz 2012). We provide here the conceptual and normative foundations for the way we explore

[1]University of Waterloo, [2]Environmental Change and Governance Group

social-ecological transformations in this paper (cf., Strunz 2012, Nielsen and D'haen 2014). Our intent is to provide a descriptive definition that clarifies our interpretation of the meaning and essence of social-ecological transformations, rather than offering a specific, universal definition (see Jax 2007).

Our perspective has a basis in resilience thinking, which emphasizes the ability of systems to accommodate ongoing change (Walker et al. 2004). A key to understanding transformations from this perspective is recognizing tensions between persistence and renewal, and recognizing that resilience can sometimes be an undesirable quality of an SES when it leads to traps or perpetuates undesirable social problems (e.g. Scheffer and Westley 2007, Cinner 2011, Folke et al. 2010, Steneck et al. 2011). Some scholars have looked at the persistence of a system in terms of path dependence, which refers to the local patterns of interaction that perpetuate current SES conditions and the ways that previous actions constrain future options (Folke 2006, Heinmiller 2009, Gelcich et al. 2010, Boonstra and Nhung 2011). In this line of thinking, processes that contribute to resilience and adaptive capacity can be the same as those that contribute to path dependence and traps. Correspondingly, elements that maintain current pathways, such as attitudes, worldviews, economic incentives, power relations, and institutions, can also be barriers to transformation. The forces that confront and challenge current conditions and the status quo contribute to transformations.

We understand SESs as interdependent and coevolutionary, in which social and ecological domains are linked by ecological knowledge, governance arrangements, and ecosystem services (Berkes et al. 2003, Glaser 2006, Kotchen and Young 2007, Cinner et al. 2009). In ecological domains transformations may manifest as new assemblages of species, different landscape/seascape patterns, or new ecosystem services (Carpenter and Folke 2006). In socioeconomic domains, transformations may involve new governance arrangements, new institutions, altered norms and values, or different livelihood practices (Olsson et al. 2006, Gelcich et al. 2010, Rosen and Olsson 2013). In adopting an SES perspective for our research, however, we sought to understand the interplay of change across both social and ecological systems, rather than within the separate subsystems. Correspondingly, transformations involve more than the physical, measurable aspects of SES: They include changes in mental models, perceptions, and understanding of SESs.

Social-ecological change will mean different things to different people because they place values on certain ecological or livelihood elements, carry cultural and emotional ties to places and activities, or express other interests related to livelihoods and well-being (Larson 2007, Bischof 2010, Bennett and Dearden 2014, Loring et al. 2014). The desirability of different SES identities is thus normative and subjective, and that influences our characterization of social-ecological transformations in terms of system identity. Determinations about the occurrence of transformations often depend on where one "sits in the system" (Waltner-Toews et al. 2003) and whether SES changes challenge or aid their own interests. We contend that these normative dimensions must be more explicitly taken into account in transformations research because opinions about what people consider as important ultimately guide decisions and actions to respond to change (Cronon 1992, O'Brien and Wolf 2010, Amundsen 2012, Armitage et al. 2012). Thus, the framework we present in this paper draws on local resource users' perceptions about their livelihoods within the context of SESs and their role in environmental changes.

The potential for alternative SES configurations hints at system identity as a way of comprehending transformations (Cumming et al. 2005). A social-ecological transformation can be considered as a fundamental shift in system characteristics that results in a qualitatively different system identity (Cumming et al. 2005). The example provided by Gelcich et al. (2010) for this type of transformation involved a coastal marine ecosystem in Chile that was overfished and facing other drivers of degradation. Destabilization of the political regime opened the opportunity for new governance arrangements based on local tenure rights for fisher collectives that promoted new fishing policies and practices. Thus, the identity shifted to small-scale artisanal fisheries and a governance network of cooperative fisher collectives, yet the authors do caution that the new system is still taking shape as adjustments are made (Gelcich et al. 2010).

Transformative reorganization has been viewed as intentional on the part of groups with the power and authority to instigate change (Olsson et al. 2008, Biggs et al. 2010, Chapin et al. 2012), and as a phenomenon that can emerge unexpectedly as a result of anthropogenic and natural forces (Batterbury et al. 1997, Scheffer et al. 2001). Regardless of whether transformations are intentional or emergent, we need rigorous research frameworks to assess what constitutes transformational change. We suggest that a broad understanding of what is transforming, as well as of cross-scale interactions, sources of novelty, and agency of various actors, is an important entry point for engaging with debates about political and normative aspects of SES change and deliberative transformations. Ultimately, we seek to develop an approach that helps provide insights into the governance implications of social-ecological transformations once an empirical understanding of their occurrence has been developed.

A FRAMEWORK TO ASSESS TRANSFORMATIONS THROUGH SYSTEM IDENTITY

If transformations research is to yield useful and novel contributions to our understanding of social-ecological change, scholars need to consider whether it is relevant and accurate to label empirical cases as transformative. We address this need by placing a greater emphasis on the relevance of social-ecological changes for livelihoods and situating the research within inherent normative and value-laden contexts, rather than expecting objective and apolitical information (Armitage 2008, Brown and Westaway 2011, Béné et al. 2012).

Resilience literature contains a robust collection of methods for assessing resilience and transformations (e.g., Resilience Alliance 2010), yet there are well-known pragmatic issues with empirical research (Walker et al. 2004, Carpenter et al. 2005). Models are often data intensive and require observations of variables at multiple levels over long time periods, quantifying variables that provide system continuity (slow variables) and those that drive change, and then parsing out feedbacks and noise with limited degrees of certainty. These problems are amplified in data-poor cases, such as developing countries where long-term monitoring has not been established (Béné et al. 2011). Furthermore, studies that only draw on ecosystem data are not geared toward capturing

normative dimensions of resource management challenges. Beyond these limitations, there has also been discussion among resilience scholars about the value of measuring individual components of a SES when we are most interested in using resilience thinking as a mindset and an approach for understanding the resilience of a system as a whole (for example, see Quinlan 2014 [http://rs.resalliance.org/2014/06/16/should-we-measure-resilience/] and Gordon et al. 2014 [http://wle.cgiar.org/blogs/2014/05/02/lose-sight-resilience-thinking-pursuit-resilience-metrics]).

We draw inspiration from a framework by Cumming et al. (2005) that uses four categories to define features of a SES identity: elements, such as objects, species, and people that make up a system; relationships, meaning the interactions between and processes that link components; sources of continuity, which we interpret as factors that maintain resilience and system identity and that may be slow to change; and sources of innovation, which are endogenous or exogenous factors that introduce novelty to the SES and may contribute to or erode resilience. These categories are captured within our approach, although we prioritize the value of local resource users' experiences and knowledge for understanding SES identity to assess whether a system has crossed key thresholds.

We appreciate the conceptual basis of approaches that attempt to track potential thresholds for individual system elements (e.g., governance arrangements, landscape patterns) as a basis for ultimately determining if the system identity has transformed (e.g., Huong 2010, Robinson and Berkes 2010, Blythe 2014). However, there remain significant challenges and limitations in attempting to determine which are the controlling, slow-changing variables that determine resilience. We argue that transformations research must also include studies that take a broad view of how the introduction of novel elements or processes alters interactions and performance across the system as a whole. Accordingly, we explore the utility of using a broad SES lens for defining the object of study and a holistic consideration of SES characteristics and processes.

Recent convergence of resilience with socio-technical transitions literature has helped inform the ways that we understand how historical phases unfold (e.g., van der Brugge and van Raak 2007, Fischer-Kowalski and Rotmans 2009, Foxon et al. 2009, Smith and Stirling 2010). We do not directly address the commonalities and differences in these literatures, although we hope that our framework and empirical work can contribute to ongoing advancements in thinking. Whereas socio-technical transitions literature offers useful ways of looking at mechanisms and pathways of change, the emphasis from resilience thinking on social-ecological linkages and the use of thresholds as a concept was particularly important for the development of our framework.

In resilience literature a threshold refers to a hypothetical point in space-time that separates alternative basins of attraction or dependent pathways (Scheffer and Carpenter 2003, Briske et al. 2010). There are indications that as SESs approach thresholds, environmental variations become amplified and instability can be observed at multiple levels (Carpenter and Brock 2006, Dakos et al. 2008, Scheffer 2009). Crossing a threshold can occur through a single event (sharp and abrupt) or manifest through a series of small, incremental changes (slow and gradual). Recent studies have demonstrated the utility of investigating socially defined thresholds through the desirability of alternative system configurations or identities (e.g., Béné et al. 2011, Biggs et al. 2011, Parlee et al. 2012). The concept of "thresholds of potential concern" has been applied as a means of exploring the relationship between real biophysical thresholds, social construction, and preferences (Biggs et al. 2011). Christensen and Krogman (2012) suggested that thresholds can be conceived as fuzzy boundaries that separate desirable and unacceptable conditions. Similarly, O'Brien and Wolf (2010) have argued that the ways that people respond to social-ecological changes depend on what those changes mean for them and whether or not the changes affect their well-being. Similarly, our interest lies less on the precise location of thresholds and more on the implications of thresholds for ecosystems and livelihoods. To identify possible thresholds between unique SES identities, we use resource-user knowledge and perceptions as qualitative surrogates (Bennett et al. 2005, Carpenter et al. 2005) of current and historical SES elements, interactions, and sources of continuity and novelty.

The ways that we understand and empirically assess social-ecological transformations are summarized through four points of interest (Table 1). Our assessment flows from defining the object of study, identifying key SES elements and interactions, analyzing historical SES dynamics, and reflecting on the possibility of thresholds and an SES transformation. There is some progression in moving from one point of interest to the next, although the assessment need not be rigidly sequential. The inclusion of a historical analysis is inspired by the resilience assessment workbook (Resilience Alliance 2010) and is common in livelihoods research, e.g., timelines used in participatory rural appraisal tools.

If a transformation has occurred, it should be possible to describe and characterize whether the transformation was emergent or if there was intention (with specified goals), the potential for reversal, predictability, and the pace of changes. The approach we present here could be tailored to provide a starting point to further investigate barriers to change (Burch 2010), possible leverage points (Westley et al. 2011), or consequences for well-being (Armitage et al. 2012, Coulthard 2012). Assessments of transformation based on resource users' knowledge and perceptions can help to surface information about desirability of alternative system identities for local people and how different actors have played a role in fostering change.

METHODS

The case study presented here is based on field research conducted primarily with small-scale fishers and aquaculture farmers. The intent of the field-based methods was to gather in-depth knowledge about SES changes as they relate to local livelihood activities and ecosystem conditions (de Vaus 2006, Yin 2006). Our approach requires recognition of the importance of epistemological pluralism and acknowledgement that there can be multiple interpretations of system identity and thresholds (Miller et al. 2008, Nielsen and D'haen 2014). Our aim was to build up a rich and holistic understanding of this particular case, rather than make generalizations about social-ecological transformations (Flyvberg 2006, Maxwell 2012). The case study approach was paired with an emphasis on community-based research that is sensitive to local interests and cross-cultural issues, and is oriented toward embracing local knowledge and the

Table 1. Analytical points of interest for conceptualizing and perceiving social-ecological transformations.

Points of Interest	Analytical Attention
Object of study	Define the scope and boundaries for the system or object of interest. What is the system that is undergoing transformation? Any consideration of transformations requires delineation of the system's spatial, environmental, and social dimensions. Involves transparency about why things are treated as part of the system or as externalities. Whether or not a transformation is perceived is closely connected to the scale of analysis.
Key SES elements and interactions	Identify key elements and interactions among them. Selection of SES elements that are relevant for system identity focuses on system attributes in which researchers and/or local actors are most interested. The process of selecting key elements is guided by earlier selection of scope and scales for analysis. Elements can include human actors, ecosystems/habitats, and abiotic variables. The interactions between elements can include natural cycles (e.g., nutrient, hydrological), food webs, economic incentives, or governance arrangements. The focus of analysis relates to the question: How do changes in key elements lead to changes in other elements and the SES as a whole?
Historical SES dynamics	Analysis of historical events and patterns of interaction help to tease out long-term processes that influence SES resilience and transformation. Sources of continuity can be analyzed as slow variables that control and perpetuate the system, and can also be considered in terms of path dependence or lock-in traps. Novelty within the system can arise bottom-up or top-down and, depending on scope, may be viewed as endogenous or exogenous drivers of change.
Thresholds for system identity	Critical reflection on earlier points of interest help to assess the possibility that thresholds have been crossed or may be approaching for the object of study (rather than for individual elements). Of interest is the social context of thresholds in terms of how people anticipated or responded, and the implications of a new system identity for well-being.

SES indicates social-ecological system.

expertise of local resource users (Gibbs 2001, Tuyen et al. 2002, Pearce et al. 2009). Collaboration with researchers at the Hue University of Agriculture and Forestry (HUAF) was integral for vetting and refining specific field-based tools and facilitating the research.

A strong foundation of research has established the value of local and traditional knowledge, especially from resource users, as a source of detailed information about ecosystem processes and changes over long time frames, as well as an expression of local values (e.g., Blaikie et al. 1997, Berkes et al. 2000, Krupnik and Jolly 2002). A caution when relying on local knowledge is that resource users' experiences and observations are often most useful for confirming system interactions that relate directly to their livelihoods, rather than objective information about underlying SES processes (Gilchrist et al. 2005, Ruddle and Davis 2011). A second limitation of this approach is that gradual changes may not be perceived in any meaningful way by local stakeholders, yet drivers of change on different levels could be pushing an SES toward thresholds (Norberg and Cumming 2008, Boonstra and Nhung 2011). Elevated levels of phosphorous, for instance, cause eutrophication, but phosphorous is generally not detectible without instrumental measurements.

We drew on the personal experiences and specialized knowledge of local resource users and other stakeholders in the Cau Hai lagoon to understand the implications of SES change in relation to their livelihoods and well-being. We used a form of thematic narrative analysis (Bryman et al. 2009) to elicit information from resource users' reflections on, and interpretations of, their experiences and their perceptions of changes ongoing in the lagoon, rather than expecting them to directly uncover specific "truths" about key characteristics of the system (i.e., elements, relationships, continuity, and novelty) or changes in SES identity. Our approach is dependent on openness to multiple types and sources of data to triangulate our analysis.

Study location

The Tam Giang lagoon complex consists of four interconnected lagoons. We resolved to focus on one of these areas to allow for clear delineation of system boundaries. The southernmost area, the Cau Hai lagoon (Fig. 1), was selected because of a combination of physical characteristics as a distinct open water area. The brackish-water Cau Hai lagoon receives saltwater from a single opening (Tu Hien opening) to the South China Sea and fresh surface water runoff from numerous rivers originating in the hill regions that surround the lagoon on the inland side. Political boundaries also roughly follow these physical features. The open-water area of the Cau Hai lagoon is approximately 9800 hectares and is bordered by seven communes and one town. Fishing communities around the lagoon have been identified as having high rates of poverty, even in comparison to national averages for rural areas (Tuyen et al. 2010). For analytical purposes we defined physical boundaries a priori as the water environment and adjacent communities. These classifications were not unconditionally accepted, but research participants generally accepted the Cau Hai lagoon as the focus of the research.

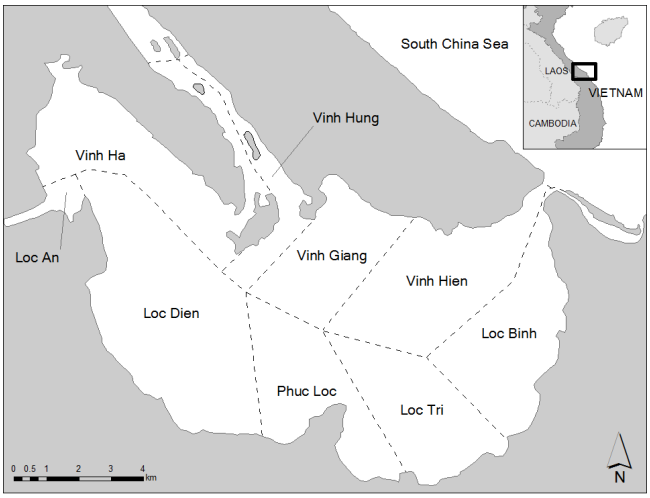
Earlier studies related to transformations have identified significant social and ecological changes across the Tam Giang lagoon (e.g., Huong 2010, Armitage et al. 2011, Boonstra and Nhung 2011). The details of interplay between environmental change, economic change, livelihoods, and governance will be discussed later in this paper. The Cau Hai lagoon brings together an interesting context for transformations research because of several decades of SES changes and the recent introduction of new property rights and comanagement arrangements. A total of 16 fishing associations (FAs) have been established in the Cau Hai lagoon, as summarized in Table 2. Each FA contains members from each of the major group of resource users in the lagoon: mobile-gear fishers, who are typically the poorest households and

Table 2. Summary of fishing associations in the Cau Hai lagoon. Main research activities involved Giang Xuan Fishing Association (FA), Loc Binh 1 FA, and Phu Loc FA.

Name of Commune/Town	Name of Fishing Association	Lagoon Area (ha)	Year Fishing Association Established	Number of Fishing Households	Number of FA Member Households	Year of Rights Allocation
Vinh Giang	Giang Xuan	997	2008	216	125	2009
Vinh Hung	Trung Hưng	370	2012	205	139	2012
Loc Binh	Loc Binh 1	987	2003	107	100	2010
Loc Binh	Loc Binh 2	367	?	220	98	2010
Vinh Hien	Dam Pha Vinh Hien	924	2008	200	100	2011
Vinh Hien	Nuoi ca long Vinh Hien	224	2010	90	70	2011
Vinh Hien	NTTS Vinh Hien	230	2008	200	148	2011
Vinh Ha	Ha Trung 5	32	2007	90	62	?
Vinh Ha	Ha Giang	37	2012	115	70	?
Phu Loc town	Phu Loc	1130	2009	190	182	2010
Loc Dien	Luong Chanh	441	2008	99	75	2011
Loc Dien	Mieu Nha	651	2008	120	97	2011
Loc Dien	Thach Son	714	2008	110	102	2011
Loc Dien	Trung Luong	566	2007	210	175	2011
Loc Tri	Dong Hai	530	2009	150	130	2010
Loc Tri	Le Thai Thien	557	2009	164	120	2010
Loc An	(no fishing association)	200	n/a	30	n/a	n/a

use simple fishing gear, e.g., bottom-traps called *lu* nets; fixed-gear fishers, who own gear that is attached to the bottom of the lagoon, e.g., fish corrals; and aquaculture farmers, with aquaculture taking the form of ponds or fish cages. The lagoon has now been zoned to facilitate the establishment of a territorial user rights for fishers (TURF) system and comanagement between FAs and local government.

Fig. 1. Communes and towns around the Cau Hai lagoon, central Vietnam. Dotted lines indicate the territories within the lagoon typically occupied by each commune/town.



Field methods

The research took place over a five-month period in 2012-2013 and a verification field season in 2014, and investigated the perspectives of fishers in three FAs around the Cau Hai lagoon (Giang Xuan FA, Loc Binh 1 FA, and Phu Loc FA). Selection of the FAs was based on geographic variety (e.g., proximity to the sea opening influences salinity and composition of species), differing levels of progress toward TURF rights allocations, and history of relationships with HUAF researchers (see Table 2). Fieldwork included a set of 9 focus groups with fishers that formed the main data set described in this paper, together with 15 semistructured interviews with key informants, e.g., FA leaders, researchers, and government agents. Three focus groups took place in each community (8-10 participants in each focus group) and were designed to promote discussion among participants to generate new insights and facilitate open deliberation of differing views (Crang and Cook 2007, Seal et al. 1998). The three subgroups of fishers (mobile gear, fixed gear, and aquaculture) were targeted separately to prioritize the opportunity for marginalized groups, particularly the mobile-gear fishers, to express their views. Focus groups took place in the homes of FA leaders or in community buildings.

The focus groups worked through a series of exercises to elicit information about key SES elements, interactions among elements, sources of stability, local and external disturbances that threaten key elements, and significant historical events and trends. These tools were inspired by community dashboards developed by Béné et al. (2011) and participatory diagnostic approaches used by Robinson and Berkes (2010), although we note that other approaches such as scenarios could also have been used to address desirability of system identities. By combining the expertise of Canadian and Vietnamese researchers, the focus group activities were tailored to be suitable for local culture and appropriate for the interests of the research participants, i.e., based on local knowledge. Table 3 summarizes these activities and highlights their connections to the system identity framework described above (see Table 1).

Table 3. Steps and activities in the focus groups.

Activities	Relevance for system identity
Generate list of important livelihood and environmental elements in the lagoon. Create influence diagram by drawing and explaining connections between system elements.	Provide a basis for understanding key SES elements and their relevance from the perspective of participants.
Remove elements one at a time from influence diagrams and discuss consequences for other elements and their livelihoods. Card sort elements into three piles: most important, somewhat important, least important.	Further examine the importance of elements relative to the broader system. Removal of certain elements reveals some sources of stability and drivers of change. Encourage participants to think about which elements are most important for the lagoon ecosystem and for their well-being.
Participants create a timeline of important historical events, and then indicate changes to system elements over this time.	Pull out historical information about system elements to understand trajectories of change over time with respect to participants' interests. Further information about longer term and broader scale influences on SES resilience and novelty. Provides insights into changes in SES identity over time, and the possibility of distinct phases and thresholds for system identity.

SES indicates social-ecological system.

RESULTS AND ANALYSIS

Object of transformation

We defined the scope of the SES as the lagoon and surrounding land, and administratively as the commune, district, and provincial government agencies that correspond to the Cau Hai lagoon. Focus group participants then determined what elements were included with respect to fishing and aquaculture in the lagoon. Larger-level processes such as climate and economic forces were viewed as part of a nested system. Our framing of the object of transformation was somewhat different from local resource users' point of view, and this was problematic in some ways. For example, fishers tended to focus on very specific areas within the lagoon where they conduct their livelihood activities, and they seldom brought attention to the interconnections with larger-level processes. Nonetheless, we adopted a set of boundaries that best suited our object of transformation and a synthetic perspective of feedback from the diversity of research participants.

Key SES elements and interactions

Part of our methods entailed detailed discussion with fishers about important system elements and the interactions among them. As shown in Table 4, the types of SES elements identified by participants were extensive (grouped categorically in the table for ease of presentation), although the ways that participants in each focus group placed emphasis on different elements were highly variable. We anticipated differences in perceptions between different gear users but expected that we would see more consistency among fishers who use the same gear across all communities, e.g., similarities among mobile-gear fishers in Vinh Giang, Phu Loc, and Loc Binh. Instead, a key insight generated from these results is that even within this relatively small area there is significant diversity in the ways that people interact with the lagoon, which in turn frames their perceptions of how this system functions. We learned to appreciate how people experience and perceive change, and the scope and extent of change, in the lagoon in diverse ways. There were similarities and differences in the ways that focus group participants explained the relevance of SES elements, as well as the interconnections between elements.

We asked whether any of the system elements, if removed or changed, would shift dynamics across the entire SES. Rather than a single element (e.g., a key species or social relationship), virtually all focus groups talked about "water conditions" (Table 4) as a way of indicating the combination of factors that influence habitat and availability of the species they typically catch. The interrelationships between rainfall, wind, currents, and water temperatures create an uneven gradient of salinity over time, which in turn impacts different groups in unique ways. For instance, Loc Binh mobile fishers explained that a type of goby fish is currently their most profitable target species and that these fish require salinity between 15% and 25% and temperatures between 20 and 32 degrees Celsius. When seawater intrusion pushes water conditions outside of these ranges, the goby migrate further inland and away from Loc Binh's fishing zone. Comparably, Loc Binh fixed-gear fishers described how heavy rainfall in the nearby mountains can cause flooding in the lagoon, especially as the rainy season commences in October and November. If flooding lasts for three to five days it can be beneficial for bringing more nutrients and potentially push mass movements of fish toward their corrals because they are adjacent to the sea mouth. However, they also noted that floods lasting longer than five days cause them stress because salinity levels drop too low and desirable species are washed out of the lagoon. The focus groups, thus, were effective for uncovering and explaining how users of different gear types in the same location had different perceptions about the feedbacks and importance of different system elements.

Research participants consistently brought attention to specific factors that impact the ways that they practice their livelihoods. For fixed-gear fishers, who chiefly rely on fish corrals, which are stationary V-shaped net structures that according to current regulations span 150 by 350 meters, discussions generally were around their ability to access economically valuable species of fish and shrimp. In Loc Binh, fixed-gear fishers pointed to the size and position of their fish corrals as playing the strongest role, whereas in Vinh Giang they felt that salinity levels and incursion of fishers from other communities using illegal electrical gear had the most significant impact on their livelihoods. In contrast, mobile fishers in Vinh Giang placed greater importance on the density of both fixed and mobile fishing activities in the lagoon, expressed as the number of households involved in these activities. They explained that open waterways, which are the spaces around fish corrals where they are allowed to fish and which they use for navigation, were a key factor in their ability to fish.

Table 4. Key social-ecological system (SES) elements identified in focus groups. All elements identified during focus groups are listed; elements identified as most important are indicated with an x.

	Vinh Giang			Loc Binh			Phu Loc		
Categories System Elements	Aqua-culture	Fixed gear	Mobile gear	Aqua-culture	Fixed gear	Mobile gear	Aqua-culture	Fixed gear	Mobile gear
Environment and Climate									
Water conditions	x	x	x	x	x	x	x	x	
Water temperature				x		x	x	x	
Salinity							x		
Rainfall		x		x				x	
Storms									
Floods									
Protected no-take areas									
Wind									
Fishery products									
Shrimp		x			x	x		x	x
Crab									x
Fish (freshwater and brackish species)		x			x	x		x	x
Seagrass									x
Seaweed									
Aquaculture									
Size of aquaculture ponds	x						x		
Shrimp fry/fingerlings	x						x		
Crab fry/fingerlings	x								
Fish fry/fingerlings	x			x					
Feed for aquaculture (natural and industrial)	x			x					
Fishing									
Boats									
Gear (all types)									x
Fish corrals (fixed gear)					x			x	
Chuom (fish aggregating device; fixed gear)								x	
Lu nets (mobile gear)			x			x			
Seine nets (illegal mobile gear)									
Electric fishing (illegal mobile gear)			x						
Open waterways			x						
Number of nets			x						
Community									
Support from community (e.g., labor)									
Support from local government									
Fishing Association					x	x			
Local knowledge (sharing of)									
Number of fishing households									
Fishers from outside (illegal)									
Market									
Market demand and prices		x							
Capacity									
Financial capital	x	x		x			x		
Skills and experience	x	x							

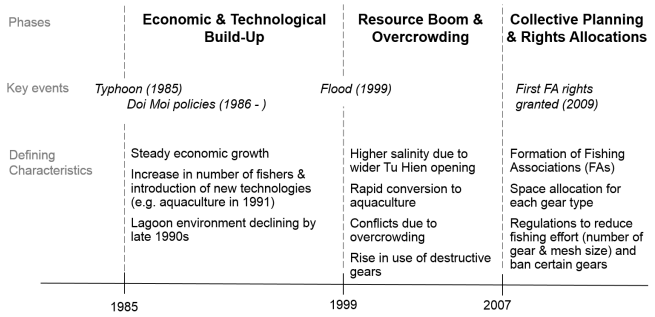
When we inquired about the influence of the FAs and government, participants often framed their responses as though these institutions exist on paper, but are not active in reality. This was particularly evident in Phu Loc because the local FA currently does not receive much support from the town government or have the capacity to enforce bylaws. In contrast, Loc Binh has a strong and functioning FA that is involved with microfinancing for members and supports management activities such as establishment of a habitat protection area. The reality for fishers in the Cau Hai lagoon is that the new TURF arrangements and FAs have uneven impacts across the communities; thus, they were often excluded as key elements that influence their livelihoods or SES interactions.

The main intent of this part of our analysis was to highlight how change can trickle across the SES and potentially contribute to a transformation (Table 1). Although there were limitations in obtaining an objective set of key elements, the findings did illustrate an understanding of the system from fishers' perspectives and provide a basis for our historical analysis. It is clear that biophysical processes such as storms are perceived by fishers to have been greater change agents than recent governance initiatives.

Historical analysis: interplay between continuity and novelty

The next step in our analysis of changes in SES identity was to consider historical sources of continuity and novelty through participant-defined timelines that were collected during focus groups. There is a strong need to understand the ways that past system conditions have shaped the trajectory of development within SESs, especially with respect to the interplay of social versus ecological drivers of change (Heinmiller 2009, Gelcich et al. 2010, Nayak 2014). We examined discussions to uncover how fishers described key historical events and changes related to their livelihoods, and to help us understand fishers' perceptions of how SES identity has changed over time. Three distinct phases of social-ecological change are apparent in the lagoon (summarized in Fig. 2): economic and technological buildup (1985-1999), resource boom and overcrowding (2000-2007), and collective planning and rights allocations (2007-present). Interpretation of these phases was verified through follow-up workshops with fishers in June 2014. We are careful to point out that these phases do not necessarily represent distinct system identities.

Fig. 2. Phases of social-ecological change in the Cau Hai lagoon.



Economic and technological build-up phase

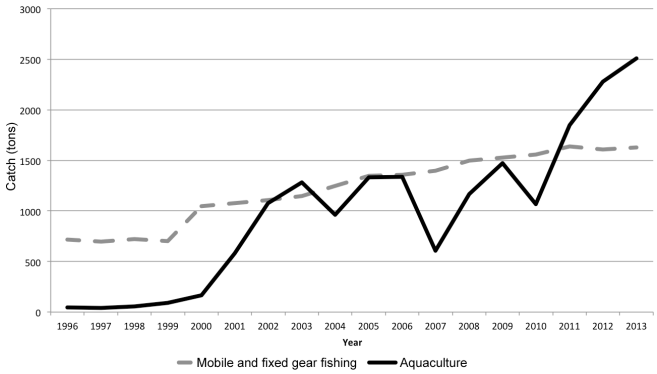
The economic and technological build-up phase (1985-1999) was characterized by expansion and intensification of fishery-related activities. At this time the lagoon was mostly freshwater because the Tu Hien opening to the South China Sea was narrow. A major influence during this phase was the initiation of *Doi Moi* economic reforms by the national government beginning in 1986 that oriented the country toward an open market economy. Livelihoods for fishers were improving as more opportunities became available for income generation through fishing activities, which in turn enabled acquisition of more gear and livelihood assets. Aquaculture first appeared but was slow to gain in popularity (1) because of the financing required for start-up and (2) because early adopters were not seeing high profit margins because the freshwater environment was not conducive to production of shrimp and market prices for shrimp were still relatively low. From the perspective of focus group participants, typhoon No. 8 (Cecil), which struck in October 1985, was significant because of the physical damage and loss of lives in the lagoon; DaCosta and Turner (2007) describe government responses, including settlement of Sampan dwellers into villages. Prior to this storm event fish corrals were built from bamboo but as households rebuilt their corrals they began to make use of more durable and effective gill nets (confirmed also by Mien 2006). These more effective corrals gained in popularity, and fishers subsequently made corrals that covered more lagoon space. The array of new activities in the lagoon meant that by the late 1990s ecological conditions had begun to deteriorate.

A flood in 1999 due to heavy rainfall throughout Thua Thien-Hue province had a major role in the system identity of the lagoon. Flooding is not uncommon, but this event was exceptional because it widened the Tu Hien opening, which is a sand formation, and increased exchange of water between the lagoon and the sea. This led to generally higher salinity in the lagoon but also higher variability in temperature and salinity due to faster currents. These new conditions supported a different assemblage of species, notably an increase in saltwater-tolerant species that often have higher market values. Most focus groups noted that the first few years after the flood had ideal conditions for both aquaculture and fishing.

Resource boom and overcrowding phase

We refer to the period following the flood as the resource boom and overcrowding phase (2000-2007), which was characterized by intensification of resource use, overcrowding, and increased marginalization of the poorest fishers. The increased brackish conditions in combination with higher market prices for shrimp led to substantial profit margins for shrimp aquaculture. Conversion to aquaculture expanded rapidly within the lagoon by enclosing fish corrals (net enclosures) and on land adjacent to the lagoon (upland and lowland ponds), which was enabled by new policies that allowed farmers to convert rice paddies into aquaculture ponds (Nayak et al. 2015). Important policy drivers on national, provincial, and district levels that contributed to economic development have been discussed by Tuyen et al. (2010) and Armitage et al. (2011). Aquaculture production increased dramatically (Fig. 3) until a peak in 2004 as diseases began appearing. Without adequate training or regulatory oversight, diseased ponds were being drained into the lagoon, impacting wild species and leading to conflicts with mobile and fixed-gear fishers.

Fig. 3. Fisheries and aquaculture production in the Cau Hai lagoon, 1996-2013. Data provided by Department of Agriculture and Rural Development, Phu Loc District.



Overcrowding within the lagoon was problematic ecologically and socially. The density of aquaculture and corral nets in the lagoon stagnated water flow to the extent that it led to a host of water quality issues and eutrophication (Marconi et al. 2010). Also within this period cage-line nets, 15-meter-long nets that are placed along the bottom of the lagoon and are known locally as *lu*, were introduced and used to some extent by all groups of fishers, and are now the primary gear type used by mobile-gear fishers. The Phu Loc District government estimates that 100,000 *lu* were in use in the Cau Hai lagoon (data provided by Department of Agriculture and Rural Development, Phu Loc District). With very small mesh size, these nets are extremely efficient and have substantial ecological impacts via removal of bottom-feeding species. As Tuyen et al. (2010) and Huong and Berkes (2011) have explained, traditional property rights regimes based on common pool resources were failing in this period because they couldn't account for new livelihood practices and the ways that aquaculture and fixed-gear fishing were in effect privatizing space. The loss of open space was particularly problematic for mobile fishers, who are in the poorest households and often are former sampan dwellers, and who faced navigation challenges, dwindling fishing yields, and space use conflicts with fixed-gear fishers (see also DaCosta and Turner 2007).

Collective-planning phase

The most recent phase in the lagoon, collective planning (2006-present), is distinguished by renewed efforts to establish FAs and comanagement through collective property rights and responsibilities to improve livelihoods and well-being. Government officials and university researchers worked together to devise a model of comanagement that would be suitable for local fishers. The processes of forming FAs, capacity building, and development of FA fisheries management plans have been described in detail in several recent papers (Tuyen et al. 2010, Armitage et al. 2011, Boonstra and Nhung 2011, Marschke et al. 2012, Ho et al. 2015). Throughout focus group discussions and key informant interviews there was a consistent message that although virtually all FAs in the Cau Hai lagoon have received rights allocations, most are still not performing their management functions. The details of these recent challenges are interesting and important. However, because this paper is about ways of understanding change and transformation, we will focus on how these management processes relate to SES identity.

In spite of limitations among the FAs, the new comanagement arrangements have enabled several initiatives: teaching aquaculture operators the benefits of switching from intensive shrimp monoculture to multispecies polyculture, establishment of three no-take habitat protection areas, and relocation of fish corrals to allow for designated space for fixed and mobile fishing. Ongoing efforts are also aimed toward regulating the number of *lu* nets per household, developing regulations for aquaculture, and planning for more tourism in the lagoon as a livelihood alternative. We note also that the interactions between physical changes and fisher perceptions is by no means linear or one-directional. As a result of education programs from HUAF researchers aimed at teaching fishers about the importance of conservation strategies and reducing overfishing, focus groups in Vinh Giang demonstrated new appreciation of their own impacts on the lagoon and changing how they conduct their livelihoods.

Thresholds between system identities in a social context

As explained above, our interest is not to define a precise tipping point to signify when a critical threshold was, or could be, crossed. Rather, we are interested in the possibility for, and relevance of, a shift from one distinct SES identity to another. What are the livelihood and governance implications of shifting from one identity to another in the Cau Hai lagoon?

Through our historical analysis it was evident that SES elements shifted substantially between the build-up and resource boom phases. All nine focus groups provided evidence of changes in ecological conditions (e.g., different flora and fauna present in the lagoon), economic conditions (e.g., changes in value of species and availability of different species), and social conditions (e.g., new tensions and conflicts due to space constraints and dwindling fish stocks), as well as new feedbacks between elements. For instance, market prices and saline water conditions were positive feedbacks for the expansion of aquaculture. The confluence of all of these changes led us to understand the flood in 1999 as a time when a threshold for SES identity was crossed. The flood coalesced a new configuration of system elements and set in motion new feedbacks. We emphasize that the flood was not the cause of the transformation; its role as part of a fuzzy transition was attributable to the previous series of social-ecological changes.

Several key system elements were not present in the earlier build-up phase, such as *lu* nets, which were introduced later. Other elements and relationships became much more prominent during the resource boom phase, including fish corrals and reliance on shrimp aquaculture. A notable element that disappeared was the traditional property rights regime, which was already strained but effectively collapsed as fixed-gear fishing and aquaculture farming made common property customs obsolete. We summarize relevant differences between the SES phases in Table 5 with respect to implications for fishers' livelihoods and well-being.

Focus group participants offered a clear indication that their livelihoods are completely different today compared with their experiences during the build-up phase and earlier. This narrative was also supported during interviews with key experts in

Table 5. Differences between social-ecological system (SES) identities with respect to fishers' livelihoods and well-being. The collective planning phase shows some potential for a third system identity, but territorial user rights for fishers (TURFs) and comanagement have yet to fully stabilize SES interactions.

Economic and Technological Buildup (1985-1999)	Resource Boom and Overcrowding (2000-2007)	Collective Planning and Rights Allocations (2007-present)
Low salinity water environment; mostly freshwater species	Brackish water environment; mix of freshwater and marine species; stronger currents and higher salinity and temperature variability	Brackish water environment; mix of freshwater and marine species; stronger currents and higher salinity and temperature variability
Open access property right	De facto privatization; fixed gear and aquaculture have seized use of lagoon space	Collective property rights; fishers share access rights based on TURFs; limited ability for FAs to enforce regulations without direct government interventions
Wide variety of gear types in use; households mostly follow traditional family practices	Fish corrals and *lu* nets are dominant gear in use	Fish corrals and *lu* nets are dominant gear in use; regulations placed on size and number of nets
Few aquaculture pilot sites	Aquaculture enclosures in open water and as mud wall enclosures on shore	Aquaculture only as mud wall enclosures on shore
Limited flushing of lagoon via small sea mouth; slow deterioration of water quality due to household waste effluents	Wide sea mouth opening but rapid deterioration of water quality due to (1) stagnation caused by corral and aquaculture nets and (2) effluents from household waste aquaculture; occasional algal blooms	Wide sea mouth and improved water flow has led to improved water quality; effluents from household waste still problematic
Households with enough resources purchase equipment for fish corrals	Households with enough resources purchase equipment for fish corrals and/or aquaculture; aquaculture profitability very high	Households feel financial pressure from limitations on gear; aquaculture seen as a greater financial risk because of potential for disease

FA indicates fishing association.

government and HUAF who reiterated that more has changed in the Cau Hai lagoon than has stayed the same over the last three decades. Expressed through perceptions of local resource users, the social-ecological transformation in the Cau Hai lagoon can be characterized as a shift from (1) a system identity based on a primarily freshwater environment, low fishing intensity, and open access property rights to (2) a system identity based on a brackish water environment, high intensity of fishing and aquaculture activities, and a mix of private and collective property rights.

At the onset of this research we expected to see evidence of TURFs and comanagement in the Cau Hai lagoon as a catalyst for transformation (see Armitage et al. 2011) and having a stronger role in the current system identity, i.e., a second transformation as a shift from the resource boom to the collective-planning phase. In some ways we do see changes across the SES and there is little question that the Cau Hai lagoon was under severe stress and was likely heading toward an ecological collapse or crisis before recent interventions. The TURFs and comanagement have helped to clarify property rights and reduce conflicts, but they have not alleviated persistent poverty traps or significantly reduced the intensity of fishing and aquaculture in the lagoon. Fishers indicated that they still feel trapped because they have to continue trying to maximize fishing yields to make ends meet for their families, in spite of acknowledgement that current practices in the lagoon are still not ecologically sustainable. Furthermore, considering continuing poverty and lack of capacity for developing alternative livelihoods, many focus group participants and key informants did not view the current system identity as more desirable than it was before TURFs and comanagement. As such, there wasn't sufficient evidence to suggest from changes in fishers' perceptions that a second transformation had occurred, although the possibility remains open that the lagoon SES is still undergoing a transition.

DISCUSSION

Grounding our research in the perceptions of local resource users was critical for both characterizing social-ecological change and understanding the normative relevance of different SES identities. Our research emphasized the relevance of drawing on local resource users' perspectives on changes in system identity and reaffirmed that the ways that fishers perceive social and ecological changes depend on how they are personally affected (consistent with O'Brien and Wolf 2010, Parlee et al. 2012). Our approach enabled useful discussion with resource users that at times revealed opposing viewpoints, but also qualitatively demonstrated the relevance of drawing on fishers' perceptions of system identity to characterize transformation processes. Rather than isolating and measuring specific controlling variables in the lagoon SES, we were interested in how fishers describe the extent and types of SES changes that may be involved in a switch to a new SES identity. We aim to show that social-ecological transformations cannot be assumed to have either positive or negative outcomes. They are complicated processes driven by many factors beyond the control of any single individual or group and impact individuals and groups in diverse ways.

Identification of key system elements and perceptions of how historical events have shaped these elements reflects values and interpretations of what people feel is important. We underscore that governance interventions aimed at alleviating persistent problems such as property rights conflicts and poverty (especially those espoused as transformative) need to be sensitive to these community values. During fieldwork and analysis, we observed several ways that the framing of SES change in literature was different from local resource users' perceptions. For example, the ways researchers (vis-à-vis resilience and transformations literature) think about SES thresholds is quite different from the ways that resource users talk about thresholds. Focus group

participants discussed thresholds in terms of policies or events that would alter the ways that they are able to pursue their households' needs, such as restrictions on the number of nets per household or the size of mesh allowed for certain gears. Many mobile-gear fishers said that plans to require them to use larger mesh size *lu* would force them to seek income from alternative sources because it is prohibitively expensive to buy new nets. These are important insights that help to understand the implications of governance interventions in the Cau Hai lagoon, but they are quite different from the ways that we set out to think about thresholds between system identities. Thus, in addition to considerations of real versus social construction of thresholds, we point to the relevance of considering practical differences between researchers' and resource users' ideas about relevant thresholds (c.f., Biggs et al. 2011).

Our research helps reconsider the relevance of how we, as scholars, frame the benefits of governance initiatives that alter social relationships or resource use systems. We acknowledge the subjectivity in our own conclusions about changes in system identity (see also Cumming et al. 2005, Blythe 2014), and we argue that there are important questions about what counts as a real transformation and how perceptions relate to objective interpretations of SES change. The introduction of FAs, allocation of rights under the TURF system, and establishment of comanagement have not, at least yet, led to another new and distinct system identity. The ways that fishers talked about the FAs and TURFs indicated that these elements play only a minor role in the ways that they carry out their livelihoods and that these new arrangements simply introduced new rules for them to follow. Analytical interpretations of this case can be taken in multiple ways: (1) a transformation occurred between the build-up and resource boom phases, and a second transformation may now to be under way as a result of governance changes in the collective-planning phase; and (2) a transformation occurred between the build-up and resource boom phases, and the current collective-planning phase is characteristic of localized experiments and realignment of SES interactions that can take many years to stabilize. Objective conclusions about ongoing transformations, however, cannot be separated from the diversity of subjective views of, and interactions with, social and ecological processes.

Assessments of governance transformations (e.g., new collaborative or participatory processes) need to be aligned with evidence of material changes in human well-being and ecological sustainability. Importantly, we need to examine the ways that governance initiatives will be beneficial for some people and detrimental for others (Nayak et al. 2015). Discussions with fishers suggest that TURFs and comanagement will only be viewed as transformational if they lead to new outcomes for their livelihoods and ecosystem conditions, not merely changes to management processes. We suggest that when scholars advocate for transformative change, they need to be aware of locally contested interests and acknowledge competing priorities for fisheries management and human well-being. As such, scholars must have greater recognition of the political framings of their research and take steps to acknowledge their positions. Because we are dealing with complex and contested SESs, we need to take some care not to overstate cases that are potentially transformative versus those that are definitively transformative. In the Cau Hai lagoon, it is apparent that positive progress has been made with recent governance initiatives, but it is unclear if there will be long-term institutional support and buy-in from fishers and evidence to suggest that SES identity has been altered.

Normative aspects of the potential ongoing transformation require additional attention. How might different groups of fishers benefit or face new risks related to social-ecological changes? For whom might governance changes be beneficial? Now that we understand some of the competing interests and perspectives in the lagoon, we have a basis to further investigate these questions. As we have shown, although some actors claim that mobile fishers have gained status and a greater ability to fish with the new TURF arrangements, the mobile fishers themselves feel that the TURFs are still not well suited for the ways that they fish. In other ways, fixed-gear fishers have been casualties as well. During relocation of fish corrals in some communities, some households have been forced to either share nets with other households, thus reducing catch and income, or have been forced to abandon their corrals. As comanagement partners work to tighten regulations on overfishing, with the broad vision of fishery sustainability, these groups of fishers will face further stresses. Until these issues are addressed and alternative livelihoods gain support, it is unlikely that the current pathway of development will stabilize.

Through engagement with subjective perceptions of change and their implications for livelihoods, our research offers a useful entry point for understanding the potential for, and consequences of, deliberative transformations in the Cau Hai lagoon. Although we are able to recognize competing priorities for fisheries management and well-being, our conclusions do not fully address the role of power, politics, interests, and worldviews in driving potential and real transformations. These are important dimensions that need to be addressed through further work in the Cau Hai lagoon and in the literature more broadly. There is also opportunity to deepen transformation analyses by considering the extent that resource users' perceptions can shape their experiences, and hence, SES interactions and feedbacks. We present our framework as a pragmatic means of analysing messy social and political aspects of emergent and deliberative transformations.

CONCLUSION

How can we empirically know if a social-ecological transformation has occurred? We framed our analysis around the notion of SES identity and drew on fishers' perspectives of social and ecological changes to tease out shifts in SES identity over time. Our findings show some promise for the use of local knowledge and the perceptions of resource user communities to understand feedbacks between environmental change, livelihoods, and governance, and to characterize social-ecological transformations. In doing so, we place greater emphasis on implications for fishers' livelihoods and well-being, rather than seeking positivistic determinations about transformations. It is difficult to draw tidy conclusions about if and when a transformation is taking place, and any claims about transformations should consider the empirical foundations upon which such judgments are made.

We have found that adoption of social-ecological transformations terminology can be most useful when considering normative aspects of SES change. Individual fishers, even within the

relatively small group we worked with, demonstrate substantial diversity in the ways that they have experienced and interpreted social-ecological changes. This diversity leads us to redirect our thinking away from whether social-ecological transformations are wholly good or bad. Instead, we need to consider the beneficial and harmful ways that transformations impact various actors. In the Cau Hai lagoon case, the establishment of the TURF system and comanagement has ameliorated some issues surrounding property rights, but persistent problems of overfishing, pollution from nonfishing activities, poverty, and empowerment have yet to be resolved. By engaging with resilience thinking and building a community-oriented assessment of how the transformation has impacted people who are part of the SES, we were able to open up questions about economic, political, cultural, and environmental aspects of undesirable path dependencies and traps.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7759

Acknowledgments:

This work was made possible through funding from the International Development Research Centre (Ottawa, Canada) and the Social Sciences and Humanities Research Council of Canada. We gratefully acknowledge the fieldwork support and contributions of Dung Ha and Le Van Nam from the Hue University of Agriculture and Forestry. We also appreciate the constructive comments from two anonymous reviewers and the subject editor, as well as feedback from Scott Slocombe, Thomas Dyck, Samantha Berdej, and Steven Alexander during preparation of earlier drafts. The map for Figure 1 was prepared by Aaron Thompson. Any errors or omissions are the responsibility of the authors.

LITERATURE CITED

Amundsen, H. 2012. Illusions of resilience? An analysis of community responses to change in northern Norway. *Ecology and Society* 17(4):46. http://dx.doi.org/10.5751/ES-05142-170446

Armitage D. 2008. Governance and the commons in a multi-level world. *International Journal of the Commons* 2(1):7-32.

Armitage D., M. Marschke, and T. V. Tuyen. 2011. Early-stage transformation of coastal marine governance in Vietnam? *Marine Policy* 35(5):703-711.

Armitage, D., C. Béné, A. T. Charles, D. Johnson, and E. H. Allison. 2012. The interplay of well-being and resilience in applying a social-ecological perspective. *Ecology and Society* 17 (4):15. http://dx.doi.org/10.5751/ES-04940-170415

Batterbury, S., T. Forsyth, and K. Thomson. 1997. Environmental transformations in developing countries: hybrid research and democratic policy. *Geographical Journal* 163(2):126-132.

Béné, C., L. Evans, D. Mills, S. Ovie, A. Raji, A. Tafida, A. Kodio, F. Sinaba, P. Morand, J. Lemoalle, and N. Andrew. 2011. Testing resilience thinking in a poverty context: experience from the Niger River basin. *Global Environmental Change* 21:1173-1184. http://dx.doi.org/10.1016/j.gloenvcha.2011.07.002

Béné, C., R. G. Wood, A. Newsham, and M. Davies. 2012. *Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes*. IDS Working Paper 405. Institute of Development Studies, Brighton, UK. http://dx.doi.org/10.1111/j.2040-0209.2012.00405.x

Bennett E. M., G. S. Cumming, and G. D. Peterson. 2005. A systems model approach to determining resilience surrogates for case studies. *Ecosystems* 8:945-957. http://dx.doi.org/10.1007/s10021-005-0141-3

Bennett, N. J., and P. Dearden. 2014. Why local people do not support conservation: community perceptions of marine protected area livelihood impacts, governance and management in Thailand. *Marine Policy* 44:107-116. http://dx.doi.org/10.1016/j.marpol.2013.08.017

Berkes, F., J. Colding and C. Folke, editors. 2003. *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press, New York, New York, USA. http://dx.doi.org/10.1017/cbo9780511541957

Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10(5):1251-1262. http://dx.doi.org/10.1890/1051-0761(2000)010[1251:roteka]2.0.co;2

Biggs, H., S. Ferreira, S. Freitag-Ronaldson, and R. Grant-Biggs. 2011. Taking stock after a decade: does the 'thresholds of potential concern' concept need a social-ecological revamp? *Koedoe* 53(2):1-9.

Biggs, R., F. R. Westley, and S. R. Carpenter. 2010. Navigating the back loop: fostering social innovation and transformation in ecosystem management. *Ecology and Society* 15(2):9. [online] URL: http://www.ecologyandsociety.org/vol15/iss2/art9/

Bischof, B. G. 2010. Negotiating uncertainty: framing attitudes, prioritizing issues, and finding consensus in the coral reef environment management "crisis." *Ocean& Coastal Management* 53:597-614. http://dx.doi.org/10.1016/j.ocecoaman.2010.06.020

Blaikie, P., K. Brown, M. Stocking, L. Tang, P. Dixon, and P. Sillitoe. 1997. Knowledge in action: local knowledge as a development resource and barriers to its incorporation in natural resource research and development. *Agricultural Systems* 55 (2):217-237.

Blaikie, P. 1989. Explanation and policy in land degradation and rehabilitation for developing countries. *Land Degradation & Rehabilitation* 1:23-37. http://dx.doi.org/10.1002/ldr.3400010104

Blythe, J. L. 2014. Resilience and social thresholds in small-scale fishing communities. *Sustainability Science* http://dx.doi.org/10.1007/s11625-014-0253-9

Boonstra, W. J., and P. T. H. Nhung. 2011. The ghosts of fisheries management. *Journal of Natural Resources Policy Research* 4:1-25. http://dx.doi.org/10.1080/19390459.2012.642634

Brand, F. S., and K. Jax. 2007. Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and Society* 12(1):23. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art23

Briske, D. D., R. A. Washington-Allen, C. R. Johnson, J. A. Lockwood, D. R. Lockwood, T. K. Stringham, and H. H. Shugart. 2010. Catastrophic thresholds: a synthesis of concepts, perspectives, and applications. *Ecology and Society* 15(3):37. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art37/

Brown, K., and E. Westaway. 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual Review of Environment and Resources* 36:321-342. http://dx.doi.org/10.1146/annurev-environ-052610-092905

Bryman, A., J. J. Teevan, and E. Bell. 2009. *Social research methods*. Second Canadian Edition. Oxford University Press, Toronto, Canada.

Burch, S. 2010. Transforming barriers into enablers of action on climate change: insights from three municipal studies in British Columbia, Canada. *Global Environmental Change* 20:287-297. http://dx.doi.org/10.1016/j.gloenvcha.2009.11.009

Carpenter, S. R., and W. A. Brock. 2006. Rising variance: a leading indicator of ecological transition. *Ecology Letters* 9:308-315.

Carpenter, S., and C. Folke. 2006. Ecology for transformation. *Trends in Ecology & Evolution* 21(6):309-315. http://dx.doi.org/10.1016/j.tree.2006.02.007

Carpenter, S. R., F. Westley, and M. G. Turner. 2005. Surrogates for resilience of social-ecological systems. *Ecosystems* 8:941-944. http://dx.doi.org/10.1007/s10021-005-0170-y

Chapin, F. S., III, S. R. Carpenter, G. P. Kofinas, C. Folke, N. Abel, W. C. Clark, P. Olsson, D. M. Stafford Smith, B. Walker, O. R. Young, et al. 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology & Evolution* 25(4):241-249. http://dx.doi.org/10.1016/j.tree.2009.10.008

Chapin, F. S., III, A. F. Mark, R. A. Mitchell, and K. J. M. Dickinson. 2012. Design principles for social-ecological transformation toward sustainability: lessons from New Zealand sense of place. *Ecosphere* 3(5):article 40. http://dx.doi.org/10.1890/es12-00009.1

Christensen, L., and N. Krogman. 2012. Social thresholds and their translation into social-ecological management practices. *Ecology and Society* 17(1):5. http://dx.doi.org/10.5751/ES-04499-170105

Cinner, J. E. 2011. Social-ecological traps in reef fisheries. *Global Environmental Change* 21:835-839. http://dx.doi.org/10.1016/j.gloenvcha.2011.04.012

Cinner, J. E., T. R. McClanahan, T. M. Daw, N. A. J. Graham, J. Maina, S. K. Wilson, and T. P. Hughes. 2009. Linking social and ecological systems to sustain coral reef fisheries. *Current Biology* 19(3):206-212. http://dx.doi.org/10.1016/j.cub.2008.11.055

Coulthard, S. 2012. What does the debate around social wellbeing have to offer sustainable fisheries? *Current Opinion in Environmental Sustainability* 4(3):358-363.

Cronon, W. 1992. A place for stories: nature, history, and narrative. *Journal of American History* 78(4):1347-1376.

Crang, M., and I. Cook. 2007. *Doing ethnographies*. Sage, London, UK.

Cumming, G. S., G. Barnes, S. Perz, M. Schmink, K. E. Sieving, J. Southworth, M. Binford, R. D. Holt, C. Stickler, and T. Van Holt. 2005. An exploratory framework for the empirical measurement of resilience. *Ecosystems* 8:975-987. http://dx.doi.org/10.1007/s10021-005-0129-z

DaCosta, E., and S. Turner. 2007. Negotiating changing livelihoods: the sampan dwellers of Tam Giang Lagoon, Viêt Nam. *Geoforum* 38:190-206. http://dx.doi.org/10.1016/j.geoforum.2006.08.003

Dakos, V., M. Scheffer, E. H. van Nes, V. Brovkin, V. Petoukhov, and H. Held. 2008. Slowing down as an early warning signal for abrupt climate change. *Proceedings of the National Academy of Sciences of the United States of America* 105(38):14308-14312. http://dx.doi.org/10.1073/pnas.0802430105

de Vaus, D. 2006. Case study design. Pages 5-20 *in* D. de Vaus, editor. *Research design*. Volume IV. Sage, Thousand Oaks, California, USA.

Fischer-Kowalski, M., and J. Rotmans. 2009. Conceptualizing, observing, and influencing social-ecological transitions. *Ecology and Society* 14(2):3. [online] URL:http://www.ecologyandsociety.org/vol14/iss2/art3/

Flyvbjerg, B. 2006. Five misunderstandings about case-study research. *Qualitative Inquiry* 12(2):219-245.

Folke, C. 2006. Resilience: the emergence of a perspective for social-ecological systems analyses. *Global Environmental Change* 16:253-267. http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002

Folke, C., S. R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* 15(4):20. [online] URL: http://www.ecologyandsociety.org/vol15/iss4/art20/

Foxon, T. J., M. S. Reed, and L. C. Stringer. 2009. Governing long-term social-ecological change: what can the resilience and transitions approaches learn from each other? *Environmental Policy and Governance* 19(1):3-20. http://dx.doi.org/10.1002/eet.496

Frantzeskaki, N., D. Loorbach, and J. Meadowcroft. 2012. Governing societal transitions to sustainability. *International Journal of Sustainable Development* 15(1/2):19-36. http://dx.doi.org/10.1504/ijsd.2012.044032

Geels, F. W. 2002. Technological transitions as evolutionary reconfiguration processes: a multilevel perspective and case study. *Research Policy* 31:1257-1274. http://dx.doi.org/10.1016/S0048-7333(02)00062-8

Gelcich, S., T. P. Hughes, P. Olsson, C. Folke, O. Defeo, M. Fernández, S. Foale, L. H. Gunderson, C. Rodriguez-Sickert, M. Scheffer, R. S. Steneck, and J. C. Castilla. 2010. Navigating transformations in governance of Chilean marine coastal resources. *Proceedings of the National Academy of Sciences of the United States of America* 107(39):16794-16799. http://dx.doi.org/10.1073/pnas.1012021107

Gibbs, M. 2001. Towards a strategy for undertaking cross-cultural collaborative research. *Society & Natural Resources* 14:673-687. http://dx.doi.org/10.1080/08941920120547

Gilchrist, G., M. Mallory, and F. Merkel. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. *Ecology and Society* 10(1):20. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art20/

Glaser, M. 2006. The social dimension in ecosystem management: strengths and weaknesses of human-nature mind maps. *Research in Human Ecology* 13(2):122-142.

Heinmiller, B. T. 2009. Path dependency and collective action in common pool governance. *International Journal of the Commons* 3(1):131-147.

Ho, N. T. T., H. Ross, and J. Coutts. 2015. Power sharing in fisheries co-management in Tam Giang Lagoon, Vietnam. *Marine Policy* 53:171-179. http://dx.doi.org/10.1016/j.marpol.2014.12.006

Huong, T. T. T. 2010. Livelihood transformations and resilience. Pages 145-182 *in Resource access and livelihood resilience in Tam Giang Lagoon, Vietnam*. Dissertation. University of Manitoba, Manitoba, Canada.

Huong, T., and F. Berkes. 2011. Diversity of resource use and property rights in Tam Giang Lagoon, Vietnam. *International Journal of the Commons* 5(1):130-149. http://doi.org/10.18352/ijc.236

Jax, K. 2008. Concepts, not terms. *Frontiers in Ecology and the Environment* 6(4):178. http://dx.doi.org/10.1890/1540-9295(2008)6[178b:cnt]2.0.co;2

Kates, R. W., W. R. Travis, and T. J. Wilbanks. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences of the United States of America* 109 (19):7156-7161. http://dx.doi.org/10.1073/pnas.1115521109

Kotchen, M. J., and O. R. Young. 2007. Meeting the challenges of the anthropocene: towards a science of coupled human-biophysical systems. *Global Environmental Change* 17:149-151. http://dx.doi.org/10.1016/j.gloenvcha.2007.01.001

Krupnik, I., and D. Jolly, editors. 2002. The Earth is faster now: indigenous observations of Arctic environmental change. Arctic Research Consortium of the United States, Fairbanks, Alaska, USA.

Larson, B. M. H. 2007. Who's invading what? Systems thinking about invasive species. *Canadian Journal of Plant Science* 87 (5):993-999. http://dx.doi.org/10.4141/cjps07116

Loring, P. A., H. L. Harrison, and S. C. Gerlach. 2014. Local perceptions of the sustainability of Alaska's highly contested Cook Inlet salmon fisheries. *Society & Natural Resources* 27 (2):185-199. http://dx.doi.org/10.1080/08941920.2013.819955

Marconi, M., M. Sarti, and F. Marincioni. 2010. Sustainability assessment of traditional fisheries in Cau Hai lagoon (South China Sea). *Marine Environmental Research* 70:253-263. http://dx.doi.org/10.1016/j.marenvres.2010.04.009

Marschke, M., D. Armitage, L. V. An, T. V. Tuyen, and H. Mallee. 2012. Do collective property rights make sense? Insights from central Vietnam. *International Journal of the Commons* 6(1):1-27.

Maxwell, J. A. 2012. *A realist approach for qualitative research*. Sage, Washington D.C., USA.

Mien, L. V. 2006. *Fishers activities in the Lagoon of the Thua Thien Hue Province*. Integrated Management of Lagoon Activities (IMOLA) Project, Hue, Vietnam.

Miller, T. R., T. D. Baird, C. M. Littlefield, G. Kofinas, F. Chapin, III, and C. L. Redman. 2008. Epistemological pluralism: reorganizing interdisciplinary research. *Ecology and Society* 13 (2):46. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art46/

Nayak, P. K. 2014. The Chilika Lagoon social-ecological system: an historical analysis. *Ecology and Society* 19(1):1. http://dx.doi.org/10.5751/ES-05978-190101

Nayak, P. K., D. Armitage, and M. Andrachuk. 2015. Power and politics of social-ecological regime shifts in the Chilika lagoon, India and Tam Giang lagoon, Vietnam. *Regional Environmental Change* 1-15. http://dx.doi.org/10.1007/s10113-015-0775-4

Nelson, D. R., W. N. Adger, and K. Brown. 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual Review of Environment and Resources* 32:395-419. http://dx.doi.org/10.1146/annurev.energy.32.051807.090348

Nielsen, J. Ø., and S. A. L. D'haen. 2014. Asking about climate change: reflections on methodology in qualitative climate change research published in Global Environmental Change since 2000. *Global Environmental Change* 24:402-409. http://dx.doi.org/10.1016/j.gloenvcha.2013.10.006

Norberg, J., and G. S. Cumming, editors. 2008. *Complexity theory for a sustainable future*. Columbia University Press, New York, New York, USA.

O'Brien, K. 2012. Global environmental change II: from adaptation to deliberate transformation. *Progress in Human Geography* 36(5):667-676. http://dx.doi.org/10.1177/0309132511425767

O'Brien, K., and L. Synga. 2013. Responding to climate change: the three spheres of transformation. *In Proceedings of Transformation in a Changing Climate, 19-21 June 2013, Oslo, Norway*. University of Oslo, Oslo, Norway.

O'Brien, K. L., and J. Wolf. 2010. A values-based approach to vulnerability and adaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change* 1:232-242.

Olsson, P., C. Folke, and T. P. Hughes. 2008. Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. *Proceedings of the National Academy of Sciences of the United States of America* 105(28):9489-9494. http://dx.doi.org/10.1073/pnas.0706905105

Olsson, P., L. H. Gunderson, S. R. Carpenter, P. Ryan, L. Lebel, C. Folke, and C. S. Holling. 2006. Shooting the rapids: navigating transitions to adaptive governance of social-ecological systems. *Ecology and Society* 11(1):18. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art18/

Parlee, B. L., K. Geertsema, and A. Willier. 2012. Social-ecological thresholds in a changing boreal landscape: insights from Cree knowledge of Lesser Slave Lake region of Alberta, Canada. *Ecology and Society* 17(2):20. http://dx.doi.org/10.5751/ES-04410-170220

Pearce, T. D., J. D. Ford, G. L. Laidler, B. Smit, F. Duerden, M. Allarut, M. Andrachuk, S. Baryluk, A. Dialla, P. Elee, A. Goose, T. Ikummaq, E. Joamie, F. Kataoyak, E. Loring, S. Meakin, S. Nickels, K. Shappa, J. Shirley, and J. Wandel. 2009. Community research collaboration in the Canadian Arctic. *Polar Research* 28:10-27. http://dx.doi.org/10.1111/j.1751-8369.2008.00094.x

Pelling, M. 2011. *Adaptation to climate change: from resilience to transformation*. Routledge, New York, New York, USA.

Resilience Alliance. 2010. *Assessing resilience in social-ecological systems: workbook for practitioners*. Revised version 2.0. [online] URL: http://www.resalliance.org/files/ResilienceAssessmentV2_2.pdf

Robinson, L. W., and F. Berkes. 2010. Applying resilience thinking to questions of policy for pastoral systems: lessons from the Gabra of Northern Kenya. *Human Ecology* 38:335-350. http://dx.doi.org/10.1007/s10745-010-9327-1

Ruddle, K., and A. Davis. 2011. What is "ecological" local ecological knowledge? Lessons from Canada and Vietnam. *Society & Natural Resources* 24(9):887-901. http://dx.doi.org/10.1080/08941921003598796

Rosen, F., and P. Olsson. 2013. Institutional entrepreneurs, global networks, and the emergence of international institutions for ecosystem-based management: the Coral Triangle Initiative. *Marine Policy* 38:195-204. http://dx.doi.org/10.1016/j.marpol.2012.05.036

Scheffer, M. 2009. *Critical transitions in nature and society*. Princeton University Press, Princeton, New Jersey, USA.

Scheffer, M., and S. R. Carpenter. 2003. Catastrophic regime shifts in ecosystems: linking theory to observation. *Trends in Ecology & Evolution* 18(12):648-656. http://dx.doi.org/10.1016/j.tree.2003.09.002

Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. H. Walker. 2001. Catastrophic shifts in ecosystems. *Nature* 413:591-596. http://dx.doi.org/10.1038/35098000

Scheffer, M., and F. R. Westley. 2007. The evolutionary basis of rigidity: locks in cells, minds, and society. *Ecology and Society* 12 (2):36. [online] URL: http://www.ecologyandsociety.org/vol12/iss2/art36/

Seal, D. W., L. M. Bogart, and A. A. Ehrhardt. 1998. Small group dynamics: the utility of focus group discussions as a research method. *Group Dynamics: Theory, Research and Practice* 2:253-266. http://dx.doi.org/10.1037/1089-2699.2.4.253

Smith, A., and A. Stirling. 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society* 15(1):11. [online] URL: http://www.ecologyandsociety.org/vol15/iss1/art11/

Steneck, R. S., T. P. Hughes, J. E. Cinner, W. N. Adger, S. N. Arnold, F. Berkes, S. A. Boudreau, K. Brown, C. Folke, L. Gunderson, P. Olsson, M. Scheffer, E. Stephenson, B. Walker, J. Wilson, and B. Worm. 2011. Creation of a gilded trap by high economic value of the Maine lobster fishery. *Conservation Biology* 25(5):904-912. http://dx.doi.org/10.1111/j.1523-1739.2011.01717.x

Strunz, S. 2012. Is conceptual vagueness an asset? Arguments from philosophy of science applied to the concept of resilience. *Ecological Economics* 76:112-118. http://dx.doi.org/10.1016/j.ecolecon.2012.02.012

Tuyen, T. V., D. Armitage, and M. Marschke. 2010. Livelihoods and co-management in the Tam Giang lagoon, Vietnam. *Ocean & Coastal Management* 53:327-335. http://dx.doi.org/10.1016/j.ocecoaman.2010.04.001

Tuyen, T. V., and Research Team. 2002. A review of participatory research methodology. Pages 17-25 *in* V. J. Brzeski and G. F. Newkirk, editors. *Lessons in resource management from the Tam Giang Lagoon*. Coastal Resources Research Network (CoRR), Halifax, Nova Scotia, Canada.

van der Brugge, R., and R. van Raak. 2007. Facing the adaptive management challenge: insights from transition management. *Ecology and Society* 12(2):33. [online] URL: http://www.ecologyandsociety.org/vol12/iss2/art33/

Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2):5. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5/

Walker, B. H., J. Sayer, N. L. Andrew, and B. Campbell. 2010. Should enhanced resilience be an objective of natural resource management research for developing countries? *Crop Science* 50: S10-S19.

Waltner-Toews, D., J. J. Kay, C. Neudoerffer, and T. Gitau. 2003. Perspective changes everything: managing ecosystems from the inside out. *Frontiers in Ecology and the Environment* 1(1):23-30. http://dx.doi.org/10.1890/1540-9295(2003)001[0023:PCEMEF]2.0.CO;2

Westley, F., P. Olsson, C. Folke, T. Homer-Dixon, H. Vredenburg, D. Loorbach, J. Thompson, M. Nilsson, E. Lambin, J. Sendzimir, B. Banerjee, V. Galaz, and S. van der Leeuw. 2011. Tipping toward sustainability: emerging pathways of transformation. *Ambio* 40 (7): http://dx.doi.org/10.1007/s13280-011-0186-9

Yin, R. K. 2006. Case study design. Pages 83-90 *in* D. de Vaus, editor. *Research design*. Volume IV. Sage, Thousand Oaks, California, USA.