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Interactive Deep Maps and Spatial Narratives for Landscape Conservation and Public Engagement

By Francis R. Eanes, Janet M. Silbernagel, Patrick Robinson, and David A. Hart

ABSTRACT Over the last two decades, landscape conservation science and practice has increasingly embraced a 'people and nature' paradigm that recognizes the dynamic complexity and bidirectional relationships within social-ecological systems. Despite this shift in focus, and despite increasing integration among relevant disciplines, conservation research remains heavily biased towards the ecological dimensions of conservation, with socially focused research comprising a relatively small fraction. The digital revolution and accompanying geospatial web, however, have spawned an ever-increasing number of platforms and methods that collectively provide a significant opportunity for further closing this social-ecological divide in the science and practice of conservation. This paper focuses on the potential contributions to conservation science and practice from one such integrative platform — that is, interactive deep maps and their resulting spatial narratives — which digitally combine the qualitative and experiential essence(s) of *place* with the quantitative capabilities of cartesian *space*. By critically exploring emerging work in fields like interactive cartography and human cognition, we propose that interactive deep maps and spatial narratives are uniquely positioned for integrating the social and ecological dimensions of place-based conservation by spatially linking the meaning-rich, lived experiences of people with the spatially represented ecological characteristics of nature.

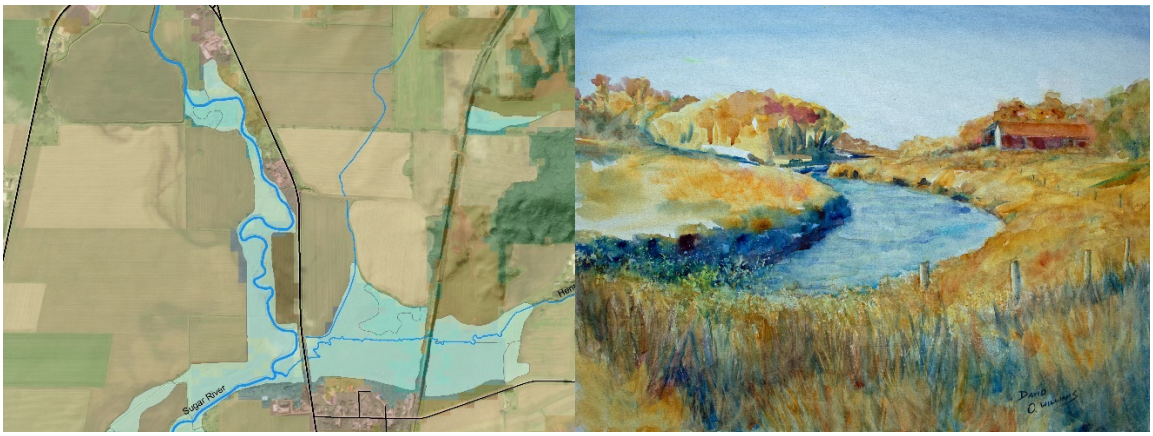
KEY WORDS Insights, interdisciplinary integration, social-ecological systems

INTRODUCTION

Over the last two decades, landscape conservation science and practice has increasingly embraced a 'people and nature' paradigm that recognizes the dynamic complexity and bidirectional relationships within social-ecological systems (Carpenter et al., 2009; Mace, 2014; Martin-Lopez & Montes, 2015). Despite this shift in focus, and despite increasing integration among relevant disciplines, landscape conservation research remains heavily biased towards the ecological dimensions of conservation, with socially focused research comprising a relatively small fraction (Velasco et al., 2015). Disciplinary differences in epistemologies, data, and methodologies continue to complicate this challenge of integration (Ostrom, 2009; DeLyser & Sui, 2014; Hertz & Schluter, 2015). Approaches to understanding the human dimensions of landscape conservation issues, for example, have traditionally relied upon qualitative and quantitative methods that appraise actors' social relations (e.g. networks, power differentials) and their linkages to biodiversity and natural resources (Bodenhamer, 2013). Conversely, conservation biologists and ecologists have long favored quantitative spatial analyses and geographic information systems (GIS) to understand species dynamics and ecosystem forms and functions across a multitude of scales (Fortin & Dale, 2005). And yet, epistemological and methodological differences notwithstanding, the digital revolution has spawned an ever-increasing number of platforms (e.g. OpenStreetMaps, ESRI Story Maps) and methods (e.g. online participatory mapping, volunteered geographic information) that collectively provide a significant opportunity for further closing this social-ecological divide in the science and practice of landscape conservation. Rapid

advancements of the geospatial web combine a host of capabilities — e.g. interactive design templates, location-based services, data visualization tools, and volunteered geographic information — with methods that prioritize participation, user empowerment, and the collaborative crowdsourcing potential of web2.0 (Sui, 2015).

This paper focuses on the potential contributions to landscape conservation science and practice from one such integrative platform — that is, interactive deep maps and their resulting spatial narratives — which digitally combine the qualitative and experiential essence(s) of *place* with the quantitative capabilities of cartesian *space* (Figure 1). Interactive deep maps spatially organize multimedia, multi-temporal perspectives of a place — e.g. photos, videos, texts, audio — into cognitively compelling and accessible spatial narratives that collectively begin to communicate the social and ecological complexities of that place. Though various urban geographers and spatial humanists have previously worked with literary deep maps and non-digital spatial narratives, the digital revolution has greatly advanced these tools' capabilities and potential applications, and broadened the sorts of users and contributors who might fruitfully build and benefit from them. As such, we propose that interactive deep maps and spatial narratives are well positioned for integrating the social and ecological dimensions of place-based, landscape conservation by spatially linking the meaning-rich, lived experiences of people with the spatially represented ecological characteristics of landscapes. Moreover we argue that, while by no means a panacea for conservation scientists and practitioners, these tools constitute an opportunity for achieving more meaningful disciplinary collaboration, and provide a powerful medium for integrating the human-nature-landscape complexities of *place* into conversations with policymakers, ecosystem managers, and the public.



a) b)

Figure 1. GIS maps, a) represent environmental features in *space* with analytical capabilities, such as a stream, forest, wetland, and farmstead. While an artistic watercolor painting, b) can represent more experiential qualities of *place*, including the stream, forest, wetland, and farmstead. Map a) created with ArcMap 10.7.1 by J. Silbernagel, shows same geographic location as painting b) along the Sugar River in southern Wisconsin. Watercolor painting b) "Around the Bend" copyright David O. Williams.

Since deep maps and spatial narratives have disciplinarily diffuse origins, their definition and potential applications are similarly amorphous and lack coherence. This paper aims to address these gaps. In so doing, we first define interactive deep maps and spatial narratives, and lay out some guiding key features. We then draw upon theories of human cognition to explain how the interactivity of deep maps and the organizational structures of spatial narratives provide uniquely effective modes for linking complex social-ecological relationships, and for communicating that complexity to various publics. We then suggest ways in which deep maps and spatial narratives can serve as boundary objects to advance lines of social-ecological inquiry within the

domains of conservation science and practice, and how they connect to and align with other emerging approaches to map people's sense of place, landscape values, and perceptions of cultural ecosystem services. We close with some thoughts and guiding questions for fruitful future research including issues of data ownership, data and map access, and the ways that power and the politics of knowledge are inflected throughout of deep map production and use.

WHAT: DEFINITIONS AND KEY FEATURES

Any reasonable attempt to define interactive deep maps and spatial narratives, whether in the context of conservation or more broadly speaking, is predicated on assumptions about the inextricably linked concepts of 'place' and 'space.' While it is well beyond the scope of this paper to provide any definitive insight into the unending space-place theorizing that divides innumerable geographers and humanists, a transparent (if incomplete) rendering of assumptions is warranted. Thus we rely on Bodenhamer's (2015: 14-15) conception of 'space' as an "abstract geometric concept," a sort of container that can be "measured and verified, thus giving it value within the scientific method." 'Place,' on the other hand, is a unique manifestation of space — a series of interconnecting flows that are at once particular (e.g. unique events and cultures) and general (e.g. we all experience *place*) (Tuan, 1977; Massey, 1994). Perhaps more concretely, 'place' is the "dense coil of memory, artifact, and experience that exists in a particular space, as well as in the coincidence and movements of people, goods, and ideas that have occurred across time in spaces large and small" (Bodenhamer, 2015: 10). To this we might add the non-human physicality of place — e.g. landscapes and all of the biotic and abiotic components of ecosystems — that affect and are affected by the human elements of place. In essence, then, places are fundamentally social-ecological systems. Multidisciplinary research connected to 'sense of place – i.e., the

multifaceted bonds that connect people to particular places – provides a rich theoretical and empirical case for the importance of place attachments, place meanings, place dependences, and place identities as they pertain to understanding human behaviors that affect landscapes and ecosystems (Stedman, 2003; Lewicka, 2011; Gifford, 2014). Understanding the complexities of place, we argue, is foundational to the work of landscape conservation.

Defining Interactive Deep Maps and Spatial Narratives

Interactive deep maps and spatial narratives are closely related yet distinct entities. The former can be thought of as the medium or platform that contain and project the various social-ecological layers of place, while the latter provide the organizational structure for helping the map user navigate the disparate components of the map in order to create a meaningful user experience. In other words, spatial narratives link specific map content in such a way as to guide the user through the multiple perspectives and artifacts contained in the map, allowing for coherent spatial experiences and arguments to emerge. We elaborate more thoroughly on these mapping and narrative concepts and their interrelationships below.

Interactive deep maps are, both in name and practice, a reaction to "thin maps," or conventional cartographic maps that are "conceived, designed, created, and maintained by experts for both general and specific audiences, often to meet specific governmental or corporate needs, and are heavily focused on the material and physical characteristics of landscape and society" (Harris, 2015: 31). Moreover, they are a cartographic adaptation of traditional deep maps — also called literary cartography — which use the literary form to blend a multitude of social and ecological elements — e.g. natural history, folklore, significant ecological and cultural events, residents' memories and stories — into a thick description of a place. At their core, interactive deep

maps draw upon the spatial structure of cartography to organize and project qualitative content not traditionally associated with 'flat' cartesian representations of space (Figure 2). The spatiality of the map, however, provides an essential opportunity to link the qualitative content with relevant quantitative ecological data, which tend to be more amenable to cartesian representation. For example, geotagged observations from multiple people in the form of audio interviews, short textual stories, memories, pictures, and videos, can be embedded into a map with base layers such as water quality, flora/fauna distributions, contamination hotspots, or any other category of ecological interest.

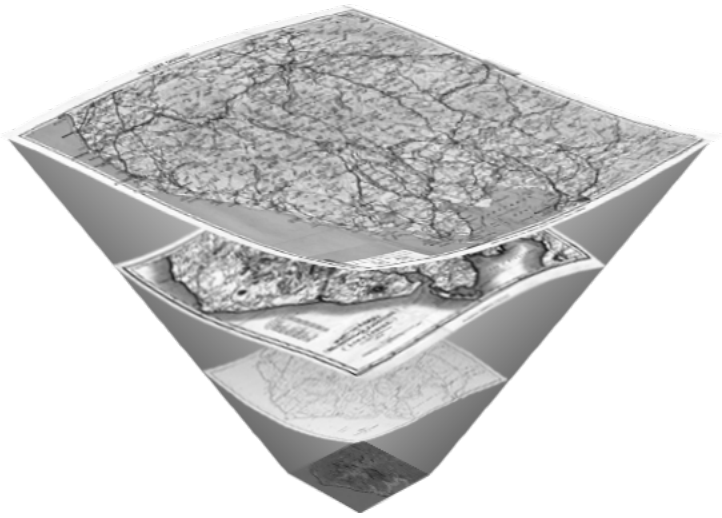


Figure 2. Conceptual illustration of a deep map (courtesy of Geospatial Innovations in the Digital Humanities, Lancaster University).

Transcending disciplinary boundaries, both in their methods and subjects of inquiry, traditional deep maps use literary tropes to evoke the complexity of regionally distinct places. Heat-Moon's (1991) *PrairyEarth*, for example, uses a multi-genre collection of countless oral histories, first-person observational/ethnographic musings, and historical ecology, to tell the social-

ecological story of Kansas's unique flint hills ecoregion. Heat-Moon grounds and organizes his rich vignettes according to several USGS quadrangle maps of the area, making frequent spatial references to the very real physicality of the quad-based grid. The result is a lively and spatially explicit narrative of a place, told from the perspective of that place's residents (and Heat-Moon, too) in such a way as to lead the reader systematically through a landscape that he or she may never have visited. Other examples of literary deep maps include: Stegner's (1962) *Wolf Willow*, which explores social and ecological forces that shaped the high plains and coulee region of northern Montana and southern Saskatchewan; Thoreau's (1854) iconic *Walden*; Powell's (1875) *The Explorations of the Colorado River of the West and Its Tributaries*; and Leopold's (1949) *A Sand County Almanac*, which takes readers on a socio-historical journey through the glacial and post-glacial landscapes of central Wisconsin. As with other authors of literary deep maps, Heat-Moon relies upon the written word in order to escape the limitations and "thinness" of traditional cartography's two-dimensional analog maps. According to Maher (2014: xiii), traditional cartographic maps "cannot contain the feel of legs on an incline, a memory of a fall drive, the nuances of a river." Such maps, moreover, tend more towards what Corner describes as *tracing* (often redundantly) what already exists and is known, rather than mapping as a process of generative and creative discovery. Such depth is essential, since in complex social-ecological systems the ability to emergently represent and discover such qualitative, experiential essences of *place* is essential for environmental management and decision making, something that has long been recognized by scholars interested in conservation-oriented topics like traditional ecological knowledge (TEK) (Lynam et al., 2007).

By themselves, however, interactive deep maps would simply be chaotic, if intriguing, collections of multimedia observations, rendered over a mashup of ecological data layers. In

sufficient amounts, such unorganized spatial information, whether qualitative or quantitative, can become cognitively overwhelming. Spatial narratives, accordingly, offer a means for structuring the content of interactive deep maps in ways that are cognitively appealing to both mapmakers and map users by weaving "pathways through deep maps to track, organize, and record people's experiences with place" (Harris, 2015:31). Spatial narratives are built through strategically placed links that connect thematically related map content in a coherent manner; they guide users through the map, allowing them to connect seemingly disparate social and ecological perspectives on a single topic of interest. In essence, spatial narratives can be thought of as the map's connective tissue — a series of threads that collectively link social and ecological data in ways that ultimately produce meaning.

Spatial narratives have somewhat hybridized conceptual origins, arising both from geographic and humanistic disciplines. In our own work, we apply a recently evolved, landscape-oriented understanding of spatial narratives (e.g. Silbernagel, 2005; Drewes & Silbernagel, 2005; Silbernagel et al., 2015). However, the concept is in fact much older and disciplinarily diverse, with 20- and 30-year-old references found in the humanistic fields of film studies, post-colonial studies, and literary criticism (e.g. Johnson, 1982; Wendorf, 1985; Karcher, 1986; Margenot, 1989; Marin, 1995). For spatial humanists such as Hallam and Roberts (2011), for example, the spatial narrative is the nexus for georeferencing, compiling, and visualizing the places — e.g. buildings, neighborhoods, icons, and open green spaces — that collectively are emblematic of London, as imagined and represented through the multitude of films shot on-location throughout the 20th century. The spatial narrative is in this way an organizing tool for enabling "new forms of navigation through a city's spaces of memory, and by extension new forms of historiographical critique" (Hallam & Roberts, 2011: 386). More recently, geographers have integrated spatial

narratives into alternative geographic information systems (or alt.GIS) mapping approaches — such as public participation GIS, qualitative GIS, volunteered geographic information, and feminist GIS — that arose as a critical response to matters of access, reductiveness, and knowledge production in traditional GIS platforms and methods (Sui, 2015). These scholars have used spatial narratives as a means for integrating stakeholder knowledge into a variety of participatory, urban planning and public health projects (e.g. Kwan, 2002; Schuurman, 2004; Elwood, 2006; Sieber, 2006; Gilmore, 2011; Ortega, 2012; and Lin, 2013). Such interests in the intersection between narratives and maps is further evidenced by the emergence of interdisciplinary subfields such as narrative cartography (e.g. Caquard, 2013; Caquard & Cartwright, 2014), geo-narratives (e.g. Kwan & Ding, 2008), and geoethnography (e.g. Matthews et al., 2005). The growing use of multiple-author story mapping platforms, both commercially and by governmental agencies (e.g. ESRI and National Oceanic and Atmospheric Administration, respectively) illustrates additional, more applied evidence for integrating space, place, and narratives. The map-narrative intersection also evokes Desimini and Waldheim's (2016) reimagining of maps and site plans – conventional tools of both architects and landscape architects – as more than mere two-dimensional instrumental tools. Rather, they are platforms where rich landscapes and cultural imaginaries are produced by simultaneously harnessing the "precision and instrumentality of the plan with the geographic and territorial scope of the map" (Desimini and Waldheim, 2016: 10).

Key Characteristics of Deep Maps and Spatial Narratives

Drawing on the work of deep map thinkers and practitioners from other disciplines, we offer six key characteristics that should guide the development of interactive deep maps and spatial narratives in the context of landscape conservation research and practice. These features form the

foundation of the argument, articulated in the following section, for why these entities are more cognitively effective and compelling than conventional maps, traditional geospatial analyses, literary narratives, or other qualitative, single-medium representations of place by themselves (see Table 1 for a typological comparison). Of equal importance, these characteristics are what make interactive deep maps and spatial narratives particularly germane for integrating and communicating the complexity of social-ecological systems in the context of landscape conservation.

Interactive multimedia capabilities. By definition interactive deep maps and spatial narratives embrace interactivity and multiple media, for reasons that will be discussed in this paper's third section on interactivity, narratives, and insight (McLucas, 2001). While weaving together content comprised of just one medium (e.g. as in a geotagged photo journal) could certainly be both interactive and engaging, the potential of the deep map lies in its *depth* — that is, its ability to meaningfully include and represent multiple kinds of data and observations.

Retain a Cartesian base. Unlike their literary deep map predecessors and despite being multimedial, interactive deep maps are undeniably rooted in a cartesian mapping platform. This is central to the goal of (at least partially) bridging the social-ecological divide, as the cartesian form allows mapmakers and map users to spatially triangulate social-ecological phenomena by simultaneously analyzing both qualitative perceptions and ecological observations (Kwan & Ding, 2008).

Fundamentally accessible and collaborative. Drawing on the alt.GIS principles of openness, inclusiveness, and access, the production of maps and narratives should be collaborative, multi-

author, and multi-user. By so doing, they include multiple, potentially contradictory perspectives derived from multiple kinds of knowledge — both lay and expert, and from multiple disciplines— associated with a place (Bodenhamer, 2015). Such issues of users' inclusion, participation, and empowerment are particularly critical in the context of conservation, in which participants' relative power are central to negotiating, for example, complex transboundary disputes, or competing land uses and values.

Embrace multiple (conflicting) narratives. In both the maps themselves and their resulting spatial narratives, no one narrative or perspective should dominate; in this sense, they resist the quest for a singular meta-narrative emerging from the deep map (Harris, 2015). While individual narratives within a map may reflect a single perspective or person, the potential of the map as a whole is realized in its embrace of a multitude of perspectives.

Support the nonlinearity of time. Interactive deep maps and spatial narratives allow for a more holistic representation of time and simultaneity. This capability imbues deep maps and spatial narratives with distinct advantages over conventional GIS (which struggles to incorporate time) and literary narratives, which can be constrained by the linearity of the written word (Bodenhamer, 2013). This both draws on and is consistent with Corner's (1999: 213) aspirational ideal for mapping as a fundamentally creative and agentic process that "unfolds potential" and "remakes territory over and over again."

Fundamentally open and unfolding. Interactive deep maps and spatial narratives are themselves, like the places they seek to represent, open and ever-evolving (Kitchin & Dodge, 2007).

They "understand space and place as the product of interrelationships, coexistence, and process, always changing and always in the state of becoming" (Bodenhamer, 2015: 22). This both draws on and is consistent with Corner's (1999: 213) aspirational ideal for mapping as a fundamentally creative and agentic process that "unfolds potential" and "re-makes territory over and over again."

Table 1. Typology comparing the characteristics of conventional analog maps, literary spatial narratives, and interactive deep maps (columns) according to six key dimensions (rows).

	Conventional analog maps	**Literary spatial narratives**	**Interactive deep maps**
Forms of content represented	Fixed characters and symbology	Text, images	Multimedia
Organizational framework	Cartesian	One or more chronological narrative arcs, character or place profiles	One or more chronological narrative arcs, character or place profiles — *plus* cartesian representation
Creators or contributors	"expert" mapmaker(s)	varied, but often one or more designated authors	multiple contributors, with varying expertise/knowledge
Narrative diversity	singular	variable	multiple, open
Representations of time	poor, if it exists at all	somewhat flexible, dependent on narrative structure	flexible, rarely linear,
Plasticity	Fixed by moment of production and publication	Fixed by moment of production and publication	Highly plastic, evolving with new content, nodes, networks

WHY AND HOW: INTERACTIVITY, NARRATIVES, AND INSIGHT

Having established a foundation of what constitutes interactive deep maps and spatial narratives, we now turn to emerging theories of interactivity and narratives to explain how they impact

users, and why they offer a compelling medium for conveying the social-ecological complexity of place in the context of landscape conservation. We examine these effects from two perspectives. First, we draw upon research from the sub-fields of interactive cartography, human-computer interaction, and cognition to show how interactivity produces unique insights in both map-makers and map users. Second, we describe how narratives work, and demonstrate why they — above other forms or devices — generate meaningful user experiences. Such experiences and insights, we argue, offer a more appealing and "deeper" understanding of place than would be achieved with either interactivity, narratives, or traditional GIS "thin" maps alone.

Interactivity, Cognition, and Insight

Both conventional analog maps and literary narratives are bounded mediums that constrain the sorts of content that can be projected or communicated, and accordingly provide limited user or reader engagement. Both tend to be static productions — artifacts that are generally intended to be passively displayed or read by their respective audiences. More specifically, GIS and conventional analog maps have been rightfully criticized for flattening complex human-environment relationships, and reducing "places and people to digital 'dots' [that] enables those in power to make decisions without involving local communities" (Pavlovskaya, 2009: 17). Literary deep maps' linearity and dependence on the written word, meanwhile, constrain their ability to interface with quantitative spatial information, and deprive them of the visual and computational advantages of cartesian representation. Holistic landscape conservation science and practice, however, relies on insights derived from dynamic understandings of people-place relationships — insights that preserve social-ecological complexity and engage both stakeholders and decision makers (Armitage et al., 2012). The combination of digital deep maps' interactivity with

structure of well-crafted spatial narratives, we argue, provide the sort of dynamic and engaging user experiences necessary for producing insights into complicated conservation issues.

Interactivity, according to Roth (2013), offers one way of moving beyond the limits of conventional analog maps that are typically designed to produce unidirectional communication of information to users. As an advance on this one-way communication model, which Roth (2013: 67) describes as the "transfer of a *known* set of geographic insights from mapmaker to map user," he proposes interactive cartography — or "the dialog between a human and a map mediated through a computing device to emphasize digital interactions." The ability of the user to manipulate the interactive map — through contributing content, exploring thematically hyper-linked artifacts, changing the map scale, or turning on/off map layers — requires the user to engage in a cyclical, multistep process involving (1) task- and intention-setting; (2) task execution; (3) perceiving, interpreting, and reacting to the task's results; and (4) evaluating the task's outcome — all of which leads to the mapmaker/user generating new questions, intentions, and tasks (Norman, 2004; Roth, 2013). Navigating this fluid, cyclical process requires the mapmaker/user to expend greater cognitive, perceptual, and motor-skill energies, resulting in greater mapmaker/user engagement than would otherwise be achieved by observing a conventional, static map or reading a linear, literary narrative (Elmqvist et al., 2011).

More importantly, this cyclical, interactive process is what leads to spatial and visual thinking, which in turn produces new and deeper insights (Roberts, 2008). As Roth (2013: 67) puts it, interactivity invites the sort of user-controlled exploration within a map that "reveals anomalies, patterns, and trends in the dataset that were previously unknown, leading to the generation of geographic insights, or any new understanding (hypotheses, ideas, explanations, conclusions, etc.), about the true nature of the studied geographic phenomenon or process." These

insights, geographic or otherwise, are a central component of and determinant of success in problem-solving (Dominowski & Dallob, 1995). Though it very well may go without saying, visual/spatial thinking, insights, and successful problem-solving are fundamental to addressing the complexities and disconnects inherent to social-ecological systems.

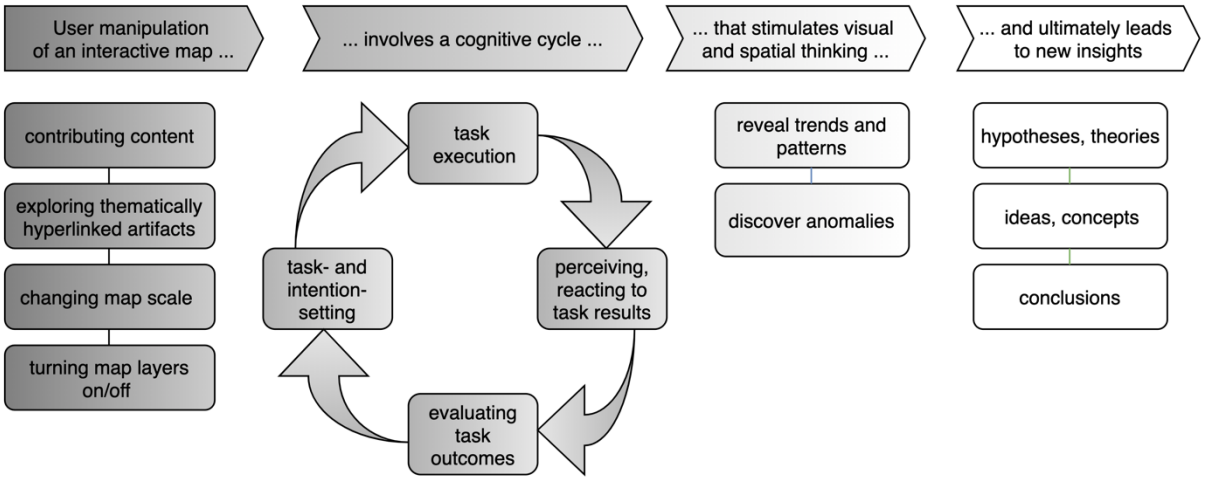


Figure 3. Conceptual diagram showing the process by which deep maps' interactivity produce new insights.

Why and How Narratives Work

Despite the centrality of interactivity to cognition, perception, and insight, interactivity is not without its challenges. The spatial ability of users is highly varied, which impacts the content and qualities of a map experience that users can effectively absorb and assimilate (Roth, 2013). Users with relatively low spatial abilities, for example, may be dependent upon additional guidance and/or cues when navigating any map, particularly an interactive map. Large troves of multimedia content — the very sort of rich, place-based observations and contributions that define interactive deep maps — may pose real cognitive challenges for users of all spatial abilities, no matter how appealing or cognitively engaging the content may be. Spatial narratives, therefore, are

central to guiding all users through a map; plots, scenes, characters, and narrative arcs are essential for channeling and maintaining users' energy and engagement generated throughout the cyclical stages of interactivity. In this way, we can think of spatial narratives as the complementary structures that not only allow users to derive meaning(s) in information-rich environments, but also as deterrents that curb interactive maps' potential to overwhelm, over-stimulate, or cognitively exhaust users.

The choice to use spatial narratives — rather than some other device — is predicated on three foundational qualities of the narrative form — qualities that both explain narratives' appeal and why they are particularly germane for interactive deep maps. First, narratives are both familiar devices and fundamental elements of what it means to be human, and in this way are the inescapable "currency of communication," even in objectivist science (Allen et al., 2001: 476). Drawing on the ideas of Heidegger, Cronon (1992: 1368) asserts that narratives are "fundamental to the way we humans organize our experience. … Our very habit of partitioning the flow of time into 'events,' with their implied beginnings, middles, and ends, suggests how deeply the narrative structure inheres in our experience of the world." Humans, after all, have for millennia used stories (oral or written) and visual depictions to make sense of the world and their experiences in it (Caquard, 2013). For both individuals and societies, stories are the means by which we continually "remind ourselves who we are, how we got to be that person, and what we want to become. … [w]e use our histories to remember ourselves, just as we use our prophecies as tools for exploring what we do or do not wish to become" (Cronon, 1992: 1369). In this sense, narratives are compelling devices in their own right.

Second, narratives by definition prioritize some details, facts, and observations while obscuring others. Unlike chronicles, which list *en masse* every detail, event, or character — no

matter how minute or mundane — narratives make value-filled judgments of what to include and what to leave out, or what to highlight and what to minimize. Narratives take a point (or points) of view, and in doing so are able to organize disparate information into something digestible — to generate order amidst chaos. If Cronon (1992: 1349) is correct in asserting that narratives are "the chief literary form that tries to find meaning in an overwhelmingly crowded and disordered chronological reality," then spatial narratives are justifiably the preeminent means of ordering spatial information in ways that ultimately produce meaning and insight, and allay interactivity's potential to overwhelm users.

Finally, narratives are open and communal; they are the products of collective telling and retelling, of critiquing, revising, and reassembling. Ideally, this quality provides a necessary corrective to narratives' unavoidable function of including some voices, observations, or events at the exclusion of others. Collective creating and editing is what rescues the narrative from itself; it is what makes the narrative sensitive and responsive to differential power among its subjects, contributors, and audiences. Using the iterative process of peer-reviewed scholarship as an example illustrating the linkages between community and narrative, Cronon (1992: 1373) says: "We write as members of communities, and we cannot help but take those communities into account as we do our work. … They are in a position instantly to remind me of the excluded facts and wrong-headed interpretations that my own bias, self-delusion, and lack of diligence have kept me from acknowledging."

At their best, narratives have the capacity to bind us not only to one another (both past and present), but to the places and natures that we shape, and in turn shape us. In this sense, narratives not only organize map content and prevent users from becoming overwhelmed, but are foundational for helping us build ontologies of the places where we live — that is, how we

categorize and conceptualize what is real in a manner that conveys meaning (Bodenhamer, 2010). And even though we no longer sit around the ancestral bonfire telling myths of the mystical "world out there," it seems reasonable to posit that contemporary spatial narratives tap into those same, age-old ontology-building sensibilities, and still have the power to inspire awe and reverence, to problematize and criticize, and to educate and engage. As Cronon (2013) points out in his presidential address to the American Historical Association, even the advent of the internet and the ensuing rise of the digital age will not change this incorrigible part of being human: "Although the shape and form of our stories will surely change to meet the expectations of this digital age, the human need for storytelling is not likely ever to go away. It is far too basic to the way people make sense of their lives … ."

WHO AND WHERE: APPLICATIONS IN LANDSCAPE CONSERVATION SCIENCE AND PRACTICE

Given the unique potential for interactive deep maps and spatial narratives to spark insight and produce meaning, where might they contribute to open fields of inquiry within contemporary landscape conservation science? Who might build, edit, and consume them? And where might they bridge the social-ecological divides within landscape conservation science and practice? Below we highlight avenues of possible integration intended to complement ongoing conservation research and practice. We pay particular attention to how the process of building and using interactive deep maps can engage individuals and communities, conservation scientists, and ecosystem planners, managers, and policymakers. Though other avenues of integration are certainly possible, we discuss three broad ways in which interactive deep maps and spatial narratives can

contribute to conservation: (1) as boundary objects that facilitate participatory processes and mutual learning; (2) as tools for communication, visualization, and representation; and (3) for augmenting and complementing academic research.

As Boundary Objects that Facilitate Participatory Processes and Mutual Learning

Addressing complex social-ecological problems often requires mobilizing diverse communities of practice (e.g. conservation scientists, practitioners, affected individuals and groups) (c.f. Wenger, 1999), who collectively form a community of interest (Waylen et al., 2013). Despite their shared goal of solving a certain conservation problem, however, differences in knowledge, assumptions, and vocabularies among individuals within a community of interest complicates the group's ability to reach a shared understanding (Arias & Fischer, 2000). In response, boundary objects have been widely applied as artifacts, objects, or concepts that overcome the shared-understanding problem by serving as common points of reference (e.g. Chrisman, 1999), means of coordination (e.g. Fischer & Reaves, 1995), and vehicles of translation among members of a community of interest (Star & Griesemer, 1989). Boundary objects are plastic, adjustable arrangements that facilitate conversation, communication, meaning-making, and learning among disparate participants collaborating on a common task (Lave & Wenger, 1991; Bowker & Star, 1999; Juhasz & Balsamo, 2012). Interactive deep maps and spatial narratives, we argue, constitute a boundary object in various conservation contexts in which one or many communities of practice and/or interest must overcome the aforementioned barriers in order to achieve conservation goals.

For example, many widely applied management approaches like place-based conservation (e.g. Brown & Weber, 2013), community-based conservation (Berkes, 2004), and place-

based management (Olsen et al., 2011) require negotiated understandings of 'place' as a requisite baseline for creating workable management plans (Lackey, 1998). Questions regarding place boundaries — not to mention *what* should be conserved, and where (on the landscape) conservation initiatives will occur — are foundational to these conservation approaches. Negotiating potential answers to them require data and perspectives that are at once social and ecological, qualitative and quantitative. The capacity for interactive deep maps and spatial narratives to integrate qualitative dimensions of place (e.g. landscape values, place-based memories) with more readily quantifiable data (e.g. flora/fauna distributions, watershed and/or ecoregional boundaries) allows for disparate stakeholders to have a common point of reference when answering the 'what is a place?' question. Alternatively, an interactive deep map could serve as an adjustable, continually updated point of reference to which participating stakeholders regularly return throughout the iterative cycles of adaptive co-management. In this context, the map and narratives act as the container for simultaneously visualizing how ecological indicators and human preferences/impacts influence each other and change over time in response to management actions.

Similarly, interactive deep maps and spatial narratives could serve as boundary objects in conservation planning processes such as alternative scenarios, which have become indispensable tools for planners, natural resource managers, and local communities interested in imaging plausible futures for a given study system. Guided by collaboratively developed stories and rigorous quantitative modeling, alternative scenarios have been variously used to assess bioregional biodiversity (Cumming, 2007); develop global millennium ecosystem goals (Carpenter, 2006); model biocomplexity (Bolte, 2007) and socioecological outcomes under different forest management regimes (Price et al., 2012); envision futures for Oregon's Willamette Valley (Baker, 2004; Hulse, 2004); and visualize ecological impacts of various development plans near Seattle, WA

(Wilhere, 2007) and northern Wisconsin (Drewes & Silbernagel, 2005; Zollner, 2008). Interactive deep maps and spatial narratives could serve as boundary objects during early phases of alternative scenarios processes. Steps such as developing a focal issue/question and identifying potential futures for social and ecological components of the system are activities that depend upon a spatial understanding of that system's social and ecological connections, disconnections, and interdependencies (Peterson, 2003). In this context, interactive deep maps and spatial narratives could serve as a means of translation between scientists and non-scientists, for example, or as a conversation starter between participants with opposing social values, land-use priorities, or management preferences.

After building the alternative scenarios and quantitatively modeling their various outcomes, interactive deep maps and spatial narratives could be reinserted into the planning process, this time as a means for visually representing each scenario's social-ecological results. These visual representations could themselves serve as anchors for stimulating evaluative discussions among not only participants, but could play a facilitative role in closing the science-policy divide through processes of social and collaborative learning (Daniels & Walker, 2001; Feurt, 2008; Reed, 2008).

As Tools for Communication, Visualization, and Representation

The visual power of maps has never been in dispute. Despite their complicity in centuries of global hegemonic projects (see Monmonier, 1991; Pickles, 1995), they have long been tools for enabling individuals and groups to represent and communicate their cultural values, knowledge, property, and priorities to external agencies and decision makers in the context of conservation (Poole, 1995). Interactive deep maps and spatial narratives, we argue, are well-suited to adding

depth, insight, and representational power to such projects. Participatory methods like landscape photo-tagging (e.g. Brabyn & Mark, 2011), photo-voice (e.g. Wang & Burris, 1997), and photo-, audio-, and/or video-elicitation (e.g. Kong et al., 2015) could be integrated into mapping services such as OpenStreetMaps to collaboratively build rich representations of place. These interactive deep maps, for example, offer a natural medium for compiling and spatially representing TEK, which can be useful when developing strategies for enhancing the management of common-pool resources (Mutenje et al., 2011). These maps' spatial narratives could, moreover, adeptly represent multiple stakeholders' views vis-a-vis land-use conflicts, and conflicts involving the politics of place, in which place meanings and identities have dimensions that are at once spatial *and* socio-cultural (Williams, 2002; Anderson et al., 2013). In addition, interactive deep maps and spatial narratives constitute a means for capturing and spatially representing the culture-loss impacts of natural resource damage and disasters on indigenous people groups (e.g. Snyder et al., 2003; Windsor & McVey, 2005).

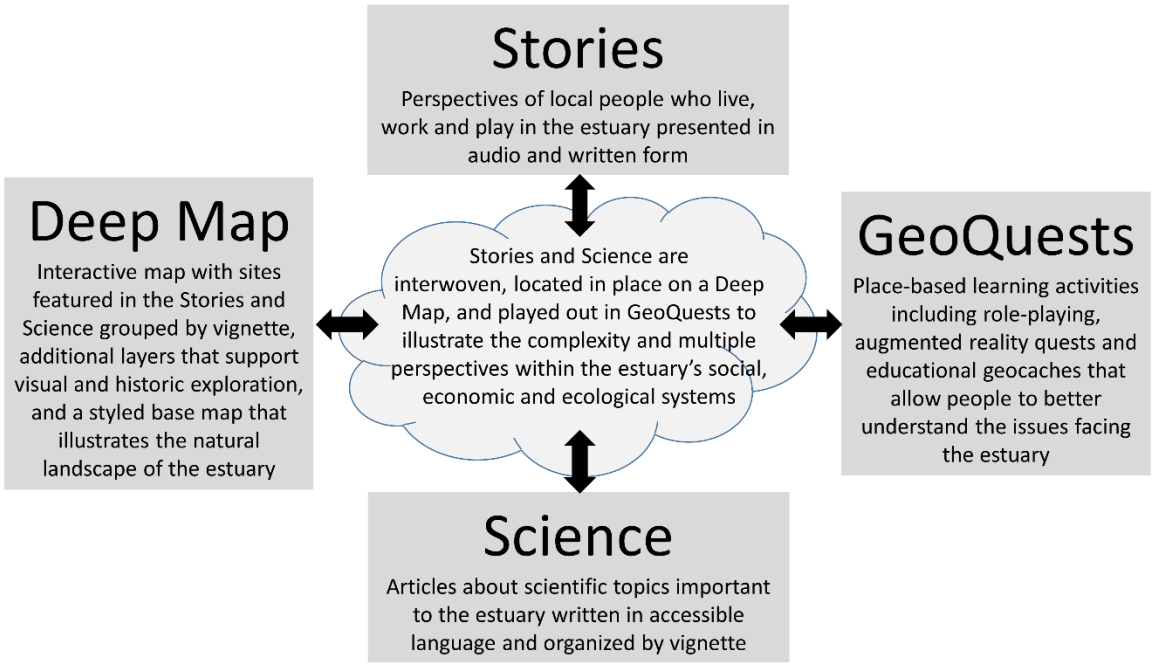


Figure 4. Conceptual depiction of how "The Stories and Science of the St. Louis River Estuary" project interweaves stories, science, a deep map, and geoquests to form spatial narratives.

As translational and educational devices, interactive deep maps provide a vehicle for conveying social-ecological complexity to various audiences. One example, "The Stories and Science of the St. Louis River Estuary" (http://stlouisriverestuary.org/), uses an interactive deep map and accompanying spatial narratives to spatially connect the people and science of contested issues in a western Lake Superior estuary (Silbernagel et al., 2015). The project draws on research about the gradient of anthropological stressors in the watershed and corresponding downstream impacts and integrates it with perspectives from local anglers, ricers, commercial shippers, birders and others who live, work and play in the estuary. The deep map takes users through a virtual tour of the estuary's natural and social history — a history that includes both degradation (e.g. mining, heavy industry) and ongoing restoration initiatives. Place-based learning activities coined "geoquests" engage people in the issues on the landscape. Figure 4 shows how the stories, science, deep map and geoquests interweave to form spatial narratives. Figure 5 shows a screenshot that illustrate how the "The Stories and Science of the St. Louis River Estuary" deep map interface appears to users. As an educational and outreach platform, the deep map and narratives have been used in workshop settings by regional elementary school teachers and outreach educators to "facilitate science-based discussion and place-based learning regarding coastal issues and resources" (Silbernagel et al., 2015: 197).

Figure 5. "The Stories and Science of the St. Louis River Estuary" deep map interface spatially connects audio narratives on a variety of community-defined topics with emerging science on estuarine water quality, legacy pollution, and restoration. Images courtesy of the authors.

For Augmenting and Complementing Conservation Research

Finally, interactive deep maps and spatial narratives could play a research-oriented, complementary role in select branches of conservation science. For example, in ecosystem services valuation (ESV) — that is, measuring the direct and indirect benefits that humans derive from ecosystems — cultural services remain relatively marginalized and under-evaluated, due in part to their seeming incommensurability and incompatibility with more traditional metrics (e.g., dollars) used in ESV (Daniel et al., 2012). Such marginalization of cultural perspectives and values, according to Chan et al. (2012: 9), results in a significant missed opportunity for actualizing holistic ecosystem-based management, and for achieving a deeper understanding of "how human well-being may change alongside ecological change." Interactive deep maps could provide a medium for integratively visualizing, analyzing, and evaluating ecosystem services' cultural dimensions alongside the framework's more quantitative components (i.e. regulating, provisioning, supporting). Analysis of hydrogeological and other biogeophysical data, for example, may reveal spatial locations where proposed restoration initiatives are *ecologically possible*, or would confer the greatest ecological benefits. Analysis of that same system's cultural "hotspots," meanwhile, could show where those same restoration initiatives are socially desirable — in other words, where restoration would confer the greatest recreational, educational, aesthetic, heritage, or spiritual benefits. Spatially overlaid in the map, the combined visualization of these social and ecological dimensions could provide intriguing insights into decision making negotiations about where restoration and/or historical preservation can and should occur on the landscape. Such an application of deep maps and spatial narratives would resonate well with the growing tradition of participatory mapping of cultural ecosystem services (see Plieninger et al., 2013 and Gould et al.,

2015 for an overview and examples of applications). Likewise, it aligns well with and could enhance participatory methods designed to elicit and map symbolic place meanings (e.g., Devine-Wright, 2011), place attachments (e.g., Brown et al., 2015), and landscape values (e.g., Brown 2004) – approaches that have been used to integrate stakeholder's sense of place into natural resource management and landscape-scale renewable energy development projects.

Interactive deep maps and spatial narratives could also provide a complementary tool for conservation researchers engaged in documenting ecosystem and biodiversity change over time. TEK, for example, has a rich tradition augmenting conventional methods for tracking the abundance, richness, and distribution of species in a given landscape. Spatially integrating these local narratives and insights into a deep map could increase their compatibility with more quantitative ecological data, and together provide scientists with richer, more robust indicators to track biodiversity and landscape change over time. Similarly, interactive deep maps and spatial narratives could allow for the addition of more qualitative observations contributed by participants in citizen science and monitoring programs. Locationally tagged pictures of water quality, for example, could be uploaded into a digital map alongside more traditional measurements (e.g. dissolved oxygen, Secchi disk readings). Geotagged audio clips of bird calls or pictures of unidentified plants could provide locationally accurate context for tracking the spread of non-native or invasive species. Interactively compiling and spatially displaying these qualitative observations alongside more conventional, quantitative data could provide ecosystem managers with additional, context-rich information. Just as significantly, these maps could provide real-time feedback and a more engaging experience for participants in the monitoring programs themselves, which frequently suffer from high rates of attrition, typically due to the unidirectional flow of

information (i.e. from citizens to professional scientists) in many monitoring programs (Conrad & Hilchey, 2011).

LOOKING AHEAD: CHALLENGES AND OPPORTUNITIES

Many of the most complicated contemporary conservation issues involve individuals and groups of people who hold diverse, and often competing, values, beliefs, and conceptualizations of the issue(s) at hand. Regardless of their social-ecological complexity, questions surrounding trans-boundary natural resource management or access to common pool resources, for example, provide ample complexity on the social side of the social-ecological equation alone. Fairly including and accurately representing these stakeholder perspectives has long been recognized as a central tenet of equitable landscape conservation initiatives (Lackey, 1998; Ostrom et al., 1999; Folke et al., 2002). Building interactive deep maps and spatial narratives offers opportunities for collaboration, mutual learning, and the development and sharing of common points of reference. But the very same participatory processes required to build interactive deep maps and spatial narratives are themselves fraught with questions of access and power. Who, for example, has access to these maps and narratives, and who does not? Who is invited to contribute their knowledge and perspectives? Who owns the data? Who has the power to moderate and delete content? What sorts of capabilities (e.g. computers, smartphones, internet connections, etc.) are necessary for participating? Who makes decisions about how narratives are developed — that is, who decides what is left in and what is left out, and whose narratives are privileged? On a logistical level, how will the cost of requisite mobile or web devices affect who can participate? Who will be the arbiter of data accuracy and reliability issues? How will the benefits of open access be balanced

against the need for participants' privacy (e.g. revealing locationally accurate data about spiritual or otherwise special places)?

Deep map practitioners and researchers must reflectively bear these questions in mind and deed, as their answers will vary from project to project, and as technologies themselves evolve. Critical geographers in the 1990s pushed back against the rise of conventional GIS — a movement that spawned the innovative and more inclusive fields of alt.GIS, and arguably broadened and improved the capabilities and applications of GIS as a whole. Likewise, these critical questions should not act as a barrier to action, but rather as a guide that will ultimately improve the quality and outcomes of any endeavor (Allen et al., 2001). Indeed, they ought to be salient in *any* participatory process that consults and includes communities in matters of conservation.

One final guiding question that this paper has not explicitly addressed concerns *when* to use interactive deep maps and spatial narratives. In our exploration of the *what, how, why, where and who* aspects in the foregoing sections, we do not intend to convey the impression that maps and narratives are always appropriate or helpful in all conservation contexts. Nor do we wish to imply that maps and narratives offer the only (or best) means of social-ecological integration, or that expressly quantitative uses of GIS are incomplete or somehow inferior. Conventional GIS methods and applications, after all, have undoubtedly served the conservation field well for decades. Indeed, the productive community of scholars that comprise the Society for Conservation GIS has applied GIS tools and approaches to myriad conservation issues across the globe (Convis, 2001; Fortin & Dale, 2005). Quantitative GIS approaches to analyzing and visualizing ecological and biodiversity phenomena will and should remain a mainstay in conservation science research.

Notwithstanding this recognition, we argue that interactive deep maps and spatial narratives constitute a potentially powerful and engaging —if under-explored — means for integrating social perspectives and ecological data. By combining methods and tools, both old and new — e.g. the appeal of narratives and the cognitive engagement of interactivity, or emerging web2.0 tools and the analytical capabilities of cartesian representation — interactive deep maps and spatial narratives occupy a unique position in the evolving toolboxes of both socially- and ecologically-oriented conservation scientists and practitioners. And while bridging the social-ecological divide is not an end in itself, the deep exploration and understanding of place — its human and non-human dimensions, and its nuances, conflicts, and contradictions — will remain a central pillar of research and action within the conservation community.

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