What can critical cartography bring to conservation?

Introduction

It can be argued that a map is one of the fundamental building blocks of geography. Some of the earliest known geographers, like Eratosthenes (circa 200 BC) and Ptolomy (circa 100 AD), developed coordinate systems, defining the idea of space and using this information for orientation and locating places via maps (Cresswell 2012). Maps have been used for innumerable purposes ranging from navigating across the oceans to navigating to the local coffee shop, and from informing wars to informing conservation. Maps have become increasingly ubiquitous over time, leaving little doubt about their general acceptance. By guiding our actions and perceptions, from the banal to the vital, maps have a certain type of power, as described by Wood (1992). This power, Wood contends, can be understood through a map's selective representation of reality, which, in turn, serves the particular interests of those who create them. Given this context, it is not surprising that within the world of conservation, maps have also become a common tool. Historically, one of the main strategies of conservation geographers has been the establishment of protected areas where human use is restricted (Agardy 1994; Leslie 2005; Naughton-Treves, Holland, and Brandon 2005; Saout et al. 2013). To identify these areas, maps play a vital role because they are used to understand, explain, and spatially delineate important habitats, wildlife movements and distributions, climates, and ecological processes (e.g. Stralberg et al. 2009; Lescroël et al. 2016; Lecours 2017). This role will become increasingly important as we advance through the climate change crisis, which has challenged the understanding of how species and ecological processes will spatially shift in response. The climate crisis has also made it more and more apparent that ecological and human systems are interconnected (Alessa, Kliskey, and Brown 2008) and may become more so at large spatial scales. In order to understand and protect these socio-ecological systems, the way conservationists think about, develop, or use maps (i.e. cartography) will have to

adapt. This adaptation can be informed through a critical approach (i.e. critical cartography) of assessing the maps of today to help shape and improve the maps of the future.

Critical cartography addresses a maps assumptions, powers, weaknesses, and inherent problems (Crampton and Krygier 2006). While at a basic level, maps may be perceived by many as a simple image depicting some part of our world (and assumed as such to be trustworthy, or at least objective in its representation of the world), this disarming simplicity belies a deep power to shape ideas; as a commonality, maps give a voice to whomever is creating them and this voice can be seen as the capacity to dictate the terms of how space is used or perceived (ibid). In this paper, I will first provide a brief overview of critical cartography concepts and findings since its socio-political foundations in the 1980's. I will then review how concepts from critical cartography have been used to highlight shortcomings and problems in conservation maps. I'll also review some ways that conservationists are already applying lessons learned from critical cartography to make maps more effectively and holistically achieve conservation goals and outcomes. Finally, I'll explore ideas on how the work I'm focusing on for my masters – penguin use of resources and a marine protected area during their winter migration – can benefit from all the critical work and ideas reviewed.

A Brief Overview of Critical Cartography

Since the late 1980's critical cartography has developed as a way to challenge the political power structure that maps have been so well used to establish. *The Power of Maps* by Wood (1992) was instrumental for this movement because it summarized how maps serve those who create them and disempower those who do not. It also developed the idea that, while maps are not objective, they are effective because they try to give the appearance of objectivity. Work by Harley (1989) and Monmonier (1991; 1995) also established how maps are used to gain power over others via what they depict or

what they don't depict. Since then, challenges to how maps are used have often come in the form of "counter-mapping" by indigenous people to establish their own voice and re-claim their lands (e.g. Peluso 1995; Rundstrom 2006; Gilmore and Young 2012; Leblond 2014). A seminal work in this respect is by Peluso (1995) who explored the socio-political implications of the mapping of forests in Indonesia. Peluso defined mapping as "an intrinsically political act" and explored how maps could be used to shift the balance of power to those living in the mapped areas. Rather than just serve those in power, maps, she argued, "can be used to pose alternatives to the languages and images of power and become a medium of empowerment or protest." In this respect, one important way that counter-maps are produced is via participatory mapping - the identification and mapping of important boundaries and resources by the people who live within those areas (Gilmore and Young 2012). Critical exploration of this concept points to issues with exactly how those boundaries are defined (Vandergeest 1996; Fox 1998; 2002). Boundaries, as defined by people who use a space, can often be "fuzzy" or may change seasonally (Roth 2009). How different groups of people are represented and given a voice is also a key topic that is grappled within critical cartography (e.g. Rocheleau, Thomas-Slayter, and Edmunds 1994; Pavlovskaya and Martin 2007; Koester 2019). Rocheleau et al. (1994) discuss how resource maps that depict "gendered space and place" can be used to empower women in small agricultural communities. For example, by simply labeling "rice fields" (how the area is used by men) as "rice fields with hedges for goat fodder" (including how women use the area), women's knowledge and space is acknowledged and symbolically given back to them. And issues of how maps can distort or misrepresent people's use and concepts of space have also been critically assessed (Fox 2002; Roth 2009). Roth (2009), for example, describes the difficulties of mapping abstract 2-dimensional space use for an indigenous group of people who relate to their environment in more complex multi-dimensional ways. Fox (1998) discusses how the four cardinal directions normally indicated on most maps, is not compatible with the way some indigenous tribes see direction in their world. While critical cartography and counter-mapping

specifically began largely with a focus on socio-political issues of maps (Crampton and Krygier 2006), concepts from this work have more recently been applied to the conservation realm.

Applying Critical Cartography to Conservation

As the desire for protected areas and space for conservation is growing (Adams 2019), are there better more effective ways to use the power of maps to give a voice to nature? Since maps have helped establish this pattern of setting aside and protecting land, how can critical cartography inform the development of better alternatives? The work of Hazen and Harris (Hazen and Harris 2006; Harris and Hazen 2011) has served as a touchstone in this regard and I will refer to their work frequently as others have in the world of critical conservation cartography. In their work, Hazen and Harris comprehensively explore and critique the impact of maps on conservation including its focus on 1) territories and boundaries, 2) its (in)ability to represent more-than-human voices, and 3) its contribution to power imbalances in how spaces are chosen for protection. Rather than explore critical conservation cartography through time, I review the literature through these three recurring topics. I examine the conservation literature in relation to each of these topics to assess how well these problems have been or can be addressed.

Critiques on Boundaries

In the conservation world, maps are often used to delineate boundaries. Boundaries demarcate where "protected" areas begin and end. As you navigate to a national park using your phone's map you reach the boundary of your destination and, in the real world, see signs such as "Entering Yosemite National Park". While these boundaries can be effective for managing people, geographers have questioned how

effective they are for managing wilderness. There are certainly several ways in which mapping rigid boundaries have been found to be problematic for effective conservation. By their fixed nature, boundaries run counter to the well-established idea that the natural world is in a state of flux - where habitats, wildlife, and ecological processes are continually shifting (Zimmerer 2000). Maps with fixed boundaries can also give the impression that a protected area is well managed when it may not be and can, paradoxically, serve to justify the increased use of and exacerbate the degradation of land that falls just outside of those boundaries (Zimmerer 2000; Naughton-Treves, Holland, and Brandon 2005; Hazen and Harris 2006). Boundaries "cleave apart the privileged spaces of nature protection and preservation from those places of heavier human use and inhabitation"(Zimmerer 2000). In this sense, thinking beyond conservation boundaries and removing the duality of protected/unprotected could encourage people to focus on reducing their overall impacts (e.g. pollution, urbanization, resource extraction) outside the boundaries of protected areas (Hazen and Harris 2006).

Addressing Boundaries

One way to address the problems of boundaries includes setting up "buffer zones" around protected areas where land use is only partially restricted or only certain types of resource extraction are allowed (Martino 2001). The aim here, from an ecological point of view, is to provide a transition zone to suppress the isolation of protected areas that can occur with intensive resource extraction around them. Another aim here is to soften the transition of restrictions placed on human communities located near the perimeter of protected areas. However, the establishment of borders of this kind, however "soft", can still be seen as another form of "expansion of state authority" over rural areas (Neumann 1997).

In terms of ecological effectiveness, rather than simply draw another line around an existing boundary, Palomo et al. (2013) suggest mapping ecosystem services and flows as a better alternative because doing so provides more meaningful information on which boundaries, buffers, and

management plans could be based. Semlitch and Bodie (2003) describe how relying on the protection of wetland habitat delineated for reptiles and amphibians is often insufficient for their ecological needs. They recommend the development of "biologically meaningful buffers" and provide recommendations on the size of these buffers based on a literature review of reptile and amphibian movements and migrations. In these cases, ecologically meaningful spatial information is gathered and used to then provide guidance on the types and locations of borders to be implemented.

Ecologists have also started to think about the impact of climate change and how in many ways it renders the idea of boundaries moot. Loarie et al. (2009), for example, mapped the velocity of climate change and how this velocity will vary and shift across the landscape. Their maps show how quickly species and habitats would have to move across boundaries to stay within their current bioclimatic zone. Wiens et al. (2011) analyzed and mapped how climate might shift in relation to protected and unprotected areas in California, quantifying how climate spaces might move into or out of protected areas. These studies serve to emphasize how simply designed or locally-focused protected area boundaries, in general, will become much less meaningful in the face of a rapidly changing climate.

Critiques on Representation

Maps can represent or "speak" on the behalf of people, habitats or wildlife by showing what is important for them and directly addressing their needs and uses. Historically, protected areas have claimed to speak for nature by offering it refuge from human impact. The selection and management of these areas has been done in a multitude of ways to, ostensibly, protect habitats, wildlife, and ecosystems. But, as Hazen and Harris (2006) show, the process of identifying what is protected and what isn't can be inherently biased because of the "mappability" of certain landscape features or habitats. For example, lakes are often mapped while cliffs are not, and forests are often mapped while oak

woodlands are not. As a result, the species that use those mapped habitats are also, by default, prioritized while others remain voiceless, unnoticed, and unprotected. The same can be said of charismatic species (e.g. panda bears, tigers, koalas) who may also drive the prioritization process when it comes to targeting protected lands.

In a similar vein, as a response to the rapid loss of habitat and species over the last century, conservationists have also worked to identify, map, and protect "biodiversity hotspots" where flora and fauna species richness is high (Myers et al. 2000). But while prioritizing these areas for protection sounds completely reasonable, some have argued that scientific justification for doing so may not be considering all the ramifications. As Kareiva and Marvier (2003) state:

> "Using hotspots to set priorities comes into question as soon as one considers a broader range of objectives, such as maintaining functioning ecosystems throughout the world, providing the greatest variety of distinct plant and animal lineages for future evolutionary breakthroughs, preserving spectacular wild landscapes that inspire the human spirit or protecting nature in a way that provides for the well being of people living alongside"

Carolan (2009) also explores the idea of biodiversity hotspots in-depth and emphasizes that such maps are often not "read negatively". In other words, "the assumptions, limitations, and potential distortions" found within such a map often go unnoticed. In this case, what goes unnoticed are things like how a species and therefore biodiversity is defined and how areas outside of hotspots are, unintentionally, represented as unimportant. Carolan argues that what is needed is more transparency with regard to the assumptions that are being made during map production. Only in this way can what a map is actually representing be made clear.

The consideration of non-human voices is a subject that is explored by Harris and Hazen (2011). Often missing from mapped representations of nature are individual voices. By protecting habitats,

biodiversity, and ecosystems, ecologists aim to address the needs of natural systems as a whole. But social critical cartography often centers on the importance of showing how specific under-represented groups of people interact with and use their environment. It is through this focus on specific people or groups of people that the shortcomings of a map are brought to light, important socio-political issues specific to a region are brought to the fore, and power is given back to those people. It is therefore worth considering if a focus on individual non-human voices can do the same for wildlife.

Addressing Representation

By identifying and mapping the spatial distribution or use of resources by wildlife, conservationists have, in a way, more directly represented or given voice to Nature. Rather than focusing on habitat, species diversity, or hotspots, some ecologists have considered using a set of representative species. Mapping the biological requirements for a set of "landscape" species, (species who's needs are ecologically diverse and have a significant impact themselves on the ecosystem) overlaying that on a map of human land uses, then evaluating where and how these intersect can be a way to define an optimal spatial-management plan (Sanderson et al. 2002). Using a set of "focal species", who together are supposed to represent a more complete array of resource uses and ecological processes within an ecosystem, has been a popular approach to identifying habitat protections and management (Lambeck 1997; Roberge and Angelstam 2004). Each of these focal species primary interactions with their environment and their needs can be mapped, painting a more inclusive and informative picture of what is being protected and why. Using this idea of representation, Sayre et al. (2014) developed an ecophysiographic map based on landforms, bioclimatic factors, land cover, and soil and rock cover. The use of such maps in conservation can help to assess and ensure a more equal representation of important ecological processes, preserving the "arenas" that species use (Beier and Brost 2010) rather than focusing on particular species of importance.

While wildlife cannot describe their needs directly, in a way tracking them provides them with a voice that can be seen as a form of participatory mapping. For many years now, ecologists have tracked and followed individual wildlife to assess their habitat requirements. Through processes like spot-mapping, where color-banded birds are followed and mapped for several weeks or months and between years, biologists can map and analyze spatially detailed life histories. These types of maps can serve to connect researchers and the general public to wildlife as individual living beings with individual needs and idiosyncrasies. This more intimate connection can foster a desire to protect them in ways that general maps of park boundaries cannot. In a paper by Lescroël et al. (2016), maps of seabird movement across large areas spanning multiple ecological and political boundaries are used to give voice not only to the birds needs but to the perceptions, norms, interests and values of various stakeholders who interact with them in unique ways, therefore fostering cooperation on conservation and management issues.

Critiques on Space

Space can be seen as an area where experiences and interactions are had. Relationships between people, animals, resources, objects, etc. happen within and define the characteristics of a space. Movement of these actors also happens within space (Cresswell 2012). By its heavy reliance on isolating protected space, conservation work has, metaphorically speaking, established mental limits on how we think about conservation in general, "cementing an overly-limited territorial approach to conservation" and "consolidating an overly-fixed and static approach to conservation" (Harris and Hazen 2011). This type of moored thinking has the potential to cause problems or lead to shortcomings in what is protected and how we manage those areas.

Setting aside protected space is also problematic because, by separating areas for nature, it assumes that we know how much area is needed or that we can even protect enough area for habitats and species to persist. As Adams (2019) points out, international targets for total area protected have ranged from 10% to as much as 50% of the planet, indicating the somewhat arbitrary nature of defining how much is needed. And even if the most generous targets for protection where met, simply equating space with success can be misleading. The definition of what a protected area affords the wildlife within it can vary widely across the globe and a space outlined on a map does not usually say anything about how effective that protection is or what the management goals are within that space. Rather, such a map may mislead readers into thinking all protected areas are well managed (Hazen and Harris 2006). Identifying things like conservation goals or targeted species population goals can make these maps more meaningful and informative.

Maps of protected areas can distort the concept of space use by nature and wildlife. These areas, for example, are not usually designed around how wildlife travel or interact with their environment, they are rather the end product of a political negotiation process, involving compromises between stakeholders and power dynamics. Harris and Hazen (2011) provide an example of bison in Yellowstone who shifted to using space outside the park in response to a harsh winter. This shift resulted in many bison being slaughtered to prevent the spread of disease to cattle outside of the park. Here we see wildlife naturally using space to protect themselves from inclement weather, but suffering harsh consequences due to the artificial space that humans had, ironically, set up for their protection. What is made clear in this example is that wildlife perceive space in a completely different way than humans do. A map simply showing the boundaries of Yellowstone National Park fails to convey this complexity, whereas a map indicating bison ecological needs and movements would be an improvement.

In thinking about space, scale is also important. Harris and Hazen (2011) caution that conservation mapping may not only harden ideas tying conservation to protected areas but also ideas about what scale nature works at. While depictions of space on a map are usually on a single scale, natural processes may be working at multiple scales. Stoms and Estes (1993), for example, discuss how diversity can be defined from the microhabitat level to the regional level and how biophysical factors that drive species diversity will also vary along these spatial scales. Scale is an intrinsic part of maps and this characteristic should be taken advantage of to communicate or develop ideas about what scale protected areas are effective at.

Addressing Space

Perhaps one of the most direct ways to begin to understand the shortcomings of protected areas is to try to understand that the notion of "wilderness" as one that is separate from humans and deserves its own space, is a culturally fabricated ideal. This is the idea Cronon (1996) explores when he states, "we mistake ourselves when we suppose that wilderness can be the solution to our culture's problematic relationships with the nonhuman world, for wilderness is itself no small part of the problem". By setting wilderness aside (a concept that maps very powerfully convey), Cronon argues, humans begin to have the illusion of not being part of the natural world and, though they live in wooden houses, "have no meaningful connection to the forests in which trees grow and die". This disconnect is the seed for how we lose the ability to develop an integrated socio-ecological solution to the problems of protected areas. We, in effect, box ourselves in to only working with protected space as a solution to environmental degradation, despite all its problems. Juxtaposing social and ecological processes visually on a map may be an important way to help bring about an acceptance of the inseparability of humans and nature. In this way, maps can integrate rather than divide.

An initial block when it comes to mapping socio-ecological integrated space may be a lack of basic definitions for the various types of spaces that exist in this arena. This is a concept that Giordano (2003) explores when he examines shared resource use and allocation in common spaces. Defining a basic typology of these shared spaces, Giordano argues, is the first step towards workable solutions for their sustainable management. He goes on to define different ways that these spaces overlap, different ways that resources shift between these spaces, and how these all vary with scale. By establishing these definitions and mapping them, we can more easily begin to see when and why there are imbalances in power or equity. At a very basic level, problems can occur when a resource overlaps the space of two or more resource users. An imbalance occurs when a resource can be exploited within the space of one user while the brunt of the cost is transferred to the space of another user. Taking advantage of these basic typologies, maps can show winners, losers, and the connections between humans, wildlife, and the natural resources on which they depend.

Application

As mentioned above, tracking wildlife can be seen as a form of representation used to foster connection and understanding with the public and diverse stakeholders. By analyzing these tracks and mapping how wildlife interact with and use their space, as well as interact with human-defined boundaries and human uses, we can also try to foster a better understanding of the ecological needs, threats, and effectiveness of areas set up to protect them. As an example, the project I am currently helping with in the Ross Sea (Antarctica) is tracking hundreds of individual penguins throughout their annual winter migrations. The information collected will also include diving data which can provide information on their feeding behavior. Using the critical approach taken by geographers, cartographers, and conservationists, I would like to use the data collected within the Ross Sea penguin project to develop

and then assess the effectiveness of various map iterations depicting penguin use of space and resources. The overall goal here would be to assess the impact of these maps on people's opinions and perceptions of the Ross Sea Region Marine Protected Area (MPA).

Focusing on boundaries, one set of maps will explore how penguins cross human-defined borders (e.g. no-fishing zones, restricted fishing zones etc) several times during their migrations, passing into and out of different legal protections. Ecological boundaries important for the penguins, such as the Antarctic circumpolar current where ocean upwelling and therefore productivity is high, can be depicted. Rather than be shown as static lines, I'll explore how natural boundaries can be drawn to show the intra- and inter-annual variations penguins encounter.

To address representation, a second set of maps exploring individual voices will be created. For some of the penguins tracked throughout the project, data across three years of their life have been collected. Maps can be made to show how an individual penguin's migration varied from year to year, highlight how the conditions it encountered varied between those years, how it responded differently or not than others to these changes, and show ecological processes relevant for the bird. Information about the individuals (e.g. age, sex, how many chicks it raised) can also be shown.

A third set of maps that focuses on space will also be created. It will show the variations in scale that penguins deal with during their migration. For example, a large-scale map can show the ocean gyres which likely are important for shaping the overall migration route. Inset maps can show things that work on smaller scales like the types of sea ice conditions that penguins prefer to spend their time in or how penguin feeding behavior changes depending on what part of their migration they are at.

An initial more typical map indicating only the boundaries of the MPA will be shown to people together with a set of dichotomous and Likert scale questions about the importance and effectiveness of the MPA. A second map addressing one of the three critiques (boundaries, representation, space) will

then be shown to participants and they will be asked follow up questions about their opinion of the MPA. I hypothesize that people will view the MPA as less effective but more important when shown the second map. Differences in how the second map changed opinions (if at all) can be explored through a final set of questions focusing on just that. Results from these surveys will be used to identify and assess map elements that drive opinions of protected areas and will also be used to develop a final map or set of maps that can be used for educational or outreach purposes.

Citations

Adams, William M. 2019. “Geographies of Conservation III: Nature’s Spaces.” *Progress in Human Geography*, March, 0309132519837779. https://doi.org/10.1177/0309132519837779.

Agardy, M. Tundi. 1994. “Advances in Marine Conservation: The Role of Marine Protected Areas.” *Trends in Ecology & Evolution* 9 (7): 267–70. https://doi.org/10.1016/0169-5347(94)90297-6.

Alessa, Lilian (Naia), Andrew (Anaru) Kliskey, and Gregory Brown. 2008. “Social–Ecological Hotspots Mapping: A Spatial Approach for Identifying Coupled Social–Ecological Space.” *Landscape and Urban Planning* 85 (1): 27–39. https://doi.org/10.1016/j.landurbplan.2007.09.007.

Beier, Paul, and Brian Brost. 2010. “Use of Land Facets to Plan for Climate Change: Conserving the Arenas, Not the Actors.” *Conservation Biology* 24 (3): 701–10. https://doi.org/10.1111/j.1523-1739.2009.01422.x.

Carolan, Michael S. 2009. “‘This Is Not a Biodiversity Hotspot’: The Power of Maps and Other Images in the Environmental Sciences.” *Society & Natural Resources* 22 (3): 278–86. https://doi.org/10.1080/08941920801961040.

Crampton, Jeremy W, and John Krygier. 2006. “An Introduction to Critical Cartography,” 23.

Cresswell, Tim. 2012. *Geographic Thought: A Critical Introduction*. John Wiley & Sons.

Fox, Jefferson. 1998. “Mapping the Commons: The Social Context of Spatial Information Technologies.” *The Common Property Resource Digest*, no. 45: 1–4.

———. 2002. “Siam Mapped and Mapping in Cambodia: Boundaries, Sovereignty,and Indigenous Conceptions of Space.” *Society & Natural Resources* 15 (1): 65–78. https://doi.org/10.1080/089419202317174020.

Gilmore, Michael P., and Jason C. Young. 2012. “The Use of Participatory Mapping in Ethnobiological Research, Biocultural Conservation, and Community Empowerment: A Case Study From the Peruvian Amazon.” *Journal of Ethnobiology* 32 (1): 6–29. https://doi.org/10.2993/0278-0771-32.1.6.

Giordano, Mark. 2003. “The Geography of the Commons: The Role of Scale and Space.” *Annals of the Association of American Geographers* 93 (2): 365–75. https://doi.org/10.1111/1467-8306.9302007.

Harley, J. Brian. 1989. “Deconstructing the Map.” *Cartographica* 26 (2): 20.

Harris, Leila, and Helen Hazen. 2011. “Rethinking Maps from a More-than-Human Perspective: Nature–Society, Mapping and Conservation Territories.” Rethinking Maps. June 2, 2011. https://doi.org/10.4324/9780203876848-9.

Hazen, Helen D., and Leila Harris. 2006. “Power of Maps : (Counter) Mapping for Conservation.” University of British Columbia. https://doi.org/10.14288/1.0357973.

Kareiva, Peter, and Michelle Marvier. 2003. “Conserving Biodiversity Coldspots: Recent Calls to Direct Conservation Funding to the World’s Biodiversity Hotspots May Be Bad Investment Advice.” *American Scientist* 91 (4): 344–51.

Koester, Tai. 2019. “The Cartographic Destruction of Bears Ears: Dispossession, Creating ‘Public’ Land, and Fighting for Indigenous Conceptions of Space.”

Lambeck, Robert J. 1997. “Focal Species: A Multi-Species Umbrella for Nature Conservation.” *Conservation Biology* 11 (4): 849–56. https://doi.org/10.1046/j.1523-1739.1997.96319.x.

Leblond, Jean-Philippe. 2014. “Thai Forest Debates and the Unequal Appropriation of Spatial Knowledge Tools.” *Conservation and Society* 12 (4): 425. https://doi.org/10.4103/0972-4923.155588.

Lecours, Vincent. 2017. “On the Use of Maps and Models in Conservation and Resource Management (Warning: Results May Vary).” *Frontiers in Marine Science* 4. https://doi.org/10.3389/fmars.2017.00288.

Lescroël, Amélie, Raphaël Mathevet, Clara Péron, Matthieu Authier, Pascal Provost, Akinori Takahashi, and David Grémillet. 2016. "Seeing the Ocean through the Eyes of Seabirds: A New Path for Marine Conservation?" *Marine Policy* 68 (June): 212–20. https://doi.org/10.1016/j.marpol.2016.02.015.

Leslie, Heather M. 2005. "A Synthesis of Marine Conservation Planning Approaches." *Conservation Biology* 19 (6): 1701–13. https://doi.org/10.1111/j.1523-1739.2005.00268.x.

Loarie, Scott R., Philip B. Duffy, Healy Hamilton, Gregory P. Asner, Christopher B. Field, and David D. Ackerly. 2009. "The Velocity of Climate Change." *Nature* 462 (7276): 1052–55. https://doi.org/10.1038/nature08649.

Martino, Diego. 2001. "Buffer Zones Around Protected Areas: A Brief Literature Review." *Electronic Green Journal* 1 (15): 20.

Monmonier, Mark S. 1991. *How to Lie with Maps, Third Edition*. University of Chicago Press.

———. 1995. *Drawing the Line: Tales of Maps and Cartocontroversy*.

Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A. B. da Fonseca, and Jennifer Kent. 2000. "Biodiversity Hotspots for Conservation Priorities." *Nature* 403 (6772): 853–58. https://doi.org/10.1038/35002501.

Naughton-Treves, Lisa, Margaret Buck Holland, and Katrina Brandon. 2005. "The Role of Protected Areas in Conserving Biodiversity and Sustaining Local Livelihoods." *Annual Review of Environment and Resources* 30 (1): 219–52. https://doi.org/10.1146/annurev.energy.30.050504.164507.

Neumann, Roderick. 1997. "Primitive Ideas: Protected Area Buffer Zones and the Politics of Land in Africa." *Development and Change* 28 (3): 559–82. https://doi.org/10.1111/1467-7660.00054.

Palomo, Ignacio, Berta Martín-López, Marion Potschin, Roy Haines-Young, and Carlos Montes. 2013. "National Parks, Buffer Zones and Surrounding Lands: Mapping Ecosystem Service Flows." *Ecosystem Services* 4 (June): 104–16. https://doi.org/10.1016/j.ecoser.2012.09.001.

Pavlovskaya, Marianna, and Kevin St Martin. 2007. "Feminism and Geographic Information Systems: From a Missing Object to a Mapping Subject." *Geography Compass* 1 (3): 583–606. https://doi.org/10.1111/j.1749-8198.2007.00028.x.

Peluso, Nancy Lee. 1995. "Whose Woods Are These? Counter-Mapping Forest Territories in Kalimantan, Indonesia." *Antipode* 27 (4): 383–406. https://doi.org/10.1111/j.1467-8330.1995.tb00286.x.

Roberge, Jean-Michel, and Per Angelstam. 2004. "Usefulness of the Umbrella Species Concept as a Conservation Tool." *Conservation Biology* 18 (1): 76–85. https://doi.org/10.1111/j.1523-1739.2004.00450.x.

Rocheleau, Dianne, Barbara Thomas-Slayter, and David Edmunds. 1994. "Gendered Resource Mapping: Focusing on Women's Spaces in the Landscape." https://vtechworks.lib.vt.edu/handle/10919/68994.

Roth, Robin. 2009. "The Challenges of Mapping Complex Indigenous Spatiality: From Abstract Space to Dwelling Space." *Cultural Geographies* 16 (2): 207–27. https://doi.org/10.1177/1474474008101517.

Rundstrom, Robert A. 2006. "Mapping, Postmodernism, Indigenous People And The Changing Direction Of North American Cartography." *Cartographica: The International Journal for Geographic Information and Geovisualization*, October. https://doi.org/10.3138/5J46-51T2-7M42-316G.

Sanderson, Eric W, Kent H Redford, Amy Vedder, Peter B Coppolillo, and Sarah E Ward. 2002. "A Conceptual Model for Conservation Planning Based on Landscape Species Requirements." *Landscape and Urban Planning* 58 (1): 41–56. https://doi.org/10.1016/S0169-2046(01)00231-6.

Saout, Soizic Le, Michael Hoffmann, Yichuan Shi, Adrian Hughes, Cyril Bernard, Thomas M. Brooks, Bastian Bertzky, et al. 2013. "Protected Areas and Effective Biodiversity Conservation." *Science* 342 (6160): 803–5. https://doi.org/10.1126/science.1239268.

Sayre, Roger, Jack Dangermond, Charlie Frye, Randy Vaughan, Peter Aniello, Sean Breyer, Douglas Cribbs, et al. 2014. *A New Map of Global Ecological Land Units — An Ecophysiographic Stratification Approach*. Washington, DC: Association of American Geographers.

Semlitsch, Raymond D., and J. Russell Bodie. 2003. "Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibians and Reptiles." *Conservation Biology* 17 (5): 1219–28. https://doi.org/10.1046/j.1523-1739.2003.02177.x.

Stoms, David M., and J. E. Estes. 1993. "A Remote Sensing Research Agenda for Mapping and Monitoring Biodiversity." *International Journal of Remote Sensing* 14 (10): 1839–60. https://doi.org/10.1080/01431169308954007.

Stralberg, D., D. Jongsomjit, C.A. Howell, M. A. Snyder, J.D. Alexander, J.A. Wiens, and T.L. Root. 2009. "Re-Shuffling of Species with Climate Disruption: A No-Analog Future for California Birds?" *PLoS ONE* 4 (9): e6825. https://doi.org/10.1371/journal.pone.0006825.

Vandergeest, Peter. 1996. "Mapping Nature: Territorialization of Forest Rights in Thailand." *Society & Natural Resources* 9 (2): 159–75. https://doi.org/10.1080/08941929609380962.

Wiens, John A., Nathaniel E. Seavy, and Dennis Jongsomjit. 2011. "Protected Areas in Climate Space: What Will the Future Bring?" *Biological Conservation* 144 (8): 2119–25. https://doi.org/10.1016/j.biocon.2011.05.002.

Wood, Denis. 1992. *The Power of Maps*. Guilford Press.

Zimmerer, Karl S. 2000. "The Reworking of Conservation Geographies: Nonequilibrium Landscapes and Nature-Society Hybrids." *Annals of the Association of American Geographers* 90 (2): 356–69. https://doi.org/10.1111/0004-5608.00199.