Rivers Run Through It: An Actor-Network Theory Approach to the Textual Analysis of a Forest Plan

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Abstract

This essay posits an actor-network theory (ANT) approach to the interpretation of an environmental text in land and resource management planning. As scientific thought and practice come to embrace complexity over linearity as the guiding paradigm, so too are human-nature relationships reconstituted and renegotiated accordingly in environmental science writing. Through an ANT-inspired lens, which celebrates rather than suppresses or ignores the power of nonhuman actors, we analyze a 2013 United States Department of Agriculture (USDA) text: The Final Environmental Impact Statement (FEIS) for the Revised Land Management Plan (MP) of the Idaho Panhandle National Forests (IPNF). Our reading pays special attention to the text's portrayal of stream ecology and its relationship to forest ecosystem functioning for illustrative purposes. In doing so, we continue building groundwork for inter- and transdisciplinary environmental thought in twenty-first century environmental science. We argue for the importance of actor-network theory in environmental studies because it amplifies the agency of nonhuman actors, a realization with resonant meaning for human thought and action in natural resource decision making. Equally, while ANT has been met with popularity in writing studies, we seek to add an environmental focus on primarily nonhuman activity.

Introduction

There is an increasing volume of environmental literature in today's scientific and technical communication. Accordingly, there is a need for approaches to textual analysis that can comprehend and even honor the complexity of the natural systems that these environmental technical documents describe. Building on recent enthusiasm for the subject in our field of rhetoric and writing studies, we employ an interpretive lens inspired by actor-network theory (ANT) to analyze a relatively ordinary 2013 United States Department of Agriculture (USDA) text: The Final Environmental Impact Statement (FEIS) for the Revised Land Management Plan (MP) of the Idaho Panhandle National Forests (IPNF), which we hereafter abbreviate simply as the MP.

Actor-network theory (ANT) was developed in the late twentieth century by sociologists of knowledge who rejected positivist and modernist claims that science has privileged access to truth and that scientific studies are definitive and permanent. This approach to research and inquiry has been used traditionally to understand human social organization by placing special emphasis on **actors**, both human and nonhuman, living and nonliving, and the **networks** in which they move and interact—the traceable, temporarily stable relations and translations that occur among sets of actors. These

Presented at ***Waterlines: Confluence and Hope through Environmental Communication***
The Conference on Communication and Environment, Vancouver, Canada, June 17-21, 2019
https://theieca.org/coce2019

concepts, called such, have been developed chiefly by sociologists—most prominently, Bruno Latour, as articulated in *Pandora's Hope* (*PH*) (1999) and *Reassembling the Social* (*RS*) (2005).

In rhetoric and interdisciplinary writing studies, the ideas of John Law, Michel Canon, and particularly Bruno Latour have had considerable uptake and adoption in recent years (Gries, 2013; Gruber, 2014; Kessler and Graham, 2018; Lynch and Rivers, 2015; Pihlaja, 2018; Potts and Jones, 2011; Spinuzzi, 2008; Spinuzzi et al., 2016; Swarts, 2010; Walsh et al., 2017). For scholars theorizing the way writing works (and *does work*) in the world, actor-network theory offers a valuable methodological and dispositional take on texts (**inscriptions**) of various kinds that significantly also participate as actors in networks of interrelated activity. More broadly, there is a substantial body of scholarship in the environmental humanities across disciplines that applies posthuman and new materialist perspectives to human/nature cultural artifacts. None yet, however, has juxtaposed ANT with forest and resource management planning, a field that attempts to account for the dynamics of environmental change in human terms and chart the course of pragmatic collective action--that is, environmental management--in sync with those changes.

The environmental setting for this study is the Idaho Panhandle National Forest (IPNF), an area of 1.5 million acres that comprises much of the northern part of the state. We have used the MP, a document of over six hundred pages, as the source for information about this site--for this network, our point of **translation**. The plan includes rich descriptions of the landscape and the animal, plants, and people there. We are especially interested in the section of the Plan concerning "Watersheds, Soils, Riparian and Aquatic Habitats, Aquatic Species" that literally and conceptually brings many living and non-living features together. Stream ecology, in fact, is the heart of our analysis; stream health is remarkably telling of forest ecosystem functioning as a whole. We note here the manner in which the site is described and interpreted by biologists who study animals and plants and geophysicists who study physical features; scientists and other experts who, through the text, position themselves as "spokespersons" for nonhumans in the forest.

Whereas some studies feature prominent human actors and cast nonhuman actors as mere supports, our work is less traditional or orthodox in that it seeks to describe primarily nonhuman activity. Just as ecology and environmental science have come increasingly to embrace complexity over reductivism in thought and practice, so too must the study of texts be conducted in ways that value, rather than suppress, complexity. We adopt a reading of this text that attempts, inductively, to identify and unpack (Kessler and Graham, 2018, p. 125) the many simultaneous actors (i.e., the "collective of participants," *PH*, p. 174) of an ecological network. In doing so, this essay extends ANT: its use to examine nonhuman actors only. While this is a speculative and theoretical exercise rather than a practical or problem-oriented one for writing practice or on-the-ground management of natural resources, we find this lens evinces much of the scientific paradigm at work in the enactment of the Plan and holds resonance for environmental thought and studies.

To begin, we define the terminology that influences our reading of this text and note the limitations of our own study. We follow this short primer with a verbal and visual description of the network in which the Forest Plan participates, underscoring rivers, trout, and benthic macroinvertebrates. Our study illustrates how the ANT approach to this environment plays out with two examples: the way that rivers are characterized, and a specific case of an endangered species, the bull trout, and how its behavior and habitat are described. We conclude with a discussion on a difficult problem in environmental studies: the fragmentation of disciplinary thinking in scientific studies, which rhetoric may be uniquely poised to ameliorate—re-assembling the assembly.

Environmental Studies and Actor-Network Theory

You are aware… in your own experience--that all human progress is in a circle; or, to use a more accurate and beautiful figure, in an ascending spiral curve. While we fancy ourselves going straight forward, and attaining, at every step, an entirely new position of affairs, we do actually return to something long ago tried and abandoned, but which we now find etherealized, refined, and perfected to its ideal.

—Clifford Pyncheon in Nathaniel Hawthorne, *House of the Seven Gables*

We see the environment as "something at once invisible yet tangible, taken for granted yet surprising, mundane but of baffling subtlety" (*RS* p. 21, on society). It is already assembled—not found or made up or created by scientists. The work of the scholar is to determine "the nature of what is or what is assembled" (*RS* p. 1). The environment is not somehow a "whole," because it is always changing, and it cannot be fully experienced or described. The researcher's "extreme attention to the vagaries of experience" opens up an ocean of uncertainties and "a much vaster backdrop of discontinuities" (*RS* pp. 243, 245). We use "environment" as a convenient term that includes the more-than-human natural world—biological, geological, physical—*and* human associations. We treat the actors in that collective as being equals; that is, we do not claim that either is (*a priori*) more important or more powerful than the other. Even so, we know that disparities in power exist: floods, pollutants, natural parasites, and population imbalances are just a few of the natural forces with potential to overpower, dominate, or kill.

The role of nonhuman actors in the environment seems obvious (to us), but this point has not been fully developed in other ANT studies. Though ANT claims to disregard the society/nature binary, ANT has focused almost entirely on social (i.e., human) activities. Examples in Latour's *Pandora's Hope* and most ANT-based studies involve several human actors and one nonhuman one, such as scallops in Callon (1986), the water pump in de Laet and Mol (2000), or information technology in Swarts (2016). A few studies have associations within complicated technologies (*RS* pp. 194-202 on the lecture hall; Bennett (2010) on power grid). Our approach, then, fills in a significant gap: primary attention to nonhuman actors. Harman (2014) points to the omission of "thing-thing" relations in Latour's program, and he accounts for that because "he does philosophy of science not philosophy of nature" (44).

Every segment of the environment, from a spoonful of dirt to a forest, contains thousands of nonhuman actors. Even though they are richly heterogeneous, nonhuman actors are associated with one another in a network through observable traces. The actors' multiple and entangled associations are dynamic and unstable, both at the current moment and over time, yet many occur simultaneously in contiguous parts of the environment (see Brooks, 2012). Actors are also affected by distant materials and faraway actors in both space and time. In many cases these associations are readably observable by humans, although some are microscopic, while others take place at a massive, sometimes global scale. Associations, for example, between animals and what they eat involves the concatenation of what is available, both animals' health and breeding cycles, as well as local topography and the season of the year. When these associations are traced and how they change over time and in different spaces, there is no credible way to identify causes and effects, or linear and deterministic paths that lead to specific outcomes. Some actors have more associations than others, so they may contribute more to the stability of the network. Interactions are relational, diffused, and fluid; for empiricists, then, only consequences can be described. For humans and obviously for nonhumans, "agencies over which we have no control make us do things" (*RS* p. 50).

Once actors are identified, the next step is to trace their associations in a network with other actors. A significant feature of a network is to recognize that associations are multiple and tangled, often uncertain and unpredictable, and can lead to chains that are quite long and associate actors distant both in time and place. Movement in a network is fluid, flexible, and ongoing: it does not have a final place where it stops, and it can be changed when new actors are recognized, "enrolled," and included. The result is an assemblage that can be mapped in two dimensions. It is topologically "flat," emphasizing the distributed agency of humans and nonhumans and the complexity of their associations. Through the network, actors are "associated in such a way to make others do things" (RS 107); therefore "any thing that does modify a state of affairs is an actor" (*RS* p. 71); "things might authorize, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid and so on" (*RS* p. 72). Intermediaries bring actors into association without changing them and are passive, while mediators "transform, translate, distort, and modify the meaning of the elements they are supposed to carry" (RS 39). The relay of mediators flows in and out of the unstable network.

Owing to the methodology's development and popularization in sociology, most ANT studies are about situations that coarticulate human and nonhuman actors in institutions (such as business settings and citizen groups) with a mind to the construction and practice of power and authority in sociotechnical systems ("working together to accomplish a goal or set of goals," Kessler and Graham, 2018, p.123). Often, networks involve one important nonhuman actor, such as the texts that emerge from a scientists' laboratory, or a technology, such as computers and online social networks.

However, ANT can serve as a powerful analytic tool to highlight the complexity of the world in which environmental impact statements and related sets of texts participate. Environmental impact statements, which synthesize a broad range of both "natural" and "social" concerns, provide more compelling and comprehensive descriptions than those that are advanced in more narrowly focused primary scientific literature. In our estimation, ANT also lends a more honest and humble perspective than studies that paint humans as synoptic observers or, more often, despoilers of the remote natural world. Its call for empiricism re-positions the researcher to be open, perhaps even surprised or challenged, to understandings that may emerge inductively. The ANT approach begins by having the actors "speak for themselves" and prompts the researcher to listen to what humans say about themselves, and to describe what nonhumans do, how they act, both of which leads to traceable associations. We also find that ANT is advantageous for environmental studies for its flexibility; it allows the addition of new actors in a network with relative ease--for example, when one has been overlooked or a new one has been discovered.

ANT is widely recognized as not being a theory as such, but, like grounded theory, as a radically empirical approach that can lead heuristically to theoretical claims. It has thus been called a toolkit, analytical methodology, or "sensibility" (Law 2004, p. 157). It rejects the idea of imposing theoretical perspectives such as those from social sciences—economics, sociology, or psychology—as ways to explain or interpret the observations. The "theory" in actor-network theory, then, which should emerge inductively from the analysis rather than imposed from the onset, can take many forms, including the political (how power is or can be exercised), moral/ethical (including ideological values), or sociological (on the involvement and effects of social institutions and citizens or the government).

It is important to note that ANT is not, itself, singular or novel in its epistemology. As a coined term, it originated in twentieth century French philosophy of science, but its essential tenets precede Latour (and, concurrently, exists outside of the ANT framework, as evidenced variously in pre-Modern Western thought and in Eastern and indigenous perspectives). Given the subject of our discussion (i.e., land and resource management), this is an especially critical point to make. In this work, we specifically name ANT as our methodological vehicle of choice to link up with current conversation in our field of rhetoric, writing studies, and technical communication (and call attention to an as-yet underexplored context for this type of work, which is natural resource planning). In doing so, we simultaneously recognize a wealth of compatible approaches under different names. For example, in her discussion of literary history, Lisa Brooks (2012) examines digital modes of storytelling that allow for a spiral, rather than linear, view of (deep) time and multiple, simultaneous actors--at times, even, across vast *distances* of space and time. Like Brooks, then, we emphasize the need for "new old modes and methods of [textual] interpretation" (Brooks, 2012, p. 314). We, too, recognize that a text can include the site's past that extends to, and has traceable connections with, innumerable other times and places.

Finally, to scholars who associate ANT primarily with ethnographic methods and the "thick descriptions" they yield, our choice to analyze a single text might seem problematic. While texts are certainly "limited" in the sense that they are abstractions of lived realities and bound by the subjectivities of their authors, we adopt a view of the MP as a rich *inscription*,

…which is to say [that it is] not just… [a] "representation" of a complex reality that always eludes [it], nor just… [a] "sedimentation" of practices (May, 1997: 157-8), but [a] technology of translation and mediation, or "mobilization of the world" (Latour, 1999b: 99-100). This means grasping texts not as reflections of reality or reports on reality but as *enactments* of reality; they are means by which some things are made present and others absent, so that specific ontologies are performed into being and others made invisible. …Thus, far from being two-dimensional or ontologically "flat," texts are themselves hybrid; material things by definition, and therefore "objects" on a strictly modern view, texts as inscriptions also mediate the relations between subjects. Seen in this light, texts are not dislocated from practice but are intrinsic to practices – indeed there is scarcely a practice in the modern world which does not have its accompanying texts, often a panoply of texts, without which the practice would be deprived of the oxygen of its networks. Thus texts as mobile and material inscriptions are active agents which assemble, shape and connect practices, and in doing so enact objects, constitute subjects, and inscribe relations, ontological boundaries and domains (Nimmo, 2011, p. 114, emphasis in the original).

The MP as an object is tied to material realities that go far beyond (and can be, in ways, entirely divorced from) the physical setting of the Idaho Panhandle National Forests. We were unable to pursue ethnographic methods or field observations in this limited study, but can still, as readers, trace the work of this inscription in establishing an intricate network of human and nonhuman activity. We recognize the document's power as an actor in environmental management, influencing human decisions on-the-ground or far away, and forming human perspectives about the more-than-human world. With this in mind, we turn to our primary text.

The Actor Network of the Final Environmental Impact Statement (FEIS) for the Revised MP

A Note on Texts

National Forests are highly regulated sites. Policies come from federal and state statutes and legal regulations and court decisions. Historically, laws began with the National Environmental Protection Act (1970) and continued with other federal laws that included, for example, the Clean Water Act, the National Register of Historic Places, and the Environmental Justice Executive Order of 1994.

For practical reasons, however, since a complete portrait of a site is not feasible, a typical document is limited to depicting the actors and associations that are relevant to the authors' rhetorical task; in this case, proposing a Management Plan (i.e., decision) for the Forest.

Documents are what Latour calls "immutable mobiles," since the text is fixed once it is published and it permits many peoples' actions to take place at a distance and over time (Latour, 1986). Those actions are ideally held in an array of secure and stable surroundings (Law 2002. p. 93). They may also be seen metaphorically as "black boxes," stand-ins for networks that "shift attention away from a field of heterogeneous actors to their punctualized whole" (Swarts, 2010, p. 148). We use this metaphor to point to the reality of law and policy; the lay reader only knows about the input and output, but not how the policy works inside. (And, to be sure, there are plenty of actors in the actual Forest that are not mentioned at all in the text under our consideration.) Black boxes are difficult to open, to garner public support, or to correct or even maintain their workings. One result is that critics often fall silent or become frustrated (*RS*, p. 108). Public and political responses to environmental impact and assessment statements nicely illustrated the effect of the black box. Public reactions are usually based on newspaper stories, press releases, and web sites--in effect, then, based on observations of the inputs and outputs. The scientific and administrative evidence and reasoning that led to the result is widely ignored (for example, see Ross 2017).

We recognize, then, the human-centered "rhetorical situation" of a text like the MP. Our analysis focuses primarily, however, on the nonhuman actors enrolled by the text. Nonhumans include physical objects both living and artificial—animals and roads, for instance. "Inscriptions" are also actors; they are types of transformations where an entity becomes materialized into a written sign, a document, a map, a blog (*PH*, p. 306). For convenience we will use "documents" to identify those elements in our study. These documents are an important indicator of how humans associate with the nonhuman environment as well as how people communicate with one another. They become mediators that lead to legally-based or voluntary actions that respond to commands and recommendations that are proposed in the government document

The IPNF Watershed

We present our ANT-influenced map visually in (Figure 1) and verbally in the subsections that follow. Necessarily, all actors associated with the rivers are distributed across swaths of time and space that vary in length and size; all maps, then, are limited. The map is based on the chapter "Affected Environment and Environmental Consequences," which predicts changes throughout the Idaho Panhandle National Forest as a result of changed management practices, separated between the broad categories of the Physical and Biological vs. Human Uses and Designations of the Forest. Of interest to us, within the Physical and Biological category, is the subsection "Watershed, Soils, Riparian, Aquatic Habitat, and Aquatic Species." Our task, then, is to re-assemble the river. It is assembled as far as "nature" is concerned and from the perspective of the casual observer. The sciences have disassembled it, however, owing to training that emphasizes specialization, and to the unconnected statutes that have led to the Management Plan. We start with the geomorphology of the rivers and then transition to the nonhuman biological actors. Finally, we make note of the impacts of humans, even in this relatively remote setting.

The Final Environmental Impact Statement for the Revised Land Management Plan (MP) covers the major drainage basins of Saint Joe River and Upper Little North Fork Clearwater River, Coeur d'Alene River and Lake, Pend Oreille Lake Basin and Lower Clark Fork in Idaho, Priest River Basin, and Kootenai River in Idaho, including Moyie River (MP, p. 168), with particular focus on the subwatersheds

(6th-level hydrologic units each marked by a 12-digit hydrologic unit code, or HUC) within these larger areas (p. 157). Stream and riparian habitats are especially intriguing to us because of the text's stated emphasis on their movement and responsivity. "Although riparian ecosystems cover a relatively small portion of the Forest," the MP acknowledges, "their ecological significance within the landscape exceeds their limited distribution. Riparian ecosystems can be highly responsive to both natural and human disturbances, although they may respond to restoration activities more quickly than other habitats due to the dynamic interaction between water, vegetation, and soils" (p. 172).

This perception of environmental elasticity, where the boundaries between land and water are porous and constantly changing, lends itself well to the aim of our analysis. Since all actors are inherently (and always already) in relationship, observable processes give a window to momentary confluences of matter and movement--erosion, ecosystem functioning, and disturbance, to name a prominent few. Scientific studies on terrestrial actors include general geomorphic, landscape, and topographic features; soils, soil productivity, wild fires, drought, shading (from trees), solar radiation; natural, annual variation, and climate change and carbon sequestration.

Perhaps the most dramatic and large-scale actors in these systems are the geophysical. "Ecological drivers [i.e., actors] such as geology, climate, glaciations, and stream gradient all influence the type, complexity, quantity, and distribution of [riparian] ecosystems and there is great variability in the size and complexity of riparian areas across the Forest" (MP, p. 172). Such forces and processes as these shape, and have shaped, the topography of the continental northwest, giving rise to watersheds, the areas of land that drain to particular water bodies. Watersheds, like nesting dolls, can be defined hierarchically by size, but always intermingle and overlap. From small tributaries and headwaters, networks of streams arise, growing gradually in size from first-order stream classification, to second order, to third order, and so on. For as long as water keeps moving, rivers enroll new actors on a continual basis. Water circulates on, above, and below the surface of the Earth in its various states of matter and in accord with seasonal variations (e.g., spring flooding with the melting of snow).

As the text indicates, stream temperatures are influenced by a number of concurrent actors: shading and canopy cover, wind velocity, relative humidity, geomorphic factors, groundwater inflow, evapotranspiration from plants, and hyporheic flow, the interaction of surface water and groundwater (MP, p. 206, citing Caissie, 2006). Warmer temperatures, as affected by decline in shade cover and particularly (as the MP names) projected increases in air temperatures with projected decreases in summer stream flows, run the risk of prompting climate-induced local extinctions of some species (p. 207, citing Casola et al., 2005). Temperature is listed as a primary pollutant, the most ubiquitous of all those listed throughout the subwatersheds (p. 168). The effects of climate change on watershed ecology in Western North America are detailed more extensively in the Kootenai and Idaho Panhandle National Forests (KIPZ) Climate Change Report (USDA Forest Service 2010b); the MP cites this report at length.

Just as water is acting on the surface of the earth as it moves (in accord with gravity, precipitation, and wind) in a process observed as continual erosion, the terrestrial channel in turn directs the flow and velocity of each river and stream. Proximate trees, shrubs, and grasses act, too, in controlling the rate and path of drainage and percolation. In this particular region, the Pacific Northwest Cascade Range has, through centuries-old volcanic activity, characterized the particular forest soils in the IPNF. "Volcanic ash soils have lower bulk density, higher porosity, and higher water infiltration and retention than soils unaffected by ash," as the text describes (p. 169). Soil and vegetation disturbance, then, is a matter of keen concern in this context of forest-based watershed management.

In this rugged and mountainous landscape, stream gradient is typically high, and the beds of rivers and streams are rocky, the layering of which provides a diversity of niche space. Debris and fallen trees, boulders and cobble in the bed of the stream, snags and submerged logs, and tree litter in the stream all structure and support riparian macro- and microhabitats. Wildlife native to this area requires such complex and detailed habitats. For example, boulders placed in the stream (either by humans or by geologic forces) not only carve out spaces in the stream or river with their own specific hydrology and topography, but they also alter the chemistry of the water; they allow for riffles to form, which oxygenate and cool the water.

Pollutants also exert power in the network: metals, nutrients, and sediment are among those that are expressly named. The three actors around which the most concern gathers are 1) temperature, 2) roads, and 3) sediments. Nonhuman actors predominate in the discussion; anthropogenic activities are certainly named and described (such as the building and using roads for timber harvesting, timber harvest and prescribed fire, recreation, mining, dams and diversions, livestock grazing, and fire suppression), they are depersonalized. We have previously discussed the interaction of temperature, and we must also emphasize the dramatic changes that roads, in particular, affect in forest environments. Roads accelerate the erosion of streams and rivers; they are impervious surfaces that enable increased runoff, and therefore, increase delivery of sediments that become deposited in the stream, lowering oxygen, sunlight, and available habitat (p. x). Roads also fragment the habitat of fish and amphibians, posing the risk of death for migrating animals (p. 159). Timber and agricultural activities also contribute to accelerated erosion by way of removing riparian vegetation and compacting soil (making it more impervious). This, in turn, influences water volume and renders existing bodies of water vulnerable due to lack of buffer, storage, and capture of runoff. These same activities lead to increased biological production in the water (i.e., eutrophication), when nitrate levels from fertilizers make their way to the waterways become increased.

Related actors, then, include swamps, bogs, fens, marshes, peatlands and wetlands. Hydrological features include stream flows and channels, impediments, erosion, sediments; geological and morphological features; subwatersheds, stream beds and banks, the water table, aquifers, flood, runoff, drainage, pool (habitats), snow pack, stream temperature and distribution of thermally suitable habitat, pH and dissolved oxygen; dissolved and transported chemicals and solids; and water quality.

All of these geophysical actors, together, support, influence, and change the river’s biota. The Forest contains some of the most diverse and productive forests in the Northern Region of the Forest Service, home to several threatened and endangered plant and animal species. Grizzly bear, woodland caribou, Canada lynx, bull trout, and Spaulding’s catchfly are examples of some of these rare and listed animal species. Among terrestrial and aquatic wildlife are rare, native and nonnative, invasive and nuisance plant and animal species, macroinvertebrates, amphibians, woody species (shrubs), and birds. Habitat and behavioral studies include those of lynx and grizzly bears, and the spawning, egg incubation, fry emergence, rearing behavior of fish, as well as diseases. Individual animals and species are variously prey and predators.

The MP identifies bull trout, westslope cutthroat trout, interior redband trout, Kootenai river white sturgeon, pathogens, land vegetation (e.g., trees, shrubs, forbs, and grasses), aquatic vegetation, and amphibians (e.g., western toad and Coeur d’Alene salamander) among the actors within this stream ecology, singled out for attention because they are variously threatened. The list is only partial because statutes mandate certain attention to some species, and others--such as brown and rainbow trout, or the plethora of invasive plant species--are named because they are nonnative.

Noteworthy to observe are the river's "macroinvertebrate assemblage" (p. 191). Benthic aquatic macroinvertebrates are known to be management indicator species (MIS), meaning that they "can be used to reveal pollution problems and are ideal bioindicators of water quality for several reasons: they live in the water for all or most of their life; stay in areas suitable for their survival; easy to collect, differ in their tolerance to amount and types of pollution; relatively easy to identify in a laboratory [or streamside]; often live for more than 1 year; have limited mobility; and are integrators of environmental condition" (pp. 191-92). In rocky-bottom streams, macroinvertebrate larvae occupy niches in the stream--along stream banks, under rocks, within crevices, inside pools, around tree roots. The pollution-intolerant species, such as mayflies or caddisflies, require more oxygen and, therefore, when present in oxygenated riffles in the stream or embedded in the cobble, "reveal" good quality of the water. If fewer of these kinds of macroinvertebrates are found and more of the pollution-tolerant species are found (such as scuds or midges), a stream may be deemed polluted; the stream, very likely, lacks oxygen by way of excessive sediment and silts (in stream types that are not "naturally" so), for example, by excess of nutrients that can be traced to agricultural activity, or by high temperatures. Only one invertebrate is mentioned by name: western pearlshell (*Margaritifera falcata*), a state species of special concern in Idaho and included on the Region 1 Sensitive Species list (p. 191).

As this section demonstrates substantially, the MP takes great length to describe the bioregion (deemed in this genre as the "affected environment (existing condition)"), covering watershed disturbance, water quality, soils, riparian areas, and aquatic habitat and species in the context of evolutionary timelines. Environmental consequences forest-wide are considered for each alternative or inaction proposed (i.e., course of action). The section's penultimate subsection, "Cumulative Effects," shows that the authors of the text understand and expressly name as the work of actors as large-scale, underscoring our point that the text participates just as profoundly in the shaping of this environment as the other nonhuman actors; "Nearly all activities proposed in the revised Forest Plan have the potential to affect soil- and aquatic-dependent resources" (p. 205). The decision to point to "Climate Change" as the final chapter emphasizes its liminality and critical uncertainty, speculating on the futures of native fish populations.

Bull Trout

Bull trout as a species are threatened with possible extinction. Their status is defined by the Endangered Species Act (1973), and they were listed as "threatened" in 1999. As a result, the federal Forest, and Fish and Wildlife Services are obliged to report periodically on their status, for example, through the FWS 2015 Recovery Plan. This plan includes reports on the "core habitats" (limited stretches of streams), of "core populations" with an eye toward whether those populations are stable, getting better, or in decline, as well as (human) conservation measures that partly address those concerns. Bull trout, like macroinvertebrates, are also a "management indicator species" (MIS), so efforts maintain a healthy habitat can indicate the success of conservation.

Table 1 uses the actor-network concept of the "map" to depict the traceable associations among many nonhuman actors that affect the species. However, it is important to recognize that the network is comprised of dynamic, variable associations, the status of which is not always predictable and can vary on a daily and seasonal basis. The table brings together research, concepts, and theories from different sciences: biology, genetics, hydrology, the chemistry of soils and rivers, weather and climate. This map illustrates what we are calling the environmental reassembly of nonhuman actors. This network should be read vertically; that is, the actors make their associations down and up in the map. All of the agents need to be in place, functioning, and associating in order for the species to survive.

Table 1. Map of the bull trout network. The table depicts seasons and months (1), life history (2), morphology (3), food sources (4), water temperature (5), and habitat (6).

1	**Sum.**	**Fall**			**Winter**			**Spring**			**Summer →**	
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
2	Spawn		Egg		Larvae		Fry		Juvenal		Adult	
3	Eggs fertilize in 30 minutes		Egg incubation is 100-145 days		Larvae live off the yolk sac, then feed on their own; 200 days				Fry emerge from bed early April through May. They have a swim bladder and can move in the water column		"Rearing," 1 to 4 years until sexual maturity and can spawn. Spawning migrations begin as early as April	
4	Eggs fertilize in 30 minutes		Egg incubation is 100-145 days		Larvae live off the yolk sac, then feed on their own; 200 days				Fry emerge from bed early April through May. They have a swim bladder and can move in the water column		"Rearing," 1 to 4 years until sexual maturity and can spawn. Spawning migrations begin as early as April	
5	41°-48° F				35°-39° F				44°-46° F			
6	Cold water springs and ground water infiltration		Low gradient stream with loose and clean gravel on the bed; bed not covered with fine silt								To avoid predators, need bank cover from plants, woody debris	

The life cycle from eggs to adult takes place during a year, from late summer to the next summer [1,2]. Each has observable physical (morphological) and behavioral differences. Transitions take place over time, but the end points are well defined [3]. Fish at each stage depend on different food sources. While the timing may vary from one freshwater species to another, bull trout are unusually sensitive to water temperature; they need relatively cold water. The changing trout's habitat is centered on the stream bed until they are adults and can forage, migrate, and overwinter throughout the stream.

Bull trout reproduce. As natural processes, a significant portion of trout eggs are not fertilized; egg, larvae, and fry are eaten by other fish or die from natural causes. Disease does not seem to be a significant threat. Stages are traditionally grouped between spawning and rearing ("SR") rearing is conducted by the stream, not by adult fish, and foraging, migration, and overwintering ("FMO").

Genetic diversity [2] is important for species survival. Recent advances in the technology, like mitochondrial and microsatellite DNA tools, allow for rapid and inexpensive allele identification. For diversity, a favorable habitat needs connectivity and unrestricted passage for adult fish among populations within a watershed. On the other hand, isolation of small trout populations increases the likelihood of local extirpation. Spawning is threatened by the ability of non-native brown and rainbow trout to hybridize with bull trout. Most of the hybrids are sterile, so the energy to produce them is wasted.

The abundance and variety of food sources [4] within the stream bed for fry and in the stream itself for adults may change, although the ability of juveniles and adults to range widely suggests that local populations are often able to adapt. Predators, such as brown and rainbow trout with overlapping diets, are better adapted to higher temperatures and encroach on and compete with bull trout for prey.

Water temperature [5] is another actor. Bull trout are different from other salmonids since their survival at each stage is related to relatively cold water; if they get too warm at a given stage, they die. The temperature ranges are called "optimal" in the biological literature.

Climate change is an important actor because bull trout depend on cold temperatures throughout their life cycle. Increased air temperature leads to increased water temperature, lower summer streamflow, and higher flows in winter and spring that come from the decreased snow pack and earlier snow melt augmented by rain-on-snow events add to streambed scour and disturb the stream bed to threaten egg and larvae survival. The exact future temperature increase cannot be predicted, but nothing suggests that warming will be stopped.

Significant threats to the stream profile include increased silt loading, channel instability, and, as noted, significant seasonal changes in water-flow velocity that are attributed to climate change. Of these, increased siltification is the most overtly anthropogenic, especially by way of runoff from roads, timber harvesting, the clearing of land for livestock, and mining activities that disturb soils. To avoid predators and reduce energy costs, bull trout need cover from undercut banks with overhead vegetation and the presence of woody debris, which these activities work against. Recovery efforts include preserving existing shelters and mitigating the effects of human vegetation and debris removal.

A Rhetorical-Ecological Approach to Environmental Communication

An environmental site is a complete assembly and people typically experience it as such. The individual can notice elements (actors) and associations for many reasons—aesthetic: the reflection of the sunset on the lake; hydrological: backwater pools; biological: an egret fishing on the shore. A site is also dynamic, changing, and unstable. (*RS* 243). John Law has pointed out that "network" is a metaphor--for us, a concept, and a way to imagine--and Latour, that the metaphor is powerful because it is mostly made up of open spaces that we don't know much about (RS 242). The environment is not viewable all at once through a synoptic lens; descriptions are always "incomplete, open-ended, and hesitant" (RS 243). Further, "traceable connections … have always to be considered against a much vaster backdrop of discontinuities" (RS 245).

Writing about a site, therefore, involves choices that depend on what the writer knows, and the writer's subjectivities. At the USDA Forest Service, the writers' rhetorical purpose for composing the MP limits the information and topics to be included in this article. The document is designed to persuade readers to accept a version of the world, often so they will consider a specific course of future action.

To conclude the article, we address two concerns about the limits of the Management Plan and documents like it: disciplinary fragmentation of scientific studies, and the many and separated topics that exist under the national agenda of "environmental protection." While the document gives voice to nonhuman activity, it is, also, a reflection of the limitations of scientific practice that constitute it. Many scientific studies are narrowly defined and are limited by location and discipline. The article titles cited in the MP illustrate the specificity of topics: "Influences of temperature and environmental variables on the distribution of bull trout within streams at the southern margin of its range," "Life history, ecology and population status of migratory bull trout [*Salvelinus confluentus*] in the Flathead Lake and river system," "Climate regimes and water temperature changes in the Columbia River: bioenergetic implications for predators of juvenile salmon," and a bit more general, "Recent water temperature trends in the Lower Klamath River, California." These studies have involved a research team's intensive focus on the narrow topic that often took years to complete. Given their disciplinary focus, scientists do not, nor do they need to, acknowledge research outside their area of expertise. Science studies' rhetorical goal is to convey information to other specialists, and activities are limited by funding; they rarely suggest a plan of future action beyond the common "more research is needed."

Documents like the Management Plan (MP) bring together a range of scientific studies in order to make a case for a preferred and recommended course of future action. Ideally, the selected actors and the network in which they are associated (as we have illustrated in this article) can be successful in achieving the writers' rhetorical goals. The analysis in such Plans as these are not quantitative (statistical); instead, they are thematic in terms of habitat condition and stream structure. (Even the recent history of water temperatures is not presented quantitatively.) All of that points to the fact that plans like these are not themselves scientific studies (nor are they expected to be) but are based on such studies.

The founding document, National Environmental Policy Act (1970), envisioned an inclusive approach. It recognized the "impact of man's activity on the interrelations of all components of the natural environment…[recognized] further the critical importance of restoring and maintaining the environmental quality to the overall welfare and development of man" (sec. 101 [42 U.S.C. § 4331]). The Council on Environmental Quality is to report on "the status and condition of the major natural, manmade, or altered environmental classes of the Nation." Further, policies and laws shall "utilize a systematic, interdisciplinary approach which will ensure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making." However, the environment as a *concept* and environmental protection as a *practice* have become fragmented, owing to the complex "legal and administrative framework" (MP, p. 155). That framework includes the many federal, state, and local statutes, executive orders, regulations and policies, as well as court decisions that have accumulated since 1970.

The deep problem is that having separate jurisdictions or areas of legal responsibility does not give ways to write a single, coherent text that can reassemble the environment (see Enzler, 2012). For example, putting the Clean Air Act (1963), and Clean Water Act (1972) in concert and conversation with the focus on animals in Fish and Wildlife (1940), and Endangered Species (1973) and the focus on plants in the Forest Management Act (1976) and Invasive Species (1996) is no easy task. Even when these topics are brought together within a document, the heterogeneous nature of the statutes does not facilitate making connections among them. As another example, climate (and climate change) have associations in air, water, and land, and with nearly all the biological and geophysical actors in the Forest; some of those associations are not significant and general, while others are specific to individual actors. In our case, lower water levels and higher temperature affect the breeding habits of bull trout. Similarly, regular seasonal changes in temperature, sunlight, precipitation, length of days and nights, and other variables have consequences for most actors in a forest or any outdoor region (and humans). Seasonal variations affect daily and even hourly weather at local and general levels.

The bureaucratic structure of the Environmental Protection Agency (EPA) is one reflection of the problem. The Agency is organized along "media" lines, such as water, air and radiation, land and emergency management, chemical safety and pollution prevention. Each has a separate area of scientific expertise (McMahon, 2006, cited in Ross, 2016, p. 232; see also Boggs 1991 and Lawrence 2000). The agency itself recognizes the problem; a study of organizational structure in 2006 noted that the agency does not consider problems when the media are interrelated. Problems also exist since the regional offices do not adequately consider geographic connectivity across regions (EPA 2006). The EPA must be cautious about explicitly making connections between endangered species and water quality unless those connections are legally warranted.

The rhetorical purpose of documents like the Management Plan, as noted above, is to persuade readers to consider a specific course of future action. According to the EPA's Center for Environmental Quality (CEQ), the argument must "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment," its goal is "decision forcing" in order to get closure on the EIS process (CEQ). Typically, evidence in these reports takes the stance of what can be called Modernist science, where findings are presented as being objective, fixed, abstract, definitive, authoritative, and not disputable. The MP does identify some topics as being liable to multiple interpretations—most notably, climate change, whose role is not well defined in the face of recent observations and future projections concerning temperature and precipitation.

Ultimately, decision making by government agencies is a political act and does not necessarily need to follow the scientific rationale for the agency's recommendations. In precise terms, a cabinet secretary, in this case from the Department of Agriculture, allows the study to be conducted and funds it. He or she then approves, rejects, or changes the recommendations; the result goes to Congress for funding. The IPNF plan's main recommendations concern the readjustment of "Management Areas" within the Forest, from those with little human-caused changes (wilderness and wild & scenic rivers) to those with substantial human-caused changes (general forest and primary recreation areas) (pg. i). We do not address the complexity of political considerations in this study but recognize their heavy influence in the production and use of such texts as these.

Once the text is published, it fixes a present moment, a snapshot in time. The decisions in the text propose future courses of action. Futures are posited as combining continuities and disruptions of varying degrees of severity. In most cases, the actions are described thematically and in qualitative terms, rather than being quantified and probabilistic which may suggest more about the likelihood of a proposal's success that is warranted. As some readers may perceive, a possible problem with ANT is its incapacity for prediction. The assignment of "cause-and-effect" is only possible in retrospect. ANT resists the quantifiable statistical probabilities that underlie planning and policy decisions and only theorizes the future.

To make sense of both the human and nonhuman complexity of natural systems, then, we align the approach to textual analysis that we have advanced here with similar work emerging from such scholars as Caroline Druschke, Bridie McGreavy, Nathan Stormer, and Debra Hawhee. Rhetoricians in recent years have spanned the boundaries of our traditionally humanistic discipline to consider material, spatial, and nonhuman dimensions of rhetoric (and, conversely, the work of rhetoric to shape the world we inhabit). As an analytical tool, the rhetorical-ecological approach is especially well poised to harmonize scientific descriptions and put humans and nonhumans on equal conceptual footing. The approach, furthermore, is not restricted by disciplinary fragmentation, which is why we advance it here as a helpful interpretative lens for environmental technical writing in theory and scholarship. Further, as a productive tool, the approach can lend to credible and more intuitive writing about the environment based on detailed scientific descriptions of sites.

Echoing Greg Myers' (1996) call for researchers in writing studies to take note of science and technology studies, we, too, advance here less of a prescription for others to follow, but, more so, a "radical shift in perspective" (p. 36) that returns to, and reclaims, a pre-Enlightenment understanding of nature and human activity within it. Studies of environmental rhetoric will continue to benefit from developments in studies of science and technology, as Myers notes. While our takeaway of the human powerlessness to environmental change might be read by some as overly deterministic or nihilistic, we find the very recognition of ourselves as *participants in*, and not masters of, networks of interrelated activity to be, itself, a powerful call to action.

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So that it can detect the vulnerable places of a forest and send notifications to the forest officers so that they can rapidly go to those places and put out the fire. Thus they will require less time and can save more natural resources by putting out the fire easily. It could save millions of dollars.â€ Immediately as such detection of fires seem to one possible use case for artificial intelligence. If firefighters can respond or appropriate measures can be taken to conserve forests that would be beneficial if implemented with considerations to the consumption of energy by the algorithms used. To the doctoral students I had the good fortune of accompanying through some of their travails. Figure 1. This page intentionally left blank.Â The other approach does not take for granted the basic tenet of the first. It claims that there is nothing specific to social order; that there is no social dimension of any sort, no â€˜social contextâ€™, no distinct domain of reality to which the label â€˜socialâ€™ or â€˜societyâ€™ could be attrib-uted; that no â€˜social forceâ€™ is available to â€˜explainâ€™ the residual features other domains cannot account for; that members know very well what they are.