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RESEARCH ARTICLE

Using decision support tools in multistakeholder environmental planning: restorative justice and subbasin planning in the Columbia River Basin

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Abstract

Decision support tools have been shown to encourage the development of shared mental models about ecosystem dynamics when they are used in collaborative processes that bring together technical experts and other stakeholders on a regular basis over an extended period. However, when a diverse set of stakeholders is involved in environmental planning, the likelihood is high that participants will come to the table with significantly different capacities for using technological tools, different epistemologies, and different standpoints. We use the Columbia River subbasin planning effort in the northwestern USA as a case example for gaining a clearer understanding of how the use of decision support systems (DSS) affects who participates and how they participate in multistakeholder environmental planning processes. We also utilize an ethical analysis to examine the implications of the subbasin planning process. We found that the ways in which decision support tools are used (i.e., as flexible or rigid frames) as well as the structure of the planning environment influenced the quality of the data entered into the models, the quality of model output interpretation, epistemological plurality, and restorative justice. We conclude, from the perspective of restorative justice, that more attention and effort needs to be paid to past, present, and future harms to different stakeholder groups in subbasin planning. We suggest ways forward using a place-based perspective and also identify a persistent problem in knitting together local solutions into a larger scale framework.

Keywords DSS · Public participation · Ecosystem management · Restorative justice · Adaptive management · Environmental planning · Participatory modeling

Introduction

We use the Northwest Power and Conservation Council's (NPCC, formerly the Northwest Power Planning Council (NPPC)) subbasin planning effort in the northwestern USA during the early 2000s as a case example for gaining a clearer understanding of how the use of decision support systems (DSS) might affect who participates and how they participate in multistakeholder environmental planning processes. In advance of the research and analysis described here, we developed several research questions concerning the effects of integrating DSS into complex environmental decision-making processes: How are these technical tools influencing the decision-making process and what is the effect on breadth of public participation? When a computer-based decision support system arrives at the table, which stakeholders have their voice amplified and which have their voice diminished? What are the effects of DSS use on the range and depth of topics that are discussed? In which contexts and scenarios do these tools promote equity among the various stakeholders? In which do they reinforce existing power differentials? What is the effect on the distribution of costs, risks, and benefits? The methods described below were intended to address these questions in the context of our case study.

From the perspective of post-normal science, when uncertainties associated with management are difficult or

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impossible to reduce, normal science, which seeks "universal, objective, and context-free knowledge" (Haag and Kaupenjohann in Frame and Brown 2008, p. 227) and which "succeeds where the relative uncertainties are low….and the stakes and outcomes associated with decisions to be made are modest" (Kay et al. 1999, p. 737), is of limited value. Instead, post-normal science, "in which uncertainty is acknowledged and science is consciously democratised", is called for (Funtowicz and Strand 2007). In post-normal science situations, broad stakeholder involvement and reliance on extended peer communities have been identified as essential means by which the inherent complexities of socioecological and sociotechnological systems can be understood (Jonsson et al. 2011; Frame and Brown 2008; Healy 1999; Myskja 2007; Guimarães Pereira and Funtowicz 2006). Post-normal science does not dismiss the value of normal science, nor the need for rigorous and replicable scientific inquiry. Instead, post-normal science suggests additional methods that are typically left out or marginalized in complex socioecological problem-solving. Some of these additional methods may be themselves approaches to scientific inquiry (e.g., participatory research); others may be techniques that help facilitate more broadly based forms of knowledge quality assessment, such as extended peer reviews.

The methods of post-normal science are particularly well adapted to an analysis of the use of decision support systems in environmental planning. Decision support systems, based on approaches such as statistical modeling, dynamic modeling, decision-analysis, and expert-systems, often serve as focal points for building and institutionalizing extended peer communities. Decision support systems have been shown to encourage the development of shared mental models about ecosystem dynamics when they are used in collaborative processes that bring together technical experts and stakeholders on a regular basis over an extended period (Cockerill et al. 2004). DSS users conceptualize them as systems or tools, or they move back and forth between usages without regard to generally accepted definitions. As Keen (1980) writes "While the orthodox (academic) faith views DSS as tools for individual decision makers… users regard the concept as more relevant to systems that support organizational processes." The social learning that occurs through the process of identifying and discussing assumptions about how system components are related to each other helps "build consensus about the way the system works and which management options are most effective" (Costanza and Ruth 1998, p. 185). More detail on our use of post-normal science appears in the analysis section below.

Williams (2018) advocates for a pluralist approach to planning in post-normal contexts, in particular plural in the epistemological sense with multiple approaches to knowledge and science. He argues that a place-based orientation points toward this pluralist approach, in particular by integrating a technoscientific standpoint with a local knowledge orientation. Similarly, in a case study by Bremer and Funtowicz (2015), the researchers uncover three epistemological standpoints or narratives: a cultural one from an indigenous population, a "local" one from more recent settlers, and an "eco-scientific" narrative. All of these standpoints and stakeholder groups worked together to manage an estuary in New Zealand. The authors argue for the value of the post-normal approach to the "social and political production of science for sustainability" one that "moves from the strict modern scientific framework, in favour of an approach that recognises plurality, and promotes it according to principles of reciprocity and co-existence." The main tactical recommendation they make is that knowledge production be "framed, produced and deployed in the context of an extended peer community." In the section below, entitled "Analysis via the post-normal science lens," we present two anecdotes from our interview data that describe similar circumstances and we argue for similar solutions.

From the perspective of restorative justice, the use of DSS in subbasin planning and consequent stakeholder interactions raise issues that require expert ethical analysis as well as an examination of the nature of the planning process. We are proposing the suitability of the perspective and approach of restorative justice for this purpose. When dealing with competing claims made by diverse constituencies, it is based on an understanding of the ethics upon which restorative justice arguably stands:

> While admitting the importance of acting on principle, restorative justice also looks to the future as an intentional exercise focused on bringing forth the greatest level of well-being for those involved… Focusing on restorative justice and the model for ethics upon which it is based helps one to realize that planning commonly operates within a moral framework such as utilitarianism, yet such frameworks, largely taken for granted, are not scrutinized. Restorative justice implies a better moral framework that withstands greater scrutiny: a relationality-responsibility model for ethics. (Humphreys et al. 2014, p. 186)

It is important to note that the justice perspectives in our case study are place-based perspectives, often represented by the positions held by the Native American tribes in the Columbia River Basin and reflecting traditional ecological knowledge. Writing about place-making and natural resource management, Williams (2018) writes that the "idea of spacing natures points toward a critical-pluralist standpoint, which holds that no one research theory or program can successfully capture all the various facets of natural systems and integrate them together into a single view of reality." By integrating the two perspectives of post-normal science and restorative justice, we attempt to respond to this advice.

In this paper, we first describe the institutional framework established by the NPCC to guide subbasin planning in the US portion of the Columbia River Basin during the early 2000s. After outlining our methods and materials, the "Results" section describes how planning team structure, modes of operation, and DSS use modalities interacted to affect stakeholder involvement, degree of participation, power differentials among stakeholder groups, development of shared mental models, and planning outputs. In the "Theoretical analysis" section, we use the post-normal science and restorative justice lenses to interpret the results. In addition to serving as tools of analysis, these theories influenced our choice of research questions.

Subbasin planning as the context

In 2000, the NPCC, a major stakeholder in salmon recovery efforts in the Columbia River Basin, adopted an ecosystem management approach to its Fish and Wildlife Program. The building blocks of its ecosystem management framework are 48 subbasin plans covering 59 of the Columbia River's 62 subbasins. Forty-six of these plans were completed in a basin-wide planning process that took place between 2000 and 2005; the remaining two subbasins (Blackfoot and Bitterroot) were completed in 2010 and were not included in our analysis. The Council viewed subbasin planning as a crucial process by which diverse sets of stakeholders could develop the shared mental models of ecosystem dynamics needed to reach consensus on management objectives. Broad-based stakeholder involvement and decision support systems were considered essential to the production of plans that would be politically acceptable and scientifically credible.

In the eyes of the NPCC, the core challenge of subbasin planning was to develop an ecosystem-wide understanding of biological management objectives while taking into account local socioecological conditions and management priorities (NPPC 2000a). To address this challenge, the Council established a tiered management framework in 2000 to guide projects funded through its Fish and Wildlife Program. The framework had three distinct but linked planning levels corresponding to different geographical and managerial scales: the Columbia River Basin as a whole (level 3), 11 ecological provinces (level 2), and 62 tributary subbasins (level 1). Level 2 planning groups also dealt with tribal and state-level planning issues.

The Council identified watershed subbasins as the fundamental planning units and developed a three-part planning template for creating subbasin plans (NPPC 2001). The planning template called for planners to assess environmental factors limiting fish and wildlife recovery, inventory fish and wildlife recovery activities, and create a management plan with a vision statement, objectives, and implementation strategy. By requiring the subbasins to use a common template, the Council hoped to foster shared understandings of ecosystem dynamics across the Columbia River Basin as a whole. To ensure that the resulting plans were scientifically credible, the NPCC's Independent Scientific Review Panel (ISRP) and Independent Scientific Advisory Board (ISAB) reviewed the plans prior to their adoption in 2004 and 2005.

Between 2000 and 2003, the regional oversight committee worked with the subregional coordinating groups to develop decision support systems, planning guidelines, and an online basin-wide information management system (NPCC 2005). Once these elements were in place, the Council contracted with local entities, such as soil and water conservation districts, tribes, and counties, to lead the development of the subbasin plans. By the end of 2005, the Council had accepted 46 plans as amendments to its Fish and Wildlife Program (NPCC 2005). The 46 plans covered 57 subbasins as a few of the plans covered multiple subbasins.

Broad-based stakeholder involvement and the use of decision support systems were the two strategies used by the Council to foster shared understandings of subbasin ecosystem dynamics (NPPC 2001). In principle, the subbasin planning process was open to all stakeholders. In practice, most of the participants on subbasin planning teams worked for state, federal, or tribal natural resource agencies; soil conservation districts; irrigation districts; or local governments. Subbasin planning teams typically divided themselves into subgroups, often a core planning team and one or more technical teams. Technical team members were usually professionally trained biologists, ecologists, botanists, or hydrologists; core planning team members had more diverse educational and occupational backgrounds. The technical teams developed the subbasin assessments, identified limiting factors for fish and wildlife recovery, and inventoried fish and wildlife projects. The core planning teams coordinated the management plans, which included a vision statement, goals, objectives, and implementation strategies. The plans typically were crafted through an iterative and collaborative process involving much information exchange between subgroups.

Stakeholders could be involved as core planning team members, technical team members, meeting participants, plan reviewers, or any combination of these roles. However, the subbasins differed greatly in their approaches to stakeholder participation, and the extent to which a broad range of stakeholders participated in the different roles was correspondingly variable. In subbasins where broad-based stakeholder networks were poorly developed, such as Crab Creek (central Washington) and the Palouse (eastern Washington), the technical teams conducted the analyses and crafted the plans in-house in collaboration with the core planning team. The core planning teams then held public meetings to obtain feedback from other stakeholders regarding the vision, management objectives, and implementation strategies.

By contrast, in subbasins with well-established basin-wide collaborative planning networks, such as Fifteenmile (north central Oregon), Walla Walla (southeastern Washington), and Kootenai (northern Idaho and northwestern Montana), the planning subgroups organized numerous, often well-attended, meetings to guide the crafting of the technical analyses and the management plan components. Coordinators in these subbasins actively encouraged broad-based participation in all planning phases, including determining what data to use in technical analyses, interpreting output from decision support systems, and developing management objectives.

The use of decision support systems was the second means by which the Council sought to foster shared understandings of subbasin ecosystem dynamics. The Council initially recommended that all subbasin planning groups use an expert-system decision support tool known as Ecosystem Diagnosis and Treatment (EDT) (NPPC 2001). EDT was designed during the 1990s to identify limiting factors for fish focal species and prioritize habitat enhancement activities according to their likelihood for improving focal fish populations in a particular stream or river segment (hereafter "reach"). The Council believed that integration of EDT workshops into subbasin planning could be invaluable for participants to develop a more comprehensive understanding of complex phenomena and arrive at consensus. Moreover, summaries of EDT's numerical outputs could easily be included in the plans, making it possible for reviewers to independently assess the validity of the working hypotheses derived from the outputs. In areas where EDT was less appropriate or too difficult to implement, the Council suggested the use of Qualitative Habitat Assessment (QHA), a tool conceptually similar to EDT but supposed to be easier for laypersons to use and understand. Of the 46 subbasin plans completed during the subbasin planning process, 39 were developed using one or both of these decision support systems. Eleven teams used EDT only, 20 used QHA only, and 8 used both.

EDT is a proprietary model which was originally developed for the NPCC in the mid-1990s to analyze the impacts of hatchery fish supplementation on wild spring Chinook salmon populations (Lestelle et al. 1996). It is a rules-based system rather than a statistically based tool following a series of steps.[1] It examines how habitat attributes of a designated reach affect the performance of a focal species as measured by the "predicted number of fish supported by the habitat over the salmonid's life history" (Mobrand and Kareiva 1999, p. 2). The system's rules are based on data gathered from empirical research, scientific literature, and expert opinion. Over time, the model has been modified to address a range of habitat issues, additional salmonid and other fish species, and a few wildlife species.

A minimum of two distinct sets of environmental attributes are entered for each reach. Users typically develop one set for current reach conditions and one for pre-Euroamerican settlement reach conditions. The model runs compare fish population performance in each reach under the two scenarios. Additional model scenarios can be developed to compare the impacts of different management options. The model scenarios are planning alternatives described using the variables, parameters, and assumptions embedded in the EDT model.

EDT has several characteristics that limit its usefulness as a decision support tool for many of the Columbia River subbasins. The model was not designed to analyze limiting factors for resident (as opposed to anadromous) fish populations, and its adaptation for portions of the river blocked to salmon runs was time-consuming and expensive. Additionally, considerable technical expertise is needed to develop appropriate reach structures, gather baseline data, assign environmental attributes, run analyses, and interpret model output, and many of the subbasins lacked the technical expertise to use EDT without outside assistance.

EDT was viewed from the beginning by the NPCC as a valuable and accessible addition to subbasin planning. The NPCC perception of EDT followed that of the creators of the software, including Blair, Lastelle, and Mobrand, who write

> The model is a freely accessible, web-based tool… designed to work within a multi-stakeholder planning process. Through the support of model users, the public has free access to the EDT data, results, documentation and off-line tools… Fishery managers and other users have applied EDT to nearly every major salmon bearing stream in Puget Sound and the Columbia Basin… EDT reach level characterization has been applied to over 10,412 reaches in the Pacific Northwest representing 122 watersheds… EDT should be considered a tool to organize information in a watershed, a process to develop explicit hypotheses on how the environment is affecting salmon survival, and a process to describe how actions will affect the environment and ultimately salmon survival (Blair et al. 2009).

However, a Federal oversight panel composed of senior scientists (the Salmon Recovery Science Review Panel) questioned the apparent accessibility and utility of EDT stressing issues of complexity and the privilege it provides to apparent experts, stating that it "exemplifies how modeling should not be done.

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[1] Using the EDT model. Step 1—Delineation of water courses and standing water bodies into reaches categorized according to their hydrological characteristics (e.g., pond, riffle, tailwater). Step 2—Definition of the focal species under study (e.g., population name, spawning timing, harvest rates). Step 3—Description of environmental attributes of each reach (e.g., fish pathogens, bed scour, peak flows). Step 4—Ratings for environmental attributes may be based on empirical data or on expert opinion if empirical data are lacking. In the use of EDT, "experts" are most often defined as professional fisheries biologists working for state or federal agencies, and not local inhabitants or fishers familiar with the area. Step 5—Assignments of habitat quality and quantity ratings to each reach for each of the focal species' life cycle stages. EDT does this using a set of biological rules that relates reach conditions to survival of each life stage. Step 6—Prioritization of reaches in terms of their protection and restoration value relative to the population of the focal species under study. Step 7—Development and comparison of action plans based on reach prioritizations.

It is over-parameterized, includes key functional relationships that cannot be known and cannot be tested, creates a false sense of accuracy, yet introduces error and uncertainty. Its very complexity makes it difficult to determine the effect of various assumptions and parameter values on the model's behavior and relation to data. The attempt at quantification through subjective 'expert opinion' compounds these fatal weaknesses, especially the model's inability to confront and improve with confrontation of data." (Paine et al. 2000). The reliance on "experts" is reiterated in a description of the EDT process that noted "The EDT process examines streams in small pieces and analyses them according to 45 different attributes, a data-intensive exercise grafted on to many places where data is scant at best. Without much data, analysts are expected to add their "expert opinion," which critics say increases uncertainty even more for the non-statistically-based analysis." (Rudolph 2007).

To address EDT's limitations, Council staff members developed the QHA model, a much simpler model that relies solely on expert opinion for input data. Like EDT, QHA provides a framework for systematically assessing habitat conditions believed to affect selected focal species through the development of model scenarios (McConnaha and Parkin 2003). Based on these assessments, users can develop hypotheses about how different focal species would fare in a particular reach in response to different types of restoration and protection activities.

However, as described by McConnaha and Parkin (2003), QHA differs from EDT in that it uses many fewer habitat attributes (8 instead of 45) and relies entirely on expert opinion (rather than supplementing expert opinion with measured data when available) to assess habitat factors, assign ratings to reaches, and draw linkages between a focal species and habitat conditions. For output, QHA provides indices of habitat conditions in a reach rather than numerical estimates of productivity, abundance, and other factors related to the reach's ability to support fish. The steps for applying QHA to focal species analysis are similar to those for EDT. The users first decide what should be included in the spreadsheet and how the elements are related to each other. They then define the reach structure, score reach attributes, and assign priority rankings for restoration. These rankings are used to develop action plans for restoration and protection activities.

The user's guide for QHA (McConnaha and Parkin 2003, p. 2) articulates the rationale for using a qualitative approach.[2]

> "…[U]sing a quantitative approach may not make sense in areas where data are limited, when there is not enough time allotted to conduct a rigorous quantitative assessment, or where appropriate tools or expertise are not available. In these situations a more qualitative approach is indicated."

Methods and materials

The analysis in this paper depends primarily on documentary materials. Specifically, we reviewed several hundred NPCC subbasin planning documents produced between 2000 and 2005, including planning guidelines, draft and final plans, scientific reviews of the plans, public comments on the plans, and minutes from regional and basin-wide planning meetings. All of these documents are publicly accessible on the NPCC's website (http://www.nwcouncil.org/). During this assessment, team members also conducted both semistructured and informal interviews and participant observations at numerous salmon recovery planning meetings and field sites. Interviewees included NPCC council staff, ecosystem modelers, fishery scientists, and subbasin planning coordinators. In the current paper, we will use this material to illustrate correspondences between interview materials and the results of the textual analysis described below. A full analysis of the interviews, combined with the results of a survey already conducted, will be the subject of a subsequent paper.

To analyze the documentary materials, we used a deductive thematic analysis approach (Braun and Clarke 2006) on the independent scientific reviews of the 46 subbasin plans, public comments on the plans, and the public involvement sections of the subbasin plans themselves. We analyzed at a semantic level, in which "the themes are identified within the explicit or surface meanings of the data and the analyst is not looking for anything beyond what a participant has said or what has been written." (Braun and Clarke 2006, p. 84). Themes used to organize the analysis included the following: factors affecting plan quality, issues (positive and negative) associated with DSS use, and characteristics of public participation. We drew on planning guidelines, regional and basin-wide planning meeting minutes, and memos issued by the NPCC between 2000 and 2006 to contextualize the analysis. We coded the scientific plan reviews, public comments, and the public involvement sections of the subbasin plans to identify patterns of stakeholder participation (and nonparticipation) and power differentials with respect to the use of decision support tools and the overall planning process.

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[2] Although EDT is generally considered to be a quantitatively based mode, key informants indicated that in many instances planning teams used qualitative expert opinion as data for populating the EDT model. Limited time and funding frequently were cited as reasons why subbasin teams used expert opinion to populate the EDT model. However, EDT outputs were always expressed quantitatively and often reported with several apparently significant digits. Thus, the use of the EDT model at times served to mask the actual type of input data (qualitative vs. quantitative), while the QHA model produced data that were clearly qualitative. As we describe later, this distinction has important implications for the ability of stakeholders to critique model output, and affects whose knowledge counts in decision-making.

Results

Our analysis of the subbasin planning process documentation revealed that the use of decision support systems affected both who could participate and how different types of stakeholders could participate in subbasin planning. In subbasins where decision support systems were used, the technical team members defined reaches, scored reach attributes, and ranked reaches in terms of restoration priority. However, few of the technical teams had the expertise to use EDT on their own, and most of the subbasin teams that used EDT turned to outside consultants to run the model and interpret the results. Stakeholders not on technical teams had even fewer opportunities to interact with the decision support systems. Often those opportunities were difficult for many stakeholders to take advantage of or involved passive roles. For example, in most subbasins, the technical team meetings were open to the public. However, documentary analysis revealed that meetings often lasted for 4 to 6 h and were held during working hours on weekdays, making it difficult for stakeholders who were not paid to do so as part of their regular employment to attend meetings. Since these meetings were the primary venue where teams defined reach structures and assigned environmental attributes, stakeholders unable to participate in these meetings had fewer opportunities to scrutinize and comment upon the data that went into the models.

Our interview data suggest that the use of decision support systems did encourage the development of shared mental models of ecosystem dynamics within the technical teams. However, it is less clear that their use was conducive to the development of shared mental models among broader sets of subbasin stakeholders. One of the critiques voiced during an evaluation meeting held at the end of the InterMountain Province's subbasin planning process was that "the process was not layperson friendly based on daylong meetings on workdays, time requirements, and lack of time to educate lay people" (NPCC 2004a, p. 31). In commenting on the InterMountain Province's draft plan, another stakeholder stated that he was "disturbed about the obvious preference to remarks presented by the various State and Tribal agencies over citizen and private party proposals and requests" (NPCC 2004b, p. J-5). These comments indicate that stakeholders differed in their ability to participate in the use of decision support systems and in their opportunities to influence planning outcomes. An emerging hypothesis is that stakeholder groups with representation on the technical teams—primarily state, federal, and tribal fish and wildlife and natural resource agencies—had greater opportunity to influence planning outcomes and were more likely to arrive at shared understandings of the subbasin's ecosystem dynamics than other stakeholder groups since they interacted most extensively with the models.

Factors inhibiting the creation of shared mental models in subbasin planning

Our documentary analysis revealed that in the NPCC subbasin planning process, two major factors hindered the development of shared mental models among a diverse set of stakeholders. First, the decision support systems were used as rigid frames rather than as tools for exploration. Second, the planning environment was structured in ways that inadvertently limited stakeholder opportunities to engage with the technology. Both of these factors may have reduced the quality of the data entered into the models, the quality of model output interpretation, and the extent to which the models could respond to emerging management concerns, such as the impacts of global climate change.

Frame flexibility

Our documentary analysis, supplemented by selections from our stakeholder interview data, revealed discrepancies between how EDT is described in the literature and how EDT functioned in subbasin planning. Decision support systems, such as EDT and QHA, are rules-based systems that reflect assumptions about what aspects of ecosystem dynamics are important to consider when making management decisions, as well as how ecosystem components relate to each other. Such systems serve as frames that shape both the substance and format of the data that can enter the decision-making process and thus the model output as well. If the underlying rule structure of a decision support tool is transparent and easily modified, we describe the tool as providing a "flexible frame." If the rule structure is opaque or difficult to modify, we describe the tool as providing a "rigid frame." All frames inevitably exclude management options from consideration, but rigid frames are likely to exclude more options. The notion of "model frame" and its flexibility or rigidity are novel analytical tools we use below to analyze our data.

EDT is not inherently a rigid frame. Indeed, its developers emphasize that it is an exploratory model meant to help managers build testable hypotheses about the relative risks and benefits of alternative habitat restoration strategies on selected species (Lestelle et al. 1994). They envisioned it as a social learning tool that would be used in a multistakeholder workshop environment to arrive at shared understandings of habitat–fish production relationships, rather than as a tool for predicting precise salmonid population counts linked to different management options (Lestelle et al. 1994, 1996). Our documentary analysis revealed that over time, however, the social learning aspect of EDT received less emphasis. In our interviews, one key informant, who played an instrumental role in coordinating the use of EDT and QHA during the subbasin planning process, indicated that managers increasingly saw EDT as a tool for producing "hard numbers" to support management decisions and less as a tool for promoting social learning. We conclude that a tool intended to generate testable hypotheses largely morphed into a tool to affirm management decisions with apparently quantitative information.

One important characteristic of a flexible modeling framework is its capacity to incorporate new variables. For example, in participatory modeling efforts, stakeholders are involved early in the modeling process to suggest key variables and relationships (d'Aquino and Bah 2013; Pahl-Wostl 2006; Voinov and Gaddis 2008; Ginger 2014). Selecting a set of variables sets the boundary of the system under consideration by the model. To the extent that the model influences the decision-making process, these early choices play an important role in framing the problem, determining which questions can be asked and ultimately what decisions can be made. In the case of EDT's use in subbasin planning, 45 habitat variables were used to assess responses by salmon and bull trout populations to changing environmental conditions. Stakeholders were asked to populate this fixed set of variables and play a role in interpreting model output. However, based on documentary evidence, within the context of subbasin planning, they had no role in determining which variables were included in the model's framework.

In the course of our interviews, informants brought up several ways in which they felt the model imposed either a constricted or inappropriate frame for problem-solving. We identified two common concerns suggested by our interviewees: the model's lack of consideration of the impacts of global climate change or of land use, and human population change. Even if modelers were to respond to these concerns, the necessary changes to a rigid frame system would be very time-consuming and, according to documentary evidence, could not respond to the time constraints of the planning process. Other interviewees expressed concern that out-of-subbasin considerations were de-emphasized by the EDT model and in the planning process in general. Salmon spend much of their life cycle outside of their natal subbasin (e.g., in the mainstem of the Columbia River, in estuarine environments, and in the ocean), and many factors from outside of the subbasin affect their mortality rates (e.g., ocean conditions, the operation of the hydroelectric dams, harvest, etc.). Out-of-subbasin effects are included in the EDT model through a fixed set of smolt to adult survival rate (SAR) parameters that incorporate a range of out-of-subbasin effects. However, these fixed parameters are hidden inside the model and, unlike the 45 habitat variables, cannot be manipulated or examined. Although the assumptions in EDT can be modified, such modifications are unlikely to happen when planning timeframes are as short as documents revealed them to be in the subbasin planning process. We conclude that the structure and function of EDT as a rigid frame system assisted in setting a framework for planning that de-emphasized the consideration of out-of-subbasin effects. As a result, the space devoted to out-of-basin consideration in the final planning documents was minimal in comparison with the habitat considerations.

Stakeholder interactions with decision support systems

For collaborative decision-making processes in which decision support systems play a key role, the question of "Who has their hands on the knobs?" is as important as the question of who is present (or absent) at the table. The "hands-on-the-knobs" question, which we asked of interviewees who were present in EDT working sessions, speaks to the issue of at which points and in what ways different stakeholders interact with the decision support systems. In the NPCC case study, stakeholders could potentially interact with decision support systems in five ways: building the systems, entering data, running the model, interpreting the data, and responding to outputs and to others' interpretations of the model's outputs. However, we found documentary evidence that participation in the earlier phases of model use was heavily skewed toward stakeholders with technical backgrounds in statistics, biology, ecology, hydrology, and fisheries science. The stakeholders who built the systems (or funded or influenced their building) were primarily employees of federal, state, and tribal fish and wildlife agencies or universities. Professional biologists or ecologists who dominated the technical teams also participated disproportionately in data input and developing model scenarios for the model runs. One notable exception was in the Walla Walla subbasin, where documents reveal that a large number of stakeholders submitted model scenarios for model runs. Documents in general reveal that technical team members tended to dominate the data interpretation process in some subbasins, but in others, the data interpretation process was opened up to a broad range of stakeholders, including participants in the core planning teams, citizen committees, and multistakeholder workshops. For the majority of stakeholders, participation took the form of interpreting and responding to model outputs.

In most subbasins, documents show that relatively few stakeholder groups participated at points in the process where the decision frame was established or significantly narrowed. For the 18 subbasin plans with useable information on stakeholder participation, we coded the stakeholders into 18 categories. We combined these categories into two summative categories: AGENCY/TRIBE and OTHER. The AGENCY/TRIBE category consists of participants employed by federal and state agencies or representing the tribes. This group of participants tended to be more familiar with decision support systems in general and with EDT in particular. The OTHER category consists of the remainder of the participants, including representatives from industry, environmental groups, citizen groups, local governments, and consultants. Using the notation %AT and %Other for the percentage that each summative category represents among all participants in a given group, we calculated the pairwise differences (%AT − %OTHER) for each subbasin, within the planning groups and technical groups separately. We found that the representation of these two summative categories for the planning groups was relatively balanced between the two summative categories for the majority of the subbasins, but in the technical groups, the AGENCY/TRIBE category clearly predominates over the OTHER category. Indeed, the median difference was 2 percentage points within the planning groups, while within the technical groups the AGENCY/TRIBE representation predominated over the OTHER representation by a median of 64 percentage points. In four of the subbasins, the technical groups consisted entirely of representatives from the AGENCY/TRIBE category. Given that much of the critical information and decision framing presented to the planning groups came from EDT-based analysis provided by the technical groups, this predominance is significant. One practical consequence of narrow stakeholder involvement in the technical groups was the failure of many subbasins to prioritize management objectives (ISRP and ISAB 2004). Structuring the process to permit greater interaction by a broader range of stakeholders in the use of decision support systems at much earlier stages might have enabled more of the planning teams to reach consensus on management priorities.

However, documents show that the short timeline imposed by the Council for completing the subbasin plans severely constrained opportunities for achieving broad-based participation and consensus on management objectives. Providing laypersons with the knowledge and skills needed to interact meaningfully with decision support systems such as EDT or QHA requires time. The tight timeframe was particularly problematic in subbasins with no history of collaborative watershed planning, or where subbasin planning coordinators did not already have the relationships of trust needed to convince stakeholders to invest time and energy in the planning process. This is considered below in our theoretical analysis in terms of rational ignorance. The short timeline was also problematic for subbasin teams that had to rely on outside experts to run the models and interpret their output, work that they might have been able to do if there had been enough time for local participants to learn the necessary skills.

In addition to the above considerations, the question of the role of decision support systems in the larger social structure of the planning process is crucial. As revealed through documentary analysis, the constraints imposed by the tight timeline and the very high workload imposed by EDT meant that subbasin planning tended to be a "tool-centered" process. Several interviewees actively engaged in subbasin planning reported that a large portion of the human and financial resources available to planning was consumed by the implementation of EDT. Such a situation left little time for stakeholders, working with professionals and researchers, to consider the larger context of planning or to reflect on issues of uncertainty and risk (Kato and Ahern 2008).

In addition to participating on subbasin planning teams or in subbasin planning meetings, stakeholders also had the opportunity to provide comments through a formal public comment process. In September 2005, the NPCC published a "findings and responses to comments" statement on the subbasin plan amendments for the plans completed by May 28, 2004. In this statement, the Council explains how it responded to public comments on the draft subbasin plans, which were treated as draft amendments to the Columbia River Fish and Wildlife Program. The Council received relatively few comments on the draft amendments, and most of the comments recommended that the plans be adopted with few or no modifications. Table 1 summarizes the public comments and the NPCC's responses to them.

Of the 36 public comments included in the NPCC's findings and response to comments document, 8 consisted of statements of support for the draft plans but included cautionary statements emphasizing the need for improved science and the incorporation of mechanisms for adjusting the plans in the future to reflect new ecological understandings. In addition, one comment called for funding more work in the Nevada portion of the Owhyee Basin but did not question the legitimacy of the subbasin planning process, the accuracy or completeness of the data, or its interpretation.

Nearly half of the commentators (48%) questioned the legitimacy of the process itself, rather than disagreeing with specific data or the analyses. Several public utility districts stated that plan mitigation strategies either exceeded the NPCC's authority under the Power and Planning Act of 1980 or potentially conflicted with their relicensing requirements. Other stakeholders, including two local governments, environmentalists, and agricultural interests, stated that the process did not provide sufficient opportunity for broad-based input or complained that their input had been ignored. NPCC made no changes in response to these critiques, asserting that it not only had the legal authority to implement subbasin mitigation strategies but that the planning process was adequately designed and implemented.

Stakeholders in three categories (farm/forestry interests, federal agencies, and tribal agencies) suggested changes in wording to plans. NPCC either incorporated these suggested changes in the current drafts or indicated its intention to include them in future versions. Just over half of the commentators (52%), representing all of the stakeholder categories except the county governments, had comments related to data accuracy, completeness, or analytical approaches. NPCC made immediate changes based on suggestions received from one of the state agencies and three of the tribal technical staff. In addition, NPCC indicated it would incorporate changes suggested by the two federal agencies, the other state agency,

Table 1 Summary of public comments on subbasin plans and NPCC's responses

Stakeholder category	Number of comments	Comment category			Changes made in plans in response to comments
		Legitimacy of process questioned	Data accuracy questioned or additional content requested	Changes in wording requested	
Environmentalist interests	4	2	3		– None regarding process legitimacy – Did not incorporate suggested content changes on grounds that wind energy developments are not relevant to plans and data about dam operations has been included in previous plans
Farm/forestry interests	8	4	1	4	– None regarding process legitimacy – Data change regarding miscategorization of a plant species to be incorporated in future versions – Reworded draft plans to use language less negative of timber harvest and grazing impacts
Federal agencies	2		2	1	None
County government	2	2			None
State agencies	2	1	2		– None regarding process legitimacy – Incorporated an addendum on bull trout (addressing 1 of the comments); leaves open the possibility to incorporate other technical suggestions in future plans
Tribal agencies/-groups	5	1	4	1	– None regarding process legitimacy – Incorporated an addendum to include a statement of tribal management priorities – Incorporated language changes relative to reintroducing anadromous fish
Utilities	3	3	1		– None regarding process legitimacy – Did not incorporate suggested content changes on grounds that the existing hydropower data is adequate
Other (individual)	1		1		None
Total	27	13	14	6	

and four of the farm/forestry groups or individuals in future revisions. However, NPCC did not make any changes based on data-related comments received from either the environmentalist or utility interests. These comments focused primarily on requesting that NPCC incorporate additional data related to hydroflows, data that NPCC countered were either included in previous plans or would not change the results of the analyses.

Theoretical analysis

Description of the post-normal science lens

Post-normal science (PNS), a theory originally developed by Silvio Funtowicz and Jerome Ravetz, provides an analytical lens that addresses methodologies for decision-making and policy formation in situations where "facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz and Ravetz 1991). In contrast to the "normal science" described by Thomas Kuhn (Kuhn 1962), the post-normal perspective emphasizes more inclusive participation in scientific knowledge production, often called "extended peer review" (Funtowicz and Ravetz 1993), as well as broader approaches to quality assessment of scientific production, or "knowledge quality assessment" (Funtowicz and Ravetz 1991), especially at the science–policy interface.

Prompted by a public scandal concerning the use of modeling in environmental assessment in 1999, the Netherlands Environmental Assessment Agency (PBL) began a process of incorporating the concepts of PNS into their scientific knowledge production and communication practices (Petersen et al. 2010). Beginning with a PNS approach to uncertainty assessment and continuing with a broader approach to knowledge production, the PBL adopted a guidance for "Uncertainty Assessment and Communication" and the associated quality assessment methodology in 2003 (Van Der Sluijs et al. 2004, 2005). In 2007, "Stakeholder Participation Guidance" was adopted following the extended peer review methodology (Refsgaard et al. 2007; Petersen et al. 2010). Subsequently, these post-normal science approaches have played an important role in scholarship and practice in the use of modeling for management, decision-making and policy in forest management (Wolfslehner and Seidl 2010), water management (Saloranta et al. 2003), coastal ecology (Farley et al. 2010), climate change (Matso and Becker 2014), land degradation (Stringer et al. 2014), and ecosystem function (Oikonomou et al. 2011) among many others (Haag and Kaupenjohann 2001; Cariboni et al. 2007). The model of the extended peer community, and extended participation in scientific knowledge production and policy more generally, has been broadly promoted (Jasanoff 2011; Sarewitz 2013; Gluckman 2014; Liberatore and Funtowicz 2003; Guimarães Pereira and Funtowicz 2009). Of particular relevance to this research, extended participation in modeling has increasingly been studied and practiced in a wide range of contexts (Jones et al. 2009; Korfmacher 2001; Ananda 2007; Haapasaari et al. 2013; Voinov and Gaddis 2008), often with an explicit inclusion of post-normal science methods (Gaddis et al. 2007; Salter et al. 2010; Röckmann et al. 2012).

Scholars working in the post-normal science tradition emphasize the importance of input from a broad range of stakeholders as part of a robust knowledge quality assessment process, particularly as it applies to the assessment of model output used in planning (Frame and Brown 2008; van der Sluijs 2006). These authors hold that in the post-normal context, the quality of planning processes and outcomes is best assessed by an extended peer community including scientists, managers, and policy makers, but also including other stakeholders from a wide range of perspectives. In particular, the post-normal science literature identifies extended peer review of the use of model-based decision support as an essential element (Refsgaard et al. 2006).

However, when a diverse set of stakeholders is involved in environmental planning, the likelihood is high that participants will come to the table with significantly different capacities for using technological tools (Elwood 2002). The risk associated with these differences is important. Fiorino (1990, p. 226) of the Environmental Protection Agency states that "standard approaches to defining and evaluating environmental risk tend to reflect technocratic rather than democratic values." Concerning multistakeholder environmental planning processes in general, Smith and McDonough (2001, p. 239) state that "very little research has been done to apply justice concepts to natural resource decision making contexts."

Analysis via the post-normal science lens

Here, we use the PNS lens to examine two aspects of subbasin planning: first, a comparison of subbasin planning with a previous large-scale scenario planning effort also conducted by the NPCC, and secondly, to analyze the value of the extended peer community in terms of plurality and place.

Basin-wide multispecies framework scenario planning: using DSS as flexible frames

Our results suggest that in the NPCC subbasin planning case, the use of decision support systems as fixed frames for developing model scenarios, in a system characterized by high levels of uncertainty and complexity, undermined opportunities for broad-based stakeholder involvement and negatively affected the quality of knowledge used to develop management objectives. An alternative to this fixed-frame approach is "scenario planning," which Peterson et al. (2003, p. 360) describe as "a structured account of a possible future" to create "alternative, dynamic stories that capture key ingredients of our uncertainty about the future of a study system." Wilkinson and Eidinow (2008) argue that scenario planning, coupled with the involvement of the wider range of epistemologies represented by a greater diversity of stakeholder involvement, may be particularly well adapted to the post-normal context. The NPCC's basin-wide multispecies framework (MSF) planning effort of the late 1990s, which used EDT in a scenario planning environment instead of a model scenario environment, provides an instructive contrast to the subbasin planning case.

The comparison of the MSF process with subbasin planning is particularly useful. Both planning processes used the same decision support tool (EDT), but due to the method of use of that tool, the two processes arrived at substantially different outcomes. A key difference was the timing of the use of the decision support tool. As described below, the MSF process began with an open-ended, stakeholder-led process to develop scenarios. Only after those scenarios were developed was the decision support tool used in a technical evaluation role. By leading with human-centered visioning, the MSF process avoided much of the framing and constriction of the decision space imposed by the use of decision support systems in the subbasin planning process where those systems played a central role from beginning to end.

The Council began the MSF process by sending out approximately 1500 letters to a wide variety of stakeholders soliciting concept papers. Proposers of concept papers were asked to "formulate a broad vision for the Columbia River Basin that reflects the biological/ecological, cultural, social and economic priorities" (NPPC 1998, p. 18). Based on these visions, proposers completed the concept papers by developing objectives, strategies, and management actions to realize their vision for the basin. The proposers of the 27 concept papers represented a wide range of standpoints including those of organizations such as the Save Our Wild Salmon Coalition, the Columbia River Inter-Tribal Fish Commission, and Reynolds Aluminum as well as a number of unaffiliated individuals (BPA 2003).

The concept papers were fleshed out in a workshop organized by the NPCC and reviewed in two public meetings.

Council staff distilled the 27 papers into 7 well-defined alternatives including Alternative 2 calling for the breaching of 1 dam on the John Day and 4 dams on the Lower Snake river to Alternative 7, envisioning a river managed for maximum economic benefits (NPPC 2000b). Only after stakeholder participation framed the alternatives to be considered was the decision support tool EDT brought in to evaluate the plans for biological benefit. The Council used a separate process to evaluate the plans for social and economic impacts. Although the process was not intended to select a preferred alternative, participants produced rankings for fish, wildlife, and social/economic benefits.

In terms of benefits for salmon recovery, their analysis found that, "Alternative 2 performs better for chinook population recovery under the Technology Pessimistic worldview and poorer under the Technology Optimistic view. Alternative 2 is projected to produce a larger increase in chinook abundance from current levels, than either of the other two alternatives regardless of the worldview" (Marcot et al. 2002). Their human effects analysis ranked Alternative 2 highest in monetary costs and lowest in nonmonetary costs (NPPC 2002).

Looking at this contrast through the post-normal lens, our analysis shows that in spite of using the same decision support systems, the MSF scenario planning process, combining a high level of extended peer involvement and scientific review, yielded a product with significantly different outcomes from the subbasin planning process. Key contrasts in the MSF planning outputs include the more sophisticated approach to the treatment of the uncertainties, a much more detailed social and economic evaluation, and the delivery by an extended peer community of a wide range of options for decision makers to consider (Marcot et al. 2002; NPPC 2002). The outcomes due to the involvement of a wide range of stakeholders illustrate the value of the participation of an extended peer community in planning, and the consequent plurality of standpoints, for improved knowledge quality assessment. A question that remains unanswered is whether this sort of flexible scenario planning could have been successfully carried out in 62 subbasins simultaneously.

Plurality, place, and the extended peer community

Returning to the implications of Williams' (2018) advocacy for a pluralistic approach to planning in post-normal contexts, we adopt the three standpoints[3] identified by Bremer and Funtowicz (2015) to analyze similar circumstances revealed in our interview data.

In one interview with a manager directing a subbasin evaluation, we discussed the output of the EDT model. Following the ontology of Bremer and Funtowicz, this individual and his colleagues would fit in the "local" category, relatively recent settlers intimately familiar with local ecological conditions. In a table of model output, describing the optimal achievable salmon populations (based on historical abundance) for a watershed, a four-digit number was reported. When asked how many of the digits he thought were significant, this interview subject reported, "None of them. I don't believe that number to an order of magnitude." This perceived high degree of uncertainty about model output was not related to the ecological complexity, or to the inner workings of the model, but rather to an informed opinion of the social complexities of populating the model with the input values required. In fact, model input data were often in the form of qualitative expert opinion of biologists personally familiar with the stream reaches in question. Subsequently, these data were transformed by the mathematical equations of the model into numerical output, giving the impression of an unwarranted level of accuracy. Taken in context, these qualitative data (expert opinions) may well have been reliable, but when transformed into numerical outputs with the illusion of accuracy, they could be quite misleading. Information properly on an ordinal scale was converted by its passage through EDT into apparently more accurate interval scale information, gaining considerably in apparent reliability, but losing the nuance and detail of these holders of local knowledge.

A second interview with two fisheries biologists employed by a tribal agency revealed the value of including a plurality of epistemologies and local traditional ecological knowledge as well as the potential value of extended peer participation in planning. The two biologists had participated in seven subbasin planning processes, leading three of them and contributing the majority of the writing on assessment, goal setting, etc. for all seven plans. All of these subbasins were within areas ceded by the Tribe to the United States in treaties. These lands consist of their "usual and accustomed places" where the Tribe maintains, via the Boldt Decision (1974), the right to fish. The interview subjects related their "access to cultural resources that federal and state agencies don't have" and appreciatively acknowledged that their "limited temporal scope doesn't compare to that of traditional ecological knowledge present in the Tribe." In the categorization of Bremer and Funtowicz, these interviewees fit in the "indigenous" perspective category, but with very strong scientific backgrounds and skillsets. They emphasized the critical absence of "a cultural factor that is not incorporated into the modeling tools we've been working with," namely EDT and QHA. As an illustration, they related a story about historic salmon populations in a tributary river told by a tribal member who related that "there used to be summer chinook" in that river "hundreds of thousands of them." But, as the interview subjects related, "the models say 'no', the water temperature wasn't right and the habitat couldn't support that." In the end, it was this model output that went into the subbasin plan, with the local knowledge relegated to an appendix.

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[3] A cultural one from an indigenous population, a "local" one from more recent settlers, and an "eco-scientific" narrative.

Our PNS lens analysis therefore confirms that the evaluation of uncertainty and knowledge quality assessment, including its epistemological plurality, is crucially informed by the holders of local knowledge as represented in these two accounts. This evaluation is one of the valuable contributions that the review by an extended peer community can make to the quality of a planning process. A lack of transparency regarding uncertainty can privilege numerical model output, even when it is derived from qualitative input data. These interviewees expressed the importance of these issues for environmental justice, as they related their concerns that recovery goals for salmon would be based on the use of model output to establish salmonid escapement goals (the number of fish allowed to survive fishery efforts to spawn in the wild). Model estimates of escapement goals amounted to only 10% of the numbers of salmonids known through traditional knowledge to have survived to spawn in the wild.

Holders of local knowledge, such as these informants, could play an important role in knowledge quality assessment as part of an extended peer review system. Indeed, in the post-normal context of high systems complexity, such perspectives may be particularly important. As Williams argues (Williams 2017):

> When applied to specific local contexts, normal science often struggles to clarify best practice because it expands rather than reduces knowledge complexity, increases scientific uncertainty, provides contesting parties with competing sets of facts, and amplifies policy conflict. In its stead, place-oriented inquiry and practice offers a post-normal context-dependent problem-solving strategy by emphasizing bottom-up social learning for the adaptive, sustainable governance of complex dynamic landscapes.

In a study of traditional knowledge and climate change, Berkes and Berkes (2009, p. 10) write that the data from Inuit informants on climate change "illustrates the ability of indigenous knowledge to deal with multiple variables and complexity, and shows that local observations can provide information at the appropriate spatial scale to complement science."

Description of the restorative justice lens

Somewhat like Aldo Leopold's celebrated land ethic, a conceptualization that is first and foremost based on an ecological conscience (Leopold 1949), a relationality–responsibility model for ethics conceptualizes and exhibits the primacy of conscience. In the case of the ethics of restorative justice, conscience is in part defined as a matter of one's own moral subjectivity. In other words, conscience entails in part at least a subject's perceptions, feelings, and thoughtfulness. Yet, if conscience were merely a matter of each individual's moral subjectivity, an ethics based upon it would be far too relative to function well in the real world of relationships, group interactions, and competing claims.

While involving one's own moral subjectivity, conscience also points toward truths that transcend any particular moral agent, i.e., truths that are greater than ourselves. As Richard Gula suggests:

> This does not mean that conscience independently determines what is good and what is evil. Nor does it mean that conscience makes all morality relative to a person's own desires, or that one's moral judgment is true merely by the fact that judgment comes from one's conscience. It does mean that the person's sincerely reflective judgment of what to do sets the boundary for acting with integrity or sincerity of heart. To say 'My conscience tells me' means 'I may be wrong, but I understand this to be an objective demand of morality and so I must live by it lest I turn from the truth and betray my truest self' (2004, p. 53).

Curran (1999) argues that a moral agent, when guided by a relationality–responsibility model for ethics, comes to know their moral responsibilities through the experiences they have within the multiple relationships they participate in, where conscience (as defined above) is recognized as the basis for moral knowledge and discernment. Those same experiences are said to "inform one's conscience." As he further elaborates, a relationality–responsibility model stands in contrast to a model for ethics where a person does as they should because they are doing their duty, i.e., a deontological model of ethics. It also differs (as suggested above) from a model for ethics where one acts to bring about consequences understood as good, i.e., a teleological model of ethics. Rather, a relationality–responsibility model entails attentiveness to the importance of the moral principles which define moral duties but also to the relevance of consequences to which one might direct their actions. It does so because it is based on conscience rather than on how moral principles or consequences are understood or defined. If one acknowledges the ethics upon which restorative justice is arguably based, restorative justice suggests that those involved in DSS, acting in good conscience, are well positioned to address competing claims that are identified by the process itself, where each participant's conscience is informed by the experiences they have with others as DSS is implemented.

Analysis via the restorative justice lens

Multistakeholder environmental planning processes inherently involve the adjudication of conflicting environmental and economic rights claims between stakeholders, and the use of

DSS in planning processes does not render the planning processes immune to the ethical implications of such rights claim adjudication. Ethical facets of apparently technical concerns like comparing the use of rigid vs. flexible frames in DSS processes, and assessing the quality of both data input and output interpretation, require a discussion based on a well-developed system of ethical discernment. Balancing harms and benefits to different stakeholder groups, and how the use of DSS empowers or disempowers the overall capacity of the process to express various normative outcomes clearly, is a situation requiring careful ethical analysis as part of the process, and temporality is a key feature of this analysis. Restorative justice relates to DSS processes as described below.

Restorative justice, temporality, and backcasting

Dealing with harms as a matter of ethics suggests doing justice to and for those involved. Doing justice is a matter of dealing with harms already done and with those that are occurring. Doing justice also suggests mitigating in some way those harms that might otherwise occur in the future. Doing justice is therefore a matter of temporality, which is to say doing justice is a process that addresses the past and present while looking to a future where those involved experience a greater measure of justice. While doing justice can be conceptualized or performed in a great many ways, restorative justice (implemented as an inexorably forward-looking process) is an especially appropriate way to deal with complex environmental issues when various injustices are present (Humphreys et al. 2014). Restorative justice deals with what has already been done and ways to remedy past injustice (Kolmes et al. 2019). Given the history of the Columbia River Basin, the long repression of Tribal interests, and the need to move forward in a thoughtful manner, the concept of restorative justice could be particularly appropriate to this setting (Humphreys et al. 2014). Tribal constituencies "strive to protect places they claim as sacred when those same places are valued for industrial, commercial or recreational uses" (Humphreys et al. 2014, p. 185). The relationship between the presence of salmon and native people's cultural claims stands in contrast to claims about factors like the role that dams play in the region's economy where those same dams disrupt salmon migration. Humphreys et al. (2014) describe restorative justice as a suitable approach for dealing with these intersecting and oftentimes competing claims. Restorative justice provides a framework for dealing with social processes or structures where other, perhaps more conventional approaches to justice, regard jurisprudence as primarily a matter of personal liability. A result of employing restorative justice in such circumstances, they argue further, is "conflict resolution and social reconciliation" (Humphreys et al. 2014).

Backcasting is often used as a tool to articulate future visions' needs to implement restorative justice, and is a tool clearly related to temporality. The backcasting method is a forward-looking version of scenario planning in that it begins with a desired future state, and in the context of restorative justice, that future state could be one in which all of the participants experience a greater degree of justice. In a backcasting process, whether or not DSS is involved, one advantage of the involvement of an extended peer review is that it brings elements of policy making into engagement with a search for desired outcomes, that can then be subjected to ethical analysis. The importance of employing extended peer review, the nature of the harms present, issues of time scale, and discernment of desired outcomes via backcasting has been described as:

> Most environmental problem-solving contexts involve a negative consequence of an external impact (often a human-induced impact) to an environmental system. As the time period for reversibility of such an impact extends further and further into the future, the need to utilize the techniques of postnormal science increases… in the case of relatively quickly reversible process, postnormal science is only needed when decision stakes are high and systems uncertainty is high. However, when reversibility of a process would take a longer and longer time… the cumulative effect of even a modest mistake becomes very much greater, and the complex and inclusive processes of post-normal science are appropriate at lower and lower immediate decision stakes... Backcasting is the name… to describe a method of analyzing future options in which the concern lies "not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backwards from a particular desirable future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point". Thus, backcasting contrasts with forecasting by the adoption of an explicit focus on desired outcomes, in advance of an emphasis on the process of modeling cause and effect. (Hill et al. 2012)

Post-normal science, with its call for backcasting, extended peer review, and recognition of the importance of acknowledging the potential impacts of irreducible uncertainties for different stakeholders, is a conceptual structure and process consistent with the inclusion of restorative justice as an ethical framework. Backcasting allows every stakeholder to express their aspirations for the future and in turn to listen to the aspirations of others. The multispecies framework process, although not articulated at the time as backcasting, in fact asked of participants to first envision just futures from a variety of perspectives in advance of describing cause-and-effect-based strategies.

In contrast to the restorative justice approach, the stakeholder interviews we discuss earlier make it clear that the use of EDT and QHA was viewed as differentially empowering to stakeholders, and the identification of needs and a "social connection" model of responsibility is diminished by that differential empowerment. The use of DSS should therefore be approached with caution so as not to reduce the future restorative justice potential of subbasin planning or other planning processes. The lack of a consensus on management objectives after a process utilizing DSS is a situation that our ethical analysis critiques as incompatible with restorative justice, a failure of backcasting, and an indication that greater scrutiny of stakeholder group participation and empowerment is required.

Procedural justice, rational ignorance, and restorative justice

The process of negotiations, utilizing DSS as a tool, inherent in subbasin planning, may increase the possibility that rather than a sense of restorative justice having been achieved, there will be a perception of procedural injustice having taken place. As Molm et al. (2003) conclude at the end of a behavioral study involving three experiments on volunteer subjects,

> Across three experiments, our results clearly show that when all other aspects of exchange are constant, the form of exchange has strong and consistent effects on actors' perceptions of fairness. Exchanges that produce equivalent outcomes, in equivalent structures, are perceived as far more unfair when those outcomes are negotiated than when they are reciprocally exchanged, without negotiation, by actors making individual choices… These results support the general thesis of procedural justice theories: Perceived fairness in social interaction is not only a function of outcomes, but of how those outcomes are obtained. Indeed, in our experiments, the effects of the form of exchange were as strong as effects of the inequality of outcomes.

It is interesting to contemplate that the indigenous peoples of the region encompassed by the subbasin planning process had a millennia-long history of sustainable management of fishery resources believed to be based on a system of salmon husbandry in a culture that used potlatches as a form of voluntary exchange (Johnsen 2009). The avoidance of the perception of procedural injustice may have been an inherent part of the culture of the Northwest before the system was stressed by massive immigration and environmental modifications. Our results indicate that the use of a flexible frame DSS approach might well allow subbasin planning participants to cooperate in a mutual design process promoting a form of exchange, at least on the conceptual level. According to the research of Molm et al. (2003) and our ethical analysis, this would likely promote more of a sense of restorative justice taking place than would be present with the use of a rigid frame DSS. Restorative justice is something that needs to be achieved by mutual agreement and belief in the process and its outcome, and not by a quantitatively based negotiation; therefore, the use of rigid frame DSS in subbasin planning may actually make the perception of procedural injustice by participants more likely.

An additional element of multistakeholder participation that relates to the process of restorative justice is what in geographical planning has called rational ignorance (Krek 2005) (and in philosophy has been called epistemological smothering):

> This self-censorship, known as "epistemological smothering" (Dotson 2011), happens when a knower has access to knowledge that they know reporting might be risky and that they have a prima facie reason to believe that their interlocutor will not believe them for pernicious reasons. Thus they have reason to believe that it will cause more trouble for them than it is worth and that they will not be believed if they report their knowledge… indigenous peoples and other marginalized groups with an interest in environments might be epistemologically smothered by the history of regulators not listening to their knowledge (Lewis 1995) and the impression that advocating for their values aggressively will result in them being treated badly. By explicitly inviting these groups to the decision-making table in a way that makes clear that their evidence and values will be considered the process can overcome the smothering barrier (Kolmes et al. 2019).

Restorative justice requires a sense of both hearing and being heard, and stakeholders who believe a priori that an attempt to be heard will merely result in them being treated badly as part of the process will be likely to absent themselves. As Krek (2005) indicates "Ignorance about an issue is said to be rational when the cost of educating oneself about the issue sufficiently to make an informed decision can outweigh any potential benefit one could reasonably expect to gain from that decision, and so it would be irrational to waste time doing so." In terms of learning to use a GIS-based tool, specifically, Krek (2005) notes "One of the crucial issues is the investment in learning how to use electronic, map-based applications and how to design them in such a way as to attract broader general public to participate in planning processes. The issues of usability of such applications gain… importance with the goal making them available to all social groups. The participation itself incurs cost to the citizens, and usually brings rather low benefit in comparison to the level of the investment. The cost of participation includes the cost of informing oneself about the form of participation, planned activities and learning how to use a public participatory GIS application." All of this suggests that the simpler a DSS system is to access and modify, the more accessible the meeting scheduling is, and the more a group of varied participants feels that their time and opinions will be valued in a process moving toward restorative justice, the less willful ignorance/epistemological smothering is likely to take place. The analysis of our results from a restorative justice perspective indicates that the selection of a flexible frame DSS tool, over a rigid frame DSS tool, would have material beneficial outcomes.

Conclusion and future directions

The NPCC subbasin planning process was an ambitious effort to build institutional capacity for implementing adaptive ecosystem management across the Columbia River Basin. Creating the conditions conducive to the emergence of shared mental models of ecosystem dynamics among stakeholders within and across subbasins was central to this effort. The use of EDT and QHA within a participatory, multistakeholder planning environment provided an important platform for stakeholders to make, and critique, explicit assumptions about ecosystem functions and processes, fostering social learning among stakeholder groups.

We used extensive textual analysis supplemented with material from numerous interviews, analyzed using the lenses of post-normal science and restorative justice, to identify a number of critical shortcomings and missed opportunities in the subbasin planning process. We demonstrated the value of utilizing multiple lenses in both critique and in searching for positive solutions, for use in future multistakeholder planning processes. Our results are consistent with a larger body of work from different planning contexts as described below.

Our work dovetails with other studies using place-based perspectives. Williams (2018) notes that "...by conceiving knowledge as co-produced in a spatial-relational network of human agents, knowledge pluralism can be more readily reconciled through real-world practice in actual places." Ramsey's (2008, 2009) findings, based on a smaller scale collaborative GIS-based planning process in Idaho relying on a GIS-based model, revealed marginalized stakeholders whose understandings of the "problem" were based on experiential knowledge rather than quantifiable data, and resulted in a lack of consensus on how to move forward in addressing water shortages. Ramsey (2008) proposes the use of multiple models and preferably models created independently by stakeholders, as a strategy for permitting a variety of understandings of the "problem" to be placed on the table for discussion. He also argues for a disentangling of the use of collaborative GIS as a problem exploration tool from its use as a problem-solving tool (Ramsey 2009). Place-based perspectives have also been employed by other researchers examining stakeholder participation in transportation planning in the presence of collaborative geospatial/geovisual decision support systems and the circumstances that produce justice deficiencies (Bailey and Grossardt 2010).

The Columbia River subbasin planning case study suggests that Ramsey's conclusions are generalizable to a much broader area, while the MSF planning example serves as a model for what an alternative process might look like. However, a major issue that remains to be solved in the context of large-scale ecosystem management is how to overcome the multiple challenges associated with managing a large number of coordinated small-scale participatory scenario planning processes that are responsive to both local and ecosystem-wide socioecological conditions, while still sharing a sufficiently common approach, allowing them to be integrated with each other. This local–global problem extends widely in contemporary environmental issues, for example the challenge of knitting together place-based climate change adaptation strategies into a global climate change mitigation framework.

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