How value conflicts infected the science of riparian restoration for endangered salmon habitat in America's Pacific Northwest: Lessons for the application of conservation science to policy

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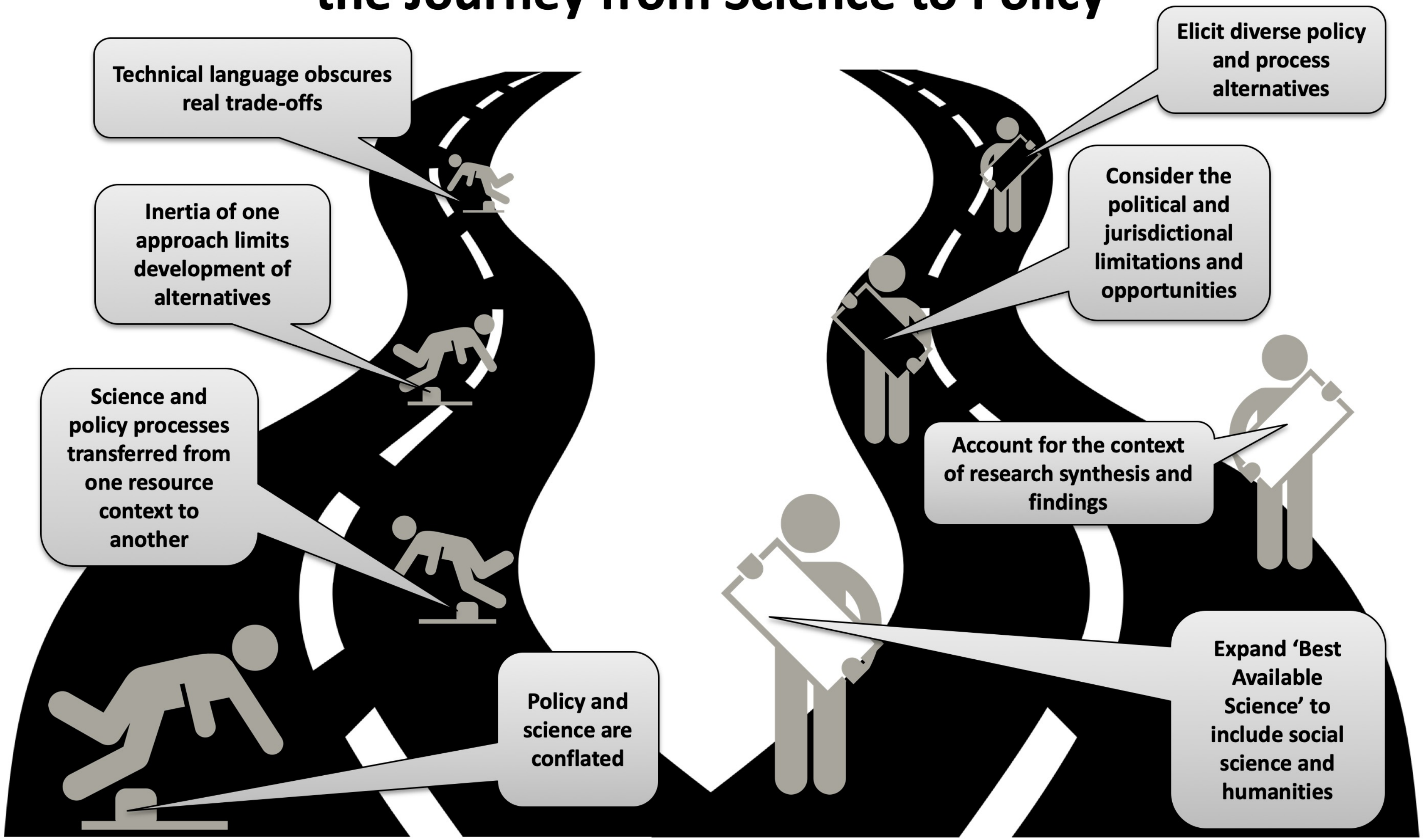
From Stumbling Blocks to Waypoints on the Journey from Science to Policy



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Abstract

Conservation policy relies on input from science, yet scientists are often frustrated by the 'gap' between their recommendations and policy decisions. In this paper we examine one such 'gap': how a long-standing conflict of values functioned to 'infect' the synthesis and application of riparian science for salmon habitat restoration projects. We do this by analysis of a policy debate over the required minimum width of riparian buffers in voluntary conservation programs on agricultural lands in the Puget Sound region of Washington State. Based on an analysis of expert interviews and document analysis, we first outline the key features of the values debate. We then show the ways values 'infected' the debate over the science of riparian restoration. We identify a set of four 'stumbling blocks' in the science to policy gap that together led to both an intractable debate and an oversimplification of the science: conflation of science and policy, application of science out of context, limited consideration of alternatives, and obscuring debate via technical and bureaucratic language. We conclude with a set of 'waypoints' that can help ecologists, conservation managers and policy makers to better navigate the journey from science to policy.

Key words: science-policy gap; best available science; riparian buffers; tribal treaty rights; salmon; ecological restoration

Acronyms

CREP	Conservation Reserve Enhancement Program
NOAA	National Oceanic and Atmospheric Administration

1 INTRODUCTION

In Western Washington State controversy erupted over demands by treaty-holding Native American tribes for stricter regulation and enforcement to protect salmon habitat. Passionate debate surrounds one rule change for conservation programs on agricultural land. The change is widely opposed by the agricultural community, despite impacting a voluntary program. At the heart is the appropriate width for restored riparian habitat on agricultural lands; are 10 meters sufficient to provide salmon habitat or should 30 meters be required?

The current controversy sits within a larger, longer debate about what actions and sacrifices should be taken (and by whom?) to protect salmon (Breslow, 2014). Salmon are a cultural keystone species for Native American tribes (Garibaldi & Turner, 2004), regional icon, and important commercial fishing resource. Efforts to address salmon declines extend decades in Washington State, as does opposition to such efforts by the agricultural community. For example, over 20 years ago Eastern-Washington farmers fiercely opposed proposals to remove three dams in an effort to open up salmon habitat. The debate has come to focus on natural science and Western law, in large part due to the efforts of Native American tribes (Breslow, 2014).

In studying this case, we address intended but also actual empirical interaction between values, policy, and science. Prescriptive work addresses ways values and science ideally interact in creating environmental policy, via structured processes or participatory dialogues (Gregory & Wellman, 2001; Ryfe, 2005). When applied well, such approaches are effective (e.g. Failing, Gregory, & Higgins, 2012). Yet empirical studies show often such guidance is not heeded. Requirements for ‘science-based’ decision making can force values to become ‘invisible’ or ‘fugitive;’ in these cases decision-making takes the shape of a values debate cloaked in scientific language (Satterfield & Levin, 2007; Turner, Gregory, Brooks, Failing,

& Satterfield, 2008; Witter & Satterfield, 2014). But do fugitive values also impact production of scientific conclusions—and not just application? When values are excluded from science-policy, do they shift to occupy science?

We explore mechanisms through which riparian buffers came to be reified at a certain width—and how that width was contested. We begin by asking: why was a small rule change in buffer-widths important to the tribes and opposed by farmers? How did riparian restoration become an intractable problem? We explore these questions by revealing unexpected ways that science and values were used in a riparian-restoration controversy over minimum riparian buffer-widths within the Washington State Conservation Reserve Enhancement Program (CREP). We elaborate value and paradigm differences, elicited via interviews and document analysis, and discuss how riparian science shaped—and was shaped by—policy. In sum, we analyze how, as one informant explained, "riparian buffers" became "fighting words."

1.1 Debates at the intersection of values, science and policy

Many have rightly argued that science-policy debates are value debates. For example, Jassanof (2005) has shown the value-basis of the GMO debate in Germany and the US. Satterfield and Levin (2007) show the value-basis for a debate about restoration of a former nuclear-testing site. Oreskes and Conway (2012) has shown how values—and power—shape the debate over climate science. These authors show that when discussion of values is precluded in controversial science-policy debates, those value debates simply shift to occupy science.

Methods exist to address this fact. From local to regional scales methods and approaches guide integration of science and stakeholder values in contexts of participatory decision making (Gregory, Failing, Harstone, Long, & McDaniels, 2012), assessment processes

(Farrell, VanDeveer, & Jäger, 2001), public participation and deliberative democracy (Beierle, 2002; Dietz, 2013; Ryfe, 2002), and environmental policy and planning (Bennett et al., 2016; Satterfield, Gregory, Klain, Roberts, & Chan, 2013).

Less is understood about how value debates infuse or infect science-policy claims. In other words, when value debates become intractable, policy responses may become intractable themselves. The result being policy built on anything but 'best available science.' We tackle this gap via the example of riparian restoration. We identify mechanisms by which one question—the width of riparian buffers—became reified. Backdropped by a values debate, government scientists were asked to define and defend riparian-restoration recommendations. Yet the response was far from what most scientists would hope: old recommendations reproduced as science, studies from one context applied without adaptation to another, and trade-offs buried.

2 METHODS

Our site—the Puget Sound—is a region of Washington State, characterized by several watersheds which drain into a common ocean sound. We focus on two groups: (1) the Treaty Rights at Risk movement, a group formed to protect the treaty rights of Native American Tribes and (2) Conservation Districts, government funded but non-regulatory organizations that implement voluntary conservation programs. Access to both interviewees and materials was facilitated by our team's close work with two local organizations: the Snohomish Conservation District and the Puget Sound Partnership. Data collection and analysis were informed by local partners and our previous research with farmers in the area (Authors 2019).

Twelve expert interviews (Flick, 2018) were conducted with staff members from Conservation Districts (3), state and federal agencies (4), tribal organizations (3), and local/regional government (2). Interviews are referred to in the text as e.g., [Interview01].[1] Interviews focused on: a) opinions about agricultural land management; b) respondent's own environmental values; c) experiences and views of current proposals regarding riparian buffer program rules. Interviews were conducted by the first author in November 2016, lasted between ½ hour and 2 hours and took place by phone or at participants' offices or homes.

We reviewed over 50 documents based on our knowledge and interviewee's suggestions. These included: reports, white papers, meeting minutes and agendas, documents shared as part of meetings (technical documents, letters), videos, images, newspaper reports, blog posts, PowerPoint slides, technical guides, summaries of legal proceedings, websites and, in a few cases, commentaries provided by interviewees. We then selected three groups of documents (19 individual documents) for detailed coding and analysis (selection listed in Supplementary Information and referred to as e.g. [Doc 1] below). Document selection comprised covering key decisions in the buffer-width debate, providing descriptive value language, and achieving diverse perspectives.

The first author coded interview transcripts and documents using NVivo qualitative analysis software and analyzed both interview transcripts and documents focusing on themes of values and paradigms (results in section 3) and the use, synthesis, and application of riparian science (results in section 4).

In addition to the 19 documents coded and analyzed, we applied a 'forensic' approach to understand how riparian science was translated into policy synthesis. This involved tracing

[1] While all interviews informed our analysis, only those sections of the paper that refer explicitly to insights or direct quotes from interviewees are specified. Interviewees are not further specified in order to maintain confidentiality.

scientific conclusions and figures across scientific papers and government reports on riparian science (cited as references in text).

3 VALUE CONFLICTS CONTEST THE FUTURE, NOT THE SCIENCE

3.1 Treaty Rights at Risk

Salmon are key resources guaranteed to over 20 Western Washington tribes with whom the US government signed treaties in 1854-55. These treaties granted tribes the right to fish *"at usual and accustomed grounds"* [Doc13]. These resources, including salmon, but also elk and deer, oysters and clams, are essential to many dimensions of tribes' way-of-life. An Upper Skagit Tribal member explains: *"It's not just fishing, it's all of it. It's the hunting, it's the gathering, it's the commercial side of it; it's the subsistence side of it; it's the religious component of it; it's the traditional side of it. It's like 'who are these people?' Probably a good part of the treaty represents who the Indian people are"* [Doc17, #6]. When tribes signed treaties, they assured protection and access to their most important resources. Securing this right in practice took decades of efforts known as the Fish Wars. Finally, the 1974 Boldt decision firmly established tribes' right to fish half of the harvestable salmon and established tribes as co-managers of the salmon resource [Doc13].

However, without sufficient salmon to fish, this treaty-guaranteed right was and is essentially meaningless. Therefore in 1980, a further ruling confirmed the responsibility of state and federal agencies to protect salmon, in light of tribal treaty-rights. Yet four of eight anadromous salmonid species native to the Puget Sound are threatened under the Endangered Species Act: Chinook (*Oncorhynchus tshawytscha*), Hood Canal summer chum

(*Oncorhynchus keta*), steelhead trout (*Oncorhynchus mykiss)* and bull trout (*Salvelinus confluentis*) (Washington State Recreation and Conservation Office, 2017).

In response, tribes published a white paper in 2011, "Treaty Rights at Risk: Ongoing Habitat Loss, the Decline of the Salmon Resource, and Recommendations for Change" [Doc12]. The white paper and associated campaign laid out a suite of policy recommendations and called on the US federal agencies such as National Oceanic and Atmospheric Administration (NOAA) and the US Environmental Protection Agency to take leadership to protect endangered salmon.

The document was taken seriously. Will Stelle, the West Coast Regional Administrator for NOAA, speaking at a salmon-recovery conference in May 2013, substantiated his agency's commitment to addressing the demands:

> *This missive is not just an idle passing observation. It is the expression of a long-term strategic perspective of the tribal leadership in an intergenerational way… advising all of us that what they see is no good and they will not and cannot accept it. . . So, we in the executive branch take these treaty-rights observations and recommendations deeply seriously. We take them at face value and we believe them to be credible. We are working very hard with the limited tools we have to turn the knobs on the machines that we run in order to change some of that trajectory. [Doc17]*

One of the 'knobs' that NOAA turned involved a set of specific policy proposals from the *Treaty Rights at Risk* white paper, asking the federal government to "align funding programs" and condition federal grants to "achieve consistency" with water quality and salmon habitat regulations and plans. In practice this involved requiring federally-funded riparian restoration projects to meet new minimum-width standards, described in a table of stream-types and associated minimum riparian-buffer-widths. This table became known as the "NOAA Riparian Buffer Matrix" [Interview05].

As no legislation requires establishment of riparian buffers in Washington, the new standards applied only to federally-funded incentive programs. Various programs exist in Puget Sound to support and incentivize voluntary riparian-buffer creation on private agricultural land. One, the federally funded Conservation Reserve Enhancement Program (CREP), covers both costs of establishing a buffer and offers landowners annual financial incentives based on width and length of restored land. Most other programs only fund the cost of buffer installation and maintenance.

Prior to the *Treaty Rights at Risk* paper, CREP required minimum buffers of 35-feet (10m) on each side of salmon-bearing streams. Implementing the NOAA Riparian Buffer Matrix would increase this minimum from 35 to 100-feet (10—30m). While other federal agencies adopted the NOAA Riparian Buffer Matrix, the agency responsible for CREP delayed doing so until 2015, when it 'reviewed the science' and chose to increase the minimum width to 50 ft, not 100.

The increase in minimum buffer-widths was opposed by local conservation districts, the agencies responsible for implementing CREP, as well as a suite of other voluntary conservation programs on private land.

3.2 Using riparian science: The contested value of a 35-foot riparian buffer

Throughout the debate, groups on both sides referred to the need to base decisions on 'science,' while accusing the other of political motivations. For example, a conservation district letter frames buffer-width policy as political and then argues that instead they should be based on science*: "We encourage that political agendas at least be grounded with some science"* [Doc06]. In parallel, the Northwest Indian Fisheries Commission, which was created following the 1974 Boldt Decision to support the Treaty Tribes, frames the conservation districts' position as 'ideological' and appeals to science (here via 'federal fish agency expertise'): *"It has been repeatedly noted that a few select conservation districts are* *ideologically opposed to working with federal fish agency expertise, and are unwilling to implement their recommendations!”* [Doc08].

How is it that both 35 and 100-foot buffers can be simultaneously based on science and politically motivated? As we will see, depending on what you count as ‘politics’ and what as ‘science’ both assertions can be considered ‘true’ in some sense. We examined how these groups differently defined the problem at hand, the scope of the system and the definition of both science and success (see Table 1).

Table 1. Points of divergence (values, paradigms, and perspectives) between Conservation Districts and the Treaty Rights at Risk movement regarding riparian science and restoration. Synthesized from analysis of interviews and documents, this table characterizes the dominant views of each of these groups. However, there is substantial variation across conservation districts and tribes as well as among the individuals that constitute each.

Points of divergence	**Conservation Districts’ View**	**Treaty Rights at Risk Movement View**
Use of riparian science	Consider riparian science in the context of what will work in practice; draw from social science as well as natural science	Demand ‘science-based’ decisions; use riparian science to argue for greater recognition of treaty guaranteed rights
Purpose of riparian restoration	Incremental restoration and harm reduction; water quality and riparian habitat	Transformative restoration; provision of fully functional salmon habitat
Goal for salmon conservation	Avoid extinction; regulatory compliance with the Endangered Species Act	Avoid ‘museum fish’ and assure use of salmon for economic and cultural purposes
Spatial scale	Think primarily at the farm scale	Concerned with landscape scale
Temporal scale	Generations	Centuries
Metric of success	Projects, miles, acres, trees	Salmon returns, treaty rights
Policy paradigm	Resource management, i.e., what is the best way to manage the resource? (accepting current political system)	Co-management/treaty rights, i.e., policy or power-oriented ideas about rights to determine natural resource management (challenging current political system)

We begin with the meaning of a 35-foot buffer. Conservation district respondents often saw diminishing returns from wider buffers. Relatively narrow riparian buffers can function to filter excess nutrients (e.g., nitrogen or phosphorous) and pesticides from agricultural runoff, and shade streams to reduce water temperature (Correll, 2005; Poole & Berman, 2001; Shaw, 2018). Most critically, the option to put in a narrow buffer allows conservation districts to get their 'foot in the door.' Conservation district staff's success depends on building relationships with land-owners. Their arguments about riparian-science use focused on ground-level consequences of stricter requirements within a voluntary program: *"There's obviously an ecological benefit to having bigger buffers. But that's not what we're talking about right now. We're not talking about bigger buffers versus smaller buffers. We're talking about a buffer versus no buffer"* [Interview03].

The Treaty Rights at Risk movement argues that narrow buffers, while benefiting water quality, fail to provide functional salmon-habitat. Few scientific studies have directly examined the salmon-habitat impacts of riparian restoration on agricultural land. However, most salmon biologists believe wider buffers are needed, particularly to provision large woody debris, likely maximized at around 100-feet (30 m) (or about the height of the tallest trees which might fall into the stream). While different tribes and individuals vary substantially in their views, for some tribal members, 35-foot buffers construction is a waste of limited restoration money, which could be spent creating fully functional habitat. Some conservation district staff see 100-foot buffers as a waste of this same limited restoration money; wider buffers means less length of stream.

The *Treaty Rights at Risk* white paper and tribal interviewees pointed out that most efforts in the Puget Sound have addressed water quality but not salmon habitat, the latter of which requires wider buffers. Constructing 35-foot buffers gives the impression (to farmers, to the public) that salmon habitat is being addressed, when only water quality is improved. In particular, as one tribal interviewee explained, wider buffers are needed to assure that salmon runs are sufficiently abundant to support tribal fishing and the tribes' cultural, traditional, and economic uses of salmon:

> *If we continue to stay at the 50-foot buffer, then what we're basically saying is that we're just going to have museum fish. We're going to just be able to go out and look at them but we're not going to be able to catch. [Interview11]*

The two groups diverge in the level of salmon recovery sought, but also in their thinking about how to achieve that recovery. For the Treaty Rights at Risk movement, frustration at seeing salmon runs stagnate or dwindle despite marginal improvements in many areas, has led many to conclude that recovery will require broad change on many fronts, not just accepting what seems feasible. Thus, the argument for larger buffers comes not from science showing that restored riparian buffers on agricultural land are the limiting factor for salmon, nor science showing compellingly that anything less than a 100-foot buffer is inadequate, but rather from a mindset-shift findimg some support in science. There is no clear-cut case that salmon recovery requires 100-foot buffers (instead of 35- or 50-foot buffers) or even that those would suffice.

Increasing minimum buffer-widths seems likely to result in less, not more, riparian restoration in the near term. But it may be a crucial long-term step towards establishing tribal treaty-rights as determinants of federal and state environmental regulations. This points to a fundamental divergence of policy paradigms; conservation districts see a resource management issue; the Treaty Rights at Risk movement, rights and responsibilities. Federal courts established that salmon recovery is required by tribal treaties. Yet corresponding laws and regulations are lacking. The Endangered Species Act serves only to prevent extinction—

resulting in 'museum fish.' State and federal regulations to increase riparian habitat are limited; and where laws would protect water quality and existing habitat, enforcement is lacking. Low enforcement of existing laws frustrates conservation districts, which sometimes feel they are expected to compensate for poor enforcement via voluntary programs. Agricultural interests are a powerful lobby in the state legislature, which controls funding for state environmental agencies tasked with enforcement. Pushing for 'higher standards' in a voluntary program is the easiest 'knob to turn.'

4 STUMBLING BLOCKS ON THE JOURNEY FROM SCIENCE TO POLICY

In section 3 we showed how debate around buffer-widths represented larger issues; concerns about how to secure tribal treaty-rights, including the requisite protections of salmon and concerns about sustaining agricultural communities, lands and culture. Yet the history, context and values behind these concerns became obscured as debate turned to science—specifically natural science—to answer a contested, complex political question. In the current section, we identify four separate missteps that together produced a problematic science-policy gap. Along the way, we explain the approach that came to dominate debate (the 'riparian buffer matrix'), how this came about and the consequences of this choice.

4.1 Policy and science are conflated: Recommendations are reproduced as scientific conclusions

While riparian restoration guidelines could potentially incorporate numerous dimensions, debate in Puget Sound focused on just one: buffer-width. There are many different kinds of riparian buffers and approaches to riparian restoration. For example, the 2008 *Conservation Buffers: Design Guidelines for Buffers, Corridors and Greenways* produced by the US Department of Agriculture recommends a planning process to address the many objectives and functions of buffers: water quality, biodiversity, productive soils, economic opportunities, protection and safety, aesthetic and visual quality, and outdoor recreation (Bentrup, 2008, p. 6). In the 136-page guidelines document, planners are guided through processes to consider the various functions associated with each objective, as well as location, structure of the buffer, and the system in which it will operate.

In contrast to this nuanced approach, debate in the Puget Sound focused on developing strict minimum buffer-widths, based on a simple stream classification. One paper in particular played a key role in framing how riparian buffer regulation would be addressed in government agency guidelines. This paper—Castelle et al. 1994—was frequently cited in buffer-width debates and as the 'scientific basis' for assessments in Puget Sound. The paper recommends fixed-width buffers of 50 to 100-feet rather than site-specific variable-width buffers. The authors explain the benefits of fixed-width buffers as follows: "more easily enforced, do not require regulatory personnel with specialized knowledge of ecological principles, allow for greater regulatory predictability, and require smaller expenditures of both time and money to administer" (Castelle, Johnson, & Conolly, 1994, p. 881). In short, fixed-width buffers are easier and cheaper. Even though the recommendation for fixed-width buffers was based on agency needs and not science, it became reproduced as a scientific conclusion. This conflation of policy decision and scientific conclusion represents a significant stumbling block in the science-policy process.

4.2 Science from one context adopted in another, without adaptation: Forestry shapes riparian buffers in agricultural contexts

The approach to riparian buffers in agriculture was shaped by experience and science from the forestry sector—for two main reasons. First was the availability of science and scientific synthesis from the forestry context. For example, agricultural riparian-recommendations often referenced the Bureau of Land Management's (1993) 'Forest Ecosystem Management Assessment Team' (FEMAT) report, which was written to address controversy around oldgrowth forest protection and forestry in the Pacific Northwest and Northern California. This report's analysis and approach were important references for synthesis applied to agriculture in the Puget Sound.

In contrast to forestry, much less is known about riparian restoration on agricultural landscapes, especially considering key salmon habitat impacts such as cooling and large woody debris (Stoffyn-Egli & Duinker, 2013). Most agriculture-focused research on buffers has addressed their use to filter nutrients, pesticides and sediment. As one riparian scientist explains: *"At present most research on riparian buffer zones has been carried out on sites where restoration was not needed. Thus, we know much more about the general water quality functions of riparian buffers than we know about how to restore buffers or how quickly and effectively they regain their functions"* (Correll, 2005, p. 437).

The second reason was a local success story from forestry. The 1987 Timber, Fish, and Wildlife Agreement specified a process to manage forests in Washington State for timber production and wildlife protection, including agreements about riparian buffers. Expert respondents in our study from different groups as well as a variety of policy documents cited this agreement as an exemplary process for agriculture (such as Britney, 2014). A similar forum was indeed convened for agriculture from 1999 to 2003 *"including participation from state and federal agencies, tribal governments and diverse agricultural interests"* [Doc10]. This forum—Agriculture, Fish and Water—sought to address water quality, irrigation and salmon habitat (Spellecacy, 2009). One goal was riparian-buffer guidelines for agriculture that "provide adequate salmon habitat and are implementable" [Doc10].

Wide, fixed-width buffers were successful in forestry; in agriculture, the same approach stalled in controversy. In forestry, we ask: as trees are cut closer to a stream, when does functioning of the riparian ecosystem being to decline? In agricultural, where the baseline is often zero trees along the stream, we instead ask: how much will be gained by each foot of vegetation planted?

Within the Agriculture, Fish and Water forum, NOAA developed recommendations later-to-be-known as the 'NOAA Riparian Buffer Matrix.' The NOAA team that developed this matrix, then called 'Federal Option 3,' felt they had determined the narrowest buffers they could justify as scientists, in order to accommodate agriculture. In the words of one interviewee, they "squeezed the rock as hard as possible" to come up with something that would "pass the red face test" for embarrassment. Nonetheless, the Agriculture, Fish and Water forum ended without agreement and Federal Option 3 was shelved.

The Agriculture, Fish and Water forum had sought to apply the science and processes successful in forestry, to agricultural without accounting for the unique ecology, economics, and politics of each sector. Ecologically, forestry involves *protecting existing riparian buffers*, likely already used by salmon and where trees may be over 100-years old. Contrast this with *restoring new riparian buffers* in agriculture; trees and shrubs must be planted, maintained, protected from wildlife (e.g., deer), and fenced from livestock. Economically, forestry centers on a few large landowners or tenure-holders whereas many farms in the Puget Sound are small. For small farms, removing 100-feet of stream-side property from production could make the farm economically unviable. In Eastern Washington, where farmers often hold large parcels, wide CREP buffers are common (Smith, 2013). But in Puget Sound, small parcels predominate, and wide buffers can remove too high a proportion of a farm's land. Politically, forestry could be regulated, but there has been little political will to require farmers to install riparian buffers. By applying the science from forestry without adapting to the ecological, economic, and political context of agriculture, this became another stumbling block.

4.3 Inertia of one approach limits development of alternatives: The life and times of the ‘Riparian Buffer Matrix’

The approach to riparian *restoration* for agricultural lands in Puget Sound took the form of fixed-width riparian forest buffers, in line with the recommendations by Castelle 1994 and the guidelines developed for riparian *protection* in the forestry context (see examples of different types of guidelines in fig. 2). Specifically, the approach taken was to define minimum widths for restored riparian buffers based on a classification of four or five different stream types. Numerous such tables (locally referred to as ‘buffer matrices’) were proposed and debated over almost 30 years (see supplementary information).

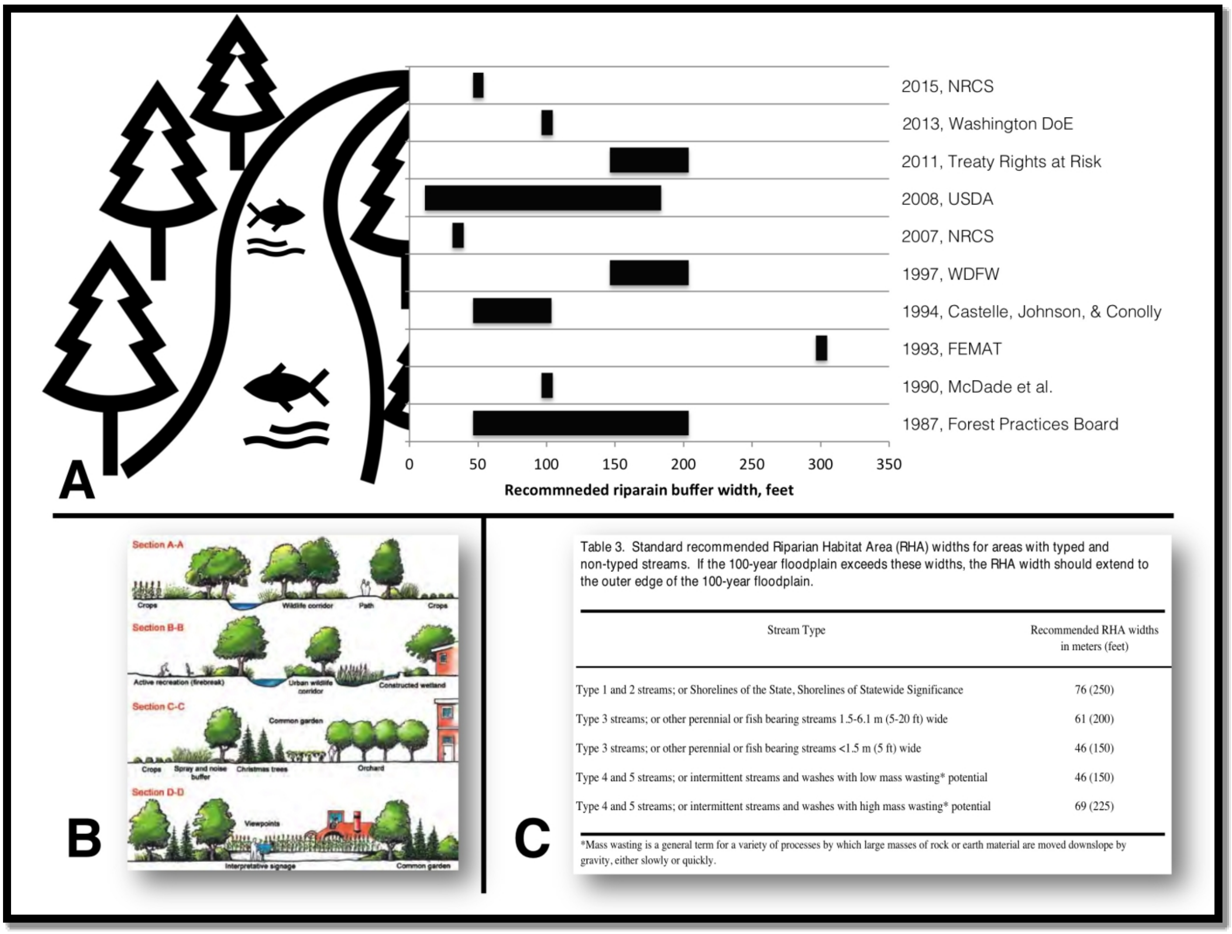

Figure 1 Different Approaches to Riparian Buffer Guidelines. In panel A, different riparian buffer-width recommendations for salmon bearing streams are illustrated. NRCS = Natural Resources Conservation Service; DoE = Department of Ecology; USDA = United States Department of Agriculture; WDFW = Washington [State] Department of Fish and Wildlife; FEMAT = Forest Ecosystem Management Assessment Team. Panel B shows a figure from the US Department of Agriculture *Conservation Buffers: Design Guidelines for Buffers,*

Corridors and Greenways, which illustrates several different types of buffers designed for different purposes. Panel C shows an example of a riparian buffer matrix, in this case from the 1997 Washington Department of Fish and Wildlife Riparian Guidelines. See Supplementary Information for details about these riparian recommendations as well as other riparian standards.

When the *Treaty Rights at Risk* white paper was published in 2011, one of the demands upon federal agencies was to condition funding of riparian restoration grants upon a particular 'buffer matrix' that was originally derived from the Washington Department of Fish and Wildlife Riparian Guidelines from 1997. This report's 181 pages contain general guidelines intended to support a variety of planning, management, and restoration activities; the riparian widths recommended were not designed for or based on the creation of restored riparian buffers within agricultural lands, where trees must be planted, not only protected. For fish-bearing streams, the recommended width is 150 to 200 feet (46-61 m) (Knutson & Naef, 1997).

NOAA's response to *Treaty Rights at Risk* was to ask federal agencies to condition restoration funding upon compliance with a riparian buffer matrix. Instead of the Washington Department of Fish and Wildlife matrix suggested by the *Treaty Rights at Risk* white paper, NOAA dusted off the matrix they had created for the Agriculture, Fish and Water Process in 2002 ('Federal Option 3,' discussed in 4.2) [Doc10]. The document became rebranded, officially as the "Interim Riparian Buffer Recommendation" but more informally referred to as the "NOAA Riparian Buffer Matrix". After a "review of the current scientific information" [Doc10], NOAA decided to attach a 10-year old table produced for but never agreed upon within a multi-stakeholder process (Agriculture, Fish and Water). According to Will Stelle, the agency's "view of the buffer table is unchanged. We supported its use in 2002, and we still support its use in 2012" [Doc10]. According to a contact at NOAA, the tribes identified the 2002 buffer-matrix as "good enough for them," despite the fact that the buffer-widths therein were significantly narrower than those called for in the *Treaty Rights at Risk* white paper: approximately 100-feet versus 150–200 feet (46–61m).

However, the NOAA Riparian Buffer Matrix required significant expertise to implement because widths were based on the tallest mature trees that could potentially grow at the buffer site [Interview05]. Later that year (Oct 28, 2013), the Department of Ecology, produced a set of width measurements that was easier to implement. By using straightforward widths (as opposed to site potential tree heights or buffer-width calculators based on site characteristics) as requirements for riparian buffers, agencies could easily determine if they had met the criteria.

By this point, numerous state and federal government agencies had been involved. Yet a buffer matrix that was "implementable" remained elusive. Then, the Washington Department of Fish and Wildlife "stepped forward" to "take on this buffer issue" [Interview05]. Their most significant decision was to avoid putting forth yet another buffer-matrix, or any "numeric description" of "what constitutes an 'adequate' riparian width" [Doc18]. In a presentation, the agency explained that their guidelines *"do not represent a policy decision about how much is enough, reasonable, or practicable."* [Doc18]. Washington Department of Fish and Wildlife had decided that drawing a line in the sand (or the field or pasture) was more than science could deliver; a scientific report could not answer a policy question. That question required a policy choice, informed—but not determined—by science. Riparian science could explain the ecological benefits of different buffer-widths, but not how to make the trade-off between those benefits and the costs in money and farmland. Neither could riparian science alone determine the consequence of a particular policy. This problematic inertia in the prescriptive power of a particular piece of policy guidance represents the third stumbling block in science-policy process.

4.4 Technical language obscures real trade-offs: Specific vegetative prescriptions and alignment with salmon recovery objectives

Throughout official letters and meeting minutes regarding controversy over riparian buffer-widths, obtuse technical language obscured actual issues. For example, the technical language 'to hold Biology Tech Note 14' can be 'translated' as 'to delay implementation of the proposed increase in minimum buffer-widths (from 35 to 100-feet) for participation in CREP.' The State Technical Advisory Committee advising on the buffer-width issue received letters from Conservation Districts across the state opposing the increased widths, which one conservation district framed as "specific vegetative prescriptions" rather than guidelines for riparian buffer projects [Doc01], framing the issue as overly prescriptive. In the *Treaty Rights at Risk* white paper, the words "buffer-widths" are never mentioned; instead, the document refers to "alignment with salmon recovery objectives" and other obtuse language, such as demanding that grants condition funding upon "buffers comparable to those that NMFS [National Marine Fisheries Service] has called for in its RPA [reasonable and prudent alternative] for FEMA's [Federal Emergency Management Agency] National Flood Insurance Program" [Doc12]. That in turn refers to the Washington Department of Fish and Wildlife Riparian Guidelines from 1997 (Knutson & Naef, 1997). The abundance of acronyms (NMFS, RPA, FEMA, etc.), which are not always defined, further obscures the information to those not fluent in their meanings.

Key questions remain unanswered: who is responsible for setting buffers—NOAA, CREP, Washington Department of Fish and Wildlife, Treaty Tribes, the conservation districts? Should riparian buffers serve only to protect water quality or also to provide salmon habitat? In some cases, are smaller buffers better than nothing? Yet these questions are obscured via vague technical or other oblique 'report-referencing' language that evades a straightforward discussion of the issues. While these questions about riparian buffers are certainly relevant for many different people and groups in the Puget Sound, the use of technical language serves as a barrier to participation and represents a final stumbling block.

5 DISCUSSION

Why is there a gap between science and policy? In our case study on riparian restoration, we have shown how the 'gap' might be more usefully understood as a journey. Along that journey, we identified four stumbling blocks that limited update of science into policy. The first is conflation of science and policy. Simple rules, such as requiring fixed-width buffers, are easier and cheaper to administer. The use of fixed-width buffers applied using a simple matrix, parallels current approaches to stream restoration by private consultants—broadly applicable, simplified methods that are easy to codify and justify (Lave, Doyle, & Robertson, 2010). While most academic scientists of stream restoration oppose such simple approaches, arguing that they obscure the complexity of natural systems, government agencies in the US have embraced them, in part because they allow agencies to justify their decisions by appealing to a seeming standard, e.g., decisions about which stream restoration consultants are hired by US government agencies and what methods are followed (Lave et al., 2010). Policymakers may choose simple guidelines fit for other contexts even over complex guidelines fit-for-purpose. This process highlights why complexity-concepts have seen little uptake in environmental management (Forsyth, 2003), despite 20-plus years of development in the field of ecology; complexity is difficult to administer.

The second stumbling block in our case was applying scientific findings outside of the context in which they were developed. Many of the challenges faced in developing buffer-width standards for agriculture stem from an attempt to apply the research, reports, and processes from riparian buffer *protection in forestry* to riparian buffer *restoration in* *agriculture*. Applying recommendations out of context fails to account for the ways those recommendations were tailored to fit the original context (Forsyth, 2003). Here we have shown an example where recommendations based on protection were applied to a restoration context, but the problem applies equally to management practices and concepts that are applied unreflexively outside of the context in which they were developed. For example, the Universal Soil Loss Equation was developed in the US Great Planes; efforts to apply the tool out of context, such as in sub-tropical regions, led to an over-emphasis on soil erosion as the primary cause of soil fertility loss (Forsyth, 2003).

In the third stumbling block, inertia of one approach (the riparian buffer matrix), served to limit discussion and development of alternative approaches to the problem. The buffer-width debate focused on specific rules for voluntary programs impacting a tiny area of potential salmon habitat. Rather than a broad search for policies that might meet a variety of needs, the matrix locked attention into its rows and columns. Alternative approaches include working buffers that could increase habitat while providing some income to farmers or enforcement of existing regulations intended to protect riparian forests in agricultural and urban areas (currently such regulations are rarely enforced). Another alternative is to focus on a smaller 'stream reach' scale, where specific local compromises may be easier to achieve than regional scale rules would allow. But once different groups zeroed in on the buffer matrix, a discussion of the real trade-offs involved in salmon conservation and farmland preservation was missed. This stumbling block parallels one of the 'pitfalls of an overemphasis on science': inadequate consideration of alternatives (Gregory, Failing, Ohlson, & McDaniels, 2006).

Finally, in the fourth stumbling block, focus on the scientific basis of buffer-widths via highly technical language served to inhibit a discussion of underlying value and political issues. Rather than discuss rights and responsibilities at the heart of the conflict, attention focused on effectiveness curves and stream classifications. When environmental conflict is forced into science-focused discussions, values become ‘fugitive,’ still dominating the discussion, but coded in technical terms that limit participation and discussion of the key points of contention (Satterfield & Levin, 2007).

Differences in ideas about place, aesthetics, nature and science across farmers and farm advocates, Treaty Tribes and advocates of restoration help explain differences in expectations regarding farmland preservation versus salmon restoration (Breslow, 2014). In this paper we have formed two broad categories of “Conservation Districts” to represent agricultural concerns and “Treaty Tribes” to represent salmon conservation concerns. This binary served to simplify, for analysis and communication, what in reality is a complex, and multi-faceted debate. There are 12 conservation districts in Puget Sound and over 20 Treaty Tribes, as well as numerous government, civil society and industry groups. Levels of trust and communication between local tribes and conservation districts vary by watershed and particular individuals in each context and constellation have served to shape the tone of dialog—by fostering collaboration or by sharpening debate. The particular appeals—of Treaty Tribes to Western science and law and agricultural interests to tradition and heritage—can also be seen as politically motivated strategic choices on behalf of each group (Breslow, 2014). But for both values and politics, science cannot be the arbitrator of these differences. Riparian science is needed to inform the debate. But as we have shown in this case study, looking to scientific synthesis for policy answers, without accounting for the politics and values of the different actors involved, only led to more and not less controversy.

6 CONCLUSION

This case study of riparian buffers for salmon revealed how an output of 'science' (the riparian buffer matrix) can make values fugitive, obscuring conflicts about the scale of the problem, exacerbated by a preference for simple policy solutions cloaked in technical language. The demands placed on the riparian buffer matrix—to answer a policy question using natural scientific synthesis—were far too great and led to a conflation of science and values. This matrix was created to determine appropriate thresholds for specific policy applications—questions that require far more judgments beyond science. We have shown how an effort to close the science-policy gap functioned to politicize science and fueled controversy. A more fruitful approach would delve into the 'gap' and acknowledge the political, economic, historical and values questions that are part of many conservation issues.

Based on this case study, we suggest a number of waypoints for a smoother journey along the road from science to policy. Each might help to remove a stumbling block to the implementation of 'best available science.' These remedies include:

1) Expand the fields of science included to incorporate social as well as natural sciences, including qualitative social science (Charnley et al., 2017). This would have allowed policy makers to consider the social and political context in which natural science is used and adapt recommendations on that basis.

2) Adapt and if needed re-think scientific recommendations taken from one context before application in new social, political, legal, or ecological contexts. By considering explicitly the ways that agriculture differs from forestry, and restoration differs from protection, agencies might develop feasible recommendations. Consideration of context should also include the historical origins of different groups' positions and of ecological changes across the landscape. The frustration of the Treaty Rights at Risk movement is based on a history of

failed promises and unfair treatment. These concerns might have been more effectively addressed via changes in decision-making process than in buffer-widths.

3) Address limitations imposed by existing legislation, power structures and agency jurisdiction (Chapman, LaValle, Furey, & Chan, 2017). A fundamental challenge involved who had jurisdiction to regulate habitat creation (i.e., what agency should regulate habitat and under what law?).

4) Elicit a wide variety of alternative approaches from diverse sources to move beyond institutional inertia. The focus on defining a buffer matrix served to limit explorations of alternative pathways that might have been more fruitful, such as the stream-reach-scale approach described above.

In Puget Sound, government agencies, NGOs, Treaty Tribes and agricultural interests are starting to form groups and processes to discuss these trade-offs. Multi-stakeholder policy-planning processes such as Snohomish County's Sustainable Lands Strategy and Agricultural Resilience plan bring together representatives from agriculture with those from environmental, government, and tribal groups to converse about the region's future, given predicted increases in population, sea level, and land prices. Recognizing their inter-related futures, these groups seek integrated land use and policy plans to address agricultural resilience, floodplain management, salmon protection and land use. By focusing on an integrated approach that address the fundamental issues, hopefully a more fruitful path forward is found.

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The authors declare no competing interests.

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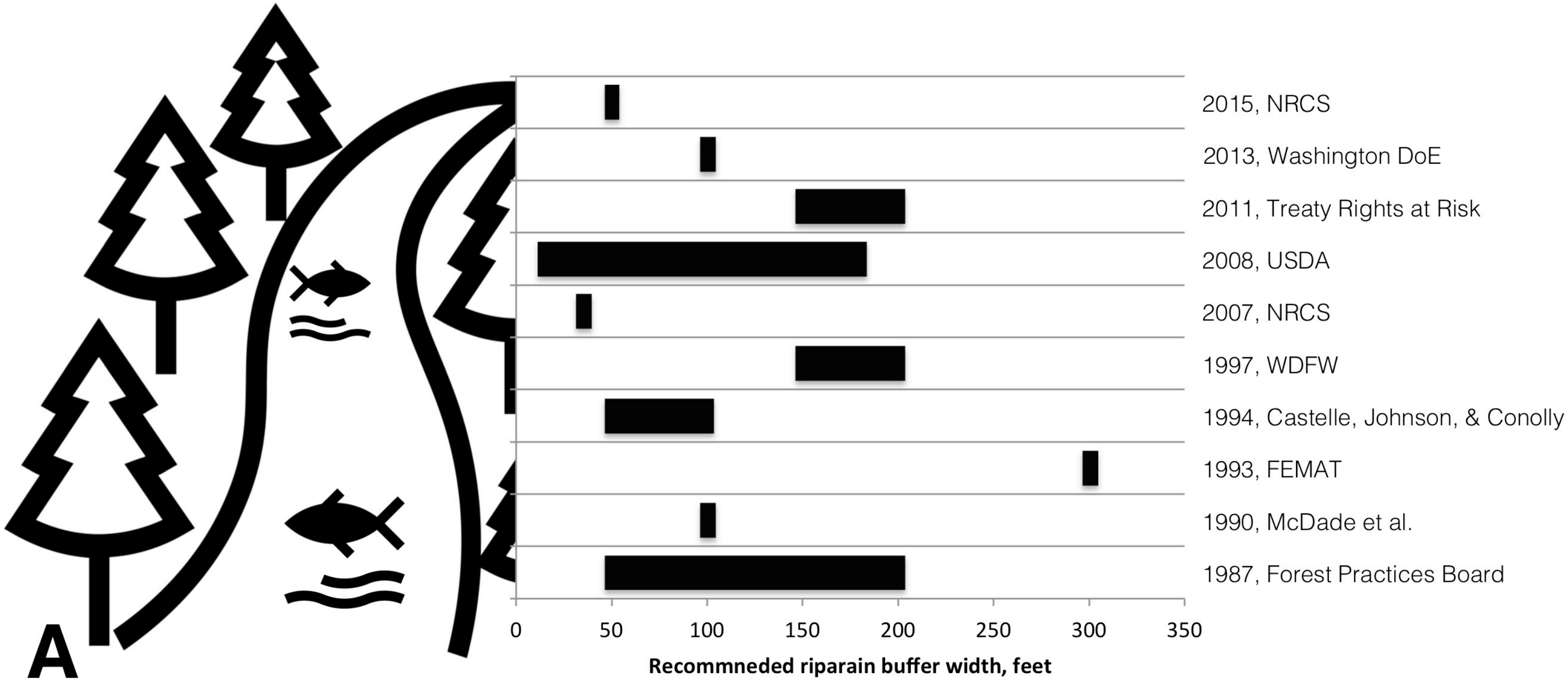

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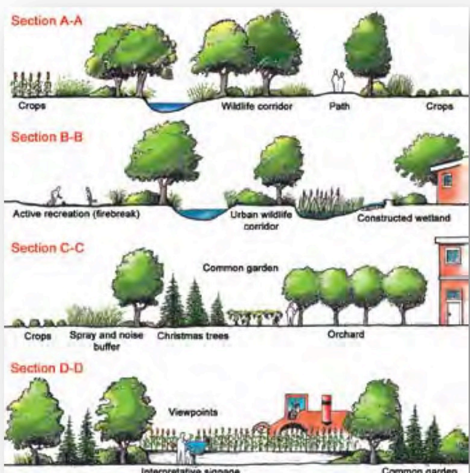

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Table 3. Standard recommended Riparian Habitat Area (RHA) widths for areas with typed and non-typed streams. If the 100-year floodplain exceeds these widths, the RHA width should extend to the outer edge of the 100-year floodplain.

Stream Type	Recommended RHA widths in meters (feet)
Type 1 and 2 streams; or Shorelines of the State, Shorelines of Statewide Significance	76 (250)
Type 3 streams; or other perennial or fish bearing streams 1.5-6.1 m (5-20 ft) wide	61 (200)
Type 3 streams; or other perennial or fish bearing streams <1.5 m (5 ft) wide	46 (150)
Type 4 and 5 streams; or intermittent streams and washes with low mass wasting* potential	46 (150)
Type 4 and 5 streams; or intermittent streams and washes with high mass wasting* potential	69 (225)

*Mass wasting is a general term for a variety of processes by which large masses of rock or earth material are moved downslope by gravity, either slowly or quickly.

1 SUPPLEMENTARY INFORMATION

Table S1. Documents analyzed in this study

No	Group	Organization	Year	Author	Type	Collection	Description/Title
1	CD	Whatcom Conservation District	December 1, 2013	George Boggs	letter	Technote14	Letter to WSCC opposing the NOAA Riparian Buffer Matrix
2	CD	Snoqualmie Watershed Forum	December 6, 2013	Jason Walker	letter	Technote14	Letter to WSCC opposing the NOAA Riparian Buffer Matrix
3	CD	Lincoln County Conservation District	December 11, 2013	Tom Schultz	letter	Technote14	Letter to WSCC opposing the NOAA Riparian Buffer Matrix
4	CD	Clallam Conservation District	December 13, 2013	Joseph F. Murray	letter	Technote14	Letter to WSCC opposing the NOAA Riparian Buffer Matrix
5	Ag	Washington Association of Wheat Growers	December 3, 2013	Nicole Berg	letter	Technote14	Letter to WSCC opposing the NOAA Riparian Buffer Matrix
6	CD	Cowlitz County Soil and Water Conservation District	January 8, 2014	Darin B. Houpt	letter	Technote14	Letter to WSCC opposing the NOAA Riparian Buffer Matrix
7	CD	Washington State Conservation Commission	November 18, 2013	Ron Schultz	letter	WSCC Meeting	Briefing for WSCC Members
8	TT	Northwest Indian Fisheries Commission	September 25, 2013	Mike Grayum	letter	WSCC Meeting	Letter to Mary Clark (Executive Director of WSCC) Re: Request for WSCC Action to Protect Treaty Rights
9	CD	Washington State Conservation Commission	October 3, 2013	Mary Clark	letter	WSCC Meeting	Letter to Michael Grayum re: NWIFC letter to the Conservation Commission dated September 25, 2013
10	Gov	NOAA	January 30, 2013	Will Stelle	letter	WSCC Meeting	Letter to Roylene Rides-at-the Door (NRCS) and Dennis McLerran (EPA Regional Administrator)
11	Gov	NOAA	April 9, 2013	Will Stelle	letter	WSCC Meeting	Letter to Roylene Rides-at-the Door (NRCS) and Dennis McLerran (EPA Regional Administrator)

No	Group	Organization	Year	Author	Type	Collection	Description/Title
12	TT	Treaty Rights at Risk (TRAR)	July 14, 2011	Billy Frank Jr. and Mike Grayum	White Paper	TRAR	Treaty Rights at Risk: Ongoing Habitat Loss, the Decline of the Salmon Resource, and Recommendations for Change
13	TT	Northwest Indian Fisheries Commission	unknown	NWIFC	White Paper	TRAR	Understanding Tribal Treaty Rights in Western Washington
14	TT	Northwest Indian Fisheries Commission	2016	NWIFC	report	TRAR	State of Our Watersheds Report 2016
15	CD	National Resources Conservation Service	November 23, 3015	Roylene Rides at the Door	Policy Memo	Policy	Bulliten re: ECS- FY16 RIPARIAN BUFFER WIDTH PLANNING CRITERIA
16	CD	Conservation Reserve Enhancement Program	December 1, 2013	Carol Smith	report	Policy	2013 Implementation and Effectiveness Monitoring Results for the Washington Conservation Reserve Enhancement Program (CREP): Buffer Performance and Buffer Width Analysis
17	TT	Treaty Rights at Risk (TRAR)	May 28, 2013	Various	Website videos	TRAR	video clip of Will Stelle quoted "case study"; video clips (n=6) of various Tribal members discussing why treaty rights are important to them
18	Gov	WDFW	January 1, 2016	Mike Kuttle	Power-point	Policy	presentation to the State Technical Advisory Committee titled, "Riparian Science: Updating the Priority Habitats and Species Riparian Document"
19	CD	State Technical Advisory Committee	January 28, 2014	Roylene Rides at the Door	Meeting Agenda	Technote14	NRCS State Technical Advisory Committee Agenda

CD=Conservation Districts; Ag=Agricultural organizations; TT=Treaty Tribes of Western Washington; Gov=Government Agency. Collections refer to document purposes. Technote 14 includes all letters presented to the NRCS State Technical Advisory Committee for the Jan 28, 2014 meeting. This meeting packet was titled 'Letters to Hold Biology Technote 14." The WSCC Meeting collection are letters presented to the WSCC meeting for Dec 5, 2013 regarding proposed buffer width changes. Sources for documents are as follows: State Technical Advisory Committee Meeting Minutes (source for Doc01-Doc11; Doc15; Doc18-19) retrieved September 13, 2017 from: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wa/technical/stc/minutes/?cid=nrcs144p2_036330; TRAR Website (source for Doc12-Doc14; Doc 17) retrieved September 13, 2017 from: http://treatyrightsatrisk.org; WSCC (source for Doc16) retrieved September 13, 2017 from: http://scc.wa.gov/wp-content/uploads/2014/02/CREP-Effectiveness-Monitoring-report-2013.pdf

Table S2. Riparian Guidelines and 'Matrices'

Year created	Document name	Organization or author that produced the guidelines	Purpose or applicability of the guidelines	Minimum recommended buffer for salmon bearing streams (feet)	Notes
1987	Forest Practices Rules: Title 222 WAC	Forest Practices Board (established from Timber, Fish and Wildlife agreement and Forests and Fish law)	Forestry, negotiated agreements on riparian buffers	50 – 200	Permitted activities are defined for each of three riparian management zones (core, inner and outer) and vary by type of site
1990	Source distances for coarse woody debris entering small streams in western Oregon and Washington	M.H. McDade, F.J. Swanson, W.A. McKee, J.F. Franklin, J. Van Sickle	Minimizing loss of existing riparian function in forests	100	100 ft buffers are to provide 85% of coarse woody debris
1993	Minimum widths of Riparian Reserves (Table V-5)	FEMAT	Forestry, addressing ESA listing of the Northern Spotted Owl	300	300 feet or the equivalent of two site potential tree heights
1994	Wetland and stream buffer size requirements—A review	A.J. Castelle, A.W. Johnson, and C. Conolly	Agency applicability; existing forested areas and new restoration	50 – 100	Recommend fixed width buffers due to regulatory ease
1997	Management Recommendations for Washington's Priority Habitats: Riparian	WDFW	"all areas throughout Washington to the greatest extent possible" (p 88)	150 – 200	150 ft for streams < 5 ft wide

Year created	Document name	Organization or author that produced the guidelines	Purpose or applicability of the guidelines	Minimum recommended buffer for salmon bearing streams (feet)	Notes
2002	Federal Option 3 for the Agriculture Fish and Water Process	NOAA	Proposed guidelines	3/4 Site potential tree height	Later simplified to 100 ft
2007	Conservation Practice Standard: Riparian Forest Buffer	NRCS	Guidelines for CREP funded buffers	35	Washington State CREP began in 1999
2008	Conservation Buffers: Design Guidelines for Buffers, Corridors and Greenways	USDA	Synthesis of scientific knowledge applicable for buffers on agricultural lands	<15 – 180	Buffer width design tool for surface runoff calculates widths based on desired 'trapping efficiency' and site characteristics
2011	Treaty Rights at Risk: Ongoing Habitat Loss, the Decline of the Salmon Resource, and Recommendations for Change (White Paper)	TRAR	addressing salmon habitat loss and restoration	150 – 200	Recommend 1997 WDFW guidelines
2012	Interim Riparian Buffer Recommendations for Streams in Puget Sound Agricultural Landscapes (November 2012)	NOAA	Response to TRAR White Paper	3/4 Site potential tree height	Later simplified to 100 ft
2013	Interim Riparian Buffer Recommendations for Streams in Puget Sound Agricultural Landscapes (October 2013)	Washington State Department of Ecology	Simplification of 2012 NOAA guidelines	100	supporting site assessment recommended to increase buffer width
2015	WA Biology Technote 14 Revision	NRCS	Guidelines for CREP funded riparian buffers in Western Washington	50	50 ft is a minimum, not an average, but needs only apply to 70% of the length of the project (increased from previous standard of 35 ft minimum)

Year created	Document name	Organization or author that produced the guidelines	Purpose or applicability of the guidelines	Minimum recommended buffer for salmon bearing streams (feet)	Notes
2016	Riparian Science: Updating the Priority Habitats and Species Riparian Document [PowerPoint slides from presentation to the State Technical Advisory Committee]	WDFW	Designate riparian areas and inform land use decision making for cities, counties, developers, foresters and government agencies	No numeric guidelines	Scientific synthesis and management considerations; guidelines will not define what is an ‘adequate’ buffer