RESILIENCE AND LAW AS A THEORETICAL BACKDROP FOR NATURAL RESOURCE MANAGEMENT: FLOOD MANAGEMENT IN THE COLUMBIA RIVER BASIN

BY

BARBARA COSENS* **

The 1964 Columbia River Treaty entered by the United States and Canada for mutual benefits in flood control and hydropower generation is under review in anticipation of expiration of certain flood control provisions in 2024. This Article asserts that nonstructural measures should be the primary focus of new expenditure on flood risk management in the Columbia River Basin over the next sixty-year period of treaty implementation to align flood risk management with management for ecosystem resilience. Resilience is the measure of the capacity of a system to maintain important functions, structures, identity, and feedback through adaptation in the face of a disturbance. Water basin governance can enhance or detract from ecosystem resilience, thus affecting the resilience of the combined social–ecological system. Floodplains provide important ecosystem function not only as natural storage in flood risk management, but also to aquatic ecosystem resilience in general and salmonid habitat in particular. From the perspective of the social system, reliance on multiple geographically widespread locations for natural storage reduces the risk of crisis in the face of collapse of a single flood-control structure. These concepts have broad applicability to any major river basin with high hydrologic variability, and the Columbia River Basin faces a unique opportunity to employ them. Columbia River Treaty review combined with a public desire for improved ecosystem function presents an opportunity to enhance ecosystem resilience outside the emotional crisis management that ensues following a flood. Phased movement from sole reliance on centralized storage-based flood

* Professor, University of Idaho College of Law and Waters of the West Program. The author would like to acknowledge the students of the 2011 Spring Law and Science Seminar—Emmi Blades, Meghan Carter, Mark Cecchini Beaver, Mary Grant, Gregory Haller, Dylan Hedden-Nicely, Tyler Olson, Saundra Richartz, and Nicholas Sackman—whose interviews and report are relied on in this Article, and Fritz Fiedler, Ashley Williams, Eva Strand, Nick Fordes, and the members of the Lapwai Research Team in the University of Idaho Waters of the West Program whose work inspired and contributed depth to this Article.

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management by incremental addition of more diffuse nonstructural measures will enhance the social–ecological resilience of the Columbia River Basin.

I. Introduction

The setting: A community of temporary public housing units built for shipyard workers then occupied by returning low-income veterans following World War II. Located on the floodplain of a major river, the housing had been necessary due both to the large influx of workers needed for the war effort and to the fact that the larger city nearby did not welcome the African American workers among the newcomers.[1] In fact, the first constitution of the state in which the community was located had prohibited African Americans from entering its borders.[2]

The crisis: On May 30, 1948, the river was flowing at a level reported to be fifteen feet above the community when the dike separating the river from its floodplain broke.[3] Fifteen people lost their lives.[4] Twenty-five percent of those left homeless were African American.[5] A residue of oil from the small refinery located in the floodplain nearby covered houses when the water receded.[6]

The location: Vanport, Oregon, a city destroyed in the 1948 Columbia River flood and never rebuilt. [7]

1 Michael McGregor, *The Vanport Flood & Racial Change in Portland*, Or. History Project, 2003, http://www.ohs.org/education/oregonhistory/learning_center/dspResource.cfm?resource_ID=000BC26B-EE5A-1E47-AE5A80B05272FE9F (last visited Feb. 18, 2012).

2 *Id.*

3 *Id.*

4 Portland Cmty. Coll., *Impact of Vanport Flood Remembered at PCC March 1998*, http://freepages.history.rootsweb.ancestry.com/~cchouk/vanport/ (last visited Feb. 18, 2012).

5 McGregor, *supra* note 1.

6 Portland Cmty. Coll., *supra* note 4.

7 *Id.*; McGregor, *supra* note 1; Manly Maben, Vanport 131–32 (1987).

The response: Dams were considered the key to taming the Columbia River, but the best remaining storage sites were located in Canada while the major flood control benefits would be downstream in the United States.[8] Collaboration would be needed.

The 1948 flood is considered a major factor in moving forward negotiations between the United States and Canada concerning Columbia River storage, although studies had already been underway.[9] The Columbia River Treaty, completed and approved in 1964, provided for the development of three dams on the river in Canada, that, combined with several new dams on tributaries in the United States, would increase storage capacity on the river from 6% to 40% of its average annual flow.[10] The United States paid approximately $65 million to Canada for sixty years of dam operation to prevent flooding.[11] No major flood damage has occurred on the river mainstem since, and operation of United States Army Corps of Engineers (Corps) dams and other federal dams is thought to have prevented $3.6 billion in damage on both the mainstem and tributaries in the United States during the major high flow events in late 1995 and early 1996.[12]

In the wake of the Vanport flood, some houses were restored, but the area directly in the floodplain was converted to a park, still protected by a levee.[13] Although some homeless flood victims were taken in by Portland residents, it would be over a decade before the civil rights movements would bring such compassionate treatment to African Americans in the city.[14] Nevertheless, no thought appears to have been given to moving development out of the floodplain as an alternative to stopping floods. More recently, in the nation's response to Hurricane Katrina, the emotional drive to rebuild New Orleans overwhelmingly prevailed over the rational plea to reconnect the river to the floodplain.[15]

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8 U.S. ARMY CORPS OF ENG'RS & BONNEVILLE POWER ADMIN., COLUMBIA RIVER TREATY: HISTORY AND 2014/2024 REVIEW 2–3 (2008), *available at* http://www.bpa.gov/Corporate/pubs/Columbia_River_Treaty_Review_-_April_2008.pdf; Barbara Cosens, *Transboundary River Governance in the Face of Uncertainty: Resilience Theory and the Columbia River Treaty*, 30 J. LAND RESOURCES & ENVTL. L. 229, 243 (2010).

9 *Cf.* Jeremy Mouat, *The Columbia Exchange: A Canadian Perspective on the Negotiation of the Columbia River Treaty, 1944–1964*, *in* THE COLUMBIA RIVER TREATY REVISITED (Barbara Cosens ed., Or. State Univ. Press, forthcoming 2012) (manuscript at 8–9) (on file with author).

10 *See* Anthony White, *The Columbia River: Operation Under the 1964 Treaty*, *in* THE COLUMBIA RIVER TREATY REVISITED, *supra* note 9 (manuscript at 1–2).

11 Treaty on the Columbia River Basin: Cooperative Development of Water Resources, U.S.-Can., art. II, IV, VI, Jan. 17, 1961, 15 U.S.T. 1555 [hereinafter Columbia River Treaty].

12 PORTLAND, OR. HYDROLOGIC ENG'G BRANCH, U.S. ARMY CORPS OF ENG'RS, THE NORTHWEST'S GREAT STORMS AND FLOODS OF NOVEMBER 1995 AND FEBRUARY 1996, at 22, *available at* http://www.nwd-wc.usace.army.mil/crwmg/reports/novfeb96/NOVFEB96RPTrev1.pdf; Portland Dist., U.S. Army Corps of Eng'rs, *Portland District History (1871–1996)*, http://www.nwp.usace.army.mil/admin/history2.asp (last visited Feb. 18, 2012).

13 *See* Portland Cmty. Coll., *supra* note 4.

14 McGregor, *supra* note 1.

15 *Cf.* John Schwartz, *New Orleans Levees Nearly Ready, but Mistrusted*, N.Y. TIMES, Aug. 23, 2010, http://www.nytimes.com/2010/08/24/us/24levee.html (last visited Feb. 18, 2012) (citing concerns that not enough ecological mitigation efforts were incorporated in the rebuilding plan).

One aspect of resilience theory pertaining to the adaptive capacity of ecosystems is that crisis caused by a perturbation presents opportunity to innovate and adapt.[16] Yet as the experience with Hurricane Katrina illustrates, it is also a time when humans are most likely to dig in and seek the comfort of the past. Thus opportunities to alter the approach to floodplain management must be sought during calmer times.

Review of the 1964 Columbia River Treaty provides that opportunity for the residents of the Columbia River Basin. In 2024 the provisions of the 1964 Treaty providing what is referred to as "assured flood control" expire.[17] The review process currently underway provides an opportunity to consider the standard approach to flood control outside of a crisis in which emotions run high and the sentiment to rebuild is impossible to ignore.[18] Interview data from the basin indicates interest in improvements in ecosystem management while retaining low flood risk and strong hydropower revenues.[19] This Article asserts that nonstructural measures should be the primary focus of new expenditure on flood risk management in the Columbia River Basin over the next sixty-year period of treaty implementation to align flood risk management with management for ecosystem resilience. Arriving at this conclusion requires first: an understanding of ecosystem resilience; second: an understanding of the value of floodplains not only as a factor in flood risk management, but also as important to aquatic ecosystem resilience in general and salmonid habitat in particular; third: an understanding of the application to the Columbia River Basin, including the treaty review process, the public desire for improved ecosystem function, and the issues associated with moving from sole reliance on centralized storage-based flood management to the addition of more diffuse nonstructural measures.[20]

16 *See* Emma L. Tompkins & W. Neil Adger, *Does Adaptive Management of Natural Resources Enhance Resilience to Climate Change?*, ECOLOGY & SOC'Y, Dec. 2004, *available at* http://www.ecologyandsociety.org/vol9/iss2/art10/print.pdf.

17 Columbia River Treaty, *supra* note 11, art. IV; *see* U.S. ARMY CORP OF ENG'RS & BONNEVILLE POWER ADMIN., UNITED STATES ENTITY SUPPLEMENTAL REPORT: COLUMBIA RIVER TREATY 2014/2024 REVIEW 4–5 (2010), *available at* http://www.crt2014-2024review.gov/Files/SupplementalReportAndExecutiveSummary.pdf.

18 Information on the review process can be found at U.S. Army Corps of Eng'rs & Bonneville Power Admin., *Columbia River Treaty 2014/2024 Review: Phased Approach*, http://www.crt2014-2024review.gov/PhasedApproach.aspx (last visited Feb. 18, 2012); U.S. ARMY CORP OF ENG'RS & BONNEVILLE POWER ADMIN., *supra* note 8, at 8.

19 Barbara Cosens et al., *Scenario Development for the Columbia River Treaty Review*, *in* COMBINED REPORT ON SCENARIO DEVELOPMENT FOR THE COLUMBIA RIVER TREATY REVIEW 3, 12–13 (Shanna Knight et al. eds., 2011) (on file with author); *see* U.S. ARMY CORP OF ENG'RS & BONNEVILLE POWER ADMIN., *supra* note 8, at 8.

20 It should be noted that the Corps is currently undertaking a flood risk management review of the Columbia River Basin as part of the 2014/2024 Treaty review. At the time of this writing, those studies are not yet publicly available, but are likely to include at least some nonstructural flood control. It is the hope of the author that this Article can provide some encouragement to that effort.

II. ECOSYSTEM RESILIENCE

The concept of resilience was initially articulated in the study of ecological systems in the work of C.S. Holling in 1973.[21] As applied to ecological systems, "[r]esilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks."[22] When applied to ecological systems without a human component, resilience theory focuses on both the capacity of the system to return to its prior level of self-organization following a disturbance,[23] and the degree to which that capacity is influenced by or sensitive to changes at smaller and larger scales.[24] Social–ecological interaction can serve to enhance or detract from ecosystem resilience. "Adaptability is the capacity of actors in a system to influence [ecological] resilience."[25] Resilience can be enhanced both from the natural adaptive capabilities of the ecological system and from the ability of the social system to respond to an ecological problem by seeking to restore the ecosystem or aid in its adaptation.[26] Natural resource management for optimization of ecosystem services with immediate commodity value, such as energy, timber, or large game, does not lead to resilience or sustainability of an ecosystem. The failure of management through "optimization" to retain

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21 C.S. Holling, *Resilience and Stability of Ecological Systems*, 4 ANN. REV. ECOLOGY & SYSTEMATICS, 1973, at 1, 17–19.

22 Brian Walker et al., *Resilience, Adaptability and Transformability in Social–Ecological Systems*, ECOLOGY & SOC'Y, Dec. 2004, *available at* http://www.ecologyandsociety.org/vol9/iss2/art5/print.pdf.

23 Referred to as the "latitude," "resistance," and "precariousness" of the system. *See id.*; *see also* Steve Carpenter et al., *From Metaphor to Measurement: Resilience of What to What?*, 4 ECOSYSTEMS 765, 777–79 (2001) (developing a definition of "resilience" in socioecological systems).

24 Walker et al., *supra* note 22; *see also* C.S. Holling & Lance H. Gunderson, *Resilience and Adaptive Cycles*, *in* PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS 25, 25–62 (Lance H. Gunderson & C.S. Holling eds., 2002) (finding and explaining evidence of resilience theory in ecological systems).

25 Walker et al., *supra* note 22.

26 *See* Sandra Zellmer & Lance Gunderson, *Why Resilience May Not Always Be a Good Thing: Lessons in Ecosystem Restoration from Glen Canyon and the Everglades*, 87 NEB. L. REV. 893, 897 (2009). Addressing environmental problems across multiple jurisdictions is under discussion by scholars looking through the lens of numerous theoretical constructs. *See, e.g.*, J.B. Ruhl & James Salzman, *Climate Change, Dead Zones, and Massive Problems in the Administrative State: A Guide for Whittling Away*, 98 CAL. L. REV. 59, 68–69 (2010). This author prefers the language and nuances of the resilience literature because it ties directly to the coupled complexity of the social ecological system rather than viewing governance as a feature independent of the ecologic system it manages. *See, e.g.*, Carl Folke et al., *Adaptive Governance of Social–Ecological Systems*, 30 ANN. REV. ENV'T & RESOURCES, 2005, at 441, 443 ("[T]he term 'social-ecological' system [is used] to emphasize the integrated concept of humans in nature and to stress that the delineation between social and ecological systems is artificial and arbitrary. Research suggests that social-ecological systems have powerful reciprocal feedbacks and act as complex adaptive systems."(citing Fikret Berkes & Carl Folke, *Linking Social and Ecological Systems for Resilience and Sustainability*, *in* LINKING SOCIAL AND ECOLOGICAL SYSTEMS: MANAGEMENT PRACTICES AND SOCIAL MECHANISMS FOR BUILDING RESILIENCE 1, 4 (Fikret Berkes & Carl Folke eds., 1998))).

the full range of ecosystem services is a key message of scholars working on the concept of resilience.[27] Thus, Walker and Salt assert:

> [I]f there is one lesson to be taken from this book it is this: optimization (in the sense of maximizing efficiency through tight control) is a large part of the problem, not the solution . . . . When we aim to increase the efficiency of returns from some part of the system by trying to tightly control it, we usually do so at the cost of the system's resilience. Other parts of the system begin to change in response to this new state of affairs—a part of the system, now constant, that used to vary in concert with others. A system with little resilience is vulnerable to being shifted over a threshold into a new regime of function and structure. And, as we've seen, this new regime is frequently one that doesn't provide us with the goods and services we want. And, very importantly, it is not a space from which we can easily return.[28]

The complexity of feedbacks both between and within the social and ecological systems has led to the recognition that there is no single panacea that will solve the question of how to achieve sustainable social–ecological systems.[29] Instead, actions must be tailored to the specific social–ecological system with careful attention to the interactions and feedbacks within them and cross-scale interactions.[30] The term "adaptive management" has been used to describe a process of learning through monitoring ecosystem response to a particular action, followed by incremental change in the action based on what is learned.[31] Under adaptive management, the natural adaptive abilities of an ecosystem are emphasized and promoted over the active management, control, optimization, and resource exploitation of the system.[32] Similarly, continual and artificial maintenance of an ecosystem within human-defined parameters is less desirable.[33] Instead, natural disruptions to the ecosystem are allowed to take place. For example, during periods of heavy rain, a stream is allowed to flood beyond its natural boundaries. By doing this, the system's resilience is promoted by allowing it

27 Zellmer & Gunderson, *supra* note 26, at 898.

28 BRIAN WALKER & DAVID SALT, RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD 141 (2006).

29 Elinor Ostrom, *A Diagnostic Approach for Going Beyond Panaceas*, 104 PROC. NAT'L ACAD. SCI. 15,181, 15,181 (B.L. Turner, II ed., 2007) [hereinafter Ostrom, *Diagnostic Approach*], *available at* http://www.pnas.org/content/104/39/15181.full.pdf; Elinor Ostrom, *A General Framework for Analyzing Sustainability of Social–Ecological Systems*, 325 SCIENCE 419, 419–22 (2009).

30 Ostrom, *Diagnostic Approach*, *supra* note 29, at 15,181.

31 Folke et al., *supra* note 26, at 447; Dave Huitema et al., *Adaptive Water Governance: Assessing the Institutional Prescriptions of Adaptive (Co-)Management from a Governance Perspective and Defining a Research Agenda*, ECOLOGY & SOC'Y, June 2009, http://www.ecologyandsociety.org/vol14/iss1/art26/ (last visited Feb. 18, 2012); Kai N. Lee, *Appraising Adaptive Management*, CONSERVATION ECOLOGY, Sept. 1999, http://www.consecol.org/vol3/iss2/art3/ (last visited Feb. 18, 2012).

32 Folke et al., *supra* note 26, at 443–44.

33 *See id.*

to naturally respond to the disruption; through natural disruptions it becomes stronger.[34]

Understanding cross-scale interactions is important in both ecological and social systems. The study of resilience in ecological systems has led to the development of the concept of the adaptive cycle (Figure 1) to describe the state and evolution of a self-organizing system and panarchy theory to describe the hierarchical structure of adaptive cycles linked across scales.[35] Panarchy recognizes that adaptive cycles occur at many scales and that linkage occurs across scales.[36] Higher, slower cycles may provide stability for smaller scales to engage in innovation and adaptation while minimizing the risk of collapse.[37] Innovation and adaptation at smaller scales can provide feedback to the maintenance of stability at larger scales. The adaptive state of systems at scales above and below the scale of a system of interest may enhance or detract from the resilience of the system of interest.[38]

While the adaptive cycle is observed to be a feature of a self-organizing ecological system, social interaction with that system can alter the state of the system either intentionally or unintentionally. Within the social system, collapse (for example, a major flood destroys a city and its ecological setting) does not necessarily present the most rational moment for human innovation. Alternatively, by working with the natural adaptive capacity of an ecological system, human intervention may serve to enhance resilience.

One lesson of panarchy theory is that attention must be paid to opportunities for that intervention at the scale of the system of interest (a river basin in the context of this Article), the scale below the system of interest (either local watersheds or federal, state, and tribal subdivisions depending on whether the ecological or political focus is warranted), and the scale above the system of interest (the international scale in the context of a transboundary river). We turn first to the role of floodplains in ecosystem function, and then return to a discussion of social interaction with that system at various scales in the context of the Columbia River.

III. THE VALUE OF FLOODPLAINS

Studies of the salmon ecosystems identify enhancement of natural variability[39] and habitat diversity and connectivity[40] as key elements to

34 *See* J.B. Ruhl, *General Design Principles for Resilience and Adaptive Capacity in Legal Systems—With Applications to Climate Change Adaptation*, 89 N.C. L. REV. 1373, 1376–77 (2011).

35 *See* C.S. Holling, *Understanding the Complexity of Economic, Ecological, and Social Systems*, 4 ECOSYSTEMS 390, 392–94 (2001), *available at* http://www.tsa.gov/assets/pdf/PanarchyorComplexity.pdf; Gunderson & Holling, *supra* note 24, at 32–33.

36 *See* Holling, *supra* note 35, at 392.

37 *Id.* at 398–99.

38 *Id.*; Walker et al., *supra* note 22.

39 *See, e.g.*, Peter A. Bisson et al., *Freshwater Ecosystems and Resilience of Pacific Salmon: Habitat Management Based on Natural Variability*, June 2009, ECOLOGY & SOC'Y, http://www.ecologyandsociety.org/vol14/iss1/art45/ (last visited Feb. 18, 2012).

restoring and maintaining ecosystem resilience. The following Parts provide insight on the role floodplains play in ecosystem resilience in general and, specifically, in salmon ecosystems.

A. Floodplains and Water Quality

Floodplains, or the low lying areas adjacent to a river that are periodically inundated with flood water when a river is left to its natural state, are wetlands that perform important ecosystem functions in reducing sediment load and filtering contaminants.[41] Wetlands can be thought of as the transition zone between land and water.[42] Similar to other ecological transition zones, wetlands are biologically rich and diverse, including elements of both zones and their own unique biota which are adapted to live in a frequently changing system.[43] According to the United States Environmental Protection Agency, wetlands cover 5% of the surface area of the coterminous United States, yet they are home to 31% of the plant species.[44] Beyond the ecological richness of the habitat, wetlands perform two important water quality functions.

First, due to their proximity to bodies of water, wetlands serve as storage areas in times of high water, both slowing the movement of surface water to a water body and providing overflow when that water body floods.[45] To humans, this function is important both for considerations of flood control and for sediment transport into waterways. One study concluded that restoration of the 100-year floodplain in the Upper Mississippi River Basin would allow natural storage of 39 million acre-feet of water—enough to prevent the floods of 1993 and the resulting roughly $16 billion in damage.[46] No similar study has been done for the Columbia River Basin. The deeply incised nature of much of the Columbia River mainstem may indicate

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40 *See, e.g.*, Daniel L. Bottom et al., *Reconnecting Social and Ecological Resilience in Salmon Ecosystems*, ECOLOGY & SOC'Y, June 2009, http://www.ecologyandsociety.org/vol14/iss1/art5/ (last visited Feb. 18, 2012).

41 LEWIS M. COWARDIN ET AL., DEP'T OF THE INTERIOR, FWS/OBS-79/31, CLASSIFICATION OF WETLANDS AND DEEP WATER HABITATS OF THE UNITED STATES 8 (reprt. 1992) (1979), *available at* http://www.nwrc.usgs.gov/wdb/pub/others/79-31.pdf; *see* U.S. ENVTL. PROT. AGENCY, EPA 843-F-01-002C, FUNCTIONS AND VALUES OF WETLANDS (2001), *available at* http://www.epa.gov/owow/wetlands/pdf/fun_val.pdf.

42 COWARDIN ET AL., *supra* note 41, at 3.

43 *See* U.S. ENVTL. PROT. AGENCY, *supra* note 41; *see also* U.S. Envtl. Prot. Agency, *Wetlands and Nature*, http://www.epa.gov/owow/wetlands/vital/nature.html (last visited Feb. 18, 2012) ("Wetlands are among the most productive ecosystems in the world, comparable to rainforests and coral reefs.").

44 U.S. ENVTL. PROT. AGENCY, *supra* note 41.

45 *Id.*; *see also* NAT'L MARINE FISHERIES SERV., U.S. DEP'T OF COMMERCE, NMFS TRACKING NO. 2006/00472, ENDANGERED SPECIES ACT—SECTION 7 CONSULTATION: FINAL BIOLOGICAL OPINION AND MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION 55 (2008), *available at* http://online.nwf.org/site/DocServer/NMFS_Puget_Sound_nfip-final-bo.pdf?docID=10561.

46 U.S. ENVTL. PROT. AGENCY, EPA843-F-06-001, WETLANDS: PROTECTING LIFE AND PROPERTY FROM FLOODING (2006), *available at* http://www.epa.gov/owow/wetlands/pdf/Flooding.pdf.

that options for natural storage of anywhere near the magnitude possible on the Mississippi River are not available and it may require looking to numerous small opportunities for floodplain restoration on tributaries and smaller watersheds. The greater difficulty associated with quantifying the benefits of reliance on many diffuse locations for natural storage is discussed below. Importantly for purposes of resilience, the restoration of wetland areas throughout a river system reduces reliance on a single structural flood control element,[47] such as the levee protecting Vanport, Oregon, or the dikes protecting New Orleans, thus reducing the risk of failure.

Second, in the process of slowing the movement of runoff from land to a water body and thus allowing suspended sediment to drop out of the water column, wetlands perform a filtration function.[48] This may be aided by the abundance of peat-like material in certain types of wetlands.[49] Similar to a manufactured water filter, this carboniferous layer of material may absorb contaminants such as heavy metals and thus prevent them from entering the water body.[50]

B. Floodplains and Salmon Habitat

As noted above, studies of the salmon ecosystems identify enhancement of natural variability[51] and habitat diversity and connectivity[52] as key elements to restoring and maintaining ecosystem resilience. Floodplains provide refugia from high velocity floods, and are important in the cycles of sediment supply and nutrient exchange that affect salmon species.[53] In fact, natural floodplains are so critical to the survival of Pacific salmon that litigation and a resulting biological opinion found that the incentives to fill or separate floodplains from a river resulting from the National Flood Insurance Program violate the Endangered Species Act (ESA).[54] The biological opinion includes discussion of the importance of floodplains to salmon habitat:

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47 *See* U.S. ARMY CORPS OF ENG'RS, BUILDING A STRONGER CORPS: A SNAPSHOT OF HOW THE CORPS IS APPLYING LESSONS LEARNED FROM KATRINA 14 (2009), *available at* http://www.mvp.usace.army.mil/docs/USACE_PK_Update_Report_Final.pdf.

48 U.S. ENVTL. PROT. AGENCY, *supra* note 41.

49 *Cf.* Stacy D. Harrop, *Municipal Separate Storm Sewer Systems: Is Compliance with State Water Quality Standards Only a Pipe Dream?*, 31 ENVTL. L. 767, 797 (2001) (explaining the use of peat in storm water filtration systems).

50 *See* U.S. ENVTL. PROT. AGENCY, *supra* note 41.

51 Bisson et al., *supra* note 39.

52 Bottom et al., *supra* note 40.

53 *See* NAT'L MARINE FISHERIES SERV., *supra* note 45, at 54–55, 103; Ashley Williams et al., Floodplain Delineation Methodology Extended to Assess Aquatic Habitat in Lapwai Creek, Idaho 4 (2011) (unpublished manuscript) (on file with author).

54 Endangered Species Act of 1973, 16 U.S.C. §§ 1531–1544 (2006 & Supp. IV 2010); *id.* § 1536(a)(2) (2006); Nat'l Wildlife Fed'n v. Fed. Emergency Mgmt. Agency (*NWF v. FEMA*), 345 F. Supp. 2d 1151, 1177 (W.D. Wash. 2004); NAT'L MARINE FISHERIES SERV., *supra* note 45, at 1–2. In *NWF v. FEMA*, the court noted that FEMA's own manual states that "'[f]loodplains perform certain natural and beneficial functions that cannot be duplicated elsewhere,' such as 'provid[ing] habitat for diverse species of flora and fauna, some of which cannot live anywhere

- "Chinook salmon, and steelhead both have life history strategies that rely on floodplains during juvenile life stages."[55]
- "Functional floodplains also moderate high flows by substantially increasing the area available for water storage. Water seeps into the groundwater table during floods, recharging wetlands, off-channel areas, shallow aquifers, and the hyphorheic zone. Wetlands, aquifers, and the hyphorheic zone in turn release water to the stream during the summer months through a process called hydraulic continuity. This process ensures adequate flows for salmonids during the summer months, and reduces the possibility of high-energy flood events that can destroy salmonid redds (nests) during the winter months."[56]
- "Floodplains generally contain numerous sloughs, side-channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows, and may be used by rearing salmonids for long periods of time depending upon the species. Off-channel areas provide an abundance of food with fewer predators than would typically be found in the river, and provide habitat for juvenile salmonids to hide from predators and conserve energy. The importance of floodplain habitat to salmonids cannot be overstated. In the Skagit and Stillaguamish Basins, more than half of the total salmonid habitat is contained within the floodplain and estuarine deltas, while this habitat encompasses only ten percent of the total basin area."[57]

The biological opinion includes identification of the following five adverse impacts on salmon that are relevant to approaches to flood risk management:

- "Levees diminish floodplain storage of water during floods, and confine the river within a walled in channel, pushing the flooding farther downstream, and adding pressure to extend the levee. As a result, the river can no longer move across the floodplain and no longer support the natural processes of channel migration that create the side channels and off-channel areas that shelter juvenile salmon."[58]
- "Barriers to fish passage and adverse effects on water quality and quantity resulting from dams, the loss of wetland and riparian habitats, and

else.'" 345 F. Supp. 2d. at 1157 (quoting FED. EMERGENCY MGMT. AGENCY, FIA-15/2007, NATIONAL FLOOD INSURANCE PROGRAM COMMUNITY RATING SYSTEM: COORDINATOR'S MANUAL 110-6 (2007), http://www.fema.gov/library/viewRecord.do?id=2434 (last visited Feb. 18, 2012)(click on link next to "Resource File" to download PDF version)); *see also* Settlement Agreement and [Proposed] Order at 2–3, Audubon Soc'y of Portland v. Fed. Emergency Mgmt. Agency, No. 3:09-cv-729-HA (D. Or. July 9, 2010) (resolving a similar lawsuit against National Marine Fisheries Service in Oregon).

55 NAT'L MARINE FISHERIES SERV., *supra* note 45, at 22.

56 *Id.* at 55 (citations omitted).

57 *Id.* (citations omitted).

58 *Id.* at 4.

agricultural and urban development activities have contributed and continue to contribute to the loss and degradation of steelhead habitats . . . ."[59]

- "Most devastating to the long term viability of salmon has been the modification of the fundamental natural processes that allow habitat to form, and recover from disturbances such as floods, landslides, and droughts. So critical are these driving processes that Spence et al. (1996) state that '. . . salmonid conservation can be achieved only by maintaining and restoring these processes and their natural rates.' Among the physical and chemical processes basic to habitat formation and salmon persistence are floods and droughts, sediment transport, heat and light, nutrient cycling, water chemistry, woody debris recruitment and floodplain structure."[60]
- "Development within the floodplain results in stream channelization, habitat instability, vegetation removal, and point and nonpoint source pollution all of which contribute to degraded salmon habitat."[61]
- "Impacts of even small scale developments in floodplains have cumulative effects. Imprecision in modeling supports assertions that each incremental increase in flood levels will be negligible. Thus, project permits are being issued on an individual basis, resulting in incremental loss of floodplain land to development. However, the cumulative loss of floodwater storage and channel confinement destabilizes hydrology. Hydrologic instability is linked to biological losses."[62]

Pacific salmon have shown resilience in their ability to adapt to a geologically active landscape and a hydrologic regime with high seasonal and year-to-year variability.[63] At the same time, that adaptation has lead to reliance on variability in flow and habitat for various life stages.[64] Thus, restoring some of that variability is important to species recovery.

C. Flood Risk Management and Identification of the Impediments to Multiple Diffuse Sources of Flood Storage

Primary federal flood control responsibility on navigable rivers in the United States is delegated to the Corps under the Flood Control Act of 1944.[65] The approach of the Corps has traditionally focused on what are

59 *Id.* at 30.

60 *Id.* at 54 (quoting BRIAN C. SPENCE ET AL., MANTECH ENVTL. RESEARCH SERVS. CORP., AN ECOSYSTEM APPROACH TO SALMONID CONSERVATION 1 (1996), *available at* http://www.nwr.noaa.gov/Publications/Reference-Documents/upload/mantech-partI.pdf).

61 *Id.* at 91 (citations omitted).

62 *Id.* at 95 (citations omitted).

63 Robin S. Waples et al., *Evolutionary History, Habitat Disturbance Regimes, and Anthropogenic Changes: What Do These Mean for Resilience of Pacific Salmon Populations?*, ECOLOGY & SOC'Y, June 2009, http://www.ecologyandsociety.org/vol14/iss1/art3/ (last visited Feb. 18, 2012); Bottom et al., *supra* note 40.

64 Bottom et al., *supra* note 40.

65 33 U.S.C. §§ 701–709b (2006).

referred to as "structural" alternatives—dams, levees, dikes, and fill.[66] In the wake of Hurricane Katrina and the massive flooding of New Orleans as the result of dike failure, the dialogue has shifted to a more diverse array of measures "that combine structural, nonstructural, and natural environmental features."[67] This new focus is based solely on the benefit of diversity and redundancy to reducing flood risk,[68] not the added benefits to ecosystem resilience as asserted in this Article. In addition the Corps now uses the terms "flood risk management"[69] rather than "flood control" to avoid the misleading message that absolute control is possible. Despite the shift in dialogue, some suggest that there is little indication of change in actual implementation.[70] Even if the focus has shifted to nonstructural and natural environmental measures, additional barriers exist in the context of an international dialogue.

Resilience scholars call on adaptive management to allow adjustment to the high degree of uncertainty associated with the complex interactions and feedbacks in a social–ecological system,[71] an approach that would be necessary as nonstructural measures are implemented and their true impact measured. Yet sovereigns engaged in transboundary negotiations prefer clear lines of division of resources with limited room for interference with the domestic management of the resource within sovereign territory.[72] In contrast, adaptive management requires continuing adjustment and cooperation. Complicating this is the lack of predictive ability associated with use of many diffuse sources of flood risk management.[73] In the effort to review flood risk management under the Columbia River Treaty, concern has been expressed that multiple diffuse sources of flood storage created by floodplain restoration cannot be modeled.[74] Without the certainty of a calculated benefit, obligations for future flood control cannot be clearly defined in advance. Addressing these impediments will be aided by placing them in the context of a specific river basin; thus, the following Part turns to the Columbia River and the 1964 Treaty.

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66 *See* U.S. ARMY CORPS OF ENG'RS, *supra* note 47, at 17.

67 *Id.*

68 *See, e.g.*, *id.* at 25–28.

69 *See, e.g.*, *id.* at 26.

70 Michael Grunwald, *The Threatening Storm, Hurricane Katrina Two Years Later*, TIME, Aug. 2, 2007, http://www.time.com/time/specials/2007/article/0,28804,1646611_1646683_1648904-2,00.html (last visited Feb. 18, 2012) ("But for all the talk about restoring wetlands, almost every dime of the $7 billion the Corps has received since Katrina is going to traditional engineering: huge structures designed to control rather than preserve nature. And its latest plan seeks to extend those structures along the entire coast, calling for such massive levees across so much of the state that scientists call it the Great Wall of Louisiana.").

71 Folke et al., *supra* note 26, at 447; C.S. HOLLING ET AL., 3 ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT 1, 7, 9, 19 (C.S. Holling ed., 1978).

72 *See* Folke et al., *supra* note 26, at 448–49, 460–61.

73 James Barton & Kelvin Ketchum, *Columbia River Treaty: Managing for Uncertainty*, *in* THE COLUMBIA RIVER TREATY REVISITED, *supra* note 9 (manuscript at 1, 3–4, 8–9) (on file with author).

74 Interview with Matt T. Rea, Program Manager, Columbia River Treaty Review, in Portland, Or. (July 21, 2011).

IV. FLOOD RISK MANAGEMENT IN THE CONTEXT OF THE COLUMBIA RIVER

A. The 1964 Columbia River Treaty

The Columbia River Basin covers 259,500 square miles with 15% in Canada and the remainder in the United States.[75] Seven states—Washington, Oregon, Idaho, Montana, Nevada, Utah, and Wyoming—and one Canadian Province—British Columbia—lie within the Basin.[76] Thirty-eight percent of the average annual flow measured at The Dalles Dam originates in Canada.[77] Due to later runoff from snowpack, flow originating in Canada can be 50% of the late summer flow.[78] The expression of runoff from the Columbia River Basin as an average annual flow of nearly 200 million acre-feet[79] masks the fact that year-to-year variability in unregulated peak flow is 1:35.[80] In the twentieth century, seasonal variability led to calls for storage from boosters and engineers.[81]

Salmon fisheries sustained the native population,[82] and there were no dams when Meriwether Lewis and William Clark explored the Columbia River in 1805.[83] Falls that slowed upriver migration of salmon had long been the sites for indigenous fishing.[84] Thousands of Native Americans from numerous tribes attended yearly gatherings at locations such as Celilo Falls

75 Barton & Ketchum, *supra* note 73 (manuscript at 1).

76 Bill Lang, *Center for Columbia River History: Columbia River*, http://www.ccrh.org/river/history.htm (last visited Feb. 18, 2012).

77 U.S. ARMY CORP OF ENG'RS & BONNEVILLE POWER ADMIN., *supra* note 8, at 2; *see also* John Shurts, *Rethinking the Columbia River Treaty*, *in* THE COLUMBIA RIVER TREATY REVISITED, *supra* note 9 (manuscript at 7) (on file with author). The Dalles Dam is located on the mainstem between Oregon and Washington and is considered the reference point for measurement of flows for flood control purposes. BONNEVILLE POWER ADMIN. ET AL., THE COLUMBIA RIVER SYSTEM INSIDE STORY: FEDERAL COLUMBIA RIVER SYSTEM 5 fig., 7, 35 (2d ed. 2001), *available at* http://www.bpa.gov/power/pg/columbia_river_inside_story.pdf.

78 Alan F. Hamlet, *The Role of Transboundary Agreements in the Columbia River Basin*, *in* 16 ADVANCES IN GLOBAL CHANGE RESEARCH: CLIMATE AND WATER: TRANSBOUNDARY CHALLENGES IN THE AMERICAS 263, 283 (Henry F. Diaz & Barbara J. Morehouse eds., 2003).

79 Nw. Power & Conservation Council, *Columbia River: Description, Creation, and Discovery*, http://www.nwcouncil.org/history/columbiariver.asp (last visited Feb. 18, 2012).

80 BONNEVILLE POWER ADMIN., COLUMBIA RIVER HIGH-WATER OPERATIONS 3 (2010), *available at* http://www.bpa.gov/corporate/pubs/final-report-columbia-river-high-water-operations.pdf. For comparison, the Saint Lawrence River has a yearly variation of 1:2 and the Mississippi River varies 1:25. Barbara Cosens, *Transboundary River Governance in the Face of Uncertainty: Resilience Theory and the Columbia River Treaty*, 30 J. LAND RESOURCES & ENVTL. L. 229, 242 (2010).

81 *See generally* Paul W. Hirt & Adam M. Sowards, *The Past and Future of the Columbia River*, *in* THE COLUMBIA RIVER TREATY REVISITED, *supra* note 9 (manuscript at 16) (on file with author) (discussing the rationale for developing the Columbia River).

82 *Id.* at 16.

83 *See* DAN LANDEEN & ALLEN PINKHAM, SALMON AND HIS PEOPLE, FISH AND FISHING IN NEZ PERCE CULTURE 21 (1999).

84 *See id.* at 17–19.

to fish and trade.[85] Celilo Falls is now inundated by slack water created by the Dalles Dam. Engineered transformation of the Columbia River for navigation began with construction of locks at the Cascades by the Corps as early as 1896, with numerous dams to follow.[86] The majority of dams built on the mainstem of the river in the United States generate hydropower and aid navigation, but provide little storage.[87] Exceptions to what is referred to as run-of-the-river dams include Grand Coulee Dam on the mainstem, a Bureau of Reclamation facility built for irrigation and in service by 1941; Hungry Horse Dam completed on a tributary, the South Fork of the Flathead, in 1952; Libby Dam completed on a tributary upstream from Canada, the Kootenai River, in 1975; and Dworshak Dam completed on a tributary, the North Fork of the Clearwater, in 1973 (Figure 2).[88]

The May 1948 flood described above that destroyed the town of Vanport, Oregon, had an estimated peak of over 1 million cubic feet per second (cfs)—twice average peak. [89] Although predicted runoff had been expected to be higher than average, the flood was the result of rapid runoff.[90] Total storage capacity on the Columbia in 1948 was about 6% of the average annual flow.[91] Conventional wisdom was to address flood control through increased storage. However, the best remaining storage sites were in Canada.[92]

The International Joint Commission formed by the 1909 Boundary Waters Treaty between the United States and Canada had already been directed to study possible storage sites within Canada to provide flood control or power benefits to both countries when the 1948 flood occurred.[93] Nevertheless, the Columbia River Treaty[94] establishing the international framework to accomplish this task was not adopted until 1964.[95] Obstacles to

85 *Id.* at 14; *see also* Paul W. Hirt, *Developing a Plentiful Resource: Transboundary Rivers in the Pacific Northwest*, *in* WATER, PLACE, & EQUITY 147, 155 (John M. Whiteley et al. eds., 2008) (noting that pre-European settlement salmon runs were estimated at 12 to 15 million salmon).

86 RICHARD WHITE, THE ORGANIC MACHINE: THE REMAKING OF THE COLUMBIA RIVER 37 (1995); *see also* BONNEVILLE POWER ADMIN. ET AL., THE COLUMBIA RIVER SYSTEM: INSIDE STORY 5 (2d ed. 2001), *available at* http://www.bpa.gov/power/pg/columbia_river_inside_story.pdf (noting how 29 major dams have been built on the Columbia River and its tributaries since 1909, along with a plethora of nonfederal projects).

87 *See* Shurts, *supra* note 77 (manuscript at 7).

88 *Id.* at 7–14; BONNEVILLE POWER ADMIN. ET AL., *supra* note 86, at 14. Grand Coulee resulted in the blockage of salmon runs from Canada on the river mainstem. John E. Bonine, *William H. Rodgers, Jr., and Environmental Law: Never Give Up, Keep on Going*, 82 WASH. L. REV. 459, 461–62 & n.15 (2007).

89 *See* Shurts, *supra* note 77 (manuscript at 6–7); Barton & Ketchum, *supra* note 73 (manuscript at 4).

90 *See* Shurts, *supra* note 77 (manuscript at 6–7); Barton & Ketchum, *supra* note 73 (manuscript at 4).

91 White, *supra* note 10 (manuscript at 2). Compare Columbia storage at 6% to the Colorado's capacity of more than 300% and the Missouri with storage capacity over 200%. Barton & Ketchum, *supra* note 73 (manuscript at 4).

92 *See* Shurts, *supra* note 77 (manuscript at 7); Mouat, *supra* note 9 (manuscript at 4).

93 Mouat, *supra* note 9 (manuscript at 8–9).

94 Columbia River Treaty, *supra* note 11.

95 *Id.*

its completion included the location of the three proposed dams in British Columbia with the majority of the flood control and hydropower generation in the United States, and disagreement between the Province and the federal government of Canada concerning the impacts and benefits of dam construction.[96] Discrepancy in benefits was easily addressed through agreement for benefit sharing by payments from the United States.[97] Solving the provincial–federal dispute in Canada was more protracted. Ultimately the federal government of Canada agreed to turn the operation and benefits under the Treaty over to the Province.[98]

Due to the shared benefit approach, the 1964 Treaty is currently considered among the best examples of international cooperation on freshwater sources.[99] This praise is due not only the sharing of benefits, but also to the fact that they are achieved through almost daily cooperation on dam operation in Canada, production of hydropower in the United States, and delivery of benefits of that production back to Canada.[100] This cooperative foundation is key to the discussion below of how a less predictable form of flood risk management might be added to the mix on the Columbia River.

The Treaty led to construction of three dams in Canada: Mica, Duncan, and Keenleyside (Figure 2); United States' payment of $65 million to Canada for flood control; and a fifty/fifty division of the benefit of the additional hydropower generated in the United States due to release from the three new dams.[101] The Treaty allowed, but did not require, the United States to build Libby Dam on the Kootenai River, which would back water into Canada and alter flows on the Kootenai River as it turns north, returning to Canada (Figure 2).[102] Implementation of the Treaty required appointment of operating entities by the United States and British Columbia. The United States appointed the Administrator of the Bonneville Power Administration and Division Engineer of the Northwestern Division of the Corps.[103] British Columbia appointed British Columbia Hydro and Power Authority.[104] Flood control operations under the Treaty are further detailed below.

96 Mouat, *supra* note 9 (manuscript at 9); Shurts, *supra* note 77 (manuscript at 8–9).

97 Mouat, *supra* note 9 (manuscript at 2).

98 *See id.* (manuscript at 9–15); Shurts, *supra* note 77 (manuscript at 9–10); Hirt & Sowards, *supra* note 81 (manuscript at 17).

99 Barton & Ketchum, *supra* note 73 (manuscript at 1).

100 *See id.* (manuscript at 2–3) (discussing the cooperation involved).

101 Columbia River Treaty, *supra* note 11, arts. II, V, VI; *see also* Canadian Entitlement Purchase Agreement, U.S.-Can., Aug. 13, 1964, 15 U.S.T. 1596. The Canadian share of hydropower benefits is referred to as the "Canadian Entitlement." U.S. Entity, Columbia River Treaty Initial Report Kicks off Public Process 2 (2010), *available at* http://www.crt2014-2024review.gov/Files/ColumbiaRiverTreatyFactSheet-ReportKickoff.pdf.

102 Columbia River Treaty, *supra* note 11, art. XII.

103 Exec. Order No. 11,177, 3 C.F.R. 184 (1964).

104 Barton & Ketchum, *supra* note 73 (manuscript at 2).

B. 2014/2024 Columbia River Treaty Review

There is neither an automatic termination date nor a renegotiation clause in the Treaty; 2024 is the earliest date either party may terminate.[105] A notice of at least ten years must be provided.[106] Certain of the flood control provisions, with coverage paid upfront by the United States for sixty years, expire in 2024.[107] The major change in flood control in 2024 and the ten-year notice requirement for termination have combined to trigger a thorough review of the Treaty before the year 2014. The operating entities are undertaking studies to inform options to be explored by 2014, and have begun a process of stakeholder input.[108] This process has led to consideration of whether the time is ripe for modification of the Treaty.[109] Changes in the social–ecological system of the basin since 1964 that may justify a new approach or a new process are covered elsewhere and will not be repeated here.[110] It is sufficient to note that changes in energy markets, public expectations and values, and local capacity to participate in resource management all warrant, at the very least, a thorough review of options.

Flood risk with potential changes in management has been a major focus of joint modeling by the United States and Canadian Entities in the process referred to as the 2014/2024 Review.[111] In addition, the Corps has undertaken a flood risk management assessment that is not available at the time of this publication. The process of public involvement by the United States Entity includes input from a "sovereign review team,"[112] comprised of representatives from basin states and tribal governments, and is likely to raise interest in exploring nonstructural measures.

The review process has illuminated some of the ambiguities in the Treaty that may lead to differences in interpretation if assured flood control provisions are allowed to expire in 2024. The ambiguities relate to language in the Treaty addressing expiration of the assured flood control provisions

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105 *See* Columbia River Treaty, *supra* note 11, art. XIX(2).

106 *Id.*

107 *Id.* art. IV.

108 U.S. ARMY CORPS OF ENG'RS & BONNEVILLE POWER ADMIN., COLUMBIA RIVER TREATY: 2014/2024 REVIEW: PHASE 1 TECHNICAL STUDIES 2, 3 (2009), *available at* http://www.bpa.gov/corporate/pubs/Columbia_River_Treaty_Review__2_-_April_2009.pdf [hereinafter PHASE 1 TECHNICAL STUDIES]; COLUMBIA RIVER TREATY 2014-2024 REVIEW: STAKEHOLDER LISTENING SESSION: SUMMARY OF SESSION DISCUSSION 1–5 (2011), *available at* http://www.crt2014-2024review.gov/Files/CRTListeningSessionSummary06102011.pdf [hereinafter STAKEHOLDER LISTENING SESSION].

109 *See generally* Shurts, *supra* note 77 (manuscript at 1–3) (discussing the Treaty provisions in which the requisite notice to terminate is three years away, and discussing the implementing nations' "2014/2024 Review" process as an opportunity to consider modification of the Treaty).

110 Cosens, *supra* note 80, at 245–55. *See generally* THE COLUMBIA RIVER TREATY REVISITED, *supra* note 9 (discussing how the treaty provided economic growth and cooperation between the United States and Canada, juxtaposed with the growing environmental costs and competing interests from specialized groups and how the burdens of the treaty may outweigh the benefits).

111 PHASE 1 TECHNICAL STUDIES, *supra* note 108, at 3–4.

112 STAKEHOLDER LISTENING SESSION, *supra* note 108, at 1; COLUMBIA RIVER TREATY 2014–2024 REVIEW: SOVEREIGN REVIEW TEAM ROSTER 1–3, *available at* http://www.crt2014-2024review.gov/Files/SRT_Roster.pdf.

that retains the United States' ability to call upon Canada for storage for flood control when needed.[113] The provisions fail to define "called upon" storage. Treaty provisions that apply up to 2024 use the same terminology, and, if applicable require the use of "all the related storage" in the United States prior to exercising the call.[114] It is not clear what is meant by "all the related storage,"[115] nor is it clear whether the level of flood protection required by the Treaty (i.e., the flow level that would lead to an exercise of the "called upon" provisions)[116] is the same as that for the "called upon" flood control prior to 2024 (600,000 (cfs)),[117] or the level at which the Corps estimates that minor flood damage begins (450,000 cfs).[118] Without resolving those ambiguities, model runs were done at both levels of flow[119] and assuming that "all related storage" includes Grand Coulee, Libby, Hungry Horse, Dworshak, and Brownlee dams (Figure 2).[120]

The results of modeling under the 2014/2024 Review highlight the need to diversify flood risk management options. The modeling looks at three basic alternatives under the two flow trigger points: 1) do nothing (assured flood control expires and "called upon" flood control begins); 2) terminate the Treaty (all provisions of the Treaty are terminated including flood control and shared benefits and only the Boundary Waters Treaty remains in place); and 3) extend the flood control provisions so that no change occurs in 2024.[121] Climate change and fish flows are not taken into account in the initial runs although the need is acknowledged.[122] Because requirements for fish are the result of listings under the ESA of the United States and are not applicable in Canada, the United States Entity separately studied the overlay of meeting requirements of current biological opinions.[123]

For purposes of this Article, the relevant outcome of these model runs is that the higher the level of flow that can be tolerated with limited flood risk, the less management of reservoirs for flood control overwhelms all other objectives for operation of the system. In other words, if flow measured at The Dalles must be kept below 450,000 cfs to avoid flood damage (as opposed to a higher flow such as 600,000 cfs or 800,000 cfs), expiration of assured flood control will result in deeper drafts of reservoirs

113 Columbia River Treaty, *supra* note 11, art. IV(3).

114 *Id.* art. IV(2)(b); Protocol for the Exchange of Notes Regarding the Columbia River Treaty, U.S.-Can., Annex 1(2), Jan. 22, 1964, 15 U.S.T. 1579 [hereinafter Protocol].

115 B.C. Hydro & Power Auth. et al., Columbia River Treaty 2014/2024 Review: Phase 1 Report iv (2010), *available at* http://www.crt2014-2024review.gov/Files/Phase1Report_7-28-2010.pdf. However the Corps has interpreted "all related storage" to include any storage project authorized by Congress for system flood control. Interview with Matt T. Rea, *supra* note 74.

116 B.C. Hydro & Power Auth. et al., *supra* note 115, at 14.

117 Protocol, *supra* note 114, at 1579; B.C. Hydro & Power Auth. et al., *supra* note 115, at 3.

118 B.C. Hydro & Power Auth. et al., *supra* note 115, at 14. It should be noted that the 450,000 cfs is an artifact of assumptions made in 1964.

119 *Id.* at 14.

120 *Id.* at v.

121 *Id.* at ii, 1.

122 *See id.* at vi, 85.

123 U.S. Army Corps of Eng'rs & Bonneville Power Admin., *supra* note 17, at i, 2.

in the United States than historically experienced,[124] and, subsequently, reduced flexibility for fish management.[125] These results will be contrary to the hopes people express for the Columbia River Basin.

C. Public Input to the Treaty Review

The formal processes to review the 1964 Treaty by the United States and Canadian Entities involves some joint technical modeling as described above; however, the stakeholder input is being undertaken separately on each side of the international border. Participants in symposia on the Columbia River Treaty held by the Universities Consortium on Columbia River Governance (UCCRG),[126] composed of faculty from the Universities of British Columbia, Calgary, Washington, Montana, Idaho, and Oregon State, in 2009 and 2010 identified the need for a neutral forum to hold an informal cross-border dialogue.[127] The UCCRG works to provide that forum and to develop research that will be relevant to basin stakeholders.[128]

As part of the efforts of the UCCRG, students at the University of Idaho College of Law and Oregon State University interviewed stakeholders in the basin in both the United States and Canada during the spring semester of 2011.[129] Included in the information sought was the identification of alternatives that stakeholders would like analyzed in the process of Treaty review.[130] Students used a qualitative approach,[131] with open-ended, confidential interviews to gather information.[132] Students also used a snowball sampling method, which includes asking each interviewee to recommend others who should be interviewed.[133] "Ideally, interviews end

124 B.C. Hydro & Power Auth. et al., *supra* note 115, at v, 58–71.

125 U.S. Army Corps of Eng'rs & Bonneville Power Admin., *supra* note 17, at v, 48.

126 For information on the first and third symposia of the UCCRG, see Univ. of Idaho Coll. of Law, *2009 NREL Symposium,* http://www.uidaho.edu/law/newsandevents/naturalresourcesandenvironmentallawsymposium/naturalresourcesandenvironmentallawsymposium (last visited Feb. 18, 2012); Univs. Consortium on Columbia River Governance, *Third Annual Symposium on Transboundary River Governance in the Face of Uncertainty: The Columbia River Treaty, 2014*, https://www.uidaho.edu/law/newsandevents/signature/nrel-symposium/2009-nrel-symposium (last visited Feb. 18, 2012).

127 Univs. Consortium on Columbia River Governance, *Third Annual Symposium on Transboundary River Governance in the Face of Uncertainty: The Columbia River Treaty, 2014: About*, https://sites.google.com/site/crtthirdannualsymposium/about (last visited Feb. 18, 2012).

128 *See* Univ. of Idaho Coll. of Law, *supra* note 126.

129 Cosens et al., *supra* note 19, at 10.

130 *Id.*

131 *Id. See generally* Thomas A. Schwandt, Dictionary of Qualitative Inquiry 213 (2d ed. 2001) (stating that qualitiative research relies on nonnumeric data in the form of words and "aims at understanding the *meaning* of human *action*").

132 Cosens et al., *supra* note 19, at 10. *See generally* John W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches 181–83, 188 (2d ed. 2003) (stating that in qualitative research, interviewers use "unstructured and generally open-ended questions that are few in number").

133 Cosens et al., *supra* note 19, at 10. *See generally* The Consensus Building Handbook: A Comprehensive Guide to Reaching Agreement 108 (Lawrence Susskind et al. eds., 1999) ("We

when either no new information is being obtained or no new interviewees are identified."[134] In this study, the interviews ended due to the time constraints of a semester course,[135] thus the results can be considered a sampling of potential alternatives, but not a comprehensive list or a representation of degree of support for any particular alternative. Interviewees included agency representatives, tribal representatives, and other stakeholders on both sides of the international border with an effort to sample someone from each major economic sector dependent on the river, but are reported without attribution to individual interviewees.[136] Interview results were organized for identification of major and minor themes.[137]

A desire to see analysis of whether ecosystem function can be elevated to a purpose of international cooperation between the United States and Canada emerged as a major theme.[138] What is meant by "ecosystem function" held varying definitions throughout the basin. With the caution that the survey data is neither quantitative nor comprehensive, generally those interests focused on the basin's headwaters (Canada and the border region of the United States on the mainstem, and the Snake River and its tributaries), seek to maintain higher reservoir levels.[139] Stakeholders who focused on the mainstem and tributaries below Chief Joseph Dam seek benefits to anadromous fish, such as operation of reservoirs to mimic natural flows.[140] Finally, some seek reintroduction of salmon to the Columbia River in Canada, or at least actions that would not preclude that possibility at some time in the future.[141] Listening sessions conducted by the United States Entity have also raised these issues.[142]

Combining interview results with the inferences on flow from the Phase I and Supplemental Studies, one avenue for mutual gain emerges: spreading flood control across all dams that provide storage in the basin and reducing reliance on dams in general through implementation of nonstructural measures for flood risk management increases operational flexibility for anadromous fish while maintaining high hydropower revenue and increases the potential for maintaining higher lake levels. In addition, the restoration of floodplains, if done in a manner consistent with habitat needs, should in itself improve ecosystem function.

think of the process of identifying stakeholders to interview as 'moving outward in concentric circles.' This ensures that all possible interests are included.").

134 Cosens et al., *supra* note 19, at 10.

135 *Id.*

136 *Id.*

137 *Id.* at 11. *See generally* CRESWELL, *supra* note 132, at 182 (noting that qualitative researchers interpret data by, *inter alia*, analyzing it for themes); THE CONSENSUS BUILDING HANDBOOK: A COMPREHENSIVE GUIDE TO REACHING AGREEMENT, *supra* note 133, at 117 (suggesting that, following stakeholder interviews in the conflict assessment process, researchers create a "matrix" to map out areas of agreement and disagreement among parties).

138 Cosens et al., *supra* note 19, at 13, 53–54.

139 *Id.* at 28.

140 *Id.* at 13.

141 *Id.* at 26.

142 *See, e.g.*, STAKEHOLDER LISTENING SESSION, *supra* note 108, at 3 (summarizing stakeholder comments from a "listening session" held in Spokane, Washington).

D. Addressing Impediments to Diffuse Flood Risk Management

With an understanding of the 1964 Treaty, the Treaty review, and the desires of stakeholders in the basin, it is now possible to analyze impediments to spreading flood risk management across many diffuse locations for floodplain storage. Impediments include the need for certainty and clear lines for international negotiations concerning resources and the absence of methodology or adequate data to quantify the benefits of floodplain restoration for flood risk reduction. This analysis begins by recognizing the highly adaptive nature of flood control implementation that already exists under the 1964 Treaty. The existing Columbia River Treaty provides sufficient latitude to adjust flood control as floodplain restoration occurs while providing a stable foundation from which adjustments can be made, thus providing the clear lines sought between sovereigns.

Flood control under the Treaty is implemented under a Flood Control Operating Plan developed jointly by the United States and Canadian Entities,[143] and additional measures can be taken when runoff exceeds levels manageable under the plan.[144] Because timing and magnitude of runoff includes surprises that may not have been planned for, actual implementation by the Entities includes development of an Assured Operating Plan (AOP) each year for six years in advance,[145] followed by a Detailed Operating Plan (DOP), prepared each year for the following year to update the AOP and to provide more details on operations.[146] A Treaty Storage Regulation (TSR) study is done during the actual operating year and is based on both the DOP and current conditions, and defines storage and draft requirements for treaty reservoirs.[147] Finally, Supplemental Operating Agreements may be used to vary from the TSR if mutual benefits in power, flood control fisheries, or other values may be achieved.[148] In addition, in actual practice, weekly and even daily conference calls occur among the Entities to make adjustments to operations as needed.[149]

This operational process describes a much more porous and adaptive structure than the clear lines often ascribed to international diplomacy concerning resources.[150] Significant room already exists under the 1964 Treaty for adaptation of flood risk management to the addition of nonstructural measures and use of additional dams in the United States. The

143 Columbia River Treaty, *supra* note 11, art. IV; *see also* PHASE 1 TECHNICAL STUDIES, *supra* note 108, at 2–4 (noting the flood control operating plan currently in existence).

144 Columbia River Treaty, *supra* note 11, art. IV.

145 Barton & Ketchum, *supra* note 73 (manuscript at 3–4, 7).

146 *Id.* at 7.

147 *Id.*

148 *Id.*

149 *Id.*

150 *See id.* at 7–9 (discussing the adaptable and flexible nature of the Treaty's structure); Christopher Marcoux, *Institutional Flexibility in the Design of Multilateral Environmental Agreements*, 26 CONFLICT MGMT. & PEACE SCI. 209, 213, 225–27 (2009), *available at* http://cmp.sagepub.com/content/26/2/209.full.pdf (discussing recent studies on international treaties that imply flexibility can facilitate resolution of international environmental problems).

fear of a much more diffuse approach blurring the lines of control can be addressed by maintaining the current operation as the starting point and making adjustments to the various levels of operating plans and agreements as storage is made available or purchased in other system reservoirs and as floodplain restoration benefits are measured. This eliminates the need to determine upfront what the benefits of floodplain restoration to flood risk management might be. Information on the effects of floodplain restoration on flood risk management would not be sought in this process to determine whether or not to build dams for flood control. Dams that have prevented any major damage since 1948 already exist.[151] The authority to alter dam operation for flood control on a year and even weekly basis already exists (at least until 2024).[152] Thus, within existing authority, provided assured flood control provisions are extended beyond 2024, a phased approach can be taken to spreading flood risk management to include all dams in the system and floodplain restoration, with changes made in reliance on dams in Canada as the benefits of other measures are shown through monitoring.

Even with this incremental or adaptive approach, the difficulty of quantifying the benefits from natural storage in a way that optimizes expenditures on storage that improves ecosystem function remains.[153] Methods are being developed to target areas for floodplain restoration that will allow modeling of benefits as data for improved calibration become available with measurements of actual benefits over time.[154]

A faculty and student research team in the University of Idaho Waters of the West program has focused on methods for floodplain mapping that recognize the link between steelhead habitat needs and floodplain modification to aid in restoration prioritization by the Nez Perce Tribe and Nez Perce Soil Conservation Service in a small watershed within the Columbia River Basin.[155] While recognizing the many values floodplains provide for anadromous fish life stages as described above, the study focused on the use of floodplains as refugia by juvenile fish during flood allowing water depth and flow velocity to serve as proxies for habitat value.[156] The study used Light Detection and Ranging, known as LiDAR, which allows detailed imaging of topography, combined with stream flow data, to identify areas in which floodplain restoration could provide the

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151 *See* Barton & Ketchum, *supra* note 73 (manuscript at 2–3, 8).

152 Columbia River Treaty, *supra* note 11, art. IV.

153 *Cf.* Barton & Ketchum, *supra* note 73 (manuscript at 3, 5) (explaining remaining uncertainties in managing the Columbia River System, including adjusting for recent emphasis on environmental sustainability).

154 *See, e.g.*, Williams et al., *supra* note 53, at 12.

155 Ashley Williams, Floodplain Delineation Methodology Utilizing LiDAR Data with Attention to Urban Effects, Climate Change, and Habitat Connectivity in Lapwai Creek, Idaho, at iii, 11–12 (May 2011) (unpublished M.S. Thesis, University of Idaho Waters of the West Program); Williams et al., *supra* note 53, at 12.

156 *See* Williams, *supra* note 155, at 118 (describing the study's adoption of juvenile life stage as a standard due to fish sensitivity to flooding); Williams et al., *supra* note 53, at 2, 4, 9 (discussing the importance on floodplains for anadromous fish and adopting the juvenile life stage as a standard).

highest habitat values.[157] Although this effort is in its infancy, it illustrates the possibility of addressing some of the conceptual difficulties with turning to multiple diffuse sources for flood risk management. Thus, improved modeling and the flexibility to incrementally adjust flood risk management that already exists under the Treaty may address some of the concerns raised.

V. CONCLUSION

Sustainability of social–ecological systems will require careful attention to ecological resilience and the management of ecological systems to enhance that resilience. Management can foster system resilience by seeking opportunities at scales of governance above and below the system of interest to implement measures that restore natural function and allow adaptation in the face of change. The review of the 1964 Columbia River Treaty presents an opportunity without a crisis that can impede rational decision making. Importantly, the measures discussed in this Article, including incremental addition of natural storage through floodplain restoration to the measures taken to prevent flood damage, are put forth as options for discussion and analysis in the current process to review the Treaty. This Article is not that definitive study. Questions must be asked: Can changes to reliance on dams for flood control open up avenues for improving lake levels and fish flows while retaining hydropower revenues as implied by modeling for the current review? Would the added benefit to ecosystem function make these measures economically competitive? Most importantly, is a river with high ecological function what the residents of the Columbia River Basin want and, if tradeoffs are necessary to achieve that, what tradeoffs are they willing to make? This Article and the continuing work of the UCCRG are intended to inform the basin dialogue. In the final analysis, it is the residents of the Columbia River Basin who must decide their future. Only with the capacity to make these decisions in the hands of the basin, can social–ecological resilience be achieved.

157 *See* Williams, *supra* note 155, at 19; Williams et al., *supra* note 53, at 7 (discussing the use of LiDAR for getting high resolution typography information combined with stream flow data).

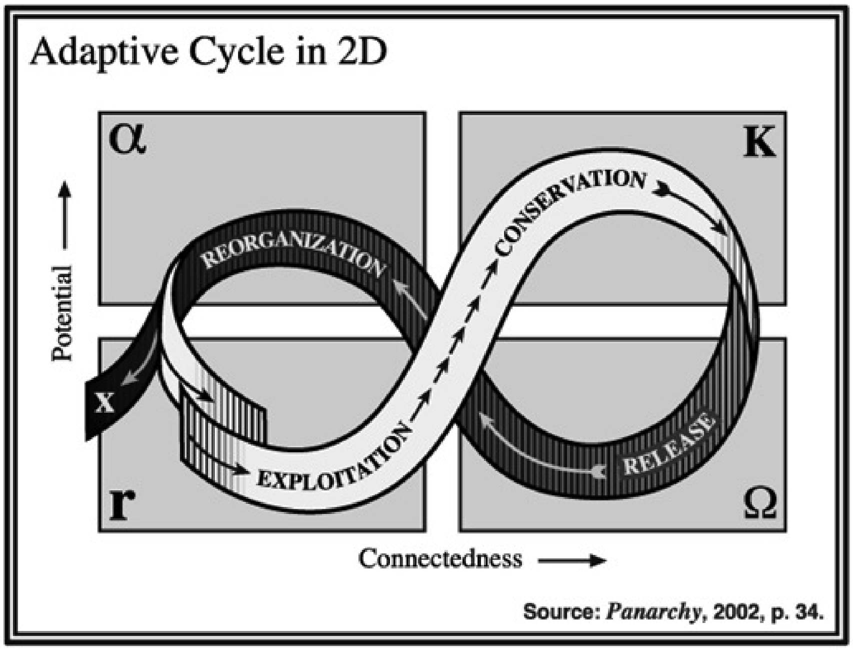

Figure 1: The adaptive cycle.[158]

[158] Panarchy: Understanding Transformations in Human and Natural Systems, *supra* note 24, at 34 (reproduced by permission of Island Press, Washington, D.C).

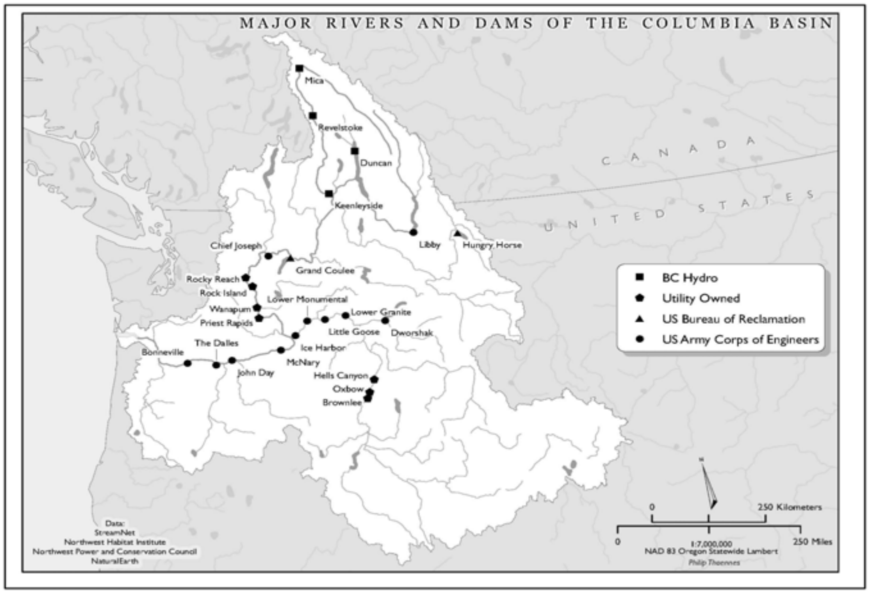

Figure 2: Major dams and rivers of the Columbia River Basin.[159]

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