The Law and Ecology of Dam Removals

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Synopsis

INTRODUCTION

For many years, what would be the nation's largest-ever dam removal project has been moving slowly towards initiation. If the project ever happens, four dams on the Klamath River, which drains a large watershed in northern California and southern Oregon, would come out.[1] The environmental benefits could be dramatic: between the Klamath mainstem and its tributaries, salmon and steelhead trout would gain access to hundreds of additional miles of habitat, wildlife would regain access to habitats now covered by reservoir waters, transfer of marine-derived nutrients in the form of spawning salmon would be reinvigorated, and the

[1] *See* Klamath River Renewal Corporation, Klamath River Renewal Project, https://www.klamathrenewal.org/the-project/ (last visited Oct. 28, 2020).

dam removal also should improve water quality in the downstream reaches.[2] The removals also are a key part of a delicate truce between farmers, tribes, and environmentalists.[3] Yet the path towards a freer-flowing river has been fraught with legal complexity, and even today, the future of the dam removals remains uncertain.[4]

The Klamath project exemplifies a broader theme. Dam removal projects involve no shortage of engineering and science questions, and they are often politically charged. But perhaps most importantly, they are legally complex.[5] Even a relatively small dam removal project tends to exist at the center of an intricate legal web, with some strands pushing toward removal and others pulling against. For a large project like the Klamath, the legal issues may take years to resolve, if they are resolved at all.

To help make sense of that web, this paper provides a primer on the law of dam removals. It begins, in Part I, with an overview of the legal regimes governing dam construction and management. Those regimes generally do not anticipate dam removals, but changing conditions and societal priorities do sometimes create pressure for taking dams out, and Part II explains how legal and ecological regimes sometimes create levers that push dams toward removal. Part III turns to a different question: what sort of legal issues arise during the process of dam removal, and how can those be managed? A dam removal project is legally analogous to a large and unpredictable construction project, with all the liability-management issues such projects entail. Part IV turns to a cutting-edge issue in dam removal law: how can lawyers and policymakers move beyond largely ad hoc, dam-by-dam removal projects and begin harnessing the benefits of planning removals at basin or even broader scales?

While much of this article focuses on law, we close with a case study of the aftermath of a dam removal. Our focus is the Elwha River in

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[2] *See generally* U.S. DEP'T OF THE INTERIOR ET AL., KLAMATH DAM REMOVAL OVERVIEW REPORT FOR THE SECRETARY OF THE INTERIOR: AN ASSESSMENT OF SCIENCE AND TECHNICAL INFORMATION (2013), http://www.klamathrenewal.org/wp-content/uploads/2020/07/A7-Full-SDOR-accessible-022216.pdf (describing the project's environmental benefits).

[3] *See* Paige Blankenbuehler, *A New Klamath Water Deal Emerges, but Unease Persists*, HIGH COUNTRY NEWS, April 8, 2016, https://www.hcn.org/articles/on-the-klamath-leaders-celebrate-dam-removal-but-unease-over-water-deal-persists; *see generally* HOLLY DOREMUS & A. DAN TARLOCK, WATER WAR IN THE KLAMATH BASIN: MACHO LAW, COMBAT BIOLOGY, AND DIRTY POLITICS (2008) (describing the history of water conflict in the Klamath basin).

[4] *See* Mary B. Powers, *FERC Ruling Could Set Back Schedule of Largest U.S. Dam Removal*, ENGINEERING NEWS-RECORD, July 21, 2020, https://www.enr.com/articles/49747-ferc-ruling-could-set-back-schedule-of-largest-us-dam-removal (describing FERC's ruling, discussed later in this paper, which required Pacificorp to remain a co-licensee for the dams).

[5] *See generally* Dave Owen & Colin Apse, *Trading Dams*, 48 U.C. DAVIS L. REV. 1043 (2016) (describing the law of dam regulation and removal). Our legal discussion in this paper draws heavily upon *Trading Dams.*

Washington, where two dams were removed over the span of three years from 2011 to 2014. Since that time, the river has rebounded in a wide variety of ways. The Elwha's story exemplifies the benefits a dam removal can produce—and the reasons why navigating the legal challenges of dam removal will often be worthwhile.

I. Dams and Their Legal Status: The Basics

The United States, like most industrialized societies, is a land of dams. According to the U.S. Army Corps of Engineers (Corps), the United States contains over 90,000 dams, which averages to roughly one dam for every day the nation has existed.[6] If one includes smaller dams in the count, the numbers would run well over two million.[7] Consequently, most major rivers in the United States move through a series of reservoirs and dams, as do their tributaries; major waterways that flow unimpeded to the ocean are vanishingly rare.[8]

These dams have come into existence, and continue to exist, through a variety of different legal arrangements, which the discussion below summarizes in turn.

a. FERC-regulated dams

Perhaps the most complicated legal regime exists for dams that occupy navigable waterways, produce hydropower, and are not owned by the federal government. The Federal Energy Regulatory Commission (FERC) has licensing authority over these dams.[9] It can issue those licenses for up to fifty years (forty is more typical).[10]

License renewals are legally complicated processes. The Federal Power Act itself provides FERC with a variety of criteria to consider, and it also obligates FERC to seek recommendations from other federal agencies and from tribal representatives.[11] Because they are discretionary

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[6] U.S. Army Corps of Eng'rs, National Inventory of Dams, https://nid.sec.usace.army.mil/ords/f?p=105:1 (last visited Oct. 28, 2020).

[7] *See* N. Leroy Poff & David D. Hart, *How Dams Vary and Why It Matters for the Emerging Science of Dam Removal*, 52 BioScience 659, 662 (2002).

[8] *See* Owen & Apse, *supra* note 5, at 1053.

[9] 16 U.S.C. § 797(e) (2013).

[10] *See* Owen & Apse, *supra* note 5, at 1064.

[11] *See* Electric Consumers Protection Act of 1986, Pub. L. No. 99-495, § 3(a), 100 Stat. 1243 (codified as amended at 16 U.S.C. § 797(e) (2006)) (granting federal land management agencies authority to impose conditions for projects located within their reservations); 16 U.S.C. § 803(j) (2013) (allowing the FWS and NMFS to request conditions designed "to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlife"); *id.* § 811 (2013) ("The Commission shall require . . . such fishways as may be prescribed by the Secretary of the Interior or the Secretary of Commerce, as appropriate."); *see also* Escondido Mut. Water Co. v. La Jolla Band of Mission Indians, 466 U.S. 765, 772 (1984) (holding that FERC must include in its licenses conditions imposed pursuant to section 4(e) of the Federal Power Act); Am. Rivers v.

federal actions, licenses also trigger the National Environmental Policy Act, which requires FERC to prepare environmental impact statements considering the impacts of the license renewal and alternatives to that renewal,[12] and section 7 of the Endangered Species Act, which forbids FERC from authorizing actions likely to jeopardize the survival of threatened or endangered species or to adversely modify those species' critical habitat.[13] FERC's licenses also trigger section 401 of the Clean Water Act, which requires state water quality certifications whenever the federal government authorizes a project involving a discharge.[14] States routinely attach conditions to their section 401 certifications, and courts have held that FERC must incorporate these conditions into its licenses.[15]

b. Federally owned dams

In addition to federally regulated dams, the federal government also builds its own dams. These dams are less numerous than FERC- and state-regulated dams, but they tend to be relatively large, which means their influence outstrips their numbers.[16] Two federal agencies—the Corps and the Bureau of Reclamation—manage most of these federal dams.[17]

Federal dams generally are authorized by specific water resource development statutes.[18] Those authorizing statutes specify the purposes for which the dams may be used and sometimes provide guidance for operating criteria.[19] Dam-management agencies then flesh out those operating criteria through operating manuals and other documents.[20] Operations also are generally governed by other federal statutes, including

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FERC, 201 F.3d 1186, 1206–11 (9th Cir. 1999) (holding that FWS's and NMFS's fishway prescriptions are mandatory). For general discussion of the importance of these requirements and the leverage they give to other agencies, see J.R. DeShazo & Jody Freeman, *Public Agencies as Lobbyists*, 105 COLUM. L. REV. 2217 (2005).

[12] 42 U.S.C. § 4332(C).

[13] 16 U.S.C. § 1536.

[14] *See* 33 U.S.C. § 1341 (2013); *see also* PUD No. 1 of Jefferson Cnty. v. Wash. Dep't of Ecology, 511 U.S. 700, 722–23 (1994).

[15] That leverage would be lessened by recent updates to EPA's implementing regulations for section 401—if those regulations stand up in court, which they may not. *See* Clean Water Act Section 401 Certification Rule, 85 Fed. Reg. 42,210 (July 13, 2020).

[16] *See* Owen & Apse, *supra* note 5, at 1067.

[17] *See* DOUGLAS G. HALL & KELLY S. REEVES, A STUDY OF UNITED STATES HYDROELECTRIC PLANT OWNERSHIP 1, 8 (2006).

[18] *Id.*

[19] *See* Owen & Apse, *supra* note 5, at 1067; Victor B. Flatt & Jeremy M. Tarr, *Adaptation, Legal Resiliency, and the U.S. Army Corps of Engineers: Managing Water Supply in a Climate-Altered World*, 89 N.C. L. REV. 1499, 1516–29 (2011) (summarizing the legal regime governing the Corps' dams).

[20] *See, e.g.*, *In re* Tri-State Water Rights Litig., 644 F.3d 1160, 1167–78 (11th Cir. 2011) (describing how legislation and manuals govern operation of Georgia's Buford Dam).

environmental laws like the Endangered Species Act.[21] But for federally owned dams, there is no licensing process akin to FERC review, which means there is no legal trigger for a comprehensive review of dam operations.[22]

c. State-regulated dams

If a dam (a) is not owned by the federal government, and (b) does not generate hydropower or generates hydropower only on a non-navigable waterway, then regulation of that dam, to the extent it happens at all, will come from state law.[23] This state-regulated category includes the vast majority of the United States' dams, though, again, the larger dams tend to be federally licensed or federally owned.[24] Legal regimes for these dams tend to be minimal. Most states have dam safety regulation programs, though, in the words of one recent study, those programs are often "pitiful."[25] Tort law also potentially applies; a manager of a dam that fails may incur liability.[26] But under most state laws, environmental regulation of dams is rare, at least for existing dams.[27] And relicensing programs directed at existing dams are generally nonexistent.[28]

II. Legal Incentives for Dam Removals

One theme of the law of dams is its lack of direct attention to dam removals. The Federal Power Act, for example, says nothing explicit about dam removals. A dam owner that fails to obtain a new license before the expiration of the old is generally allowed to keep the dam in place; the owner just operates under a temporary one-year license.[29] This suggests that Congress, at the time it enacted the Federal Power Act, was not thinking about the possibility that dams might not last forever. Similarly, the legislation that authorized the construction of federally owned dams says nothing about their removal. And while a few states have recently developed small administrative programs for helping dam owners navigate

[21] Owen & Apse, *supra* note 5, at 1068.

[22] *Id.* at 1067–68.

[23] *Id.* at 1069.

[24] *Id.*

[25] Naomi Schalit & John Christie, *Maine's High-Hazard Dams Lack Inspection*, Bangor Daily News (Aug. 24, 2011), http://bangordailynews.com/2011/08/24/news/state/half-of-high-hazard-dams-lack-state-inspection (quoting University of Hawaii civil engineering professor Peter Nicholson).

[26] *See* Catherine C. Engberg, Note, *The Dam Owner's Guide to Retirement Planning: Assessing Owner Liability for Downstream Sediment Flow from Obsolete Dams*, 21 Stan. Envtl. L.J. 177, 190–91 (2002).

[27] Owen & Apse, *supra* note 5, at 1070.

[28] *Id.*

[29] *See* 16 U.S.C. § 808(a)(1).

removal processes,[30] no state, to our knowledge, has enacted dam-removal legislation, except in specific situations involving specific dams. The implicit assumption of much of the law of dams is that all dams will last forever.

That assumption is plainly wrong. Over time, sediment fills in the reservoirs behind dams, reducing their storage capacity. For some dams, that process could take millennia, but in rivers with heavier sediment loads the process can occur in just decades.[31] For example, on Washington's Elwha River, thirty metric tons of sediment piled up behind the uppermost of two dams in under 100 years—enough sediment to keep filling seventy dump trucks running 24 hours a day for five years.[32] Dams themselves generally are not engineered to last forever.[33] They can fail, particularly as they age, creating a risk of catastrophic flooding for communities downstream.[34]

In addition to potential structural inadequacies, dams cause environmental impacts that, in some places, people find increasingly undesirable. Dams often diminish downstream water quality.[35] They also alter the quantity and timing of downstream flows, often in ways that are problematic for downstream (and sometimes upstream) ecosystems.[36] One of the greatest ecological costs of dams is that they block upstream movement of fish and other aquatic species, disrupting important migratory pathways.[37] In the United States, those blockages are particularly important for coastal rivers, most of which once contained substantial migrations of diadromous fish, including all species of Pacific and Atlantic salmon.[38] By blocking anadromous fish from their natal streams, dams also deprive

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[30] *See, e.g.*, Wis. Dep't of Nat. Res., *Dam Removal Grant Program*, http://dnr.wi.gov/Aid/DamRemoval.html (last visited October 28, 2020).

[31] *See* Emily H. Stanley & Martin W. Doyle, *Trading Off: The Ecological Effects of Dam Removal*, 1 FRONTIERS IN ECOLOGY 15, 16 (2003) (describing sedimentation problems).

[32] Andrew C. Ritchie et al., *Morphodynamic Evolution Following Sediment Release from the World's Largest Dam Removal*, 8 SCI. REPORTS (Sept. 5, 2008).

[33] *See* Wayne L. Graham, A PROCEDURE FOR ESTIMATING LOSS OF LIFE CAUSED BY DAM FAILURE 1–10 (1999).

[34] *See, e.g.*, Erin Einhorn, *Thousands Fled for their Lives when Two Michigan Dams Collapsed. More Disasters are Coming, Experts Say*, NBC NEWS, June 13, 2020, https://www.nbcnews.com/news/us-news/thousands-fled-their-lives-when-two-michigan-dams-collapsed-more-n1230841.

[35] *See, e.g.*, Klamath Tribal Water Quality Consortium, KHP Impacts on Water Quality, https://klamathwaterquality.com/water_quality.html (last visited Oct. 28, 2020) (describing downstream impacts from the Klamath dams).

[36] *See* Owen & Apse, *supra* note 5, at 105; Stuart E. Bunn & Angela H. Arthington, *Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity*, 30 ENVTL. MGMT. 492, 492 (2002)

[37] *See* Owen & Apse, *supra* note 5, at 1057–59.

[38] *Id.*; *see* JOHN WALDMAN, RUNNING SILVER: RESTORING ATLANTIC RIVERS AND THEIR GREAT FISH MIGRATIONS 8 (2013).

rivers of marine-derived nutrients that are so important for everything from aquatic macroinvertebrates to bears, and to the vegetation surrounding streams.[39] Moreover, reservoirs that hold water behind dams cause significant losses of habitat for terrestrial wildlife. If the many benefits of dams explain why so many exist, their negative impacts explain why there is so much pressure, not just from environmental advocates, to take them out.

The catch, however, is that even if a dam removal would make sense for society as a whole, it may not make sense for the owners. That may be because the owners are making money off the dam without needing to invest significant capital in it—because the upfront cost of building the dam was covered long ago—and without internalizing the costs of the dam's environmental and safety effects. It also may be because many laws, including environmental laws, are biased toward the status quo: changes require legal review, but simply continuing a present course of action implicates no procedural complexities.[40] Consequently, and ironically, even environmental laws may make it easier to leave an environmentally harmful dam in place than to take it out.[41] And even without the status quo bias of governing law, leaving a dam in place avoids the engineering and construction costs associated with removal. Consequently, dam removals tend to happen where some combination of legal and economic incentives changes the calculus.

That typically happens in one of a few ways. For smaller, state-regulated dams, the most likely impetuses are safety issues and associated liability and the possibility of removal funding from environmental groups or government agencies.[42] Sometimes that funding may come from grant funds or private fundraising.[43] For a few dams it has come from compensatory mitigation programs; hydropower producers or developers have funded dam removals, sometimes directly and sometimes through mitigation banks, to compensate for the impacts of continued dam operations or development projects in other locations.[44]

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[39] *See* DAVID MONTGOMERY, THE KING OF FISH: THE THOUSAND-YEAR RUN OF SALMON 29 (2003) ("Trees growing along salmon-bearing streams grow up to three times faster than those growing along salmon-free streams.").

[40] *See* Owen & Apse, *supra* note 5, at 1095–96.

[41] *Id.*

[42] *See id.* at 1096.

[43] The Wisconsin grant removal program exemplifies a state-level program to provide such funding. *See supra* note 30.

[44] *See generally* JESSICA WILKINSON ET AL., ENVIRONMENTAL MARKETS AND STREAM BARRIER REMOVAL: AN EXPLORATION OF OPPORTUNITIES TO RESTORE FRESHWATER CONNECTIVITY THROUGH EXISTING MITIGATION PROGRAMS (2017), https://www.nature.org/content/dam/tnc/nature/en/documents/2017_Stream_Barrier_Removal_and_Mitigation_Report.pdf; U.S. Army Corps of Eng'rs, Regulatory Guidance Letter, Sept. 25, 2018, https://www.nap.usace.army.mil/Portals/39/docs/regulatory/regs/RGL-18-

Removals of FERC-regulated dams have been rarer, but some have occurred, typically in response to environmental objections raised by environmental groups and tribes. The removal of the Edwards Dam, on the Kennebec River in Maine, provides an early and classic example of the kinds of levers and incentives that can generate such removals.[45] The Edwards Dam was environmentally problematic; it was the first dam to block fish migrations up a once-productive river, and it also generated water quality problems in and below its impoundment.[46] But it was still profitable for its owners, who, in the mid-1990s, sought to renew its license from FERC.[47] Environmental groups opposed that relicensing, and they used a combination of legal leverage and political activism to stop it.[48] In 1998, FERC, in a historic move, agreed with the objectors, declined to relicense the dam, and ordered the owners to remove it at their own expense, a requirement that led to an appeal and threats of litigation.[49] That litigation never occurred; instead, the dam owners reached a settlement whereby a downstream industrial plant would partly fund the removal in return for obtaining permission to fill an area of low-productivity wetlands, and whereby upstream dam owners would contribute funding in return for delays in their own fish passage obligations.[50] But the dam did come out, and fisheries and water quality in the Kennebec River both have dramatically improved, producing a variety of secondary benefits.[51]

Each dam removal story has its own distinctive history and complexities.[52] Yet several common threads run through them. Dams generally come out because of a combination of sticks and carrots.[53] The sticks usually come from environmental law; regulators demand

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01-Determination-of-Compensatory-Mitigation-Credits-for-Dams-Structures-Removal.pdf?ver=2019-02-22-140711-787 (providing guidance for using dam removals to generate mitigation credits).

[45] *See* Jeff Crane, *"Setting the River Free": The Removal of the Edwards Dam and the Restoration of the Kennebec River*, 1 WATER HIST. 131 (2009).

[46] *See* Tara Lohan, *How Removing One Maine Dam Twenty Years Ago Changed Everything*, THE REVELATOR, February 11, 2019, https://therevelator.org/edwards-dam-removal/.

[47] *See* Crane, *supra* note 45, at 138.

[48] *See generally id.* (describing the long history of activism seeking the dam's removal).

[49] *Id.* at 140–43 (describing the order and subsequent reactions).

[50] *See* Edwards Mfg. Co., 84 FERC ¶ 61,227 (1998) (approving the settlement agreement).

[51] *See* Lynne Y. Lewis et al., *Dams, Dam Removal and River Restoration: A Hedonic Property Value Analysis*, 26 CONTEMP. ECON. POL'Y 175, 185 (2008) (documenting rising property values after the Edwards Dam removal); *see also Recreational and Economic Benefits of Edwards Dam Removal*, ME. RIVERS, June 22, 2009, http://mainerivers.org/wp-content/uploads/2010/09/Edwards-Dam-Benefits-NRCM.pdf.

[52] For several other examples, see Michael C. Blumm & Andrew B. Erickson, *Dam Removal in the Pacific Northwest: Lessons for the Nation*, 42 ENVTL. L. 1043, 1043 (2012).

[53] *See* Owen & Apse, *supra* note 5, at 1102–08.

operational changes or impose fish passage requirements that decrease or eliminate the economic viability of the dam. And the carrots typically come from governmental or NGO funding; someone other than the dam owner winds up picking up the tab for taking the dam out. Often neither the stick nor the carrot is sufficient on its own. The combination, instead, is what gets the deal done.

III. Creating Legal Structures for Managing Dam Removals

The legal issues surrounding dam removal don't end when the dam owner calculates that the dam might be worth more removed than intact, or when removal advocates get regulators and other stakeholders to agree with, or at least acquiesce to, that conclusion. Someone still has to demolish the dam, and that can create a second set of legal issues. A dam removal is a massive construction project, and, as with many construction projects, managing insurance, assigning financial responsibility for cost overruns, and allocating liability for mishaps and other contingencies all can be important.

These issues are likely to be somewhat less salient if the dam removal is managed by a major power company. Such companies routinely manage construction projects and typically have sufficient assets to address unforeseen contingencies.[54] But in some removal processes, the previous dam owners are not interested in managing the removal or the associated liabilities; indeed, the opportunity to shed those obligations and liabilities may have been one of the inducements that led the company to accept dam removal as an option. For a major dam removal project on Maine's Penobscot River, for example, The Nature Conservancy actually purchased several dams from their previous owners.[55] On the Klamath, Pacificorp, the power company, hopes to surrender its dam licenses to the Klamath River Renewal Corporation, a new corporate entity created for the specific purpose of managing, paying for, and managing liability for the dam removals.[56]

That proposed transfer is creating several challenges for the Klamath dam removal process. In a recent decision, the FERC declined to allow PacifiCorp, which currently owns the dams, to fully transfer its license to the Klamath River Renewal Corporation, partly because FERC was skeptical that the renewal corporation had sufficient capital to deal with

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[54] *See* Order Approving Partial Transfer of License, Lifting Stay of Order Amending License, and Denying Motion for Clarification and Motion to Dismiss, 172 FERC ¶ 61,062, P 71 (2020) (noting these advantages).

[55] *See* Jeffrey J. Opperman et al., *The Penobscot River, Maine, USA: A Basin-Scale Approach to Balancing Power Generation and Ecosystem Restoration*, 16 ECOLOGY & SOC'Y, no. 3, 2011, *available at* http://www.ecologyandsociety.org/vol16/iss3/art7.

[56] *See* Klamath River Renewal Corporation, Our Story, https://www.klamathrenewal.org/our-story/ (last visited Oct. 28, 2020).

unforeseen contingencies or cost overruns and sufficient experience to manage the project.[57] FERC instead ordered PacifiCorp to remain as a co-licensee, an outcome that PacifiCorp has described as undercutting key elements of the deal.[58]

IV. BEYOND INDIVIDUAL DAMS

In the United States, dam removals have often happened on an individual, ad-hoc basis. But the Klamath Project exemplifies a different and promising approach to dam removal: making decisions about, and taking action upon, multiple dams at the same time.

The potential advantages of coordinated planning and action are significant.[59] It can focus removal efforts upon dams with the worst ratios of public benefit to environmental harm.[60] It can also take advantage of the benefits of coordinating multiple removals. Consider, for example, dam removals designed to improve habitat access for diadromous fish. If two dams are to be removed, it may do far more good to remove the lowest dam in a river system and a second dam that blocks a major tributary than to remove two dams higher up on the mainstem. At larger scales, multiple studies have demonstrated that the benefits of coordinated dam removals, both in increased environmental benefits and in minimizing losses of hydropower, can be dramatic.[61]

Some individual projects provide promising examples of this potential. The most prominent and ambitious involves the Penobscot River in Maine.[62] There, a coalition of tribes and environmental groups worked with regulators and a power company to negotiate a multi-dam deal. Under the deal, two dams have been removed and others have received fish passage improvements, while other dams have received upgrades to their hydropower-generating capacity.[63] Because of these changes, hundreds of

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[57] Order Approving Partial Transfer of License, Lifting Stay of Order Amending License, and Denying Motion for Clarification and Motion to Dismiss, 172 FERC ¶ 61,062, PP 45–46 (2020).

[58] Gillian Flaccus, *Federal Agency Throws Curveball at Klamath Dams Demolition Plan*, OPB, July 16, 2020, https://www.opb.org/news/article/federal-agency-curveball-klamath-river-dams-removal/.

[59] *See generally* Owen & Apse, *supra* note 5.

[60] For examples of studies identifying such opportunities, see Samuel G. Roy et al., *A multiscale approach to balance trade-offs among dam infrastructure, river restoration, and cost*, 115 PNAS 12069 (2018); Erik H. Martin & Colin D. Apse, NORTHEAST AQUATIC CONNECTIVITY: AN ASSESSMENT OF DAMS ON NORTHEASTERN RIVERS (2011).

[61] *See* Sarah E. Null et al., *Optimizing the Dammed: Water Supply Losses and Fish Habitat Gains from Dam Removal in California*, 136 J. ENVTL. MGMT. 121 (2014); Opperman et al., *supra* note 55; Michael J. Kuby et al., *A Multiobjective Optimization Model for Dam Removal: An Example Trading off Salmon Passage with Hydropower and Water Storage in the Willamette Basin*, 28 ADVANCES IN WATER RESOURCES 845 (2005).

[62] *See* Owen & Apse, *supra* note 5, at 1073–80.

[63] *Id.* at 1077.

additional river miles will open to a variety of migratory species, potentially leading to dramatic environmental improvements within the river and in the adjacent ocean.[64] Meanwhile, the basin will actually generate more hydropower after the deal than it did before.[65]

Despite this promising example, multi-dam projects have remained rare. The reasons are largely legal. In many basins, FERC-licensed dams have different owners and come up for removals at different times, making multi-dam decisions differently. The Federal Power Act appears to obligate FERC to make its dam-licensing decisions pursuant to basinwide plans, but the agency has systematically ignored that obligation, with the acquiescence of the courts. And bringing federally owned dams and state-regulated dams into decision-making processes can be even more difficult, largely because those dams are not subject to relicensing or to any other sort of structured process designed to evaluate whether they should continue to exist or whether their environmental costs have become too great.

There are promising signs of a different approach. Academic and governmental studies have begun identifying opportunities for coordinated management decisions and criteria for reaching those decisions.[66] One recent study, for example, focuses on identifying "production possibility frontiers," which are convenient tools for identifying tradeoffs associated with different basin-scale dam removal plans.[67] A recent memorandum of understanding reached by hydropower industry representatives and environmental groups also includes the promise of increases in coordinated planning.[68] And the Klamath Project is an example of this sort of coordination in action. But to date, the achievements of coordinated dam planning have fallen well short of the potential.

V. AFTER THE DAMS: A CASE STUDY OF THE ELWHA RIVER

So why would anyone want to work through these complexities? And what happens after a dam comes out? Once the legal battles have been fought and the excavators and dynamite have finished the job of

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[64] *Id.* at 1078.

[65] *Id.*

[66] *See, e.g.*, G.E. JOHNSON ET AL., U.S DEP'T OF ENERGY, THE INTEGRATED BASIN-SCALE OPPORTUNITY ASSESSMENT INITIATIVE: PHASE 1 METHODOLOGY AND PRELIMINARY SCOPING ASSESSMENTS FOR THE CONNECTICUT AND ROANOKE RIVER BASINS (2013); Simon Geerlofs et al., *The Deschutes River Basin Scale Opportunities Assessment: A National Initiative to Help a Basin Increase Hydropower, Improve Environmental Sustainability While Considering Other Basin Values*, RIVER MGMT. SOC'Y J., Winter 2011.

[67] Roy et al., *supra* note 60.

[68] *See* Joint Statement of Collaboration: U.S. Hydropower: Climate Solution and Conservation Challenge, October 13, 2020, https://woods.stanford.edu/sites/g/files/sbiybj5821/f/hydropower_uncommon_dialogue_joint_statement.pdf.

dismantling a dam, river restoration can take many forms, depending on the scale and scope of the dam removal.

To date, close to 1,400 dams have been removed in the United States, varying widely in size and complexity.[69] One recent synthesis of dam-removal studies found common themes among ecosystem responses to dam removal projects:

1) physical restoration happens relatively quickly, with rapid downstream transport and deposition of sediment, though rates of sediment erosion depend on sediment type and dam removal process;

2) ecological responses following dam removal vary depending on whether one looks downstream, upstream, or within the former reservoirs;

3) connectivity between upstream and downstream reaches is quickly restored, resulting in increased movement of both organisms (i.e., fish, marine-derived nutrients) and material (i.e., wood and sediment);

4) surrounding geography and land-use history provide a larger context and may influence river restoration outcomes; and

5) predictive modelling is improving, providing useful information for looking at potential long-term effects of dam removal on ecosystem processes.[70]

With interest in dam removals growing across the nation, it is important to look at examples of successful dam removal projects to understand how future dam removals may unfold. One such example is the Elwha River.

To date, the largest dam removal in the world has been on the Elwha River on Washington's Olympic Peninsula. For nearly 100 years, two hydroelectric dams on the Elwha River blocked anadromous fish from over 70 miles of high-quality spawning habitat, most of it protected in near-pristine condition within Olympic National Park.[71] The Elwha River historically supported 10 species of native anadromous salmon and trout, but in the years following dam construction, when fish were restricted to the lower 4.9 miles of river, fish numbers declined by 90%.[72] Dam construction also inundated nearly 800 acres of land, including 534 acres of

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[69] *See* Brian C. Chaffin & Hannah Gosnell, *Beyond Mandatory Fishways: Federal Hydropower Relicensing as a Window of Opportunity for Dam Removal and Adaptive Governance of Riverine Landscapes in the United States*, 10 WATER ALTERNATIVES 819, 822 (2017).

[70] M.M. Foley et al., *Dam Removal: Listening in*, 53 WATER RES. RESEARCH 5229 (2017).

[71] *See* Nat'l Park Serv., Elwha River Restoration, https://www.nps.gov/olym/learn/nature/elwha-ecosystem-restoration.htm (last visited Oct. 28, 2020).

[72] George R. Pess et al., *Biological Impacts of the Elwha River Dams and Potential Salmonid Responses to Dam Removal*, 82 NORTHWEST SCI. 72, 73 (2008).

low elevation riparian communities and natural wetlands, removing important floodplain habitats for fish, wildlife, and native plants.[73] The lower of the two dams, the Elwha Dam at river mile 4.9, impounded the reservoir known as Lake Aldwell; the upper dam, the Glines Canyon Dam at river mile 13.4, impounded the reservoir known as Lake Mills. The dams also blocked more than 100 years of downstream transport of sediment and wood, trapping more than 25 million cubic yards of sediment behind the dams and leaving the lower river deficient of sediments and large woody debris.[74]

People of the Lower Elwha Klallam Tribe, whose reservation spans nearly 1,000 acres at the mouth of the Elwha River, opposed the dams when they were built in the early 1900s and have advocated dam removal ever since.[75] Historically, the Elwha River and surrounding forests and mountains provided year-round food, shelter, and sustenance for Klallam people. The river was at the heart of their cultural, ceremonial, and spiritual well-being. Fishing was not only a way of life, but also the mainstay of the economy.[76] Dams, however, blocked the return of these culturally and economically important salmon runs and inundated numerous cultural sites, leaving an indelible mark on the Klallam people. One of the Tribe's most important cultural sites, the site where the Creator made the Elwha Klallam people, was flooded as the waters rose behind the Elwha Dam, rendering this site of spiritual guidance completely inaccessible.[77]

Removal of the Elwha dams became a viable option when, after years of motions and petitions regarding FERC relicensing, Congress passed the Elwha River Ecosystem and Fisheries Restoration Act of 1992,[78] with the goal of fully removing both dams and restoring ecosystem functions, including restoring native anadromous fisheries and revegetating the dewatered reservoirs. Nearly 20 years later, the first jackhammer fell and dam decommissioning finally began on September 17, 2011.[79] Within a year, the Elwha Dam had been completely dismantled and the former floodplain, including the Tribe's Creation Site, exposed for the first time in

[73] U.S. DEP'T OF THE INTERIOR, NAT'L PARK SERV., OLYMPIC NATIONAL PARK, ELWHA RIVER ECOSYSTEM RESTORATION IMPLEMENTATION, FINAL ENVIRONMENTAL IMPACT STATEMENT (1996).

[74] Jonathan A. Warrick et al., *River Turbidity and Sediment Loads during Dam Removal*, 93 EOS 425 (2012); J.A. Bountry et al., 2010 *Survey Report and Area-Capacity Tables for Lake Mills and Lake Aldwell on the Elwha River, Washington* (2010).

[75] *See* LINDA V. MAPES, ELWHA: A RIVER REBORN (2013).

[76] *Id.*

[77] *Id.*

[78] Pub. L. No. 102-495, 106 Stat. 3173 (1992).

[79] *See* Nat'l Park Serv., *supra* note 71.

100 years.[80] Glines Canyon Dam removal proceeded simultaneously and was completed by 2014, finally opening the river to salmon.[81]

While restoration processes can take many years, the approximately nine years since dam removal began on the Elwha have brought dramatic changes to the watershed.[82] The two former reservoirs have been transformed from barren moonscapes to lush green landscapes, anadromous fish are once again spawning upstream, wildlife are recolonizing formerly inundated floodplain habitats, and sediment has been washed downstream into the Strait of Juan de Fuca while also adding 148 acres of sand to the mouth of the Elwha River, transforming the river mouth from a cobble shore to a sandy beach.[83] Here we provide a more detailed look at several aspects of Elwha restoration: the revegetation program, wildlife response to dam removal and habitat reemergence, fish recolonization, and sediment transport.

a. Revegetation

While fish restoration was the primary impetus for dam removal, revegetation of the former reservoirs and stabilization of sediment deposits was an important piece of ecosystem recovery in the Elwha.[84] Because sediments that remained in the lakebeds were prone to secondary erosion, they needed to be stabilized as soon as possible through vegetation establishment. Rapid revegetation of bare soils would also help impede invasion by exotic plants. Once established, riparian vegetation provides organic matter to the aquatic system, contributes to nutrient cycling, helps reduce the severity of flood events, provides important fish and wildlife habitat, and helps to stabilize the sediment that remains in reservoirs after dam removal.[85] With this in mind, Olympic National Park and the Lower Elwha Klallam Tribe established an ambitious restoration plan for the floodplains, with three primary goals: 1) minimize invasive, exotic species; 2) restore ecosystem processes; and 3) establish native coniferous forests.[86]

By 2018, the Elwha Revegetation Program was by most measures a resounding success. Revegetation of the two former reservoirs had occurred in three phases over a period of seven years: 1) testing of planting

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[80] Nat'l Park Serv., Dam Removal, https://www.nps.gov/olym/learn/nature/dam-removal.htm (last visited Oct. 28, 2020).

[81] *Id.*

[82] *See* Nat'l Park Serv., Restoration and Current Research, https://www.nps.gov/olym/learn/nature/restoration-and-current-research.htm (last visited Oct. 28, 2020).

[83] *Id.*; *see* Ritchie et al., *supra* note 32.

[84] *See* JOSHUA CHENOWETH ET AL., REVEGETATION AND RESTORATION PLAN FOR LAKE MILLS AND LAKE ALDWELL (2011).

[85] *Id.*; *see* Dep't of the Interior, *supra* note 73; Ellen K. Mussman et al., *Predicting Secondary Reservoir Sediment Erosion and Stabilization Following Dam Removal*, 82 NORTHWEST SCI. 236 (2008).

[86] Chenoweth et al., *supra* note 84.

and seeding methodologies over two years during dam removal; 2) active planting and seeding over the three years after dam removal; and 3) an additional two years of supplemental planting, seeding, and control of invasive species.[87] Seeds used in the revegetation program were collected or propagated locally, resulting in 6,559 pounds of seed representing 39 species being sown into reservoir soils between 2012 and 2018.[88] An additional 61 plant species were propagated as rooted plants for the project, and a few thousand live stakes were moved from elsewhere along the Elwha River; these efforts resulted in the planting of nearly 325,000 trees, shrubs, and herbaceous plants across both reservoirs between 2012 and 2018.[89] Finally, natural revegetation of native plants via wind and water dispersal of seeds resulted in over 400 acres of former reservoir regenerating naturally, though several species of invasive plants did take root in the former reservoirs. Many of the most invasive plants were successfully knocked back by aggressive weed treatments between 2014 and 2017.[90]

Active revegetation efforts are complete in the Elwha Valley, and the former reservoirs are now densely populated by plants. Deciduous trees (especially red alder, black cottonwood, and willow) are the most abundant woody plants in both basins, and form a lush stand of pioneering trees. Coniferous trees like western red cedar and western hemlock have also gained a foothold, contributing to the long-term goal of establishing native coniferous forests in the former lakebeds. The substantial efforts dedicated to revegetation had the intended effect, at least in these early years of ecosystem recovery: to minimize invasive species, to restore ecosystem processes, and to begin establishing native forests (a process that will take upwards of 100 years). These efforts also created early seral habitats for terrestrial wildlife, resulting in recolonization by several mammalian and avian species.

b. Wildlife

Dam construction significantly alters habitats available to wildlife, inundating floodplain habitats with water and causing losses for terrestrial wildlife, but adding habitat for aquatic species such as waterfowl. Dam construction also blocks passage of salmon and therefore marine-derived nutrients in the form of salmon carcasses, depriving upstream wildlife of important dietary sources of nutrients. Subsequent dam removals then shift the dynamic—removing habitats for waterfowl, but adding habitat for terrestrial wildlife and reconnecting nutrients linkages from the sea to

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87 Joshua Chenoweth et al., *Draft Final Report: Elwha River Restoration Project: Revegetation Report* 2011-2018.

88 *Id.*

89 *Id.*; Nat'l Park Serv., Restoration and Current Research, *supra* note 82.

90 Chenoweth et al., Draft Final Report, *supra* note 87.

upper reaches of a watershed. Moreover, some wildlife species modify habitats, alter community structure, and shift ecosystem dynamics over short and long time scales.[91] For example, several species in the terrestrial mammalian and avian communities may provide beneficial services in the form of seed dispersal and nutrient transport, while others could influence plant reestablishment, mostly through browsing planted seedlings, seed predation, or stripping woody stems of their bark.

Within the Elwha Valley, wildlife is expected to play an important role in the success of revegetation, in the movement and dietary uptake of marine-derived nutrients, and in its use of emerging habitats. To look at the impacts of dam deconstruction on wildlife and the role that wildlife might play in restoration, wildlife research in the Elwha has focused on two primary impacts: 1) the return of marine-derived nutrients via spawning salmon, and 2) the recovery of floodplain habitats in dewatered reservoirs.

To examine the relationship between salmon, wildlife, and marine-derived nutrients, between 2011 and 2014, wildlife researchers closely monitored a river-dependent bird, the American dipper, which is a consumer of aquatic prey, including salmon fry, salmon eggs, and aquatic macroinvertebrates.[92] They found that barriers to salmon migration (i.e., dams) negatively impacted dipper body condition and life histories, likely due to lack of access to marine-derived nutrients. Conversely, among dippers that had access to salmon, and therefore marine-derived nutrients, females were larger-bodied, were twenty times as likely to attempt multiple broods (nests) during a given season, had higher annual survival, and were more likely to maintain year-round territories instead of migrating within the river system.[93] Moreover, within one year of Elwha dam removals, American dippers had an increase in marine-derived carbon and nitrogen in their diets, indicating restored access to returning salmon.[94] Results of this study of American dippers suggest that wildlife benefit from restored access to salmon, and that marine-derived nutrients can rapidly return to a system following dam removal, constituting an important element of overall ecosystem recovery.

Terrestrial wildlife communities such as deer, elk, small mammals, and beavers are often overlooked when considering impacts of dam removal, but they may play a large role in the restoration of dewatered reservoirs.

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[91] Robert J. Naiman, *Animal Influences on Ecosystem Dynamics*, 38 BIOSCIENCE 750 (1988).

[92] Christopher Tonra et al., *Barriers to Salmon Migration Impact Body Condition, Offspring Size, and Life History Variation in an Avian Consumer*, 39 ECOGRAPHY 001 (2016).

[93] *Id.*

[94] Christopher M. Tonra et al., *The Rapid Return of Marine-Derived Nutrients to a Freshwater Food Web Following Dam Removal*, 192 BIOLOGICAL CONSERVATION 130 (2015).

Between 2014 and 2018, researchers studied mammalian colonization and ungulate herbivory on the two former Elwha reservoir sites.[95] They live-trapped small mammals, and found mice, shrews, and voles across the revegetated reservoirs, with species diversity driven by the proportion of logs and coniferous plants on study plots. Mice were the earliest and most widespread of the colonizers—perhaps due in part to the widespread sowing of seeds across the lakebeds and their ability to thrive in a wide variety of habitats. While not explicitly examined on this study, the authors hypothesized that mice played a functional role on the former reservoirs, eating or caching seeds, and therefore having the potential to affect plant establishment. Predators, particularly ermine, were also found in more open habitats, likely responding to availability of mice to hunt.[96] Small mammal use of the former reservoirs demonstrates restoration of ecological processes after dam removal, and these results could be widely applicable to future dam removals.

Floodplain bottomlands and riparian zones are key habitats for Columbian black-tailed deer and Roosevelt elk on the Olympic Peninsula; as such, both species recolonized the former Elwha reservoirs relatively quickly after dam removal.[97] Herbivory by deer and elk has the potential to be an important driver of plant successional development on the two former Elwha reservoirs, and McCaffery et al. examined the distribution of these two species and the browsing pressure they exerted on woody plant species in the restoration zone.[98] Elk and deer were found on both former reservoirs, but elk demonstrated the strongest influence. Browsing intensity of willows and cottonwoods by elk, in some cases, affected the stature of the plants, with potential impacts on the long-term growth trajectories of those plants.[99] On a large scale, however, woody plants are growing relatively unimpeded across much of the former reservoirs, creating a lush canopy for wildlife.

As restoration of the Elwha ecosystem continues to unfold, wildlife are expected to continue playing a role—from interacting with new vegetation in the former reservoirs to consuming and transporting marine-derived nutrients brought to the system by anadromous fish. Comprehensive restoration of the Elwha ecosystem will take years, but will ultimately include restoration of important terrestrial-aquatic linkages. Anadromous fish will leave nutrients on the river banks, to be taken up like fertilizer by the surrounding vegetation—further contributing to vegetation

[95] Rebecca McCaffery et al., *Small Mammals and Ungulates Respond to and Interact with Revegetation Processes Following Dam Removal*, 25 FOOD WEBS e00159 (2020).

[96] *Id.*

[97] *Id.*; personal observation.

[98] *Id.*

[99] *Id.*

reestablishment—and moved about the terrestrial landscape by everything from mice to otters to bears.

c. Fish

The Elwha River historically supported all ten species of native anadromous salmon and trout, and tribal elders passed down stories of the size of the fish and the density of the salmon runs that are still told today by the people of the Lower Elwha Klallam Tribe.[100] Chinook salmon were said to grow to over 100 pounds, and tribal elders will talk about days of plenty when one could "walk across the backs of salmon" to cross the river.[101] Dam construction halted those legendary fish runs, reducing salmon populations in the Elwha by 90%.[102] The primary goal of dam removal was restoration of fish passage and rebuilding of the anadromous fish populations that were once plentiful in the Elwha.[103]

Since dam removal, numerous researchers and agency personnel have documented fish recovery in the Elwha. Environmental DNA (eDNA) monitoring has shown that five Pacific salmon species, as well as Pacific lamprey, have passed upstream of both former dam sites, including a detection of Chinook salmon three weeks after the final blast that finally allowed for fish passage above the concrete remnants of Glines Canyon dam (the upper dam).[104] Winter and summer steelhead have also made it past the former Glines Canyon dam.[105] Movement upriver towards the headwaters of the Elwha depended on species and season, but Chinook salmon and coho salmon, which numerically are more abundant in the river, migrated farther upriver than less common pink and chum salmon, with Chinook more reliably making it into the upper parts of the watershed.[106] Chinook and coho salmon have also been detected upstream of the former dam sites using redd (salmon "nest") surveys, walking surveys, and radio-telemetry studies.[107] Sockeye salmon have been detected with eDNA, tangle net, and snorkel surveys, even though they were extirpated from the Elwha following dam construction; in fact,

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[100] MAPES, *supra* note 75.

[101] *Id.*

[102] Pess et al., *supra* note 72.

[103] Dep't of the Interior, *supra* note 73.

[104] Jeffrey J. Duda et al., *Environmental DNA Is an Effective Tool to Track Recolonizing Migratory Fish Following Large scale Dam Removal*, ENVIRONMENTAL DNA (Aug. 18, 2020), https://onlinelibrary.wiley.com/doi/full/10.1002/edn3.134.

[105] Wash. Dep't of Fish & Wildlife, Extension of Recreational and Commercial Fishing Closure Announced for Elwha River and Its Tributaries (April 9, 2019), https://wdfw.wa.gov/news/extension-recreational-and-commercial-fishing-closure-announced-elwha-river-and-its-0.

[106] Duda et al., *supra* note 104.

[107] *Id.*

sockeye salmon were detected higher in the watershed than any other Pacific salmon species.[108]

Of the interesting results of salmon restoration to the Elwha, one of the more exciting responses has been that of reawakened life history expression in the form of upriver migrations and anadromy.[109] Bull trout are federally threatened under the Endangered Species Act and are known to occur in the Elwha where, prior to dam removal, their movements were restricted in the fragmented river, and they only used the reservoirs and river. Using multi-year radio-telemetry data, fisheries biologists were able to document bull trout response to dam removal, discovering that within three years of dam removal, they were among the first of the salmonid species to make it to the headwaters.[110] Movement data revealed that bull trout migrated up to 168 km from the river's estuary to the headwaters, and researchers suspect that bull trout also used the marine environment,[111] suggesting the reawakening of anadromy in this population.[112] Summer steelhead are also experiencing a reemergence of a migratory life-history trait.[113] Rainbow trout (the non-anadromous form of steelhead) were retained in the upper reaches of the Elwha after dam construction; once the dams came down, young rainbow trout smolts began travelling to the sea, and Elwha summer run steelhead are now among the largest populations in Puget Sound.[114]

Because salmon recovery is still in its early stages in the Elwha watershed, there is currently a fishing moratorium to protect all species of Pacific salmon and trout, extending at least until July 2021.[115] Meanwhile, the Lower Elwha Klallam Tribe maintains a fish hatchery on the Elwha to boost fish restoration goals. Nine years out from dam removal, progress has been made, but restoration takes decades, and the Elwha fish story will continue to unfold and teach us lessons about ecosystem recovery after removal of two large dams.

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[108] *Id.*

[109] Thomas P. Quinn et al., *Re-awakening Dormant Life History Variation: Stable Isotopes Indicate Anadromy in Bull Trout Following Dam Removal on the Elwha River, Washington*, 100 ENVTL. BIOLOGY OF FISHES 1659 (2017).

[110] Samuel J. Brenkman et al., *Rapid Recolonization and Life History Responses of Bull Trout Following Dam Removal in Washington's Elwha River*, 39 N. AM. J. OF FISHERIES MGMT. 560 (2019).

[111] *Id.*

[112] *See* Quinn et al., *supra* note 109.

[113] Personal Communication from Mike McHenry, Fish Habitat Biologist, Lower Elwha Klallam Tribe.

[114] *Id.*

[115] Wash. Dep't of Fish & Wildlife, *supra* note 105.

d. Sediment

Aside from salmon recovery, one of the most talked-about aspects of Elwha dam removal was "mud," and just exactly what would happen to the estimated 33 million tons of sediment that was trapped behind the dams. Numerous researchers have looked at questions of sediment, modelling where it might end up and studying where it ultimately did end up. One of the most comprehensive research reports to date was published in 2018, with researchers reporting that 65% of the sediment locked up behind the upper dam eroded and was carried downstream, resettling 8 million tons of sediment at the mouth of the Elwha River while 14 million tons flowed out to sea.[116] Only 10% of the released sediment was deposited in the fluvial system (in other words, along the river banks, for you non-geomorphologists). The vast majority of sediment washed downstream within two years of dam removal, with the peak flow happening over an even shorter period of five months.[117] The sediment deposited at the mouth has resulted in the addition of 148 acres of sandy shoreline to the Elwha river mouth,[118] adding a magnificent new beach for the people of the Lower Elwha Tribe and causing much excitement and anticipation for a future where clams and flounder may once again feed the people as they did once before.[119]

As the largest dam removal project to date, the Elwha River released a sediment load that was 5 times greater than the next largest dam removal, creating a flush of sediment only rivaled by the 1980 eruption of Mount St. Helens.[120] The Elwha sediment story leaves a legacy of learning, research, and modelling that will undoubtedly inform future dam removal projects.

CONCLUSION

Dam removals are legally complicated. But as the Elwha's story illustrates—and as is illustrated by the stories of the Penobscot, the Kennebec, and many other waterways where dams have been removed—the environmental benefits can be substantial. In many places, coordinating dam removals and other dam-related decisions could make these benefits even greater. Consequently, future dam removals and future development of dam-removal law are both well worth pursuing.

[116] Ritchie et al., *supra* note 32.

[117] *Id.*

[118] *Id.*

[119] *See* MAPES, *supra* note 75.

[120] Ritchie et al., *supra* note 32.