www.water-alternatives.org Volume 10 | Issue 3

Chaffin, B.C. and Gosnell, H. 2017. Beyond mandatory fishways:
Federal hydropower relicensing as a window of opportunity for dam removal and adaptive governance of riverine landscapes in the United States.
Water Alternatives 10(3): 819-839

# Beyond Mandatory Fishways: Federal Hydropower Relicensing as a Window of Opportunity for Dam Removal and Adaptive Governance of Riverine Landscapes in the United States

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ABSTRACT: Over the past two decades dam removal has emerged as a viable tool for ecological restoration of riverine landscapes, partially as a result of changing societal values toward the ecological trade-offs associated with dammed rivers. Dam condition, purpose and ownership are key factors that determine the legal and political processes that lead to dam removal in most cases. In the United States removals of small, privately owned dams are most common, although the most high-profile removals are associated with large hydropower dams subject to a federal relicensing process. Scholars cite this legal process for periodic re-evaluation of hydroelectric dams as an important window of opportunity for institutionalising adaptive environmental governance toward the renegotiation of social and ecological values associated with rivers. It is clear, however, that this policy process alone is not sufficient to facilitate large-scale dam removal and larger transitions toward adaptive governance. In this paper we review several high-profile cases of dam relicensing and removal in the Pacific Northwest region of the US to better understand the combination of factors that couple with dam relicensing policy to present a window of opportunity for adaptive governance and social-ecological restoration. Examples from the Pacific Northwest reveal patterns suggesting the critical role of endangered species, Native American tribes, local politics and economics in determining the future of large hydropower dams in the United States.

KEYWORDS: Dam removal, social-ecological restoration, adaptive governance, hydropower, FERC, Pacific Northwest

## INTRODUCTION

Dam removal is an increasingly common phenomenon in developed nations, such as Australia, France (Pittock and Hartmann, 2011), Switzerland (Tonka, 2015) and the United States (O'Connor et al., 2015; American Rivers, 2016). Concurrent with the need to address safety hazards associated with ageing dam infrastructure and to consider the costs and benefits of repair vs. removal, societal values regarding the ecological trade-offs associated with dammed rivers are shifting toward acceptance of dam removal as a viable tool for ecological restoration of riverine landscapes (Poff and Hart, 2002; Doyle et al., 2003; Bellmore et al., 2016). As this narrative develops, especially within the unique constraints of United States (US) environmental and energy law, it is apparent that dam removal can offer opportunities for renewal and restoration that are as much sociocultural as ecological. For example, recent dam removals in the US have, among other things: (1) provided pathways for the restoration of aquatic species central to the identity and cultural practices of Native American tribes;

and (2) created opportunities to re-evaluate and redesign the governance of riverine landscapes towards more holistic models that integrate principles of good governance attuned to both social and ecological needs (e.g. Guarino, 2013; Chaffin et al., 2014a).

In this way, dam removals – specifically the combination of societal processes that drive and organise them – represent an example of a much larger global transition in environmental governance that explicitly recognises the coupled nature of social-ecological systems. Framing systems as 'social-ecological systems' recognises that social and biophysical aspects of systems are intimately linked and that any attempt to evaluate or manage them in isolation is counterproductive for the sustainability of societies and the ecosystems upon which they depend (Berkes and Folke, 1998; Folke et al., 2003). The concept of social-ecological systems is not exceptionally novel and is described across disciplines by terms such as 'human-environment interactions' or 'nature-society relations'. Within the past few decades, however, the concept of social-ecological systems has inspired novel contributions to scholarship on governance, increasing the recognition that environmental governance for sustainability must include the capacity to adapt and persist with limited, imperfect information and despite the extreme uncertainty and complexity inherent to rapid environmental change (Dietz et al., 2003). Environmental governance is best defined as the processes by which society mediates competing values, determines collective goals and takes actions to manage the use and conservation of natural resources (Rogers and Hall, 2003; Delmas and Young, 2009; Cosens et al., 2017). Environmental governance includes not only government and legal or policy processes but also the myriad actors, institutions, markets and networks, both formal and informal, that influence human-environment interactions (Lemos and Agrawal, 2006). Governance for sustainability is often referred to as adaptive governance – environmental governance that fosters the emergence of collective action and innovative institutions toward the goal of sustainable and just social-ecological systems (Folke et al., 2005; Chaffin et al., 2014b; Schultz et al., 2015; Cosens et al., 2017). Recent scholarship on adaptive governance has considered the ways in which law, one aspect of governance, has evolved, or failed to evolve, to support the protection, restoration and overall sustainability of social-ecological systems (Cosens et al., 2017; Craig et al., 2017).

In the context of environmental governance, elements of adaptive governance, such as dynamic leadership, collective action, institutional experimentation and a bioregional focus, consistently seem to emerge after a social-ecological crisis or the societal perception thereof; but strong political and economic forces often hinder or derail their full institutionalisation (Huitema et al., 2009; Chaffin et al., 2014b; Chaffin and Gunderson, 2016). Scholars refer to the need for a 'window of opportunity' to link the emergence of adaptive governance with the institutional changes necessary to ensure its survival (Olsson et al., 2006). In this paper we investigate one example of a potential window of opportunity for the institutionalisation of adaptive governance: the US Federal Energy Regulatory Commission (FERC) licensing process for power generation facilities. Besides fulfilling its main role of licensing facilities, this process has also led to hydropower facility decommissioning and dam removal in relatively limited cases across the US. Changing social and ecological conditions illuminate dams as a major cause of rigidity, inflexibility and decreased resilience in systems, specifically given the context of a changing climate. We argue that the FERC process for relicensing hydropower facilities provides a venue for re-negotiating societal values in dammed watersheds and provides a window of opportunity to institutionalise emergent aspects of adaptive governance present in efforts to remove dams for the social-ecological restoration of river systems.

Myriad studies report the biophysical implications of dam removal, including common management challenges (e.g. Tullos et al., 2016). Research and data revealing the social, political, cultural and governance contexts of dam-removal projects are emerging but remain sparse (Lejon et al., 2009; Germaine and Barraud, 2013; Jørgensen and Renöfält, 2013; Fox et al., 2016; Magilligan et al., 2017). In this paper we begin to bridge this information gap by analysing a high-profile subset of dam removals in the US: large, corporately owned hydroelectric dams in the Pacific Northwest US decommissioned as a result of relicensing proceedings under the FERC process for licensing energy-generation facilities. We limit our scope of analysis to this subset of dam removals for two main reasons. First, while we recognise that small dams are the most commonly removed river impoundments in the US (American Rivers, 2016), these are often single-owner proceedings with very little data collected regarding non-hydrologic contexts of removal. In contrast, there is a wealth of publically available information found in both peer-reviewed and grey literatures (e.g. government reports) on the generally more high-profile removals associated with FERC relicensing processes (e.g. Blumm and Erickson, 2012). Second, an analysis of the dynamics surrounding FERC relicensing is timely. The era of hydroelectric dam construction and regulation in the US began in the mid- to late-20th century, and most dams were granted an initial licensing period of 50 years. Thus, many of the original FERC licenses have expired or will expire before 2030 and the next decade will see a growing number of relicensing processes taking place around the US.

As more dams are removed under the auspice of FERC relicensing, a growing body of information is available to analyse the governance processes and decisions that led to dam removal in each case. Such a review is necessary to critically evaluate the FERC process as either a window of opportunity or a barrier to the emergence of adaptive governance and social-ecological restoration of riverine landscapes in the US. In the sections that follow we first review the history of policy changes that have culminated in the current processes for FERC hydropower relicensing and potential dam removal. Second, we critically examine primary and secondary literature on three dam removals and one pending removal resultant from the FERC relicensing process in the Pacific Northwest region of the US. Across cases we compare the relative extent to which the FERC regulatory process alone can be credited with facilitating dam removal and we explore the importance of other legal, political, social and economic variables that signal the potential emergence of adaptive governance. Specifically, we discuss the presence of species listed under the US Endangered Species Act (ESA), the presence of Native American tribes with legal fishing and associated water rights, local politics, the costs of mitigation vs. removal and the changing social values of riverine ecosystem services in the FERC relicensing process and in the decision to remove dams.

## BACKGROUND

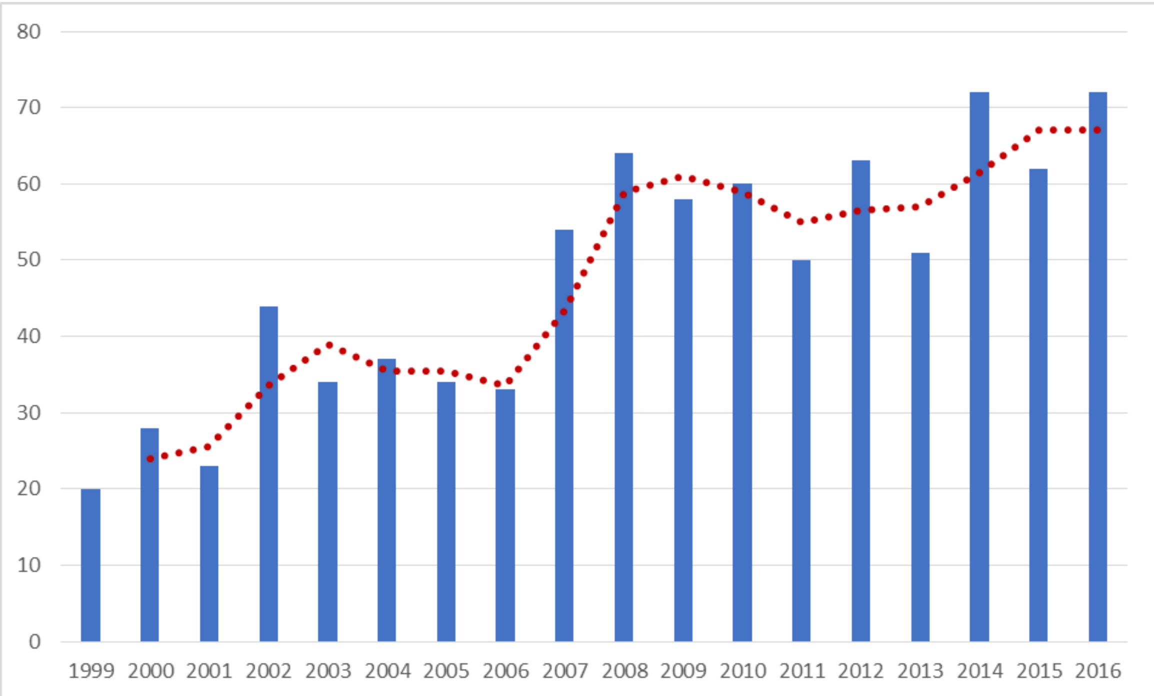
### Dams and dam removal in the US

According to an estimate by the US Army Corps of Engineers, which maintains and updates a comprehensive database of US dams, there are just under 88,000 dams in the US (NID, 2016); the vast majority of these are less than 15m in height. US dams are often categorised by primary purpose. Recreation (36%), fire and farm ponds (17%), flood control (15%), water supply (10%), irrigation (10%) and tailings and waste (9%) make up the majority of primary dam utility (Heinz Center, 2002). Magilligan et al. (2017) also note that there are likely thousands of small (< 1 m), run of the river mill dams operating since the 19th century industrial revolution in the Northeast US that go unreported in the National Inventory of Dams. Although there are only about 2500 hydroelectric dams in the US currently (3% of dams catalogued in the NID), hydroelectric dams are of specific interest because they are the largest renewable energy source (26% of all renewable energy) in the US (NID, 2016; USGS, 2016). Hydroelectric dams are usually larger, publicly visible dams, and those that generate more than 10 megawatts (MW)[1] of electricity are governed by FERC and a unique policy mechanism for review, retrofitting and potential removal.

[1] One Megawatt (MW) of hydroelectricity was enough to power 750-1000 average US homes in 2014 (National Hydropower Association, 2017, www.hydro.org/policy/faq/). This measurement, however, depends on both the electricity consumption in a given region and the efficiency of the generation facility. For example, a hydroelectric facility may be rated as a 100MW facility

As recently as 25 years ago dam removal for purposes aside from safety would have been considered a "heretical idea" (Gowen et al., 2006: 508). Today, however, the non-profit river advocacy group American Rivers (2016) reports that there were 72 dam removals in the US in 2016 alone, and 1384 recorded dam removals since 1912 (part of an upward trajectory: 62 in 2015, 72 in 2014, 51 in 2013, 63 in 2012 and 50 in 2011; see Figure 1). As dam removals increase, the monitoring and evaluation of such projects expand the availability of biophysical data to enhance future decision-making (Grant and Lewis, 2015; Bellmore et al., 2016). Available biophysical studies suggest that dam removal reconnects critical physical and biological processes such as sediment transport and fish production (e.g. see five articles in *Geomorphology* Vol. 246, Iss. 1, 2015; Null et al., 2014; Magilligan et al., 2016a). Thus, dam removal provides an avenue for restoring degraded riverine landscapes toward more diverse ecosystem function, which in turn supports ecosystem services relied upon by local human communities. For example, one year after the removal of the Edwards Dam on the Kennebec River in Maine, many resident fish species accessed habitat for the first time in over 150 years (Hart et al., 2002). After 10 years it was estimated that more than 2 million alewives (fish) returned to previously inaccessible habitat (Farlund, 2000). In addition, there has been a substantial increase in aquatic insects and resident birds, as well as improved water quality conditions in the river (Farlund, 2000).

Figure 1. Number and trend of US dam removals 1999-2016.




Source: Dams removed 1999-2016, American Rivers (2016).

Despite documented ecological benefits, disrepair and safety concerns are the most common reasons for dam removal, accounting for the majority of the almost 1400 removals recorded in the US since

at full capacity but may only run at 60% efficiency throughout the year due to water availability, maintenance needs, the need to operate dams for flood control and other management demands. The MW measurement is used in this paper as a relative measure for roughly comparing hydroelectric dams in Section 3.

1912 (American Rivers, 2016). Beyond safety, dam ownership (Table 1) is the most critical factor determining the institutional feasibility of dam removal in the US as a result of the complex legal system that separately governs water quality, water quantity, energy production, the use of public waterways and environmental impacts (Amos, 2014). To determine the prospect of removal, dams can be placed into five basic categories: (1) privately owned, non-hydropower dams; (2) privately owned, hydropower dams licensed by FERC or state agencies; (3) publicly owned, non-federal hydropower dams licensed by FERC or state agencies; (4) non-federal, publicly owned, non-hydropower dams; and (5) federally owned dams operated for hydropower or other purposes. The first category, privately owned, non-hydropower dams, which includes many investor-owned dams, comprises the majority of dam removals in the US to date (Heinz Center, 2002; American Rivers, 2016) due to the lack of a regulatory structure guiding their operation and the relative simplicity of a decision to remove a structure, especially when a dam owner also owns surrounding property. Many of these dams are small and located on non-navigable rivers; the combination of private ownership and the potentially minimal impact of removal on stream resources often allows owners to avoid complex environmental permitting under federal statutes, such as the Clean Water Act (CWA) and the Rivers and Harbors Act. Federally owned dams, such as those owned and operated by federal agencies like the Army Corps of Engineers, Bonneville Power Association or Tennessee Valley Authority, rest on the other side of the spectrum as likely the most difficult to remove (Bowman, 2002; Amos, 2014). These dams, authorised by legislation or executive action, are subject to environmental review of operations through provisions in the National Environmental Policy Act (NEPA) and Endangered Species Act (ESA), as well as state water quality certifications as outlined by the CWA. The ESA in particular can force a federal agency to mitigate impacts to threatened and endangered fish species through either operational adjustments, retrofitting or potentially through removal.

Table 1. US dam ownership.

| Owner | Number | Percentage of Total |
|---|---|---|
| Private | 56,541 | 64.7 |
| Local | 15,938 | 18.2 |
| State | 6,435 | 7.4 |
| Federal | 3,808 | 4.4 |
| Public Utility | 1,686 | 1.9 |
| Unknown | 2,951 | 3.4 |
| Total | 87,359 | 100.0 |

Source: US Army Corps of Engineers National Inventory of Dams (2016); analysis compared with Altinakar (2016).

Privately owned, federally licensed hydropower dams, as well as some publicly owned, non-federal hydropower dams, are governed by a unique regulatory structure that provides a mechanism through which a handful of large hydropower projects were decommissioned and dams removed over the past decade, beginning with the Edwards Dam on the Kennebec River in 1999 (Crane, 2011; Amos, 2014). Under the Federal Power Act (FPA) of 1920 FERC is charged with licensing all privately and publicly owned non-federal hydropower facilities producing more than 10MW of power that are either located on federally owned land, utilise surplus water from a federal hydroelectric project, affect interstate commerce or are built on a waterway that affects interstate commerce (FPA, 1920; Amos, 2014; FERC, 2017). Other hydropower facilities are licensed by individual states, although a third of US states do not have provisions for potential dam decommissioning (Doyle et al., 2003). Time-limited operating licenses issued under the FPA explicitly recognise that hydropower dams should be sited only in the public interest, and that dams have a finite, useful lifespan. As such, the FPA created a process of periodic evaluation of hydropower infrastructure to keep dams operating in the public interest. It is hard to imagine that in 1920 the engineers of the FPA envisioned that dams would be removed under this process for any reason outside of disrepair or safety; today, however, the amended FPA, and specifically the FERC relicensing process, facilitate a venue and process for the potential renegotiation of the societal value of river functions and has led to dam removal in multiple instances.

**FERC hydropower relicensing**

FERC issues 30- to 50-year (duration) licenses to privately owned and some publicly owned, non-federal hydropower projects. There are three avenues through which a new license or a renewed license for a continuing project can be obtained by a private entity: the Integrated Licensing Process (ILP), the Traditional Licensing Process (TLP) and the Alternative Licensing Process (ALP). ILP, currently the default and preferred method of hydropower licensing, is a streamlined process designed to identify potential barriers to licensing early on and to consolidate associated permitting requirements for licensure, including federal environmental permitting and state water quality certification (FERC, 2016). When entities such as other federal agencies, states or tribes are significantly affected by the issuance of a FERC license, or the facility in question is controversial or publicly contested, applicants for hydropower licenses can obtain permission from FERC to undertake either TLP or ALP. The TLP utilises an explicit, three-stage, pre-filing consultation process to identify issues affecting other entities, to provide opportunity for written comments and to pursue additional studies or dispute resolution between entities prior to filing a license application (FERC, 2016). According to FERC (2016), the ALP is a custom process through which applicants can "[t]ailor the pre-filing consultation process to the circumstances of each case" in order to "improve communication among affected entities". In relicensing proceedings, hydroelectric project owners request ALP when they foresee substantial opposition to dam relicensing by an affected entity that will likely require lengthy, mediated conflict resolution. Hydroelectric project owners may also request ALP in cases where they will not pursue further project licensure. In these cases, under a 1994 policy statement issued by FERC, hydroelectric project owners are responsible for decommissioning and physically removing facilities (FERC, 1994). ALP is the FERC relicensing process that can end in project decommissioning and dam removal and is thus the focus of our analysis.

A review of these processes alone, however, does not go far enough in explaining (1) the role of affected entities in dam relicense proceedings or (2) why a private dam owner would voluntarily abdicate a FERC license for a project that produces hydropower. Answers to these questions lay in the requirements of the FPA that state federal hydropower licenses must be in the public interest and, specifically, that equal consideration must be given to both power development and environmental considerations. The Electric Consumers Protection Act of 1986 amended the FPA to read:

> In deciding whether to issue any license under this Part for any project, the Commission [FERC], in addition to the power and development purposes for which licenses are issued, shall give equal consideration to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of, fish and wildlife (including related spawning grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality (Public Law 99-495 § 3).

Environmental considerations are substantively borne out in the 'condition and prescription' authority of the FPA, a series of both suggested and mandatory conditions and prescriptions for licensure that certain state and federal agencies can place on a potential licence (Amos, 2014). These conditions and prescriptions include the general Section 10(a) recommendations that affected natural resource management agencies can place on a licence or relicense application; under the FPA Section 10(a) recommendations must be part of FERC’s equal consideration analysis. Although FERC holds discretion to deny Section 10(a) recommendations, the process provides federal agencies the opportunity to present data and scientific research for consideration in licence and relicense proceedings. Legal precedent suggests that FERC must show expert agencies deference, potentially rendering Section 10(a) recommendations difficult to deny for fear of legal challenge under the arbitrary and capricious standard for agency action (Amos, 2014). If the hydropower project in question is or will be located on federal land, the federal agencies managing that land can submit mandatory conditions under section 4(e) of the FPA; FERC has no discretion to deny these conditions in processing a licence.

Similarly, Section 18 'fishway prescriptions' allows the US Fish and Wildlife Service and NOAA Fisheries, through their respective US Department Secretaries, to issue mandatory prescriptions for fish passage to ensure the protection of fishery resources managed by either agency. Non-federal agencies, such as state fish and game and environmental quality departments, state parks and municipalities may also submit fishway prescriptions under Section 10(j) of the FPA. Like the 10(a) recommendations, FERC has the authority to deny these non-federal prescriptions, but, when contested, courts have shown considerable deference to these non-federal agency experts (see Amos, 2014, footnote 35 for list of cases).

The condition and prescription authority detailed above creates a substantive framework through which rivers can be valued for more than just hydropower in the FPA's regulatory process. As Amos (2014) points out, the cost-benefit analysis of Section 18 mandatory fishway prescriptions alone can undermine a dam owner's decision to relicense a hydropower project that requires substantial retrofitting to allow for the mandatorily prescribed level of fish passage. As of 2005 amendments to the FPA (Energy Policy Act of 2005, Public Law 109-58 § 241), the licensee can request a trial-type hearing to dispute the facts of mandatory prescriptions, but, as in the Klamath case detailed below, the burden of proof on the licensee to overturn mandatory fishway prescriptions is substantive and difficult to overcome. Thus, the FERC regulatory process, specifically applied to hydropower relicensing, has prompted some private dam owners, such as corporations beholden to shareholder returns, to request ALP, abdication of previously held FERC licences and decommissioning of facilities (Blumm and Erickson, 2012). The details of these processes are intensely political. In response, FERC proactively encourages settlement negotiations between the private hydropower owner, affected entities and legal process intervenors, such as states and Native American tribes with claims to affected water rights and other resources potentially impacted by relicensing or decommissioning (Ray, 2016).

Although FERC relicensing creates a substantive mechanism that allows for critical re-evaluation of the social, cultural and economic value of river systems and associated ecosystem services, it is clear that the regulatory process alone is not sufficient to catalyse dam removal. What is yet unclear is the combination of additional factors that allows the FERC process to realise the potential for dam removal and associated social-ecological river restoration. How closely, if at all, do these factors mirror the emergence of adaptive governance? In the remainder of this paper we explore these questions through a regional review of FERC ALP processes that culminated in dam removals and one example of a decision to remove dams yet to be completed. Although the first FERC ALP dam removal occurred in 1999 with the removal of the Edwards Dam on the Kennebec River in Maine (Crane, 2011), in the years since the majority of ALP-facilitated dam removals have occurred in the Pacific Northwest region of the US. We chose to review Pacific Northwest dam removals in this paper in order to make relative comparisons across a region with similar geography and environmental governance contexts.

## EXAMPLES OF DAM REMOVAL FROM FERC RELICENSING PROCEEDINGS

It is notable that recent FERC-related dam removals have occurred in the Pacific Northwest region of the US. This is likely related to the frequent co-occurrence of ESA-listed anadromous fish species and the plethora of dams in this relatively water-rich region, many of them federally licensed, private hydropower dams subject to the FERC relicensing requirement. In addition, the Pacific Northwest, and Western US generally, has seen an upheaval in the distribution of water rights and associated political power in water governance over the past two to three decades based on the legal recognition and quantification of tribal water rights in watersheds with Native American reservations and treaty rights claims. This shift in water rights is significant. In state-based water adjudications – court proceedings for determining who has rights to how much water in what order – tribal water claims are given priority dates that date back to original treaties with the US government or earlier. Often, but depending on US state water law, tribes are able to assert these water rights as instream flow for culturally important fish species and other aquatic habitat needs – a right physically protected from infringement by state water rights enforcement agencies. In many water basins, such as in the Klamath case presented below, this equates to a distinct shift from how water has been applied to the landscape over the past century. This recent reorganisation of water and indigenous rights in the Pacific Northwest, combined with the region's history of environmental advocacy, sets a unique stage on which FERC relicensing proceedings play out with other powerful actors, such as endangered species, environmental NGOs and the agriculture and hydropower industries. The common history and stakeholders in this region create a unique opportunity to compare and contrast FERC ALP processes and the relative influence of external factors.

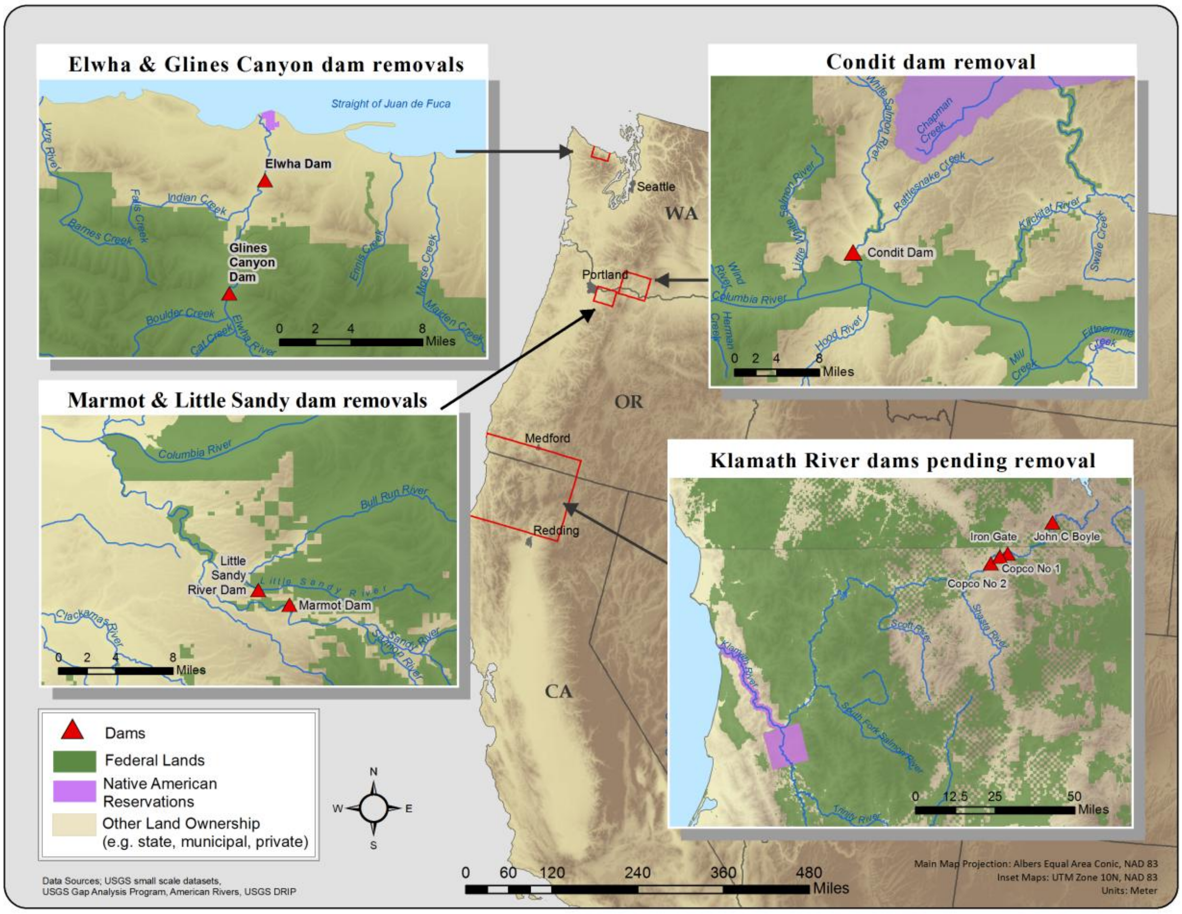
In this section we briefly describe four FERC ALP dam removal processes in the Pacific Northwest (Figure 2) and identify aspects of environmental governance, such as the emergent economic, socio-cultural and political variables that were important in each case. In the discussion that follows we compare and contrast the role of these factors in each FERC-related dam removal, drawing on existing scholarship on dam removal in other geographic contexts, as well as scholarship on the environmental governance generally and the emergence of adaptive governance in particular. We also present hypotheses about the continued relevance of the FERC regulatory mechanism for dam re-evaluation and potential removal given shifting US politics and a climate-constrained future.

## Marmot and Little Sandy Dams, Sandy River, Oregon

The Marmot Dam was removed by owner Portland General Electric (PGE) in 2007 as part of the decommissioning of the Bull Run Hydroelectric Project, which included another, smaller dam removal on the Little Sandy River in 2008 (Blumm and Erickson, 2012). Marmot Dam was a 14m tall, 59m long concrete dam that diverted waters from the Sandy River flowing off the western slopes of Mt. Hood, across a watershed divide to the Little Sandy River where water was further diverted by the 5m Little Sandy Dam and finally conveyed to the Bull Run Powerhouse on the Bull Run River, of which the Little Sandy is a tributary (Taylor, 1998; Blumm and Erickson, 2012). All told, the Bull Run Hydroelectric Project generated 22MW of electricity at full production and began initial hydroelectricity production in 1912 (Keller, 2009). The Bull Run Project was constructed to supply the nearby city of Portland, Oregon with drinking water storage and electricity (Taylor, 1998).

Although the Marmot Dam was originally constructed with fish ladders it is estimated that the entire project, including the diversions and interbasin transfer of water from the Sandy River reduced historic populations of anadromous fish (chinook and coho salmon, steelhead) between 10-25% by entraining juvenile fish and reducing streamflow and associated habitat (Taylor, 1998; FERC, 2003). The initial 30-year FERC licence for the Bull Run Project expired in 2004. Prior to its expiration PGE decided that the cost of potential yet likely conditions and prescriptions would be too high to maintain profitable hydroelectric power generation in the near term, and thus project decommissioning and dam removal were more in line with the goal of delivering profit to shareholders (Blumm and Erickson, 2012). In 2001 PGE initiated an ALP with FERC and gathered key stakeholders to discuss potential dam removal: the state of Oregon, local municipalities including the City of Portland and the federal land management agencies adjacent to the project, the Bureau of Land Management (BLM) and the US Forest Service (USFS). PGE proceeded to submit a request to surrender their FERC licence and fully pay for project removal according to the process laid out by FERC in the 1994 project decommissioning policy guidance (FERC, 1994; FERC, 2002). By 2003 they had secured all the necessary state and federal environmental permits and analyses necessary to pursue dam removal (Blumm and Erickson, 2012).

Figure 2. Dam removal from FERC relicensing processes in the Pacific Northwest, USA.




Blumm and Erickson (2012) argue that the Marmot and Little Sandy dam removals differ from subsequent Pacific Northwest removals in relative ease and expedience. For example: PGE agreed to remove dams without cost caps; state and local governments fully supported dam removal as evidenced by signing the settlement agreements and quickly advancing necessary permits; and Oregon lacks a state-level environmental policy act which expedited the process (Blumm and Erickson, 2012). In addition, the surrounding landscape is rural and remote in character, and mostly federally owned, with very few private landowners and thus little potential for private property loss.

## Condit Dam, White Salmon River, Washington

The Condit Dam on the White Salmon River in Washington State was a 38m tall and 144m wide concrete structure prior to its removal in 2011. The dam was located only 5.3 kilometres upstream from the confluence of the White Salmon and Columbia Rivers in a major corridor for commerce and development, especially in 1912 when the dam was constructed (Blumm and Erickson, 2012). The White Salmon River drains the eastern slopes of the Cascade Mountains, including the volcano, Mt. Adams, as well as the agricultural lands of the continental interior, the present and ancestral homeland of the Yakama Nation. Condit Dam produced 15MW of electricity and had no fish passage after 1917 when high water destroyed the original wooden and concrete fishways (Becker, 2006). The lack of fish passage significantly affected five species of salmon and steelhead that are currently listed under the ESA as either threatened or endangered, as well as endangered resident bull trout in the upstream portions of the river and other, non-ESA-listed species (FERC, 1996; Becker, 2006). At the time of removal anadromous fish once abundant in the White Salmon River were no longer present anywhere upstream of Condit Dam.

The construction of Condit preceded the FPA, and thus its first hydropower licence was only issued in 1968 and expired 25 years later, in 1993 (Becker, 2006). Prior to the expiration of the licence the Northwest Power and Conservation Council, the Yakama Tribe, the Columbia River Inter-Tribal Fish Commission and a host of environmental groups began advocating for the installation of adequate fish passage or the removal of Condit Dam (Blumm and Erickson, 2012). Despite this pressure the dam's owner, PacifiCorp, pushed ahead with a relicensing application in 1991 that included a request to increase power generation (FERC, 1996). After the USFWS and NOAA Fisheries placed fishway prescriptions on the relicense application and the cost of necessary retrofit was estimated at roughly US$30 million, PacifiCorp decided to pursue dam removal as the more economical option (Becker, 2006). In 1999 PacifiCorp entered an agreement with the Yakama Tribe, the Columbia River Intertribal Fish Commission and environmental groups to remove the dam, and submitted it to FERC for approval.

However, the Washington counties of Klickitat and Skamania leveraged political will to delay or derail the dam removal proposal on behalf of their residents with property on Northwestern Lake, the reservoir created by the dam. The counties attempted to enforce local permitting requirements on the dam removal for noise, floodplain, zoning, shoreline and road use/construction (Blumm and Erickson, 2012). The State of Washington stepped in, conducted its own environmental analysis, issued the necessary water quality certifications under section 401 of the CWA and otherwise quelled the vocal anti-dam removal counties. PacifiCorp received its final permits and approval from FERC in 2011, twelve years after its initial application to remove Condit Dam (Blumm and Erickson, 2012).

### Elwha and Glines Canyon Dams, Elwha River, Washington

The Elwha River drains north on the Olympic peninsula of Washington State. The river is ideal spawning habitat for anadromous fish, dropping approximately 50m per kilometre in just 72.4 kilometres through temperate rainforest; pre-dam, the Elwha supported every salmon species native to the Pacific Northwest (Wunderlich et al., 1994). The 32 m tall concrete Elwha Dam was constructed in 1913, 8 kilometres upstream from the river mouth in salt water at the Straight of Juan de Fuca (Crane, 2011). In 1927 a second dam, the 64m tall Glines Canyon Dam, was built 13.7 kilometres further upstream (Grossman, 2002). Together these two dams produced more than 28MW of electricity and supplied power to local lumber mills and nearby towns, such as Port Angeles, WA. Since their construction, Elwha and Glines Canyon dams completely blocked fish passage to the upper 64 kilometres of the river, decreased salmon populations by around 75% (Brown, 1995) and altered the geomorphology of the watershed by significantly limiting sediment transport (Crane, 2011). Olympic National Park was founded in 1938, protecting roughly 64 kilometres of the Elwha River above Glines Canyon Dam (Blumm and Erickson, 2012).

Formal efforts to remove the Elwha River dams started far earlier than those to remove the Marmot, Little Sandy or Condit dams. A removal proposal in the state legislature failed in 1937 (Brown, 1995), and the Glines Canyon FERC licence expiration in 1973 was heavily contested because some believed that operating a private hydropower facility on the border of a national park was not consistent with park values (Crane, 2011). The Lower Elwha Klallam Tribe officially intervened in the FERC relicensing proceeding of Glines Canyon Dam in 1986 and was promptly joined by USFWS, NOAA Fisheries, the National Park Service and environmental groups (Blumm and Erickson, 2012). Some intervenors argued for the removal of the dams in order to restore tribal sovereignty over river and fishery resources for the Lower Elwha Klallam Tribe and to restore ecological integrity to the river, which was dominated by national park ownership. Opposition came from residents and lumber mill owners of the nearby town of Port Angeles, who feared that it would weaken the viability of the local economy by reducing the available power and increasing the overall cost of electricity (Crane, 2011; Blumm and Erickson, 2012).

In 1992 all parties agreed to a compromise in the form of the Elwha River Ecosystem and Fisheries Restoration Act, through which the federal government purchased the Elwha and Glines Canyon dams from the Crown Zellerbach Corporation and ensured that local mills would receive reasonable, market-rate replacement electricity. The Act, however, left funding the purchase and removal of the Elwha River dams up to future decisions of the US Congressional appropriation committees. Elected officials, most notably, Slade Gordon (R-WA), an initial champion of Elwha dam removal, were able to block appropriations until 2000, based on the 'slippery-slope' argument that removal of the Elwha River dams may set a precedent for the removal of other major hydroelectric dams, such as the Lower Snake River dams (Blumm and Erickson, 2012). The federal government incrementally amassed the sum needed (over US$200 million) for the purchase of the dams in 2000 and the initiation of their removal in 2011.

### Copco 1, 2, JC Boyle and Iron Gate Dams, Klamath River, California

For decades agricultural stakeholders, Native American tribes, commercial fishermen, conservation and environmental groups, federal and state agencies, hydropower interests and the local citizenry have been at odds – and at times in direct conflict – over the allocation and use of Klamath River water. A central point of contention has been the decline of anadromous fish species associated with the series of dams along the Klamath River, once the third most productive salmon-bearing river system in the contiguous US. Historically salmon migrated from the Pacific Ocean in northern California to the tributaries above Klamath Lake in south central Oregon, but the Copco 1 Dam blocked passage in 1918, followed by Copco 2 Dam, J.C. Boyle Dam and Iron Gate Dam over the next 44 years. The dams range in height from 9m to 52m, with Iron Gate the tallest and J.C. Boyle generating the most energy at 80MW. While the J.C. Boyle Dam provides fish passage, the current ladder does not meet federal passage standards, and the dams have created other problems for fish, including altered flow regimes due to peaking power operations and water quality impacts. In 1997 coho salmon were listed as threatened under the ESA and in 2002 dam operation was at least partially implicated in a massive salmon die-off caused by low flows and warm temperatures (USFWS, 2003).

In 2006 the 50-year FERC licence for the privately owned Klamath Hydroelectric Project expired and FERC indicated that mandatory fishway prescriptions would require the dam's owner, PacifiCorp, to construct costly structures for anadromous fish (salmon) passage at the four mainstem Klamath River dams. PacifiCorp was initially committed to maintaining the dams, even with initial estimated mitigation costs of over $300 million (Gosnell and Kelly, 2010). After exhausting legal appeals to these terms, PacifiCorp requested ALP to engage the broader group of basin stakeholders to potentially leverage a comprehensive settlement of basin water issues and absolution of liability for fish passage through dam removal as the most likely alternative. After years of intense private negotiations by formal intervenors in the FERC ALP, including affected entities such as federal, tribal and state governments and local stakeholder groups such as environmental NGOs and irrigation organisations, the parties reached a series of agreements that: (1) settled contested water claims in the agriculturally dominated portions of the basin; (2) attempted to comprehensively restore fisheries in the basin; and (3) provided for the removal of the four large, mainstem Klamath River dams owned by PacifiCorp (Gosnell and Kelly, 2010; Chaffin et al., 2014a).

Due to local political opposition from two conservative counties in California and Oregon, a politically gridlocked US Congress unable to authorise federal agency participation and approval of tribal water rights, and the large sum of money needed to implement some aspects of these agreements (~US$750 million), the Klamath Agreements were never authorised and expired in 2016. During the extended ALP negotiations that led to these agreements, FERC provided the Klamath Hydroelectric Project with a yearly operating licence (from 2006 to 2016). After the expiration of the

Klamath Agreements, and thus the de facto end of the ALP, the necessity of a FERC relicensing decision remained. During the intervening time period since 2006 the dam's owner, PacifiCorp, had amassed the sum of money necessary to pay for dam removal from the passage of state bonds (California) and the collection of rate-payer fees from electricity use (Oregon). This strong economic position, combined with powerful momentum for dam removal from environmental groups, tribes and the commercial fishing industry, led to a 2016 settlement with the Department of Interior to remove the four mainstem Klamath dams that currently awaits California water quality certification and final approval from FERC.

## DISCUSSION: FERC RELICENSING AS A WINDOW OF OPPORTUNITY FOR DAM REMOVAL AND THE INSTITUTIONALISATION OF ADAPTIVE GOVERNANCE

Dam removal is often characterised as a means to pursue the ecological restoration of degraded river systems. Post-dam removal monitoring and assessment of rivers previously fragmented with large dams (some hydroelectric) has clearly shown the biophysical benefits of dam removal, specifically in terms of fish population resurgence (e.g. Poulos et al., 2014; Null et al., 2014; Quinones et al., 2015) and renewed physical dynamics such as sediment transport (e.g. Warrick et al., 2015; Magilligan et al., 2016b). Although the term restoration is contested given our limited understanding and conceptualisations of pre-historic ecological conditions and human influences (Bliss and Fischer, 2011), today it is easy to recognise a dam as a physical barrier to the natural spatial and temporal processes that define connected river networks. What is more difficult to recognise without substantial social and economic investigation is the degree to which dams can both stifle and support human systems through the provision of marketable economic goods (e.g. fish species, hydroelectricity, property values), non-market values (e.g. cultural and spiritual resources, recreation opportunities, aesthetic value) and potentially marketable services (e.g. clean water, flood control). In some cases dams are critical to producing services necessary to support established human communities; for example, a single dam can be a source for hydropower, flood control, recreation and even drinking water. In other cases a dam that has outlived its structural life may pose a physical hazard to communities downstream, or a climatic shift causing decreasing annual precipitation may render a dam obsolete for its intended purpose, such as flood control, hydropower or recreation. Either way, given the regulatory structure of hydropower licensing in the US and its interaction with environmental legislation such as the ESA, NEPA and the CWA, the periodic re-evaluation of dam infrastructure is less a diametric decision over dammed versus free-flowing rivers and more a negotiation over changed and changing social and ecological values of river systems, associated resources and services. Dam removal is thus distinctly a question of changing environmental governance. The recent and increasing decisions to remove dams, both in the US and globally, may signal the emergence of adaptive governance toward the pursuit of sustainability and the restoration of social-ecological resilience in degraded river basins.

Evidence from the Pacific Northwest cases that dam removal may signal a transition toward adaptive governance of river landscapes starts with the underlying perception that each river basin was socially and ecologically degraded prior to dam removal vis-à-vis the loss of fish species and aquatic habitat, the loss of cultural identity and culturally important resources or simply that the river system no longer addressed major societal needs or reflected societal values. From this perception of degradation or crisis aspects of adaptive governance began to emerge, such as charismatic leadership, shadow networks of informal governance actors, and diffuse, multi-sectoral attempts to institutionalise a change in river management (e.g. Gosnell and Kelly, 2010; Guarino, 2013; Chaffin et al., 2014a). Each case highlights a relatively different pathway from the emergence of these initial aspects of adaptive governance to dam removal as institutionalised adaptive governance, but across all four cases the FERC ALP stands out as a window of opportunity linking the two key phases of the governance transition. The unique aspects of the FERC ALP in each case may help scholars of adaptive governance to better understand windows of opportunity and why they are rarely utilised to address social-ecological degradation (see Olsson et al., 2006; Huitema et al., 2009; Walker et al., 2010).

As a goal of adaptive governance, social-ecological restoration can serve as a helpful mediating concept to better understand the potential of dam removal as a window of opportunity (Higgs, 2005; Gosnell and Kelly, 2010). Restoration implies a return to a previous condition, i.e. a historic baseline, but can also be interpreted as renewing desired functionality through structure and process in both human and biophysical aspects of systems (Higgs, 1997). Dam removal can facilitate this type of restoration in river systems as evidenced by the rapid return of previously extirpated anadromous fish in both the White Salmon and Elwha River systems post-dam removal. But the ecological renewal of these rivers post-dam removal is also partly social renewal; in both cases salmon and steelhead species are culturally and spiritually significant to Native American tribes, who retain lands and fishing rights in these watersheds. In addition, restoration of the Elwha River has enhanced the biophysical integrity of Olympic National Park, land reserved for public enjoyment of its natural character. The White Salmon River is an important river for whitewater recreation, serving as a social draw to the region as well as an economic engine for local communities; the removal of Condit Dam opened up additional kilometres of whitewater boating access.

As Fox et al. (2016) and Magilligan et al. (2017) point out, however, dam removal, as well as social-ecological restoration, is a product of complex political processes influenced by national and regional dynamics that often play out at a local scale. Fox et al. (2016) and Magilligan et al. (2017) found this to be true of small dam removal initiatives in the New England region of the US, many of which contemplate the removal of dams built prior to 1850 that were integral to the region's early industrial production and fuelled the economic development of the US. Local social and political dynamics dictate the power and salience of competing narratives around dam removal in these cases and can lead to stalled or thwarted dam removal efforts even when similar institutional arrangements have proven ripe for removal in other contexts (Magilligan et al. 2017). This raises important questions about the FERC relicensing process and the corresponding potential for the removal of large, privately owned hydropower dams. In the absence of the unabated desire of an individual private dam owner to remove a hydroelectric dam, the FERC license re-evaluation process is a necessary condition for removal, but it is not sufficient. It is important to note, however, that the New England dam removals explored in the research referenced above were carried out under different underlying legal contexts defining rights to water and river volume abstraction (riparian rights) than were the Pacific Northwest dam removals detailed in Section 3 (prior appropriation). This highlights the importance of factors, such as climate, industry, regional social norms, history of water development and local political power, and the roles these play in the changing governance of dammed river basins, including the potential for social-ecological restoration. Below we attempt to distinguish the relative importance of some of these additional dynamics inherent in Pacific Northwest FERC ALP processes reviewed (Table 2), although additional research exploring the micro-situational politics of each case is warranted.

Table 2. Comparison of non-process factors influencing dam removals from FERC relicensing in the Pacific Northwest, USA.

| Dam removal | Facility details | ~Cost of removal | Ecological issues | Economic issues | Social, cultural, political issues |
|---|---|---|---|---|---|
| Marmot & Little Sandy dams, Sandy River, OR | 14 m & 5 m high; 22 MW; PGE paid for removal | $12-17M | Degraded habitat and population impacts to ESA-listed species; headwaters dams impacting water quality and fragmenting habitat | Dam electricity production profitable; potential necessary retrofit uneconomical for shareholder return | USFS and BLM major land owners; environmental groups as major intervenors for fishery restoration; City of Portland interested in water supply and quality |
| Condit dam, White Salmon River, WA | 38 m high; 15 MW; PacifiCorp paid for removal with cost cap at $17.15M | $37M | No fish passage for ESA-listed anadromous species 5.3 kilometres from river mouth | Mandatory conditions and prescriptions un-economical for shareholder return | Yakima Tribe interested in return of salmon and steelhead to reservation at the headwaters; local opposition to reduced property values |
| Elwha and Glines Canyon dams, Elwha River, WA | 32 m & 64 m high; 28 MW; US Congress legislation and appropriations | $200M | No fish passage for ESA-listed anadromous species 8 kilometres from river mouth; cessation of critical river dynamics, e.g. sediment transport | Dams marginally profitable; fish passage prohibitively expensive if possible at all | Elwha Klallam Tribe interest in salmon restoration; perception of dam removal as loss of cheap power and non-indigenous way of life; bordered Olympic National Park |
| CopCo 1 & 2, JC Boyle, and Iron Gate dams, Klamath River, CA | 9-52 m high; up to 80 MW; removal paid for with bonds (CA) and rate-payer fees (OR) | $292M | No fish passage for ESA-listed anadromous species 310 kilometres from river mouth; altered timing and amount of flows; water quality concerns in reservoirs and downstream; toxic blue-green algae blooms | Cost of dam removal roughly half that of building mandatory fish passage at all four project dams | Quality of life for all users of Klamath River degraded in some aspect; tribal marginalization at both headwaters and mouth of river due to loss of culturally important fish species; involvement of federal government and local stakeholders looking for solutions for entire basin |

## Tribes and salmon: The critical role of Endangered Species Law and the US-Tribal Trust Responsibility

Anadromous species, specifically ESA-listed salmon and steelhead, are a driver of dam removal due to the mandatory fishway prescriptions placed on a relicense application by NOAA fisheries under Section 18 of the amended FPA. Despite Section 18 of the FPA, however, Section 7 of the ESA requires all federal agencies contemplating an 'action' (including FERC's issuance of a hydropower licence) to 'consult' with NOAA Fisheries (in the case of anadromous species) to ensure the agency's actions are not likely to jeopardise ESA-listed species (Bean, 2009). All of the cases we profiled exemplified the ways in which Section 7 of the ESA can tip the scales in a benefit-cost analysis such that mitigation required for ESA compliance becomes more onerous and expensive than outright removal. Given that most dam removals associated with FERC ALPs have also been associated with ESA-listed species, and requirements under Section 7 of the ESA were applied to the relicense application through the Section 18 fishway prescriptions of the FPA, the question is raised whether Section 18 by itself (on a dam relicense application with no ESA-listed species) provides enough of a trigger to lead to a removal. Technically, the agencies charged with Section 18 prescriptions could require onerous and expensive fish passage retrofits in order to protect non-listed species, but there are no current examples to examine this. Furthermore, without the backing of Section 7 of the ESA, a legal challenge of mandatory fishway prescriptions as 'arbitrary and capricious' may be more likely.

Also common to the Pacific Northwest is the presence of Native American tribes historically dependent on salmon for cultural and dietary sustenance since time immemorial (Wilkinson, 2005). Due to a series of important 20th-century court cases in the Pacific Northwest related to water rights for tribal reservations of land and for hunting and fishing treaty rights, the rights of these tribes to significant amounts of water are incontrovertibly established (Cosens, 1997; Chaffin et al., 2014a). In addition, all indigenous peoples in the United States are the beneficiaries of a suite of federal tribal trust responsibilities that require "the application of fiduciary standards of due care with respect to Indian lands, tribal trust resources, and the exercise of tribal rights" (1089 Secretarial Order, Sec 4, in Wilkinson, 1997). These rights provide tribes with significant leverage during ALP negotiations. Several dam removals have resulted from powerful alliances between tribal interests and environmental organisations – an alliance somewhat unique to the Pacific Northwest (Spain, 2007). In the Condit, Elwha and Klamath examples tribes became a central political actor, along with their trustee, the federal government, to advocate for dam removal to strengthen tribal sovereignty and restore culturally important fish and landscapes; in both cases environmental groups and an active dam-removal campaign complemented tribal interests even though they did not always work in concert.

## Cost-benefit analyses, the politics of opposition and shedding liability

FERC dam removals in the Pacific Northwest are a product of both economics and political will. The first and most expeditious case of removal, Marmot Dam, highlights very little opposition to dam removal, strong institutional actors advocating for removal, including federal agencies and the City of Portland, and the willingness of the dam owner, PGE, to unilaterally pay for dam removal. Subsequent removals were associated with significant local opposition that manifested in political action, such as intensification of county permitting requirements (Condit) and elected officials campaigning against removal (Elwha and Klamath) (Blumm and Erickson, 2012; Guarino, 2013; Chaffin et al., 2014a). The reasons for opposition in these latter cases resonate with the cultural and identity issues cited by Fox et al. (2016) and Magilligan et al. (2017) in the northeast US, except the local rhetoric was focused less on the historical preservation of the dam structure and more on the need to preserve the identity of what the dams stood for, e.g. past generations who built them, and no 'good' reasons to remove functioning dams that produce hydropower. In the Klamath case specifically a rhetoric of the loss of cheap power reigned over the public discourse around potential dam removal. This sentiment, however, was misplaced, as the 'cheap' power local residents and agriculturalists had enjoyed for years was a product of below market rate contracts negotiated between dam owners and the irrigation community in the mid-20th century – agreements that came to a swift end at the expiration of the original FERC licence (Spain, 2007).

In the cases of the Condit and Klamath dams some of the most vocal antagonists of their removal became property owners along the reservoirs created by the dams. These individuals and land ownership organisations were certain that a loss of reservoirs would diminish the value of individually owned, 'lake-front' parcels, essentially creating a federal 'taking' of property through FERC-authorised dam removal. In the Klamath case the initial settlement agreements that proposed a plan of action for dam removal and basin restoration included financial compensation for property owners along several reservoirs that would be drained in dam removal (KBRA, 2010). While local opposition to removal was also an issue in the case of the Elwha dams, it was more a fight over perceptions of the dam's role in each community's way of life (Guarino, 2013). Both Crane (2011) and Guarino (2013) found that non-tribal residents of Port Angeles opposed dam removal because of a deeply held belief that removing the dams would alter the local community and the economy, and affect their sense of place. In contrast, local opposition to the Marmot Dam removal was relatively minimal. This is likely in large part due to the physical geography of the watershed, isolated and surrounded on all sides by federal lands (Blumm and Erickson, 2012). In addition, the sense of place held by those individuals and communities who used the watershed was likely much different than those of Port Angeles or Klamath Falls, based on the utility of this particular landscape. The rugged, forested, Sandy River watershed was relied on not only as a drinking water source for nearby urban residents but also by sport fishers interested in seeing an increase in anadromous fish species for fishing and potential harvest.

The Condit and Elwha dam removals saw the advent of dam owners attempting to use the FERC ALP to negotiate 'out' of fully paying for dam removal (e.g. PacifiCorp negotiated cost caps for removal in the Condit case, and federal government paid for the removal of the Elwha and Glines Canyon dams (Blumm and Erickson, 2012; Headwaters Economics, 2014). In each case the federal government was willing to step in, likely due to the unavoidable legal nexus of the tribal trust responsibility and the ESA. The pending Klamath removal, however, has the potential to take ALP settlement to the next level; PacifiCorp, affected agencies and local stakeholders (intervenors) leveraged the ALP to address a myriad of related water issues toward an attempt at basin-scale agreement and the settlement of tribal water rights disputes, endangered species issues and general social-ecological restoration (Gosnell and Kelly, 2010). Unfortunately, the federal price tag (roughly US$750 million), combined with local political and ideological opposition, derailed a basin-scale settlement but did not stop the FERC regulatory process (Chaffin et al., 2014a). Social-ecological restoration will not proceed as envisioned in the settlement, but dam removal will proceed, especially because PacifiCorp leveraged the ALP to negotiate (1) that dam facilities would be transferred to the federal government prior to removal to absolve PacifiCorp of liability; and (2) payment for removal would come from a combination of a state bond passed in California and the collection of fees from electric utility rate payers in Oregon (Chaffin et al., 2014a). In three of the four cases highlighted here private corporations have leveraged the ALP process for relicensing to negotiate less than the actual cost of dam removal, contrary to what was prescribed in the 1994 FERC policy guidance on dam removal (FERC, 1994). In two cases, Elwha and Klamath (pending), corporate owners were able to negotiate out of both paying the full costs of dam removal and holding the liability for potential environmental problems associated with the physical removal of dams (e.g. Tullos et al., 2016). Federal tax-payers were responsible for the costs of the Elwha and Glines Canyon dam removals through Congressional legislation and appropriations, and a combination of Oregon rate-payers and California tax-payers will foot the bill for the pending Klamath dam removals. Although very few cases exist generally, this trend is striking, and the precedent it sets is troubling given recent, substantial reductions in the budgets of US land and natural resource management agencies under a new administration. Will private dam owners be held accountable for future costs of dam removal resultant from FERC ALP and abdication of a hydropower licenses?

### Dam removal in a climate-constrained future

While the past several decades have seen growing momentum, led by the environmental community, to reclaim free-flowing rivers, the spectre of climate change could shift some of that momentum and the associated politics, as the threat of both increased flooding and more frequent drought force a reconsideration of the benefits of dams. Couched in terms of environmental security, arguments in favour of dams are no longer automatically construed as anti-environmental. These arguments are often associated with the ability to help fish adapt to climate change by enabling releases of cold water when fish are temperature stressed (Thompson et al., 2012). With their ability to produce 'clean energy', hydroelectric dams have also been billed as a 'climate-smart' alternative to fossil fuel-produced energy (see USDOE, 2017).

Alternatively, increasing drought may make hydropower dams less viable along with the problem of reservoir evaporation in arid and semi-arid regions. Increased seasonal discharge associated with altered hydrologic cycles may require the removal of some dams to ensure public safety (Palmer et al., 2009; Lustgarten, 2016). In sum, climate resilience is an increasingly important topic in conversations and decisions regarding dam removal. Future research should seek to identify ecosystem-based approaches to climate change adaptation and mitigation so that there are viable alternatives when dam relicensing processes reveal insurmountable economic, sociocultural and political problems, such as those related to fish passage and the incompatibility of dammed rivers and the promotion of tribal sovereignty.

## CONCLUSION AND FUTURE RESEARCH

Our review of FERC relicensing process-facilitated dam removals in the Pacific Northwest region of the US supports the following general hypotheses: (1) the presence of ESA-listed species is an important factor leveraging a window of opportunity created by the FERC relicensing requirement; (2) similarly, the involvement of tribal stakeholders leverages powerful legal forces and the commitment of the federal government to negotiate a settlement or agreement that supports tribal sovereignty; (3) private dam economic cost-benefit analysis associated with continued dam operation (often related to the fishway requirement) is a strong indicator that a FERC ALP will result in dam removal; (4) local politics are pivotal in delaying dam-removal processes although not always sufficient to stop removal; and (5) the complex interactions of legal drivers, socio-cultural factors and resource degradation are changing the nature of the FERC ALP process with significant implications for potential private and public hydropower dam removals given the uncertainties of federal funding and climate change impacts on stream flow, water storage needs and dam viability. A critical question raised by these findings is whether and to what degree dam removal is feasible under a FERC ALP scenario when no ESA-listed species are present. How far will federal agencies go to protect fisheries under Section 18 of the FPA when not also backed by the traditional and recognised legal 'hammer' of the ESA? As such, we suggest that restoration scientists, as well as decision makers shaping the trajectory of dam-removal policy in the US, would benefit from better and more accessible information regarding important sociocultural and political factors with the potential to impact the outcome of FERC ALPs, including: public perceptions of dams and dam removal; the role of scientific information and uncertainty in dam-removal decision-making processes; the strengths, weaknesses and applications of various institutional arrangements associated with dam removal; and the socioeconomic impacts of dam removal beyond those felt by the dam owner alone.

With regard to transitions toward adaptive governance of social-ecological river basins, the FERC ALP highlights the importance of a consistent and persistent venue for both negotiating changes in societal values and for allowing a public space for economic and political forces to play out. Windows of opportunity such as the FERC ALP need longevity in order for their capacity for creative solutions to be realised (e.g. Elwha and Glines Canyon dams). In addition, windows of opportunity may require a trigger to close if powerful internal or cross-scale factors hijack or stagnate the process (e.g. Klamath). Scholars of adaptive governance have struggled to understand why more windows of opportunity are not opened and/or utilised for the institutionalisation of adaptive governance toward sustainability in social-ecological systems. This research suggests that windows of opportunity may not be a single event or discrete moment in time, such as policy windows referenced by Kingdon (1984), but instead the space and time necessary to negotiate solutions to complex environmental policy problems supported by both the informal emergence of adaptive governance capacities and powerful sidebars of law protecting marginalised species and human communities (DeCaro et al., 2017). Further research is needed to better understand both the FERC relicensing processes and windows of opportunity generally. For example, why did the FERC relicensing process result in the reissuance of a licence to the Pelton Dam (Pelton Round Butte Hydroelectric Project, FERC Project No. 2030) in Oregon when faced with similar issues of degraded anadromous fish populations and the marginalisation of tribal resources? Are there other thresholds, such as demographics or profitability, that dictate whether the FERC process is a viable window of opportunity? Alternatively, was there a lack of crisis and therefore an absence of the emergent properties of adaptive governance? The continued exploration of FERC relicensing processes – both those that lead to dam removal and those that do not – is a fruitful avenue for expanding understanding of the contexts and viability of windows of opportunity for transitions toward adaptive governance of social-ecological systems.

## ACKNOWLEDGEMENTS

The authors would like to thank the guest editors of this special issue: Régis Barraud, for organising a meeting of international dam-removal researchers that provided impetus for this research, and Anna Crockett for GIS support.

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