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Introduction

"The dam must fall. It's the only way . . . to free the forest."

—Princess Anna, *Frozen II*

I'm standing at the road's edge, toes touching a line of upside-down yellow triangles painted across its width like a row of cartoon monster teeth. It's a warning. Past this point the pavement disappears into the fast-moving Elwha River. I'm hoping to make it three more miles upriver, uproad, to where Glines Canyon Dam once stood. Crews finished tearing down the 210-foot-tall monolith in Washington's Olympic National Park in 2014, along with the 105-foot Elwha Dam just downstream a few years before. The river, freed from its bounds, wasted little time in doing its own reclamation. It slipped its banks in 2015 and again in 2017, washing out a campground and hungrily swallowing bites of asphalt. That left a section of the road that ran along its course—and to the former dam—impassable.

The irony isn't lost on me. The river has stolen the road to the site of its impoundment. Reclamation. Or maybe retribution. Or more likely, a river just doing what a river does. That may not sound like much, but these days, it's actually quite a feat. With more than 550,000 dams in the United States, free-flowing rivers are an endangered species.[1] We've dammed, diked, and diverted almost every major river in the country. Straightening curves, pinching off floodplains, and blocking passage for fish and other aquatic animals. But it's come at a great cost. Freshwater biodiversity—all the organisms that hail from our rivers, streams, lakes, and wetlands—is among the most threatened on the planet. Dams have played a large role in that demise, pushing fish, mussels, and other animals to the brink—and some over it. In North America, nearly 40 percent of fish are imperiled, and sixty-one species have blinked out in the last 125 years.[2]

That makes the Elwha's wildness a beautiful rarity. And at this moment for me, also a bit of a nuisance. To skirt the missing section of road, I have to take a bypass trail that's been blazed through the forest. In about a mile I can be reunited with the road, so I decide to ride my bike. It's a decision I regret almost immediately when the trail climbs so steeply—and my pace slows so abruptly—that I nearly tip over. I dismount and push my bike over roots and rocks, slick with mud as the path ascends skyward. At last, I reach the crest and peer through a curtain of cedars to view the Elwha's churning waters below me. Then I'm back in the saddle for the perilously steep descent. When I reach the forest floor my whooping flushes birds from the thick understory of sword ferns. Riverside again, I survey where the road turns from rubble to water. A section of it sits in the middle of the river—an island of asphalt already reclaimed by green—as the Elwha hurries along its sides.

I turn upriver and begin riding the road, relieved by the ease of the wide, relatively flat surface. I pass a collection of campground and park buildings, lonely since the washout, with a mossed-over parking lot. From there the road takes me over a bridge as the Elwha emerges a dazzling blue-green from canyon walls and widens, flanked by a rocky beach. I pedal to a watery soundtrack: the river in one ear and creeks spilling from the steep hillsides in the other. It's a Monday in February and so far, I haven't encountered another human soul on this trek. I feel a nervous anticipation building in my stomach as I near the former dam site, like getting ready to meet someone in person for the first time whom I've only known remotely. It was five years ago when I first began calling researchers—biologists, ecologists, geologists, anyone who'd studied the Elwha in the years before and after dam removal—to learn about its restoration, which was the largest effort of its kind at the time. I'm eager now to see how a free-flowing river, and all the life it supports, is on the mend after a century of being dammed and disrupted. In a world where each year brings more development, it's a welcome change to see more wildness.

I didn't know how much I needed it. In the nearly twenty years I've been working as an environmental journalist I've mostly seen forests uprooted, mountains blasted, and water polluted. For years I covered the fossil fuel extraction beat, visiting pipelines, gasfields, oilfields, coal mines, and those living beside it all. I still remember the stomach-turning smell of the fumes from oil and gas wells when I visited with a landowner in Colorado who had lost his sense of taste—and his health—after he leased his property for fracking. I also wrote about the West's diminishing water, including the Colorado River basin's growing aridification, the unhappy union of climate change and drought. When I turned to wildlife—how were they coping with all our development, pollution, and climate change—much of that wasn't good either. Along the way I wrote stories about dam removals. They were an odd bright spot on an often-bleak reporting landscape. Not surprisingly, I began to realize that dam removal stories were my favorite ones to write. And other than a big hit I had about the environmental consequences of our obsession with really soft toilet paper, they also tended to be the most popular among readers. Soon my dam removal stories began crowding out everything else I was writing. It was talking to researchers about the Elwha that made me realize why: Dam removals offer us a pathway to begin undoing some of the harm we've done. In a world of rising temperatures and shrinking biodiversity, that's critical for nature and people. For me, it's been a kind of lifeline—an antidote to my crisis fatigue and snowballing environmental grief. I'm looking forward to a reporting road trip where the highlights are seeing free-flowing rivers, paddling newly created water trails, and celebrating environmental justice wins.

That's part of what led me here to this river and what has led me on a much longer journey across the country to understand a growing dam removal movement that's resulted in about 2,200 dams blasted and backhoed from US rivers—most of those in the past twenty-five years.[3] It's an extraordinary turn of events for a dam-loving country. Europeans began erecting river barriers soon after arriving in North America. Massachusetts's Old Oaken Bucket Pond Dam, built in 1640, is one of the country's oldest known dams. Thousands more followed across New England and then down the East Coast, and eventually westward. They powered mills that ground corn, cut lumber, forged tack, produced textiles. As dams raised the height of the water behind them, they also smothered rapids and pesky whitewater so that logs could be floated from upstream forests where they were felled, to downstream industry to be processed. After hydroelectric power replaced mechanical power in the 1880s, they kept towns and cities alight.

As dam building pushed westward, dam heights pushed skyward. Hoover Dam, built in the 1930s with the labor of 21,000 men, sits 726 feet high and 1,200 feet long—more fortress than infrastructure. Grand Coulee Dam on the Columbia River in Washington rises 550 feet high and stretches nearly a mile long. The United States emerged from the Great Depression on a dam-building frenzy that lasted more than thirty years—decades dubbed the "go-go years" by Marc Reisner in *Cadillac Desert,* his iconic book on western water. Between 1950 and 1979 about

1,700 dams were built a year.[4] The US Bureau of Reclamation, which built many of the country's mammoth dams and reengineered its rivers, had a motto: "Our rivers: total use for greater wealth." Millions of Americans cashed in on it, often without giving it a thought. Politicians and regulators championed dams for their power, flood control, water storage, and recreation. Indeed, dams shaped the architecture of the West, irrigating millions of arid acres to grow crops for people and cows, corralling drinking water for cities hundreds of miles away, churning the engines of war to create aluminum for fighter planes and plutonium for bombs, and turning valleys and canyons into giant swimming pools for our amusement.

Woody Guthrie captured the sentiment of the "go-go years" in his 1941 song "Grand Coulee Dam," which refers to the Columbia River as a "wild and wasted stream." Wasted until it was dammed, that is. The folksinger, spurred by a government paycheck for his efforts, penned twenty-six songs espousing the virtues of the Columbia River's dams. It was also a natural extension of an ethos brought to the Americas by European colonists: Nature should be harnessed, subjugated, bent to the will of those manifesting their destiny. Along the way, any impacts to fish and river health were either poorly understood or simply ignored. Often the latter. Ignored too were obligations to tribes who had treaty rights to fish rivers quickly becoming empty of fish. For most Indigenous people, dams didn't bring enrichment or progress; it was one more theft from the enduring process of colonization in which food, community, ceremony, and sovereignty were stolen. Barry McCovey, a member of the Yurok Tribe in California, called the dams on the Klamath River where his people reside "cultural genocide." Dams have swallowed creation sites, burial grounds, gathering places, fishing holes, homelands, and human history.

In the 1990s interior secretary Bruce Babbitt reflected that we have been building, on average, one large dam a day, every day since the

Declaration of Independence. It hasn't been without ecological consequences, either. Dams have decimated migratory fish populations by blocking access to vital upstream habitat for spawning, feeding, and evading predators. The barriers also obstruct the downstream movement of sediment and nutrients, which depletes riverbanks and coastal beaches, hastening erosion and reducing riverside plant growth that feeds insects, birds, and other animals. The water that backs up behind a dam—its impoundment—turns a river into an unnatural lake. Migrating young salmon that once rode spring freshets quickly to the ocean now have to navigate slow-moving water over a wide expanse, which takes more energy and increases the chances they'll end up as dinner to a hungry predator—of which there are many if you're a tiny fish. And that's all before they have to run the turbine gauntlet and the drop from the dam's height to the water below. The slackwater in an impoundment can also heat up behind the dam, turning reservoirs into bathtubs that provide lethal temperatures for some fish, incubate disease, or spur the spread of invasive species that prey on native residents.

Dams upend so many natural processes, it could be argued that a river dammed isn't really a river at all. It's also possible, I think, as I bike with the Elwha River singing in my ears, that many of us don't really remember how a free-flowing river really looks and sounds. Dam removals can help restore not just river function but our collective memory. And I think we'll need to do a lot more of it. The US dam-building flurry hit its peak in the 1970s, and for the last twenty-five years we've been taking down more dams than we've been building. But the dam removal movement didn't happen spontaneously. It was fought for—by tribes, conservationists, fishers, and eventually broad, somewhat unlikely coalitions. It was also aided by environmental laws that protect clean water and endangered species, by scientific studies of dam removals and their impacts, and by regulators willing to manage adaptively.

Many people may see removing dams as outlandish. After all, they provide clean, cheap energy, right? It turns out only 3 percent of dams produce hydropower. Although hydropower is often counted in the "clean energy" column, dams and reservoirs do produce greenhouse gases, such as methane—some significantly. Climate change also poses additional challenges. Too little water in drought-plagued regions such as the Colorado River Basin could leave major reservoirs too low to produce hydropower or deliver water supplies. On the flip side, many dams today aren't designed to withstand climate-amplified storms that are increasing in frequency and severity, which can threaten public safety and leave big cleanup bills. After a big storm in 2023 put Montpelier, Vermont, under water, experts found dams actually made flooding worse.

There are many compelling environmental reasons to remove dams—including the long list of ecological consequences above—but public safety is also paramount. The American Society of Civil Engineers gave the nation's dam safety a "D" grade. With some 15,000 "high-hazard" dams where a failure would result in loss of life, this isn't a class we should come close to flunking. There's ample reason to be worried. The average age of our dams is fifty-seven years, and more than 8,000 have surpassed ninety years. Aging dams need regular maintenance to keep them safe, but that comes at a price—right now we need $66 billion for all nonfederal dams in need of rehabilitation and another $27 billon for federal ones.[5] Dams also don't have to fail to be dangerous. About 1,400 people in the United States have drowned at low-head dams, many only a few feet tall, because of the unseen and unsafe hydraulics they produce. The 6-foot-tall Dock Street Dam in Harrisburg, Pennsylvania, for example, has claimed at least twenty-nine lives.

Of course, many of our dams serve critical purposes, and I've yet to meet any dam removal advocate who thinks they all should come down. I certainly don't. But there's no shortage of low-hanging fruit when it comes to dams worthy of demolition. Tens of thousands of dams—in some states the majority of dams obstructing rivers and streams—no longer serve a useful purpose. These so-called deadbeat dams include mill dams where the mills are decades (or centuries) gone and obsolete dams, such as the 168-foot-tall Matilija Dam in Southern California, which was built for water storage but filled with silt in just fifty years. Some dams are orphans, with no known owner and therefore no one overseeing upkeep. In many cases it's cheaper to take dams down than to refurbish and retrofit them to meet modern safety and environmental laws.

Dam removals can also be a necessary step toward ameliorating harm to Indigenous communities from the loss of food sovereignty, treaty rights, cultural resources, and homelands.

More people are also realizing the benefits of restoring nature for nature's sake. For the bears, birds, and beavers. For the salmon and cedars. Certainly that's been the case here on the Elwha. People also benefit from that ecological restoration. Over the last few decades we've started to better account for what healthy rivers provide. These ecosystem services have helped put a value on something that's invaluable.

As I ride, I think back to 2018, when I first started learning about how the Elwha was recovering. That year crews tore down 107 dams across the country. Now, as I pedal in 2023, the two-year process of removing four dams on the Klamath River has just begun, kicking off the largest dam removal and river restoration project yet in history. It's a massive feat. Big dam removals matter. So do smaller ones, like the eighty-one low-head dams removed from the Cleveland National Forest in Southern California. So do fictional dam removals. Recently, my six-year-old friend Aspen treated me to my first—and her umpteenth—viewing of *Frozen II*. Imagine my surprise when Princess Anna decides the only way to save nature and the community is to raze a dam. Dam removals, apparently even in popular culture, are no longer reserved for leftist "monkey wrenchers," as they were in 1975 when Edward Abbey published his titular novel about blowing up Glen Canyon Dam. They're now as common as an overlooked plot point in a Disney movie. Of course, that doesn't mean that dam removals are universally embraced. They're complicated—often technically and usually culturally. Sometimes it's for the simple reason that people inherently dislike change. But it can be deeply rooted in values and politics, too. I think that's part of what makes dam removal stories so interesting to me. Sometimes in the process of transforming a landscape, ideas and norms are reconfigured, too. Personally, I've gone from being fish agnostic to a true believer in these extraordinary animals.

These days we're still building dams, although less than before, which is a step in the right direction. But to undo centuries of environmental harm we'll need bigger leaps. I want to know how dam removals can help and how we can do more of them. How can they boost biodiversity, build climate resilience, and make communities safer? How can they help us soften the edges of political divides? I think there's a lot riding on it, especially for Atlantic salmon, Chinook, alewives, Pacific lamprey, American eels, James spinymussels, American dippers, eastern hellbenders, Southern Resident killer whales, and many more animals. And there's a lot riding on it for all of us living in a dramatically warming world.

My first stop is the ghost of Glines Canyon Dam. But I'll also visit other former dam sites, ones in the process of being deconstructed and others whose fates are still being decided. We'll get to see how a tiny dam removal changed a Virginia river and how the largest dam removal project is changing the world. A good dam removal story isn't about simply removing infrastructure, though; it's about what happens next.

CHAPTER 1

Rewilding the Elwha

"To love a place is not enough. We must find ways to heal it."

—Robin Wall Kimmerer, *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants*

It takes only a three-and-a-half-mile bike ride from the trailhead parking lot to reach the former site of Glines Canyon Dam. Along the way, I've fallen in love with my companion, the Elwha River. I steal glances as it skips between rollicking rapids and placid meanders; its shockingly turquoise waters make my stomach drop to my shoes. This is probably a one-sided affair. As I arrive at my destination, clouds loom ominously gray overhead, and wind howls down the canyon. It's not the warm welcome I'd hoped for. But no matter. The 210-foot-tall Glines Canyon Dam blocked the Elwha River's flow for nearly a century, along with its downstream counterpart, the Elwha Dam. Both have been gone for more than a decade. Standing at the site of the river's emancipation, I wonder how many times I've actually stood next to a river that runs entirely free from source to sea. The only number I can be sure of right now is *one*.

I set my bike against the railing of a concrete catwalk that used to be part of the dam's spillway, one of the few industrial remnants left behind. Globe-shaped streetlights line the walkway, which looks like a pier built out into a bay. When I reach the end, I find myself looking down a narrow, jagged canyon. The water riffles before me a blue-green and then plunges steeply into a well of churning whitewater below, near where the powerhouse would have sat, turbines spinning, buzzing with electricity. All of that's now gone, but the energy naturally moving through this canyon still hums.

I look upstream where the river channel winds through what used to be Lake Mills, the reservoir that pooled behind Glines Canyon Dam. The impoundment once stretched 3 miles and climbed high enough that the water lapped at the steep hillsides covered in hemlocks, cedars, and Douglas firs. Now with the lake drained, the river braids through the bottom of the valley, and there's a ribbon of recently planted alders and willows, a chaperone between the water and the evergreens. Farther upstream, somewhere far beyond my gaze in the snow-dusted mountains, their peaks obscured now by storm clouds, lies the Elwha's source: a perennial snow field in the Bailey range near Mt. Olympus. As the river rushes from the Olympic Mountains, it drains a 300-square-mile steep and forested watershed that has remained largely undeveloped, much of it now in Olympic National Park. The river runs north—tightening into canyons and stretching across floodplains—for 45 miles to the Strait of Juan de Fuca, which connects the Pacific Ocean to the Puget Sound. At the river's mouth a clear day will reveal the southern tip of Vancouver Island.

From my perch I can't see anything below the surface of the churning water, but I know there's a reclamation under way. When crews finished tearing down Glines Canyon Dam in 2014, one wily bull trout didn't even wait for the demolition to be completed before swimming past the barrier to upstream waters. Other fish soon followed. But that's nothing compared to what used to be here. Before dam construction the Elwha teemed with ten runs of anadromous fish—those that begin life in the river, migrate to the sea, and then return to the river to spawn. That included summer and winter steelhead (*Oncorhynchus mykiss*) and all five species of Pacific salmon: coho (*O. kisutch*), sockeye (*O. nerka*), pink (*O. gorbuscha*), chum (*O. keta*), and Chinook (*O. tshawytscha*). It's estimated that about 400,000 salmon and steelhead returned to the river each year to spawn,[1] including some monster 100-pound Chinook and runs of pink that exceeded 100,000. It was a highway for other migratory fish, too, such as Pacific lamprey (*Entosphenus tridentatus*), coastal cutthroat trout (*O. clarkii clarkia*), and bull trout (*Salvelinus confluentus*). Resident fish, such as rainbow trout (*O. mykiss*) and sculpin (*Cottus aleuticus* and *C. asper*), spent their whole lives flitting about the Elwha's waters and its tributaries. But with dam construction they hit a concrete wall just 5 miles from the ocean. With no way around the barriers, migratory fish suddenly found most of their historic habitat out of reach. And resident fish were limited to life above, between, or below the dams. Not surprisingly, populations of salmonids, which include salmon and trout, plummeted more than 90 percent from their historical numbers.[2] In the early 2000s, researchers were hard pressed to find the once-plentiful pink salmon at all some years, sockeye were virtually gone, and chum numbered fewer than 500 returning fish every other year. Fall-run chinook, coho, and steelhead spawned in low numbers, boosted only by state and tribal-run hatcheries built in the 1970s that kept the fish from oblivion.

Dam removal has given the river a new life. I close my eyes and try to imagine what it would have been like to stand there as the dam was breached. As exciting as I imagine that moment was—the concrete torn by an excavator sitting atop a barge, the first gush of water rushing over its jagged lip—I admit I'm more interested in what comes next. Not just the days or months that followed but the years. That's why I'm here nearly a decade after dam demolition has finished to listen to the howl of a free river and what it can teach us. I'm about to find out the first lesson: Reclamation is reconnection. Migratory fish reconnected to their historical waters for the first time in a century. Floodplains reconnected to the river. People reconnected to their culture. With that reconnection has come something astounding. And I get a glimpse of it the very next day.

A gray morning greets me as I greet a group of twentysomethings from the Washington Conservation Corps. They're huddled around a trailer bed loaded with tiny potted plants, like they're warming themselves around a fire. I wish. This February day on the Olympic Peninsula feels like the sun forgot to get up. The Corps members seem unaware and enthusiastically take directions from Allyce Miller, who shuttles about with a thick brown braid swaying across her back like a metronome keeping pace. They remove plants from their pots and place the seedlings gently into black plastic garbage bags. The only one I recognize is Western red cedar, with its feathery wisp of green. Miller, a project biologist and revegetation manager for the Lower Elwha Klallam Tribe, calls out the others: Pacific ninebark, elderberry, baldhip rose, oceanspray, strawberry. When the bags are full, they're strapped to metal frame backpacks and hoisted to the Corps members' shoulders. After everyone is loaded up, shovels in hand, they file out along a dirt and rock path.

I follow the line of yellow helmets and green waders as we traipse over cobbles and into the brush. At times it feels a bit like we're walking along a dry creek bed. Close. A little more than a decade ago this area we now walk sat under the waters of Lake Aldwell, the impoundment formed by the construction of the Elwha Dam, which was built in 1910 to power the growing seaside town of Port Angeles, Washington, and its mills. It was immediately a formidable foe for fish. As game warden James Pike wrote in 1911, "I have personally searched the Elwha River & Tributaries above the Dam, and have been unable to find a single Salmon. . . . I have visited the Dam several times lately . . . and there appear to be [t]housands of [s]almon at the foot of the Dam, where they are continually trying to get up the flume. I have watched them very close, and I am satisfied now that they cannot get above the Dam."[3] Fifteen years later construction began on Glines Canyon Dam, 8 miles upstream, on land that would soon become Olympic National Park. Neither dam contained fish passage, even though it was required by state law. It would be another century before a restorative hand could begin to undo the damage.

Corps members dig holes for their tiny charges, deposit the seedlings, and pat the earth gingerly around them. Their work is part of years of active, intensive, intentional restoration driven by the Lower Elwha Klallam Tribe and government agencies to restore the Elwha River and its ecosystem—a process propelled by the historic removal of the Elwha and Glines Canyon dams. After crews breached dams, the two reservoirs, totaling nearly 700 acres, converted to muddy moonscapes pocked with tree stumps that had been submerged for a century. It wasn't pretty. As the river worked to reestablish its course, a team from the National Park Service and the tribe immediately began a revegetation plan in the former reservoirs that had been outlined before dam removal. The effort itself broke new ground. Because the project was the largest of its kind at the time, there was no prior guide for how they should go about reseeding and planting or trying to ward off invasive species that rush into areas after a disturbance. The work began even before the dams came down, with the removal of noxious weeds in 2008 and the gathering of native seeds around the same time. After the dams were gone, they sowed 7,000 pounds of seeds to jumpstart grasses and flowering plants and keep invasives out. They also added more than 430,000 rooted plants from sixty native species.[4] Seeds buried in the sediment or carried by the wind also naturally regenerated. Logs were brought in to help provide shade and protect seedlings from the wind.

Walking through the former reservoir, I'm astounded by the fruits of their labor. A forest is under way. Tall and slim cottonwoods, willows, and alders abound, reaching some 20 and 30 feet high. I'm impressed with not just how fast the restoration seems to be progressing but the diversity. The mosaic of species looks beautiful, but the reasons for this kind of revegetation aren't just aesthetic. Plants help keep banks stable and prevent erosion. They provide browse for elk, seeds for birds, and shelter for mice. They can help filter the water, add nutrients to the river and the soil, and, when they get big enough, provide shade to lower water temperature. "I think of revegetation as the building block of everything else," Miller tells me. "Fish can't be there without riparian plants because the river would be too hot." And riparian plants grow stronger with the influx of nutrients from salmon. It's a nice win–win. She points to a dried brown husk in the dirt and tells me that this plant has been the champion of revegetation: riverbank lupine. It doesn't look like much of anything right now, but it can grow 3 feet tall and 3 feet wide. Around May it blooms a sea of bright, tall purple flowers that thrill pollinators. Seeded after the reservoir drawdowns, lupine proliferated. And it's been a boon for the restoration. It fixes soil with nitrogen, which is sorely needed, and dies every two years, providing more organic material.

The plants going into the ground on this day are filling in some gaps among areas where many shrubs and trees have already taken root. The active work of revegetation will probably continue for a few more years, if the funding stream doesn't run dry. Miller hopes to see more species diversity, including among conifers and hardwoods, and more pollinator plants. The effort is already a hearty affirmation that nature can rebound—if we let it. And, especially, if we help it. While the revegetation team works to transform a mud-slicked lake bed into a functional riparian forest, others are working to restore habitat for native fish and track returning bears, elk, beavers, and other animals.

But everything I see before me—and hear in the rushing river by our side—wouldn't have been possible at all if the tribe and its allies hadn't first fought an arduous battle for dam removal.

Eight and a half minutes, Vanessa Castle tells me. That's how much time Lower Elwha Klallam Tribe members were told they had to flee the valley should the Elwha Dam fail, a prospect not without precedent. A mere two years after construction began on the dam, a breach summoned a flood that sent downstream tribal members clamoring for safety and left fish breathless in trees. Despite the early failure, workers rebuilt the dam but not the tribe's trust. Castle, now in her thirties, works as a resource technician for the tribe—a job that includes planting seedlings, tracking cougars, and counting salmon. She grew up on the reservation, just a few miles downstream of the dam—and in the floodplain. She knew to be wary not just of a catastrophic rupture but of routine flooding that would inundate the valley for weeks when dam operators opened the floodgates to release excess water stored behind the dam. It wasn't the tribe's only problem with the infrastructure.

After construction of the dams, boosters hailed the hydroelectric power as a limitless engine to fuel growth in Port Angeles, where resource extraction—mostly trees—drove the economy. But by 1937, paper company Crown Zellerbach had acquired both dams and used the energy to power its pulp mill. Port Angeles found power via connection to the larger regional grid. The dams' economic contribution was questionable, but less in doubt were the ecological and cultural impacts of the dams. Both were built in the traditional homelands of the Lower Elwha Klallam Tribe, against their wishes. When Lake Aldwell filled, it drowned the tribe's creation site. One more cultural blow in a few centuries of battering.

In a familiar story across North America, the arrival of Spanish explorers and later other Europeans and Americans to the area brought diseases and utter devastation to the Indigenous population. Then the surviving Klallam Tribe members lost their traditional homelands in the 1855 Point No Point Treaty with Washington Territory governor Isaac Stevens. The Klallam people had been fishing the river's waters and relying on its bounty for millennia, and although they did retain a treaty right to fish the river, after dam construction little of the fishery remained for them to feed their families or make a living. The loss of fish was a loss of food, livelihood, and spirit.

The dams didn't just block the river's flow; they obstructed the natural movement of sediment and organic materials, which are critical components of river ecosystems. The sediment flux of a free-flowing river helps create sandbars, dunes, marshes, and islands. Taking away sediment transport also takes away a coastline's defenses. Without the resupply, beaches diminish, erosion increases, and coastal development becomes more vulnerable to storms and rising seas. For nearly a century the Elwha River dams banked massive amounts of sediment and nutrients that starved the lower portion of the river. The shoreline retreated hundreds of feet. With the loss of small sediment and woody debris, suitable spawning and rearing habitat for fish disappeared, the estuary shrank, and so too did diversity in the river and along its banks. That scarcity was passed down to the people who lived with the river. "It impacted all parts of our lives; we are salmon people," says Castle. "We relied on that for survival."

Tribal members weren't the only ones concerned about the dams. As early as the 1930s other local residents sounded the alarm about the ecological harm caused by the dams. Those calls went unheeded by those in power, on the Olympic Peninsula and across the West. Instead the concrete came pouring down, and up went some of the country's biggest dams: Hoover, Shasta, Bonneville, Grand Coulee, and Fort Peck. They turned desert lands into farm fields and powered growing cities. But the science was clear, even in the 1940s, that dams obstructed salmon migration upstream to spawning habitat, and the turbines threatened the downstream journey of smolts—young salmon—headed to the ocean. Research on the negative impacts to fish from dams grew in the 1950s and 1960s, even as dam building soldiered on.[5] Salmon—and all who depended on them—were to be sacrificed for growth.

But by the 1970s the Elwha River dams were due for a reckoning. Hydroelectric dams are given thirty- to fifty-year operating licenses by the Federal Energy Regulatory Commission (FERC). And Glines Canyon was up for relicensing in 1973. A few years earlier, Crown Zellerbach had applied for a license for the Elwha Dam, which predated federal licensing. The issue took on even more urgency when the Elwha Dam failed its safety inspection in 1978. Not surprisingly, the tribe wanted a say in the future of the dams—and more specifically, they wanted them gone. After FERC lumped the relicensing for the Elwha Dam and Glines Canyon together into one project, the Lower Elwha Klallam Tribe formally requested to intervene in the proceedings in January 1986 and were joined later that year by a coalition of environmental groups that included Seattle Audubon Society, Friends of the Earth, a local Sierra Club chapter, and Olympic Park Associates. Collectively they advocated for dam removal—a far-fetched notion at the time. But change was in the air. That same year, the newly passed Electric Consumers Protection Act stipulated that dam relicensing must also weigh environmental concerns. The ripple effect from that legislation would shake the energy world on both coasts.

Dam removal on the Elwha didn't yet have widespread public support, but the case had a lot of merit. One of the dams sat in a national park, and so did the majority of the watershed, which provided about as good a chance for fish recovery as could be found. The dams provided power for only a single mill—and not even all of it. And a recent court ruling upheld long-neglected tribal treaty rights that affirmed that Washington tribes, such as the Lower Elwha Klallam, were guaranteed a right to half of the catchable fish in the river, but their subsistence fishery had been obliterated by the dams.

More support would soon come. The tribe devoted water resource funds from the Bureau of Indian Affairs to initiate studies about the river's ecology and fisheries. Researchers found that dam removal not only was the best ecological option for restoring the river but also was more cost-effective than trying to find a way for fish to bypass 100- and 200-foot-tall dams. The tribe spent the next several years establishing common ground—and eventually a settlement agreement—with other parties, including the owner of the dams and mill, which had become the James River Corporation in the mid-1980s and then Daishowa America a few years later. By 1991, the companies, the National Park Service, the US Fish and Wildlife Service, the Bureau of Indian Affairs, and a slew of environmental groups all championed dam removal. But before FERC could reach a decision on the dams, Washington senator Brock Adams introduced legislation in Congress to enshrine the settlement agreement in law. Lower Elwha Klallam tribal elders traveled to Washington, DC, to give testimony in support. One of them was Castle's great-aunt, Beatrice "Bea" Charles, who was born just nine years after the Elwha Dam construction began. She told legislators,

> As the years went by, the fish depleted and it's to the point where it's nothing. Our creator gave us this fish to live on, and it was rich and an abundance of fish. It was given to us, and we cherished it and we respected it. We never got more than what we could use. . . . I feel again I would like to see the dam removed while I'm still alive. I may not see the abundance of fish come

> back in my lifetime, but I would like to see it come back for my grandchildren, my great-grandchildren and for the rest of my people, the following generations to come. It was a gift from our creator. It was our culture and our heritage.[6]

Congress passed the Elwha River Ecosystem and Fisheries Restoration Act, and President George H. W. Bush signed it into law on October 24, 1992. It funded efforts to restore the river and fish populations, but didn't require dam removal to do it. The suspense was short-lived, though. Two years later a report from the US Department of the Interior confirmed dam removal as the preferred option. FERC seconded the decision in 1995, although the agency's sign-off was no longer necessary. Despite overwhelming support from government agencies, after the law passed it would still take nearly twenty years of studies, planning, and political wrangling for demolition to begin. Part of that was political. Republican senator Slade Gorton, who sat on the Senate Appropriations Committee, held up the allocation of funds for years over fears that it could trigger more support for dam removals along the Snake River near his home district in eastern Washington.[7]

Part of the holdup was also social. The listing of the spotted owl as threatened under the Endangered Species Act in 1990 set off a culture war in the Pacific Northwest. Protections for the imperiled bird, which needs old-growth trees to survive, curtailed timber harvesting. In logging communities across the region, such as Port Angeles, it stoked anger at the federal government and resentment of environmentalists. Spotted owls didn't figure into the Elwha River restoration plan, but pitting the environment against the economy became a convenient narrative for those who opposed dam removal, even when the dam removal agreement assured that no mill jobs would be lost and restoration would be an economic boon. Also convenient was framing the debate about the dams as a matter of meddling "outsiders" versus locals, which wholly ignored the fact that the tribe supported dam removal and had been "local" for thousands of years.

Nevertheless, the dam removal effort inched forward, with only a small but vocal minority opposed. In 2000, the federal government purchased the dams, and the final environmental impact statement was released in 2005. With a price tag that climbed to $324 million, funding came mostly from the National Park Service budget and, in 2009, the American Recovery and Reinvestment Act. On September 17, 2011, 400 people gathered on the banks of the Elwha River to celebrate groundbreaking on the project. A series of scheduled blasts would come in the weeks, months, and years to follow.

The large accumulation of sediment—particularly behind Glines Canyon upstream—required a phased drawdown that took three years. When water could finally move freely downstream, so too could 20 million tons of silt, sand, and gravel—so much sediment that if it were piled onto a football field, it would reach nearly 2.5 miles high. Most of it made it all the way to the sea, buffering coastal habitat and beaches, and creating a 120-acre estuary at the river's mouth that welcomed Dungeness crab, sand lance, and forage fish. This newly liberated sediment, along with woody debris washed down from the forested hillsides, changed the shape and flow of the river itself. As the river eventually came into equilibrium with the sediment supply, it braided in sections, islands emerged, gravel bars grew, side channels formed, logs jammed, and pools filled.

If salmon could cheer, they would have.

With so much of the Elwha River watershed a rugged and roadless wilderness, the potential for restoration and the resurrection of its diminished migratory fish populations excited researchers and conservation enthusiasts. For years scientists from the tribe, state and federal agencies, and universities took stock of fish, invertebrates, water chemistry, sediment, and much more. They snorkeled, seined, and waded the waters. When the dams came down, the work began again. What has changed? Where? How? Much of it still continues.

As a resource technician for the tribe, Castle takes part in monitoring fish populations. "I tell people I literally live, eat, and breathe this river," she says. She grew up on the Elwha River, helping her mother, who worked as a commercial fisher. And now she swims beneath its surface, counting tiny smolts as they hurry to the ocean, adding to a tally of newfound hope. The Elwha today, she says, is a completely different river than when dammed. For starters, fish are on the move. In just two and a half years researchers found that eight runs of migratory fish species swam past the former Elwha Dam. Biologists doing snorkel surveys in the days after demolition at Glines Canyon spotted Chinook in the former reservoir—the first signs that intrepid swimmers had passed the second barrier. A rockslide obstructed the river from October 2014 until it was removed in September 2016. But by 2019, all but chum salmon had passed Glines Canyon. Since then traces of their DNA have been found in the water, but they've yet to be seen in the flesh.

Movement of fish is one metric to track the success of river restoration. Another is fish abundance. There's still a long way to go to recover robust and stable wild populations. And things are really just getting started, as Mike McHenry, fish habitat manager for the tribe, likes to remind people. For the first few years after dam removal, a lot of sediment was still moving downstream, and the river channel was busy resetting its course. It wasn't until 2018 or 2019 that things stabilized and recovery could begin in earnest, he says. Since then, there's been some reasons for optimism.

For Chinook, a hatchery-supported fish, abundance increased threefold from 2007 to 2019, although that's only in part because of dam removal, George Pess, a biologist at the National Oceanic and

Atmospheric Administration's Northwest Fisheries Science Center, tells me.[8] After dam removal a moratorium on fishing has helped boost numbers of Chinook, but they're still a long way from a healthy wild population. Coho, another hatchery-supported fish, have slowly begun to expand upstream of the dams and increase in numbers, especially in two of the Elwha's tributaries, where a portion of the population was moved to safely wait out dam removal. Returning pinks were estimated at around 2,000 in 2021 and climbed to 5,000 in 2023. They were historically the largest population in the river, and researchers believe there's hope their numbers can improve significantly. Chum salmon have also gotten above the first dam, but researchers don't have a good gauge on their numbers yet. Pacific lamprey jumped twelvefold. Bull trout numbers were up 241 percent. Winter steelhead climbed from a few hundred in 2013 to a few thousand by 2020.[9] Summer steelhead can claim the award for "most improved," having gone from undetected in surveys before dam removal to 341 five years after—and for a surprising reason. Rainbow trout and steelhead are the same species but have different life histories. Rainbow trout remain in rivers their entire lives, whereas steelhead are anadromous, venturing to the sea and back. But with the dams removed, scientists believe that resident rainbow trout now head downstream and out to the ocean, returning as steelhead. "When we do our population estimate for steelhead now, we have this whole other reawakening of a life history strategy that's contributing to the overall abundance," says Pess. A diverse life history gives fish more options. And more options give them a greater chance of resilience and success.

Rainbow trout aren't the only fish changing how they operate. Researchers have noticed that before dam removal, Chinook would start returning from the ocean around July, August, and September. But now they're being seen in the river as early as May. That simple shift in timing puts their return during higher flows, which may help them more easily pass tricky canyon sections farther upstream where too little water can turn steep rocky stretches into waterfalls too high to leap. And bull trout, once confined to the upper basin, can now outmigrate to the ocean and access a better stocked supermarket. "The marine environment has many more nutrients and things to eat than freshwater environments," says Pess. Bull trout are taking advantage—they've gotten bigger since dam removal.[10]

"It's exciting to see the upper watershed and all the tributaries being recolonized by these species," says Castle. "We're always told that the land and the water never forget. So it's nice to think that these fish knew they were supposed to go there, and they have returned."

There's one giant challenge to the recovery of migratory fish that managers of the Elwha have no control over: the ocean. While salmon fatten up in the marine environment for a few years, they risk landing in the gullet of a hungry whale or seal or being swept up in fishing nets in Alaska or Canada. Things are also heating up. Since the 1970s, the ocean has been absorbing more than 90 percent of the excess heat we've pumped into the atmosphere from burning greenhouse gases. That means more acidic waters, higher average global sea surface temperatures, and more frequent marine heat waves, none of it good news for salmon.

But when salmon do make it back to the river, the entire ecosystem benefits. The fish put on most of their weight while out in the ocean. In the process they acquire large amounts of marine-derived nitrogen, phosphorus, and carbon. When they return to the rivers to spawn and die, these nutrients become a part of the inland environment. It's like a shot of vitamins for food webs both in the river and on land. The bodies of salmon have been found to nourish 130 species of fish, birds, insects, and mammals. Studies have shown that they increase the abundance and diversity of birds, and they help enrich streamside vegetation so much that the changes in greenery are visible from space.[11]

Salmon also feed people. The fishing moratorium on the Elwha River enacted in 2011, when dam removal began, is still in place, but in October 2023 Lower Elwha Klallam tribal members participated in a small ceremonial and subsistence fishery for adult coho salmon, which allowed them to fish their ancestral river for the first time in more than a decade—and, for some youngsters, the first time in their lives. Castle was one of those casting a line when the fishery opened and joining the celebration with her community. "We always say that it feeds our spirit to eat salmon from our own natal stream," she says. "It was healing for a lot of people," including Castle. The first fish she shared with family. It fed her sister, her sister's husband, her sister's two kids, her son, her mom, and a camera crew that was filming the day. It was the first time her five-year-old had eaten salmon from the Elwha River, which he lives beside.

Eating the fish was an act of healing, but so was gathering together on the riverbank again. Decades ago, tribal members would spend weeks together at camp catching and cleaning salmon. The dams diminished salmon runs, and then dam removal initiated a much-needed moratorium. That's been good for fish but tough for tribal members who've lost connection to a place and to each other. When the fishery opened, Castle's entire family gathered by the river, cooked fish on a stick in the traditional way, and brought elders to join them. Where there had been disconnection there was reclamation. "It was amazing," she says. "I knew that it would instill those teachings that we've been missing."

Castle reminds me that despite all the encouraging signs of river restoration we see now, the process has also been painful. "It took a toll on our people to not be able to fish for twelve years," she says. "It took a toll on our mental health. Something that people didn't study is the effect that dams have on *people*. And the effect that restoration has on *people*."

A black bear rubbing his back on a tree. A snowshoe hare jumping through the air. Deer sparring. Close-ups of woodpeckers, great blue herons, and weasels. I listen to Kim Sager-Fradkin and Sara Cendejas-Zarelli rehash their favorite photos as we slip and slide in a fresh couple of inches of snow on steep hillsides surrounding the former Aldwell reservoir, not far from where I watched Washington Conservation Corps members plant seedlings the day before. Sager-Fradkin is the wildlife program manager for the Lower Elwha Klallam Tribe, and Cendejas-Zarelli is a wildlife biologist for the tribe.

They're checking a network of camera traps they've discreetly deployed across the basin and the upstream reservoir area to see which animals are visiting this new habitat since reservoir drawdown has turned water to land. It's a long list that includes the above-mentioned critters as well as bobcats, beavers, mustelids, snowshoe hares, Roosevelt elk, pumas, and Columbian black-tail deer. The favorite so far is a cougar catching a coho in December. It's peak river restoration goodness.

Twenty years earlier Sager-Fradkin did her graduate work trapping and radio-collaring bears in the Elwha watershed. Every fall the bears remained in the high country eating huckleberries and would come down to the river only in the spring. But now they're starting to see some fall bear activity on the cameras, and they even have footage of bears fishing on the former Mills reservoir. "They are coming for fish," she says excitedly. "It's going to take a while. But the bears will slowly start to figure it out."

Terrestrial wildlife reclaiming these once-submerged lands is made possible by the years of planting native species and pulling invasive ones. It was a job infinitely more difficult in the upstream reservoir—Lake Mills—where the largest amount of sediment had accumulated while the dams were in place. When the river came into Lake Mills and hit slow water, the heaviest bits of sand, gravel, and cobble fell out first. Over time that formed a wedge of sediment 80 feet thick and a half-mile long that required that the reservoir be drawn down in increments during dam removal. About 3 feet of water would be released each day until it dropped 15 feet, and then they'd hold for two weeks, and the river would erode more of the mass. The stepdown strategy worked well to get the sediment downstream and not overwhelm the system. But it left behind a legacy of terraces, 20 to 60 feet high in places, with coarse material on top of fine sediment. Not ideal. Fine soil below the bigger sediment is "upside down for planting," Joshua Chenoweth tells me. He directed the revegetation work for the National Park Service, and I call him when I return from my trip to the Elwha to understand better how they pulled off such a feat. Since so much of what they were doing was trial and error, he says, they planted lightly in the first couple of years with as many species as possible and then learned from the data and adjusted as they went. Adaptive management, as the experts call it. It should tell people not to fear post–dam removal landscapes, he says.

Of course, they're also still learning as they go, and the environment is still changing. Case in point: the conifers. As I walk in the former Aldwell reservoir, I'm so taken by how tall and dense the deciduous trees have grown already that I almost missed the squat conifers, barely the size of tabletop Christmas trees below them. Hemlocks, cedars, and grand firs are all shade tolerant and will grow in the shadow of the alders and cottonwoods for decades. In a century, they will have outlived their leafy neighbors and reclaimed their place along the banks of the Elwha in another succession of the forest.

But already the trees here provide for a litany of wildlife. Sager-Fradkin's research found fourteen species of mammals on the former reservoirs between the summer of 2021 and 2023, which included one sighting of a Pacific fisher, a cat-sized weasel recently reintroduced to the area.[12] Amphibians established themselves in the wetland areas, and diverse bird populations colonized the newly emerging vegetation and even helped it grow by spreading seeds. They found out that the logs that were placed to help shield seedlings from the wind also became perches for songbirds and refuges for mice and protected the plants from the grazing mouths of hungry ungulates.[13]

But that's not all. Her work before and after dam removal also includes studying American dippers (*Cinclus mexicanus*). Not long after she tells me about it, I hear one. While Cendejas-Zarelli repositions one of the cameras on a tree trunk, I wander toward the river's edge, following the trill. I scan the shoreline, which is where I'd expect to see a songbird that likes to get wet. Dippers swim, dive, and dunk in the water. And, as their name suggests, they also make a dipping—or squatting—motion, like a ballet dancer doing a plié. Dippers eat insects mostly, but they'll also consume salmon eggs and fry when they can. And it's this connection to salmon that made them the focus of a few studies by Sager-Fradkin and colleagues. Before the dams were removed, the researchers found that female dippers below the dams, which had access to salmon, had greater body mass, were more likely to attempt to have two broods in a season instead of just one, and produced larger female chicks than those upstream that didn't have salmon. Not only that, but the downstream dippers were more likely to remain in the same territory year-round, instead of migrating somewhere else, and they had higher rates of survival.[14] Dippers, it turns out, are one of the benefactors of the marine-derived nutrients that make salmon so bountiful.[15] And when salmon eggs are available, dippers, it seems, take full advantage. Just two years after dam removal the researchers found that the upstream dippers who had access to the fish again already had evidence of marine-derived nutrients in their bodies.

Sager-Fradkin isn't studying dippers now, but the work she started is being continued by Scott Walters, a PhD student at Western University in Ontario, Canada. His work uses a technique called compound specific isotope analysis to identify different kinds of fat in the plasma of the birds. That should be able to confirm that the marine-derived nutrients in the birds are in fact coming from salmon. And if the birds are choosing salmon from among all the choices they have, that indicates they have a high value. When I call him to find out more about his work, he tells me something that I've never considered with dam removal before: By blocking salmon we've interrupted something in the body of these birds at their most basic evolutionary level. We animals who have been long removed from the aquatic environment have evolved the ability to synthesize important fats from other ones because we can no longer count on marine fats, he explains. But animals such as dippers that evolved in constant contact with those marine fats don't have that ability. "So when you suddenly do a big change to the environment where these birds don't get salmon, even though evolutionarily they were expecting to, they might not have the chemical internal mechanisms to deal with that," he says. That could help explain why Sager-Fradkin and her colleagues found that dippers that had access to salmon were more successful than those that didn't.

This gets me thinking about what else we don't know. We've had centuries to learn the harms caused by dams but just decades to begin to understand the benefits of removing these river barriers. What I'm learning so far is how connected everything is. Of course we know that ecosystems are *systems*, but the concept feels abstract to me until I see it in the Elwha—what sediment means for salmon, what salmon means for birds, what birds mean for plants, what plants mean for elk, what elk mean for bears, and so on.

And I'm learning the value of floods with the help of Rebecca Brown, a researcher at Eastern Washington University. When I call to talk to her about her work, I mention my bike trip around that washed-out section of road on the way to Glines Canyon Dam. "The river has returned to what I assume was its former level of dynamics," she says of the overtopped banks and crumpled asphalt. It's a much better—and more river-centric—way of describing floodwater. A river doing what a river does. It should be celebrated. If you study riparian plants, as she does,

(continued...)

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