Dam Removals

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General and Reviews

Aspen Institute. 2002. Dam removal: a new option for a new century. Aspen Institute, Washington. https://calisphere.org/item/ark:/86086/n2k93745/

Offers recommendations and advice aimed at making it easier to integrate the consideration of dam removal into river management decisions, to evaluate it fairly and, if appropriate, to implement it effectively.

Bellmore, J. R., J. J. Duda, L. S. Craig, S. L. Greene, C. E. Torgersen, M. J. Collins, and K. Vittum. 2016. Status and trends of dam removal research in the United States. WIREs Water 4(2):e1164. https://doi.org/10.1002/wat2.1164

Examines the literature on dam removals, outlines the need for further case studies focused on biological and water quality impacts of dam removals rather than existing hydrologic and geomorphic responses.

DiFrancesco, K., and K. Woodruff, editors. 2007. Global perspectives on large dams: evaluating the state of large dam construction and decommissioning across the world. Yale Forestry & Environmental Studies Publications Series Report 13. https://elischolar.library.yale.edu/fes-pubs/33

Report of a conference covering subjects such as technical aspects of removal, ecological impacts, indigenous peoples’ rights, legal hurdles and opportunities, watershed and cross-boundary issues, and climate change.

Ding, L., L. Chen, C. Ding, and J. Tao. 2018. Global trends in dam removal and related research: a systematic review based on associated datasets and Bibliometric analysis. Chinese Geographical Science 29(1):1–12. https://doi.org/10.1007/s11769-018-1009-8

Quantitatively and qualitatively analyzed datasets of dam removal and publications of dam removal research published between 1953-2016. Most removals are of old, small dams in Europe and North America.

Duda, J. J., D. J. Wieferich, R. S. Bristol, J. R. Bellmore, V. B. Hutchison, K. M. Vittum, L. Craig, and J. A. Warrick. 2016. Dam Removal Information Portal (DRIP)—A map-based resource linking scientific studies and associated geospatial information about dam removals. U.S. Geological Survey Open-File Report 2016-1132. http://dx.doi.org/10.3133/ofr20161132

Describes the architecture and concepts of the DRIP visualization tool which contains information about completed dam removal projects and sources and details of associated of scientific studies.

Foley, M. M., F. J. Magilligan, C. E. Torgersen, J. J. Major, C. W. Anderson, P. J. Connolly, D. Wieferich, P. B. Shafroth, J. E. Evans, D. Infante, and L. S. Craig. 2017. Landscape context and the biophysical response of rivers to dam removal in the United States. PLoS ONE 12(7):e0180107 https://doi.org/10.1371/journal.pone.0180107

Meta-analysis to compare the landscape context of existing and removed dams and assess the biophysical responses to dam removal for 63 studies. Biophysical responses to dam removal varied by landscape cluster, indicating that landscape features are likely to affect biophysical responses to dam removal.

Friends of the Earth, American Rivers, and Trout Unlimited. 1999. Dam removal success stories: restoring rivers through selective removal of dams that don't make sense. https://calisphere.org/item/ark:/86086/n2dj5f82/

Describes potential ecological, safety, and economic benefits accompanying dam removals.

Grabowski, Z. J., H. Chang, and E. F. Granek. 2018. Fracturing dams, fractured data: empirical trends and characteristics of existing and removed dams in the United States. River Research and Applications 34(6):526–537. https://doi.org/10.1002/rra.3283

Analyzes the national data on dams from the National Inventory of Dams (NID), dam removals from American Rivers, the U.S. Geological Survey, and the National River Restoration Science Synthesis databases to compare trends and characteristics of removed versus existing dams in the United States.

Graf, W. L., editor. 2003. Dam removal research: status and prospects : proceedings of the Heinz Center's Dam Removal Research Workshop, October 23-24, 2002. H. John Heinz III Center for Science, Economics and the Environment, Washington. https://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/d6f5c7b2-578c-46f6-99bf-9c5cffdd0fc3

Summary of the papers and discussion at a workshop discussing science and the state of knowledge about dam removal available for decision makers.

Guetz, K., T. Joyal, B. Dickson, and D. Perry. 2021. Prioritizing dams for removal to advance restoration and conservation efforts in the Western United States. Restoration Ecology 30(5):e13583. https://doi.org/10.1111/rec.13583

Uses geospatial analysis and a multi-criteria decision framework to evaluate dams suitable for removal in the western United States in watersheds with existing conservation priorities, and to examine watershed dynamics in which they are situated.

H. John Heinz III Center for Science, Economics, and the Environment. 2002. Dam removal: science and decision making. H. John Heinz III Center for Science, Economics, and the Environment, Washington. https://semspub.epa.gov/work/01/273439.pdf

Examines the potential environmental, economic, and social science aspects of small dam removal to aid decision making processes.

Kibler, K. M., D. D. Tullos, and G. M. Kondolf. 2011. Learning from dam removal monitoring: challenges to selecting experimental design and establishing significance of outcomes. River Research and Applications 27(8):967-975. https://doi.org/10.1002/rra.1415

Discusses study design principles and analysis procedures that can be used to inform monitoring of dam removal projects, further analyzes the strengths and shortcomings of various forms of analysis and monitoring options available.

Pohl, M. M. 2002. Bringing down our dams: trends in American dam removal rationales. JAWRA Journal of the American Water Resources Association 38(6):1511–1519. https://doi.org/10.1111/j.1752-1688.2002.tb04361.x

Study constructed and analyzed a dataset of dam removals in the United States. Found two primary motivations for dam removals: economic/safety, and environmental concerns. Found an increase in dam removals over environmental concerns over time.

Tonitto, C., and S. J. Riha. 2016. Planning and implementing small dam removals: lessons learned from dam removals across the Eastern United States. Sustainable Water Resources Management 2(4):489–507. https://doi.org/10.1007/s40899-016-0062-7

Presents outcomes from well-documented small dam removals covering ecological, chemical, and physical change in rivers post-dam removal, including field observation and modeling methodologies.

U.S. Bureau of Reclamation. 2012 Detailed plan for dam removal - Klamath River dams : Klamath hydroelectric project, FERC license no. 2082, Oregon-California. U.S. Bureau of Reclamation Technical Service Center, Boulder, Colorado. https://digital.osl.state.or.us/islandora/object/osl:372209

Plan detailing physical methods of dam removal, sediment management, remediation and restoration, costs of removal, and third-party oversight of removal.

U.S. Department of the Interior, U.S. Department of Commerce, National Marine Fisheries Service. Klamath Dam removal overview report for the Secretary of the Interior : an assessment of science and technical information. https://www.fws.gov/sites/default/files/documents/Full%20SDOR%20accessible%20022216.pdf

Presents a synthesis of new peer-reviewed scientific studies conducted by a multi-agency Technical Management Team, as well as other relevant existing reports, to assist the Secretary of the Interior to make a determination on whether or not to remove the four Klamath River dams.

Winter, B. D. 1990. A brief review of dam removal efforts in Washington, Oregon, Idaho, and California. NOAA technical memorandum NMFS F/NWR-28. https://repository.library.noaa.gov/view/noaa/3132

Describes seven previous and current (as of 1990) dam removal efforts and one dam failure in Washington, Oregon, Idaho, and California.

Ecology

Abbott, K. M., P. A. Zaidel, A. H. Roy, K. M. Houle, and K. H. Nislow. 2022. Investigating impacts of small dams and dam removal on dissolved oxygen in streams. PLOS ONE 17(11):e0277647. https://doi.org/10.1371/journal.pone.0277647

Quantifies the effects of small dams and dam removal on dissolved oxygen in order to determine the dam, stream, and watershed characteristics driving inter-site variation in responses.

American Rivers. 2002. The ecology of dam removal: a summary of benefits and impacts. American Rivers, Washington. https://docs.cbfwl.org/StreamNet_References/MTsn87238.pdf

Examines potential ecological benefits and impacts from dam removal including flow, water quality and temperature, sediment release and transport, and connectivity.

Ba, M. M., J. Heyman, A. Rivière, M. O. Soulayrol, V. Stubbe, F. Meric, B. Kergosien, P. Rolland, C. Petton, N. Lavenant, J. J. Kermarrec, and A. Crave. 2023. A dataset on physico-chemical hyporheic variables in the Selune river: Towards understanding the impact of dam removal on riverbed clogging processes. Data in Brief 46:108837. https://doi.org/10.1016/j.dib.2022.108837

Presents field measurements that document the physical and chemical response of riverbeds to critical hydrological and sedimentary changes caused by the removal of dams on the Sélune River, France.

Bednarek, A. T. 2001. Undamming rivers: a review of the ecological impacts of dam removal. Environmental Management 27(6):803–814. https://doi.org/10.1007/s002670010189

Reviews potential ecological impacts of dam removal, highlights fish passage and the return of riverine conditions and sediment transportation.

Bellmore, J. R., G. R. Pess, J. J. Duda, J. E. O'Connor, A. E. East, M. M. Foley, A. C. Wilcox, J. J. Major, P. B. Shafroth, S. A. Morley, C. S. Magirl, C. W. Anderson, J. E. Evans, C. E. Torgersen, and L. S. Craig. 2019. Conceptualizing ecological responses to dam removal: If you remove it, what's to come? BioScience 69(1):26–39. https://doi.org/10.1093/biosci/biy152

Uses existing studies to develop conceptual models for ecological restoration post dam removal in three spatial locations: upstream of the former reservoir, within the reservoir, and downstream of the removed dam.

Bohrerova, Z., E. Park, K. Halloran, and J. Lee. 2016. Water quality changes shortly after low-head dam removal examined with cultural and microbial source tracking methods. River Research and Applications 33(1):113–122. https://doi.org/10.1002/rra.3069

Analyzes water samples for *Escherichia coli* concentrations, nitrates, phosphates, turbidity and human-specific marker and antibiotic resistance marker before and after dam removal during dry weather conditions.

Bushaw-Newton, K. L., D. D. Hart, J. E. Pizzuto, J. R. Thomson, J. Egan, J. T. Ashley, T. E. Johnson, R. J. Horwitz, M. Keeley, J. Lawrence, D. Charles, C. Gatenby, D. A. Kreeger, T. Nightengale, R. L. Thomas, and D. J. Velinsky. 2002. An integrative approach towards understanding ecological responses to dam removal: the Manatawny Creek study. JAWRA Journal of the American Water Resources Association 38(6):1581–1599. https://doi.org/10.1111/j.1752-1688.2002.tb04366.x

Interdisciplinary study to determine the physical, chemical, and biological responses to the removal of a 2-meter-high dam on lower Manatawny Creek in southeastern Pennsylvania.

Claeson, S. M., and B. Coffin. 2015. Physical and biological responses to an alternative removal strategy of a moderate-sized dam in Washington, USA. River Research and Applications 32(6):1143-1152. https://doi.org/10.1002/rra.2935

Examines the removal of Hemlock Dam in Washington, which sought to limit channel erosion and improve fish passage and habitat by excavating stored fine sediment and reconstructing a channel in the former reservoir.

Doyle, M. W., E. H. Stanley, C. H. Orr, A. R. Selle, S. A. Sethi, and J. M. Harbor. 2005. Stream ecosystem response to small dam removal: Lessons from the Heartland. Geomorphology 71(1–2):227–244. https://doi.org/10.1016/j.geomorph.2004.04.011

Synthesizes a number of small dam removal studies. Suggests that ecosystems may fully recover to pre-dam conditions, or that ecosystems may only partially recover to pre-dam conditions as the legacy of environmental damage of long-term dam presence may not be reversible or because other watershed changes inhibit full recovery.

Duda, J. J., M. M. Beirne, J. A. Warrick, and C. S. Magirl. 2018. Science partnership between U.S. Geological Survey and the Lower Elwha Klallam Tribe: understanding the Elwha River Dam removal project. U.S. Geological Survey Fact Sheet 2018-3025. https://doi.org/10.3133/fs20183025

Fact sheet briefly describing changes to the Elwha River post dam removal.

Foley, M. M., J. R. Bellmore, J. E. O'Connor, J. J. Duda, A. E. East, G. E. Grant, C. W. Anderson, J. A. Bountry, M. J. Collins, P. J. Connolly, L. S. Craig, J. E. Evans, S. L. Greene, F. J. Magilligan, C. S. Magirl, J. J. Major, G. R. Pess, T. J. Randle, P. B. Shafroth, C. E. Torgersen, D. Tullos, and A. C. Wilcox. 2017. Dam removal: Listening in. Water Resources Research 53(7):5229–5246. https://doi.org/10.1002/2017WR020457

Reviews previous studies on dam removal, finds that physical and ecological systems react quickly to dam removal, but the overall response trajectories depend on where the dam was removed and the overall watershed conditions.

Foley, M. M., J. J. Duda, M. M. Beirne, R. Paradis, A. Ritchie, and J. A. Warrick. 2015. Rapid water quality change in the Elwha River estuary complex during dam removal. Limnology and Oceanography 60(5):1719–1732. https://doi.org/10.1002/lno.10129

Examines the rapid and large-scale changes in estuary conditions which occurred during and after the removal of dams on the Elwha River.

Foley, M. M., J. A. Warrick, A. Ritchie, A. W. Stevens, P. B. Shafroth, J. J. Duda, M. M. Beirne, R. Paradis, G. Gelfenbaum, R. McCoy, and E. S. Cubley. 2017. Coastal habitat and biological community response to dam removal on the Elwha River. Ecological Monographs 87(4):552–577. https://doi.org/10.1002/ecm.1268

Examines how the physical changes to the Elwha River delta and estuary habitats during the dam removals were linked to responses in biological communities.

Gold, A. J., K. Addy, A. Morrison, and M. Simpson. 2016. Will dam removal increase nitrogen flux to estuaries? Water 8(11):522. https://doi.org/10.3390/w8110522

Examines 7550 dams in the New England region for possible tradeoffs associated with dam removal, with a focus on assessing potential nitrogen fluxes associated with removals.

Gregory, S., H. Li, and J. Li. 2002. The conceptual basis for ecological responses to dam removal: resource managers face enormous challenges in assessing the consequences of removing large dams from rivers and evaluating management options. BioScience 52(8): 713-723. https://doi.org/10.1641/0006-3568(2002)052[0713:TCBFER]2.0.CO;2

Reviews effects of dams and the responses to dam removal, to illustrate the challenges faced in the Pacific Northwestern United States.

Hart, D. D., T. E. Johnson, K. L. Bushaw-Newton, R. J. Horwitz, A. T. Bednarek, D. F. Charles, D. A. Kreeger, and D. J. Velinsky. 2002. Dam removal: challenges and opportunities for ecological research and river restoration. BioScience 52(8)669-682. https://doi.org/10.1641/0006-3568(2002)052[0669:DRCAOF]2.0.CO;2

Presents a framework for determining the magnitude, timing, and range of physical, chemical, and biological responses that can be expected following dam removal.

Kane, W., R. Brown, and J. Bastow. Monitoring the return of marine-derived nitrogen to riparian areas in response to dam removal on the Elwha River, Washington. Northwest Science 94(2)118-128. https://doi.org/10.3955/046.094.0203

Assesses the reintroduction of marine-derived nitrogen into the Elwha River, Washington, following dam removals. Was unable to identify marine-derived nitrogen at any sites, finds heightened nitrogen levels along the river but posits this may be due to anthropogenic activities.

Katopodis, C., and L. P. Aadland. 2006. Effective dam removal and river channel restoration approaches. International Journal of River Basin Management 4(3):153–168. https://doi.org/10.1080/15715124.2006.9635285

Compares two approaches to dam removal, removal with no channel restoration, and removal with channel restoration. Removal without channel restoration can lead to sedimentation of the downstream habitat, but the replication of natural river channel function poses some challenges.

Lei, Y., F. Dong, X. Liu, B. Ma, and W. Huang. 2023. Short-term variations and correlations in water quality after dam removal in the Chishui River Basin. Journal of Environmental Management 327:116917. https://doi.org/10.1016/j.jenvman.2022.116917

Investigates the immediate response of multi-element and multi-form water quality parameters after the removal of four dams along the Chishui River, China.

Lin, A.C., and H.J. Lin. 2023. Long-term response of trophic structure and function to dam removal in a subtropical mountain stream. Ecological Indicators 156. https://doi.org/10.1016/j.ecolind.2023.111136

Examines changes in trophic structure of a mountain creek in Taiwan for 8 years after dam removal, noted increasing vitality and diversity after dam removal both upstream and downstream from the dam location.

Magilligan, F. J., B. E. Graber, K. H. Nislow, J. W. Chipman, C. S. Sneddon, and C. A. Fox. 2016. River restoration by dam removal: enhancing connectivity at watershed scales. Elementa: Science of the Anthropocene 4:000108. https://doi.org/10.12952/journal.elementa.000108

Authors constructed a GIS database of all inventoried dams in New England, finding that the National Inventory of Dams significantly underestimates the actual number of dams in the region. Examines regional efforts at dam removal in New England.

Magilligan, F. J., K. H. Nislow, J. T. Dietrich, H. Doyle, and B. Kynard. 2021. Transient versus sustained biophysical responses to dam removal. Geomorphology 389:107836. https://doi.org/10.1016/j.geomorph.2021.107836

Charts the channel and species recovery after the removal of a dam in Massachusetts. Finds geomorphic adjustments have been generally sustained since removal, upstream establishment of resident fish species occurred in the first year.

Magilligan, F. J., K. H. Nislow, B. E. Kynard, and A. M. Hackman. 2016. Immediate changes in stream channel geomorphology, aquatic habitat, and fish assemblages following dam removal in a small upland catchment. Geomorphology 252:158–170. https://doi.org/10.1016/j.geomorph.2015.07.027

Examines geomorphic responses to dam removal and conducts an electrofishing survey above and below the former dam site to assess the richness and abundance of fish pre and post dam removal.

O'Meara, S., B. Cluer, B. P. Greimann, J. Godaire, and R. Synder. 2011. Reservoir area management plan for the Secretary's determination on Klamath River dam removal and basin restoration. U.S. Bureau of Reclamation Technical Report SRH-2011-19. https://calisphere.org/item/ark:/86086/n26d5spb/

Describes current and anticipated conditions in the reservoir areas after removal of J.C. Boyle, Copco No.1, Copco No. 2, and Iron Gate dams on the Klamath River and the management plan for the reservoir areas.

Perry, R. W., J. C. Risley, S. J. Brewer, E. C. Jones, and D. W. Rondorf. 2011. Simulating daily water temperatures of the Klamath River under dam removal and climate change scenarios. U.S. Geological Survey Open-File Report 2011-1243. https://pubs.usgs.gov/of/2011/1243/pdf/ofr20111243.pdf

Simulates Klamath River temperatures using a one-dimensional daily averaged water temperature model for two management alternatives under historical climate conditions and six future climate scenarios.

Poff, N. L., and D. D. Hart. 2002. How dams vary and why it matters for the emerging science of dam removal: an ecological classification of dams is needed to characterize how the tremendous variation in the size, operational mode, age, and number of dams in a river basin influences the potential for restoring regulated rivers via dam removal. BioScience 52(8):659-668. https://doi.org/10.1641/0006-3568(2002)052[0659:HDVAWI]2.0.CO;2

Builds a conceptual foundation for dam removals by reviewing how dams impair ecosystems, the criteria used to classify dams and the shortcomings of these criteria, quantifying patterns of variation withing these criteria, and suggesting a framework that can better classify the ecological impacts of dams.

Riggsbee, J. A., R. Wetzel, and M. W. Doyle. 2011. Physical and plant community controls on nitrogen and phosphorus leaching from impounded riverine wetlands following dam removal. River Research and Applications 28(9):1439–1450. https://doi.org/10.1002/rra.1536

Investigated leaching of interstitial nitrogen and phosphorous to the river channel after a low-head dam removal from the Little River, South Carolina. Suggests that plants can help control this in the long term, but that the initial release of sediment will release high amounts of phosphorous and nitrogen.

Schmitz, D., M. Blank, S. Ammondt, and D. T. Patten. 2009. Using historic aerial photography and paleohydrologic techniques to assess long-term ecological response to two Montana dam removals. Journal of Environmental Management 90(s3):S237-S248. https://doi.org/10.1016/j.jenvman.2008.07.028

Utilizes paleoflood hydrology, hydrologic modeling, and aerial photo interpretation to assess the long-term ecologic responses to dam failure and breach.

Stanley, E. H., and M. W. Doyle. 2003. Trading off: the ecological effects of dam removal. Frontiers in Ecology and the Environment 1(1):15-22. https://doi.org/10.1890/1540-9295(2003)001[0015:TOTEEO]2.0.CO;2

Posits that ecological consequences of dam removals are best understood by viewing the removal process as a disturbance. Urges consideration of negative impacts of the dam removals as well as positive prospects.

Stillwater Sciences. 2009. Dam removal and Klamath River water quality: a synthesis of the current conceptual understanding and an assessment of data gaps. Prepared for State Coastal Conservancy, Oakland, California. https://calisphere.org/item/ark:/86086/n237785h/

Describes current understanding of the potential water quality impacts of dam removal, presents an assessment of data gaps, and offers a set of conceptual study plans for addressing identified data gaps and improving our understanding of water quality in the Klamath River.

Sullivan, S. M., D. W. Manning, and R. P. Davis. 2018. Do the ecological impacts of dam removal extend across the aquatic–terrestrial boundary? Ecosphere 9(4):e02180. https://doi.org/10.1002/ecs2.2180

Examines density and trophic metrics of nearshore tetragnathid spiders, riparian swallows, and their aquatic insect prey in a riverine environment post dam removal.

Sheehan, T.F., M. P. Wynne, G. A. Clarke, S. Coghlan, M. Collins, A. Kelley, R. Kelshaw, D. Kusnierz, J. Royte, R. Saunders, C. Schmitt, K. Wilson, G. Zydlewski, and J. Zydlewski. Implementing a monitoring framework and data archive for dam removal : pre-project ecological monitoring of the lower Penobscot River, Maine USA. NOAA Technical Memorandum NMFS-NE-272. https://purl.fdlp.gov/GPO/gpo182625

Describes the development of a restoration monitoring program, the 9 priority studies that constitute the monitoring program, and the available pre-dam removal data.

Tullos, D. D., M. J. Collins, J. R. Bellmore, J. A. Bountry, P. J. Connolly, P. B. Shafroth, and A. C. Wilcox. 2016. Synthesis of common management concerns associated with dam removal. JAWRA Journal of the American Water Resources Association 52(5):1179–1206. https://doi.org/10.1111/1752-1688.12450

Examines concerns associated with dam removal: degree and rate of reservoir sediment erosion, excessive channel incision upstream of reservoirs, downstream sediment aggradation, elevated downstream turbidity, drawdown impacts on local water infrastructure, colonization of reservoir sediments by nonnative plants, and expansion of invasive fish.

U.S. Army Corps of Engineers. 2010. Lower Columbia River Power System adaptive management implementation plan, lower Snake River fish passage improvement study, dam breaching update: plan of study. U.S. Army Corps of Engineers, Walla Walla, Washington. https://docs.cbfwl.org/biblio43511.pdf

Defines how a Lower Snake River Fish Passage Improvement/Dam Breaching Feasibility Study will be managed and conducted, should such a study be initiated in accordance with provisions set forth in the Federal Columbia River Power System Biological Opinion Adaptive Management Implementation Plan.

Velinsky, D. J., K. L. Bushaw-Newton, D. A. Kreeger, and T. E. Johnson. 2006. Effects of small dam removal on stream chemistry in southeastern Pennsylvania. Journal of the North American Benthological Society 25(3): 569–582. https://doi.org/10.1899/0887-3593(2006)25[569:EOSDRO]2.0.CO;2

Examines changes in stream chemistry following the removal of a 2-m-high dam on Manatawny Creek in southeastern Pennsylvania.

Wagner, M. J., and P. A. Moore. 2024. Longitudinal study of stream ecology pre- and post- dam removal: physical, chemical, and biological changes to a northern Michigan stream. Science of The Total Environment 912:168848. https://doi.org/10.1016/j.scitotenv.2023.168848

Measures physical, chemical, and some biological aspects of the Maple River, Michigan, for 8 years prior to dam removal and two years after dam removal.

Wan, Y., D. Sun, and J. Labadie. 2014. Modelling evaluation of dam removal in the context of river ecosystem restoration. River Research and Applications 31(9):1119–1130. https://doi.org/10.1002/rra.2805

Models potential outcomes of dam removal on the Loxahatchee River, Florida. Finds that the removal of the dam would lead to an increase in river salinity during the dry season, potentially putting riverine vegetation at risk.

Warner, K., and L. Pejchar. 2001. A river might run through it again: criteria for consideration of dam removal and interim lessons from California. Environmental Management 28(5):561–575. https://doi.org/10.1007/s002670010244

Reviews the case of the Daguerre and Englebright Dams on the Yuba River and the Scott and Van Horne Dams on the South Eel River, California, and how the removal of these dams was impacted by ESA listings for anadromous fish as well as FEC hydropower benefit-costs analysis.

White, K. D., and J. N. Moore. 2002. Impacts of dam removal on riverine ice regime. Journal of Cold Regions Engineering 16(1). https://doi.org/10.1061/(ASCE)0887-381X(2002)16:1(2)

Provides an overview of the evolution of the typical ice regime, followed by a discussion of potential impacts resulting from dam removal and ways to mitigate issues with associated ice control measures.

Winter, B. D., and P. Crain. 2008. Making the case for ecosystem restoration by dam removal in the Elwha River, Washington. Northwest Science 82(sp1):13-28. https://doi.org/10.3955/0029-344X-82.S.I.13

Records pre-dam removal numbers for the Elwha River on water quality within the reservoirs and river, fish populations and habitat availability, fish passage mortality through the dams and reservoirs, effects of the hydro-power projects on wildlife habitat, and economics.

Zhang, Y., L. Zhang, and W. J. Mitsch. 2014. Predicting river aquatic productivity and dissolved oxygen before and after dam removal. Ecological Engineering 72:125–137. https://doi.org/10.1016/j.ecoleng.2014.04.026

Models potential changes to dissolved oxygen concentrations caused by combined sewer overflows in an urban river in Ohio post dam removal. Finds dissolved oxygen concentrations will continue to be significantly impacted by combined sewer overflow discharges even after dam removal.

Zheng, P. Q., B. F. Hobbs, and J. F. Koonce. 2009. Optimizing multiple dam removals under multiple objectives: Linking tributary habitat and the Lake Erie Ecosystem. Water Resources Research 45(12): W12417. https://doi.org/10.1029/2008WR007589

Proposes a model for optimizing the net benefits of removing multiple dams in U.S. watersheds of Lake Erie by quantifying impacts upon social, ecological, and economic objectives of importance to managers and stakeholders.

Economy

Anonymous. n.d. Revenue stream : an economic analysis of the costs and benefits of removing the four dams on the lower Snake River. https://www.wildsalmon.org/images/PDFs/revenuestream8.pdf

Examines potential economic benefits of removing the four lower Snake River dams.

Camp Dresser & McKee Inc. 2008. Evaluation and determination of potential liability associated with the decommissioning and removal of four hydroelectric dams on the Klamath River by any agent. Report to U.S. Department of the Interior through U.S. Bureau of Reclamation. https://docs.cbfwl.org/BureauReclamation/KlamathDamRemoval-2008.pdf

Identifies and attempts to quantify specific potential liabilities and the associated costs related to the decommissioning and removal of the four dams based upon the existing information developed to date.

Duda, J. J., S. Jumani, D. J. Wieferich, D. Tullos, S. K. McKay, T. J. Randle, A. Jansen, S. Bailey, B. L. Jensen, R. C. Johnson, E. Wagner, K. Richards, S. J. Wenger, E. J. Walther, and J. A. Bountry. 2023. Patterns, drivers, and a predictive model of dam removal cost in the United States. Frontiers in Ecology and Evolution 11:1215471. https://doi.org/10.3389/fevo.2023.1215471

Compiles reported costs from 455 unique sources for 668 dams removed in the United States from 1965 to 2020. The dam removals occurred within 571 unique projects involving 1–18 dams. Analyzes the costs of dam removals and assesses where and why some dam removals are more costly than others.

ECONorthwest. 2019. Lower Snake River dams : economic tradeoffs of removal. Prepared for Vulcan, Inc. https://static1.squarespace.com/static/597fb96acd39c34098e8d423/t/5d41bbf522405f0001c67068/1564589261882/LSRD_Economic_Tradeoffs_Report.pdf

Analyzes the economic trade-offs and implications of the dams' removal for regional stakeholders, policymakers, and other individuals who may be directly or indirectly impacted by the removal of the dams.

Energy & Environmental Economics, Inc. 2022. BPA lower Snake River dams power replacement study. https://purl.fdlp.gov/GPO/gpo184613

Investigates the value of the lower Snake River dams to the Northwest power system and models the replacement resources and cost impacts to replace the dams' power output.

Fowler, C. 2001. Applying the least-cost transportation model to estimate the effects of major transportation system changes: case study of dam breaching on the Snake River. Transportation Research Record 1763(1):65-72. https://doi.org/10.3141/1763-10

Estimates the effects on producers, agricultural production levels, transportation providers, highway and railroad infrastructure costs, and changes in fuel efficiency and emissions because of transportation mode shifts, based on a single least-cost transportation model that simulated the transportation patterns for wheat and barley in eastern Washington.

G&G Associates. 2003. Klamath River Dam removal investigation: J.C. Boyle Dam, Copco 1 Dam, Copco 2 Dam, Iron Gate Dam. G&G Associates, Seattle, Washington. https://klamathwaterquality.com/documents/Klamath%20dam%20deconstruction%20costs%20final.pdf

Study to determine the feasibility and cost of removing four dams on the Klamath River based on public information available to American Rivers and limited information available from PacifiCorp. Includes approaches to diversion of river flow away from demolition activities.

Guilfoos, T., and J. Walsh. 2023. A hedonic study of New England Dam removals. Ecological Economics 203:107624. https://doi.org/10.1016/j.ecolecon.2022.107624

Compiles data on 75 New England dam removals to assess changes in property prices on nearby properties.

HDR Engineering, Ogden Beeman and Associates, and TW Environmental. 2000. Breaching the lower Snake River dams : transportation impacts in Oregon. Summary report for Port of Portland, Oregon Department of Agriculture, Oregon Economic and Community Development Department, and Oregon Department of Transportation. https://digital.osl.state.or.us/islandora/object/osl:1541

Identifies and quantifies transportation impacts specific to Oregon that could occur if the four lower Snake River dams are removed.

Headwaters Economics. 2018. Dam removal: case studies on the fiscal, economic, social, and environmental benefits of dam removal. Headwaters Economics, Bozeman, Montana. https://headwaterseconomics.org/wp-content/uploads/Report-Dam-Removal-Case-Studies.pdf

Describes methods used to measure the benefits of dam removal when comparing costs to benefits, including five case studies and a summary of small dams.

Lewis, L. Y., C. Bohlen, and S. Wilson. 2008. Dams, dam removal, and river restoration: a hedonic property value analysis. Contemporary Economic Policy 26(2):175–186. https://doi.org/10.1111/j.1465-7287.2008.00100.x

Uses hedonic property value analysis to assess the impact of the removal of Edwards Dam in Augusta, Maine. Examines property values along the river near the site of the former dam and other hydroelectric dams.

Mojica, J., K. Cousins, and T. Briceno. 2016. National economic analysis of the four lower Snake River dams: a review of the 2002 lower Snake feasibility report/environmental impact statement economic appendix (I). Earth Economics, Tacoma, Washington. https://static1.squarespace.com/static/561dcdc6e4b039470e9afc00/t/5b7f1c4d0ebbe8d5b497b141/1535056979298/EarthEconomics_AnalysisoftheFourLowerSnakeRiverDams_Feb2016.pdf

Presents an analysis of the benefits and costs of the four Lower Snake River dams in both “keep dam” and “breach dam” scenarios presented in the 2002 Lower Snake River juvenile salmon migration feasibility report/environmental impact statement.

Perera, D., and T. North. 2021. The socio-economic impacts of aged-dam removal: a review. Journal of Geoscience and Environment Protection 09(10):62–78. https://doi.org/10.4236/gep.2021.910005

This paper summarizes dam removal impacts on the local economy and industry, culture, history and heritage, property value, recreation, aesthetics, and disaster avoidance, focuses on water storage dams as they reach the end of their lifespan.

Silva, C., and C. Erickson. 2023. The impact of dam removal on county level earnings. Journal of Environmental Planning and Management. https://doi.org/10.1080/09640568.2023.2268825

Examines the economic impact on the county level of dam removals using a difference-in-differences approach on the leisure and hospitality sector. Finds little effect on earnings at the county level and suggests this should not be considered when evaluating dam removals.

Smith, M. G. 2006. Dam removal: a taxonomy with implications for economic analysis. Journal of Contemporary Water Research & Education 134(1):34–38. https://doi.org/10.1111/j.1936-704X.2006.mp134001007.x

Seeks to classify types of dam removal based on the scale of the dam, the condition of the dam, associated economic benefits of removal, and the time-scale for any economic benefits to be seen, aims to create this classification to assist economic analysis of dam removal project.

Whitelaw, E., and E. Macmullan. 2002. A framework for estimating the costs and benefits of dam removal: sound cost–benefit analyses of removing dams account for subsidies and externalities, for both the short and long run, and place the estimated costs and benefits in the appropriate economic context BioScience 52(8):724-730. https://doi.org/10.1641/0006-3568(2002)052[0724:AFFETC]2.0.CO;2

Presents principles for assessing the economic consequences of environmental management decisions. Describes how those principles might be used for a cost–benefit analysis regarding dam removal using the dams on the lower Snake River as a case study.

Fish and Wildlife

Aadland, L. P. 2010. Reconnecting rivers : natural channel design in dam removals and fish passage. Minnesota Department of Natural Resources, Fergus Falls. https://www.dnr.state.mn.us/eco/streamhab/reconnecting_rivers.html

Provides an overview of technical and social issues relevant to dam removal and fish passage projects with case examples from Minnesota to illustrate problems that were encountered and how they were handled.

Allen, M. B., R. O. Engle, J. S. Zendt, F. C. Shrier, J. T. Wilson, and P. J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam–planning efforts and recolonization results. Fisheries 41(4):190-203. https://doi.org/doi/10.1080/03632415.2016.1150839

Describes the work of the White Salmon Working Group, which was formed to create plans for fish salvage in preparation for fish recolonization and to prescribe the actions necessary to restore anadromous salmonid populations in the White Salmon River after Condit Dam removal.

Bartholomew J. L, J. D. Alexander J. Alvarez, S. D. Atkinson, M. Belchik, S. J. Bjork, J. S. Foott, A. Gonyaw, M. E. Hereford, R. A. Holt, B. McCovey, N. A. Som, T. Soto, A. Voss, T. H. Williams, T. G. Wise, and S. L. Hallett. 2023. Deconstructing dams and disease: predictions for salmon disease risk following Klamath River dam removals. Frontiers in Ecology and Evolution 11:1245967. https://doi.org/10.3389/fevo.2023.1245967

Reviews the salmonid species in the Klamath River and provides an overview of their historical pathogen challenges and associated diseases and use this as a framework to predict the effects of dam removals on disease dynamics.

Battle, L., H.-Y. Chang, C.-S. Tzeng, and H.-J. Lin. 2016. The impact of dam removal and climate change on the abundance of the Formosan landlocked salmon. Ecological Modelling 339:23–32. https://doi.org/10.1016/j.ecolmodel.2016.08.005

Assesses threats to the Formosan salmon, finding that the removal of dams from 1999-2001 was able to help reverse population decline by creating more suitable habitat for fish, but climate change and increased typhoons continue to pose a threat to the population.

Brenkman, S. J., G. R. Pess, C. E. Torgersen, K. K. Kloehn, J. J. Duda, and S. C. Corbett. 2008. Predicting recolonization patterns and interactions between potamodromous and anadromous salmonids in response to dam removal in the Elwha River, Washington State, USA. Northwest Science 82(sp1):91-106. https://doi.org/10.3955/0029-344X-82.S.I.91

Summarizes the distribution and abundance of potamodromous salmonids, determined locations of spawning areas, and mapped natural barriers to fish migration at the watershed scale to predict impacts of the Elwha River dam removals.

Brenkman, S. J., R. J. Peters, R. A. Tabor, J. J. Geffre, and K. T. Sutton. 2019. Rapid recolonization and life history responses of bull trout following dam removal in Washington's Elwha River. North American Journal of Fisheries Management 39(3):560–573. https://doi.org/10.1002/nafm.10291

Discusses how bull Trout rapidly responded to barrier removal and were the first among the Pacific salmonids to move into the newly accessible headwaters of the Elwha River, Washington, following the dam removals.

Brewitt, P. K. 2016. Do the fish return? A qualitative assessment of anadromous pacific salmonids' upstream movement after dam removal. Northwest Science, 90(4):433-449. https://doi.org/10.3955/046.090.0405

Assesses the effectiveness of dam removal as a tool to restore anadromous Pacific salmonid habitats, compiles data from 40 dam removals where anadromous salmonid restoration was a goal in Oregon, California, and Washington.

Burdick, S. M., and J. E. Hightower. 2006. Distribution of spawning activity by anadromous fishes in an Atlantic slope drainage after removal of a low-head dam. Transactions of the American Fisheries Society 135(5):1290-1300. https://doi.org/doi/10.1577/T05-190.1

Examines the extent to which anadromous fishes utilized restored spawning habitat after the removal of Quaker Neck Dam.

Bureau of Reclamation. 2012. Final biological assessment and essential fish habitat determination on the proposed removal of four dams on the Klamath River. https://docs.cbfwl.org/BureauReclamation/Klamath_BA_Final_08-30-2012.pdf

Provides information on the potential effects of the proposed removal on listed species and critical habitat for use by the USFWS and NMFS in preparation of their Biological Opinion.

Burroughs, B. A., D. B. Hayes, K. D. Klomp, J. F. Hansen, and J. Mistak. 2010. The effects of the Stronach Dam removal on fish in the Pine River, Manistee County, Michigan. Transactions of the American Fisheries Society 139(5):1595–1613. https://doi.org/10.1577/T09-056.1

Evaluates fish populations during the removal of the Stronach Dam (1997–2003) and the four years after removal (2003-2007). Finds general increases in fish abundance in most species observed and larger geographical ranges for observed species.

Carlson, P. E., S. Donadi, and L. Sandin. 2018. Responses of macroinvertebrate communities to small dam removals: implications for bioassessment and restoration. Journal of Applied Ecology 55(4):1896–1907. https://doi.org/10.1111/1365-2664.13102

Analyzes macroinvertebrate data taken from 29 studies including 34 small dam removals, finds that immediately after dam removal macroinvertebrate populations decline, but often recover and exceed pre-removal numbers within 15-20 months.

Catalano, M. J., M. A. Bozek, and T. D. Pellett. 2007. Effects of dam removal on fish assemblage structure and spatial distributions in the Baraboo River, Wisconsin. North American Journal of Fisheries Management 27(2):519–530. https://doi.org/10.1577/M06-001.1

Evaluates the effects of dam removal on fish assemblage structure and spatial distributions after four low-head dam removals in the Baraboo River, Wisconsin. Study took place over 7 years and examined data from 35 collection sites.

Chang, H. Y., M.C. Chiu, Y. L. Chuang, C. S. Tzeng, M. H. Kuo, C. H. Yeh, H. W. Wang, S. H. Wu, W. H. Kuan, S. T. Tsai, K. T. Shao, and H. J. Lin. 2017. Community responses to dam removal in a subtropical mountainous stream. Aquatic Sciences 79(4):967–983. https://doi.org/10.1007/s00027-017-0545-0

Quantifies the environmental factors and major biotic communities of a Taiwanese stream after the removal of a 15-meter dam. Increases in fish abundance at the upstream sites after the dam removal suggests that the corridors created by the dam removal allowed access to more habitats for the fish.

Cheng, F., U. Zika, K. Banachowski, D. Gillenwater, and T. Granata. 2006. Modelling the effects of dam removal on migratory walleye (*Sander Vitreus*) early life-history stages. River Research and Applications 22(8):837–851. https://doi.org/10.1002/rra.939

Models the availability of spawning habitat for migratory walleye on the Sandusky River, Ohio, with and without the existing high-head dam. Finds that the removal of the dams would increase the availability of spawning habitats 10 times.

Coffin, Bengt. 2011. Hemlock Dam removal project. Final Report to Bonneville Power Administration, Project 2007-077-00, Portland, Oregon. https://www.cbfish.org/Document.mvc/Viewer/P122401

Documents some of the key steps in the process leading to removal of the dam and restoration of habitat in a stream reach that had been obstructed and inundated for over 100 years.

Cooper, J. E. 2023. Short-term effects on unionid mussel density and distribution before and after low-head dam removal in northern New York. River Research and Applications 39(9):1724–1735. https://doi.org/10.1002/rra.4179

Examined unionid mussel population response to dam removals on the Salmon River, New York. Did not find an increase in population, some areas decreased as substrate was covered with released sediment.

Davis, R. P., S. M. Sullivan, and K. C. Stefanik. 2017. Reductions in fish-community contamination following lowhead dam removal linked more to shifts in food-web structure than sediment pollution. Environmental Pollution 231:671–680. https://doi.org/10.1016/j.envpol.2017.07.096

Investigates changes in sediment concentrations and fish-community body burdens of mercury (Hg), selenium (Se), polychlorinated biphenyls (PCB), and chlorinated pesticides before and after two lowhead dam removals in the Scioto and Olentangy Rivers, Ohio.

Duda, J. J., M. S. Hoy, D. M. Chase, G. R. Pess, S. J. Brenkman, M. M. McHenry, and C. O. Ostberg. 2020. Environmental DNA is an effective tool to track recolonizing migratory fish following large-scale dam removal. Environmental DNA 3(1):121–141. https://doi.org/10.1002/edn3.134

Utilizes environmental DNA analysis to assess the effectiveness of dam removal to restore fish passage on the Elwha River in Washington State.

Duda, J. J., C. E. Torgersen, S. J. Brenkman, R. J. Peters, K. T. Sutton, H. A. Connor, P. Kennedy, S. C. Corbett, E. Z. Welty, A. Geffre, J. Geffre, P. Crain, D. Shreffler, J. R. McMillan, M. McHenry, and G. R. Pess. 2021. Reconnecting the Elwha river: spatial patterns of fish response to dam removal. Frontiers in Ecology and Evolution 9:765488. https://doi.org/10.3389/fevo.2021.765488

Compiles a timeline of migratory fish passage upstream of the two former dam sites on the Elwha River, Washington.

Fraik, A. K., J. R. McMillan, M. Liermann, T. Bennett, M. L. McHenry, G. J. McKinney, A. H. Wells, G. Winans, J. L. Kelley, G. R. Pess, and K. M. Nichols. 2021. The impacts of dam construction and removal on the genetics of recovering steelhead (*Oncorhynchus mykiss*) populations across the Elwha River watershed. Genes 12(1):89. https://doi.org/10.3390/genes12010089

Compares population genetic diversity and structure prior to and following dam removal on the Elwha River, Washington.

Gillenwater, D., T. Granata, and U. Zika. 2006. GIS-based modeling of spawning habitat suitability for walleye in the Sandusky River, Ohio, and implications for dam removal and river restoration. Ecological Engineering 28(3):311–323. https://doi.org/10.1016/j.ecoleng.2006.08.003

Uses a one-dimensional hydraulic model of the Sandusky River, Ohio, to predict changes to the river after a dam removal and the availability of suitable habitat for walleye.

Grote, A. B., M. M. Bailey, and J. D. Zydlewski. 2014. Movements and demography of spawning American Shad in the Penobscot River, Maine, prior to dam removal. Transactions of the American Fisheries Society 143(2):552–563. https://doi.org/10.1080/00028487.2013.864705

Seeks to understand the migratory movements and age and spawning histories of American Shad in the Penobscot River, Maine during and after dam removals.

Hansen, A. G., J. R. Gardner, D. A. Beauchamp, R. Paradis, and T. P. Quinn. 2016. Recovery of sockeye salmon in the Elwha River, Washington, after dam removal: dependence of smolt production on the resumption of anadromy by landlocked Kokanee. Transactions of the American Fisheries Society 145(6):1303–1317. https://doi.org/10.1080/00028487.2016.1223752

Evaluate the extent to which estimates of Sockeye Salmon smolt production and recovery are sensitive to the resumption of anadromy by kokanee after dam removal.

Hansen, H. H., K. H. Andersen, and E. Bergman. 2023. Projecting fish community responses to dam removal – data-limited modeling. Ecological Indicators 154:110805. https://doi.org/10.1016/j.ecolind.2023.110805

Presents a multi-species size spectrum model for a fish community in the Mörrum River in Sweden to predict possible outcomes from a dam removal in 2020. Results demonstrate that recovery from a dam removal scenario is not necessarily a benefit for all species.

Hansen, J. F., and D. B. Hayes. 2011. Long-term implications of dam removal for macroinvertebrate communities in Michigan and Wisconsin rivers, United States. River Research and Applications 28(9):1540–1550. https://doi.org/10.1002/rra.1540

Charts the recovery of macroinvertebrate populations by assessing 8 rivers in Wisconsin and Michigan in various time-periods after dam removal. Finds macroinvertebrate communities may recover within 3–7 years following removal both in terms of taxonomic similarity and richness, although densities could take decades to recover.

Hatten, J. R., T. R. Batt, J. J. Skalicky, R. Engle, G. J. Barton, R. L. Fosness, and J. Warren. 2015. Effects of dam removal on tule fall chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7):1481–1492. https://doi.org/10.1002/rra.2982

Investigated over a 3-year period (2010–2012) how dam breaching affected channel morphology, river hydraulics, sediment composition and tule fall Chinook salmon spawning habitat in the lower 1.7 km of the White Salmon River post dam removal.

Hess, J. E., R. L. Paradis, M. L. Moser, L. A. Weitkamp, T. A. Delomas, and S. R. Narum. 2021. Robust recolonization of Pacific lamprey following dam removals. Transactions of the American Fisheries Society 150(1):56-74. https://doi.org/10.1002/tafs.10273

Quantifies changes in Pacific lamprey populations and spawning following dam removals on the Elwha River using genetic stock identification, parentage assignment, and sibship assignment methods.

Hill, N. L., J. R. Trueman, A. D. Prévost, D. J. Fraser, W. R. Ardren, and J. W. A. Grant. 2019. Effect of dam removal on habitat use by spawning Atlantic Salmon. Journal of Great Lakes Research 45(2):394–399. https://doi.org/10.1016/j.jglr.2019.01.002

Surveys spawning grounds after the Willsboro Dam removal from the Boquet River, New York in 2014, 2016 and 2017. Finds that positive shifts in the quality of habitat used can occur rapidly following dam removal.

Hitt, N. P., S. Eyler, and J. E. Wofford. 2012. Dam removal increases American eel abundance in distant headwater streams. Transactions of the American Fisheries Society 141(5):1171–1179. https://doi.org/10.1080/00028487.2012.675918

Evaluates eel abundances in headwater streams of Shenandoah National Park, Virginia after the removal of downstream dams. Eel abundances in headwater streams increased significantly.

Hogg, R., S. M. Coghlan, and J. Zydlewski. 2013. Anadromous sea lampreys recolonize a Maine coastal river tributary after dam removal. Transactions of the American Fisheries Society 142(5):1381–1394. https://doi.org/10.1080/00028487.2013.811103

Examines sea lamprey recolonization of a tributary to the Penobscot River, Maine, after two small dam removals which had previously prevented any spawning runs. Results indicated a fourfold increase in the annual abundance of spawning-phase sea lampreys.

Hogg, R. S., S. M. Coghlan, J. Zydlewski, and C. Gardner. 2015. Fish community response to a small-stream dam removal in a Maine coastal river tributary. Transactions of the American Fisheries Society 144(3):467–479. https://doi.org/10.1080/00028487.2015.1007164

Surveys fish community response of a tributary to the Penobscot River, Maine, after two small dam removals. Finds that overall, the density, biomass, and diversity upstream from the former dams increased post-removal.

Hurst, C. N., R. A. Holt, and J. L. Bartholomew. 2012. Dam removal and implications for fish health: *Ceratomyxa shasta* in the Williamson River, Oregon, USA. North American Journal of Fisheries Management 32(1):14-23. https://doi.org/10.1080/02755947.2012.655843

Evaluates the risk of disease resulting from infection with C. shasta in the Williamson River and the potential for returning adult salmon to transport parasite genotypes after dam removal.

Izzo, L. K., G. A. Maynard, and J. Zydlewski. 2016. Upstream movements of Atlantic salmon in the lower Penobscot River, Maine following two dam removals and fish passage modifications. Marine and Coastal Fisheries 8(1):448–461. https://doi.org/10.1080/19425120.2016.1185063

Examines the response of Atlantic salmon to dam removals and fishway alterations along the Penobscot River, Main. Finds that dam removals made transit time comparable to open river reaches, but that the fishway at Milford Dam continued to cause long delays.

Jezorek, I. G., and J. M. Hardiman. 2017. Juvenile salmonid monitoring in the White Salmon River, Washington, post-Condit Dam removal, 2016. U.S. Geological Survey Open-File Report 2017-1070. https://doi.org/10.3133/ofr20171070

Results of a study on juvenile salmonid distribution, abundance, species diversity, and production of smolt and other migrant life stages in the White Salmon River and tributaries.

Jezorek, I. G., and J. M. Hardiman. 2018. Juvenile salmonid monitoring following removal of Condit Dam in the White Salmon River watershed, Washington, 2017. U.S. Geological Survey Open-File Report 2018-1106. https://doi.org/10.3133/ofr20181106

Results of a study on juvenile salmonid distribution, abundance, species diversity, and production of smolt and other migrant life stages in the White Salmon River and tributaries.

Jezorek, I. G., and J. M. Hardiman. 2023. Juvenile salmonid monitoring to assess natural recolonization following removal of Condit Dam on the White Salmon River, Washington, 2016–21. U.S. Geological Survey Open-File Report 2022-1117. https://doi.org/10.3133/ofr20221117

Assesses juvenile anadromous salmonid abundance and distribution in the subbasin from 2016 through 2021 to evaluate the efficacy of natural recolonization.

Jolley, J. C., G. S. Silver, J. E. Harris, and T. A. Whitesel. 2017. Pacific lamprey recolonization of a Pacific Northwest River following dam removal. River Research and Applications 34(1):44–51. https://doi.org/10.1002/rra.3221

Surveys Pacific lamprey over the course of the Condit Dam removal on the White Salmon River, Washington, found that Pacific lamprey were present in areas they were not before the removal, including upstream from the dam and the river mouth area.

Johnston, C., G. B. Zydlewski, S. Smith, J. Zydlewski, and M. T. Kinnison. 2018. River reach restored by dam removal offers suitable spawning habitat for endangered shortnose sturgeon. Transactions of the American Fisheries Society 148(1):163-175. https://doi.org/10.1002/tafs.10126

Surveys newly available spawning habitat on the Penobscot River, Maine, after dam removals. Describes the distribution and amount of suitable spawning habitat for shortnose sturgeon in the first 5-km reach upstream of the removed dam.

Jones, A. C., S. J. Meiners, E. Effert-Fanta, T. Thomas, S. C. F. Smith, and R. E. Colombo. 2022. Low-head dam removal increases functional diversity of stream fish assemblages. River Research and Applications 39(1):3-20. https://doi.org/10.1002/rra.4063

Studies fish responses to dam removals in two Illinois rivers. Finds that after river there was an overall increase in habitat suitability and stream quality, coinciding with a more robust fish population.

Kornis, M. S., B. C. Weidel, S. M. Powers, M. W. Diebel, T. J. Cline, J. M. Fox, and J. F. Kitchell. 2014. Fish Community Dynamics following dam removal in a fragmented agricultural stream. Aquatic Sciences 77(3):465-480. https://doi.org/10.1007/s00027-014-0391-2

Examines post-removal responses in two distinct fish communities formerly separated by a small aging mill dam. Emphasizes that barrier removal in highly fragmented stream networks can facilitate the unintended and possibly undesirable spread of species into headwater streams.

Lasne, E., M. R. Sabatié, N. Jeannot, and J. Cucherousset. 2014. The effects of dam removal on river colonization by sea lamprey Petromyzon marinus. River Research and Applications 31(7):904-911. https://doi.org/10.1002/rra.2789

Surveys sea lamprey community response to the removal of a small dam in France from 1994-2011, tracking the upstream distribution of nests and changes in the spatial patterns of habitat colonization.

Lincoln, A. E., J. A. Shaffer, and T. P. Quinn. 2018. Opportunistic use of estuarine habitat by juvenile bull trout, *Salvelinus confluentus*, from the Elwha River before, during, and after dam removal. Environmental Biology of Fishes 101:1559-1569. https://doi.org/10.1007/s10641-018-0800-9

Surveys bull trout use of newly available estuarine habitat evaluates how dam removal on the Elwha River influenced bull trout estuarine occupancy by sampling before, during, and after dam removal.

Mahan, D. C., J. T. Betts, E. Nord, F. Van Dyke, and J. M. Outcalt. 2021. Response of benthic macroinvertebrates to dam removal in the restoration of the Boardman River, Michigan, USA. PLoS ONE 16(5):e0245030. https://doi.org/10.1371/journal.pone.0245030

Examines changes in stream macroinvertebrate communities from 2011–2016 after dam removal on the Boardman River, Michigan. Finds that invertebrate populations quickly increased after an initial drop immediately after the removal. Also notes larger populations of invasive New Zealand mud snails, cautions managers to be aware of risk of introducing invasive species around previous barriers.

Maloney, K. O., H. R. Dodd, S. E. Butler, and D. H. Wahl. 2008. Changes in macroinvertebrate and fish assemblages in a medium-sized river following a breach of a low-head dam. Freshwater Biology 53(5):1055–1068. https://doi.org/10.1111/j.1365-2427.2008.01956.x

Analyzes the effects of a dam breach on benthic macroinvertebrate and fish assemblages in the Fox River, Illinois, also examined the effects of the breach on associated habitat by measuring average width, depth, flow rate and bed particle size at each site.

McCaffery, R., K. J. Jenkins, S. Cendejas-Zarelli, P. J. Happe, and K. A. Sager-Fradkin. 2020. Small mammals and ungulates respond to and interact with revegetation processes following dam removal. Food Webs 25:e00159. https://doi.org/10.1016/j.fooweb.2020.e00159

Examines the responses of small mammals and ungulates to the dam removal and subsequent revegetation efforts after the removal of dams on the Elwha River, Washington.

McMillan, J. R., G. R. Pess, M. Liermann, S. A. Morley, M. L. McHenry, L. A. Campbell, and T. P. Quinn. 2015. Using redd attributes, fry density, and otolith microchemistry to distinguish the presence of steelhead and rainbow trout in the Elwha River Dam Removal Project. North American Journal of Fisheries Management 35(5):1019–1033. https://doi.org/10.1080/02755947.2015.1074965

Evaluates the utility of using redd attributes, fry (age-0) size, and fry density to distinguish the presence of steelhead and Rainbow Trout in the Elwha River, Washington after dam removals. Otolith microchemical analyses were also conducted.

Morley, S. A., J. J. Duda, H. J. Coe, K. K. Kloehn, and M. L. McHenry. 2008. Benthic invertebrates and periphyton in the Elwha River basin: current conditions and predicted response to dam removal. Northwest Science 82(sp1):179-196. https://doi.org/10.3955/0029-344X-82.S.I.179

Assesses periphyton and benthic invertebrate assemblages vary across regulated and unregulated sections of the Elwha River and across different habitat types and establishes baseline data for tracking future changes following dam removal.

Morley S. A., M. M. Foley, J. J. Duda, M. M. Beirne, R. L. Paradis, R. C. Johnson, M. L. McHenry, M. Elofson, E. M. Sampson, R. E. McCoy, J. Stapleton, and G. R. Pess. 2020. Shifting food web structure during dam removal - disturbance and recovery during a major restoration action. PLoS ONE 15(9): e0239198. https://doi.org/10.1371/journal.pone.0239198

Describes and analyzes food availability and diet composition of juvenile salmonids both before and during the removal of dams along the Elwha River.

Orr, C. H., S. J. Kroiss, K. L. Rogers, and E. H. Stanley. 2008. Downstream benthic responses to small dam removal in a Coldwater Stream. River Research and Applications 24(6):804–822. https://doi.org/10.1002/rra.1084

Surveys the response of algae and macroinvertebrates following the removal of two small dams from Boulder Creek, Wisconsin. Finds immediate decreases in both populations which recovered partially over the following year.

Pess, G. R., M. L. McHenry, T. J. Beechie, and J. Davies. 2008. Biological impacts of the Elwha River dams and potential salmonid responses to dam removal. Northwest Science 82(sp1):72-90. https://doi.org/10.3955/0029-344X-82.S.I.72

Collects data on the impacts of the Elwha River dams on salmonid populations and developed predictions of species-specific responses (coho salmon, Chinook salmon and steelhead) dam removal.

Peters, R. J. J. J. Duda, G. R. Pess, M. Zimmerman, P. Crain, Z. Hughes, A. Wilson, M.C. Liermann, S.A. Morley, J.R. McMillan, K. Denton, D. Morrill, and K. Warheit. Guidelines for monitoring and adaptively managing restoration of Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) on the Elwha River. U.S. Fish and Wildlife Service. https://purl.fdlp.gov/GPO/gpo172672

Provides a framework for developing goals that define project success and for monitoring project implementation and responses. Also serves as a guide to help managers adaptively manage fish restoration actions during and following dam removal.

Peters, R. J., M. Liermann, M. L. McHenry, P. Bakke, and G. R. Pess. 2017. Changes in streambed composition in salmonid spawning habitat of the Elwha River during dam removal. JAWRA Journal of the American Water Resources Association 53(4):871-885. https://doi.org/10.1111/1752-1688.12536

Examines the effects of sediment release in the years following the Elwha River dam removals. Finds that changes in substrate composition during dam removal varied by year and channel type.

Peters, R. J., G. R. Pess, M. L. McHenry, P. Bakke, M. Elofson, and E. Sampson. 2015. Quantifying changes in streambed composition following the removal of the Elwha and Glines Canyon dam on the Elwha River. Prepared for Olympic National Park, Port Angeles, Washington. https://purl.fdlp.gov/GPO/gpo172350

Examines if fine sediment intrusion in spawning habitats of the mainstem and floodplain channels reaches levels likely to impact incubation survival and if the proportion of the substrate that is appropriate size for spawning increases following dam removal.

Perry, R. W., J. M. Plumb, M. J. Dodrill, N. A. Som, H. E. Robinson, and N. J. Hetrick. 2023. Simulating post-dam removal effects of hatchery operations and disease on juvenile Chinook salmon (*Oncorhynchus tshawytscha*) production in the Lower Klamath River, California. U.S. Geological Survey Open-File Report 2022–1106. https://doi.org/10.3133/ofr20221106

Uses the Stream Salmonid Simulator (S3) model to assess how changes in hatchery management and disease-caused mortality by the parasite *Ceratonova shasta* after dam removal will influence abundance of salmon populations entering the ocean.

Poulos, H. M., and B. Chernoff. 2016. Effects of dam removal on fish community interactions and stability in the Eightmile River system, Connecticut, USA. Environmental Management 59(2):249–263. https://doi.org/10.1007/s00267-016-0794-z

Evaluates fish populations 1 year prior to, 2 years during, and for 3 years after a small dam removal event. Finds that even after 3 years the populations of the dam removal river do not compare with reference sites on non-dammed rivers.

Poulos, H. M., K. E. Miller, R. Heinemann, M. L. Kraczkowski, A. W. Whelchel, and B. Chernoff. 2019. Dam removal effects on benthic macroinvertebrate dynamics: a New England stream case study (Connecticut, USA). Sustainability 11(10):2875. https://doi.org/10.3390/su11102875

Examines the effects of dam removal on the structure, function, and composition of benthic macroinvertebrate communities after a small dam removal on a temperate Connecticut stream. Finds the removal resulted in a large shift in upstream benthic macroinvertebrate communities.

Quinn, T. P., M. H. Bond, S. J. Brenkman, R. Paradis, and R. J. Peters. 2017. Re-awakening dormant life history variation: stable isotopes indicate anadromy in bull trout following dam removal on the

Elwha River, Washington. Environmental Biology of Fishes 100:1659-1671. https://doi.org/10.1007/s10641-017-0676-0

Utilizes stable isotopes of carbon and nitrogen to investigate the possible use of marine habitats for foraging by bull trout, in years immediately after removal of impassable hydroelectric dams on the Elwha River.

Quinn, T. P., G. R. Pess, B. J. G. Sutherland, S. J. Brenkman, R. E. Withler, K. Flynn, and T. D. Beacham. 2021. Resumption of anadromy or straying? Origins of sockeye salmon in the Elwha River. Transactions of the American Fisheries Society 150(4):452-464. https://doi.org/doi/10.1002/tafs.10294

Investigates whether adult sockeye salmon in the Elwha River post dam removal were strays or indicate a resumption of anadromy.

Quiñones, R. M., T. E. Grantham, B. N. Harvey, J. D. Kiernan, M. Klasson, A. P. Wintzer, and P. B. Moyle. 2014. Dam removal and anadromous salmonid (Oncorhynchus spp.) conservation in California. Reviews in Fish Biology and Fisheries 25(1):195–215. https://doi.org/10.1007/s11160-014-9359-5

Describe factors specific to dam removal in California, proposes a method to evaluate dam removal effects on salmonids, applies this method to evaluate 24 dams, and discusses effects of removing four dams on the Klamath River.

Raabe, J. K. and J. E. Hightower. 2014. Assessing distribution of migratory fishes and connectivity following complete and partial dam removals in a North Carolina river. North American Journal of Fisheries Management 34(5):955-969. https://doi.org/doi/10.1080/02755947.2014.938140

Evaluates distribution and connectivity in recently accessible habitat following multiple small dam removals and assesses upstream fish passage efficiency and potential delays at a partially removed (“notched”) dam.

Ramos, M. M., and D. M. Ward. 2022. Modelling the reestablishment of coho salmon (Oncorhynchus kisutch) in Klamath River tributaries after dam removal. Ecology of Freshwater Fish 32(1):133–146. https://doi.org/10.1111/eff.12679

Models six upstream tributaries of the Klamath River to assess where could serve as potential spawning ground for coho salmon after the proposed dam removals.

Renöfält, B. M., A. G. Lejon, M. Jonsson, and C. Nilsson. 2012. Long-term taxon-specific responses of macroinvertebrates to dam removal in a mid-sized Swedish stream. River Research and Applications 29(9):1082–1089. https://doi.org/10.1002/rra.2592

Examines the effects of dam removals on downstream macroinvertebrate communities, tests 6 months before removal, 6 months after, and 3.5 years after the removal. Found that dam removal reduced some macroinvertebrate taxa at the downstream site, but we found no effect on community composition.

Rubin, S. P., I. M. Miller, M. M. Foley, H. D. Berry, J. J. Duda, B. Hudson, N. E. Elder, M. M. Beirne, J. A. Warrick, M. L. McHenry, A. W. Stevens, E. F. Eidam, A. S. Ogston, G. Gelfenbaum, and R. Pedersen. 2017. Increased sediment load during a large-scale dam removal changes nearshore subtidal communities. PLoS ONE 12(12):e0187742. https://doi.org/10.1371/journal.pone.0187742

Examines how the coastal marine ecosystem and nearshore communities near the Elwha River, Washington were altered by the sediment influx associated with the removal of two dams.

Scherelis C., G. B. Zydlewski, and D. C. Brady. 2020. Using hydroacoustics to relate fluctuations in fish abundance to river restoration efforts and environmental conditions in the Penobscot River, Maine. River Research and Applications 36(2):234-246. https://doi.org/10.1002/rra.3560

Utilizes hydroacoustic measurements to detect fish and quantify their abundance after dam removals on the Penobscot River, Maine. Reports that a threefold increase in mean fish abundance was recorded after dam removal.

Sethi, S. A., A. R. Selle, M. W. Doyle, E. H. Stanley, and H. E. Kitchel. 2004. Response of unionid mussels to dam removal in Koshkonong Creek, Wisconsin (USA). Hydrobiologia 525(1-3):157–165. https://doi.org/10.1023/B:HYDR.0000038862.63229.56

Investigates the effects of a small dam removal on unionid mussels in Koshkonong Creek, Wisconsin. Finds high immediate mortality rates for mussels and an overall decline in mussel populations associated with the increase in sedimentation along the creek.

Shaffer, J. A., F. Juanes, T. P. Quinn, D. Parks, T. McBride, J. Michel, C. Naumann, M. Hocking, and C. Byrnes. 2017. Nearshore fish community responses to large scale dam removal : implications for watershed restoration and fish management. Aquatic Sciences 79:643-660. https://doi.org/10.1007/s00027-017-0526-3

Examines fish communities responses to the removal of the dams on the Elwha River, finds that the increase in sedimentation led to increased area of the Elwha River Delta, that this was quickly colonized by fish, but that overall richness and diversity remained similar to pre-removal and control numbers.

Shaffer, J. A., S. Munsch, and F. Juanes. 2018. Functional diversity responses of a nearshore fish community to restoration driven by large-scale dam removal. Estuarine, Coastal and Shelf Science 213:245-252. https://doi.org/10.1016/j.ecss.2018.08.030

Reviews the responses of nearshore fish to assess the functional ecology of fish to the removal of the Elwha River dams.

Shaffer, J. A., D. Parks, K. Campbell, A. Moragne, B. Hueske, P. Adams, J. M. Bauman. 2023. Coastal beaver, Chinook, coho, chum salmon and trout response to nearshore changes resulting from diking and large-scale dam removals : synergistic ecosystem engineering and restoration in the coastal zone. Nature Conservation 53:61-83. https://doi.org/10.3897/natureconservation.53.85421

Assesses long-term trends and habitat changes to understand the relationships between coastal beaver, salmon, shoreline alterations, large-scale dam removals and nearshore ecological restoration related to dam removals on the Elwha River.

Stanley, E. H., M. J. Catalano, N. Mercado-Silva, and C. H. Orr. 2007. Effects of dam removal on brook trout in a Wisconsin Stream. River Research and Applications 23(7):792-798. https://doi.org/10.1002/rra.1021

Examines fish community composition two years prior to and two years after the removal of a pair of low-head dams from Boulder Creek, Wisconsin.

Storch, A. J., H. A. Schaller, C. E. Petrosky, R. L. Vadas, B. J. Clemens, G. Sprague, N. Mercado-Silva, B. Roper, M. J. Parsley, E. Bowles, R. M. Hughes, and J. A. Hesse. 2002. A review of potential conservation and fisheries benefits of breaching four dams in the Lower Snake River (Washington, USA). Water Biology and Security 1(2):100030. https://doi.org/10.1016/j.watbs.2022.100030

Reviews the impacts of the Columbia River hydropower system on Sockeye salmon, Chinook salmon, Steelhead, bull trout, white sturgeon, and Pacific lamprey. Asserts that dam removal on the Lower Snake River can help mitigate the negative impacts on these fish.

Sullivan, B. G., M. K. Taylor, C. Carli, T. D. Ward, R. J. Lennox, and S. J. Cooke. 2019. Partial dam removal restores passage for a threatened salmonid. River Research and Applications 35(6):669–679. https://doi.org/10.1002/rra.3426

Examines a partial dam removal in Banff National Park (Alberta, Canada), the resulting passage resembling a nature-like fishway, and its usage by bull trout.

Tabor, R. A., J. R. Johnson, R. J. Peters, R. Mahan, M. L. McHenry, S. J. Brenkman, G. R. Pess, T. R. Bennett, and M. C. Liermann. 2022. Distribution, relative abundance, and length of sculpins in the Elwha River watershed following the removal of two hydroelectric dams. Northwest Science 95(3-4):292-306. https://doi.org/10.3955/046.095.0305

Assesses the impact of dam removals on the Elwha River, Washington on sculpin, in order to contribute to research on the impact of dam removals on less migratory fish. Finds a decrease, potentially associated with habitat loss, but also provides a baseline for future research.

Tang, L., K. Mo, J. Zhang, J. Wang, Q. Chen, S. He, C. Zhu, and Y. Lin. 2021. Removing tributary low-head dams can compensate for fish habitat losses in dammed rivers. Journal of Hydrology 598: 126204. https://doi.org/10.1016/j.jhydrol.2021.126204

Utilizes a hydro-morphodynamic model to simulate the changes in hydrodynamic features and riverbed elevation to assess habitat suitability after the removal of a low-head dam on the Jinsha River, China.

Terêncio, D. P. S., F. A. L. Pacheco, L. F. Sanches Fernandes, and R. M. V. Cortes. 2021. Is it safe to remove a dam at the risk of a sprawl by exotic fish species? Science of The Total Environment 771: 144768. https://doi.org/10.1016/j.scitotenv.2020.144768

Discusses the process of removing small obsolete dams from the Portuguese section of the Douro River; and the constraint of attempting to avoid opening the river to introduced invasive species while allowing greater access to native anadromous species.

Tomsic, C. A., T. C. Granata, R. P. Murphy, and C. J. Livchak. 2007. Using a coupled eco-hydrodynamic model to predict habitat for target species following dam removal. Ecological Engineering 30(3):215-230. https://doi.org/10.1016/j.ecoleng.2006.11.006

A habitat suitability index model is used to predict fish and macroinvertibrate ranges post dam removal on the Sandusky River, Ohio.

Tonra, C. M., K. Sager-Fradkin, S. A. Morley, J. J. Duda, and P. P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134. https://doi.org/10.1016/j.biocon.2015.09.009

Examined the transportation of marine-derived nutrients by salmon and the integration of these marine-derived nutrients into upstream food webs following the removal of the Elwha Dam, Washington.

U.S. Army Corps of Engineers Walla Walla District. 2002. Lower Snake River juvenile salmon migration feasibility report/environmental impact statement. U.S. Army Corps of Engineers, Walla Walla, Washington. https://www.nww.usace.army.mil/Library/2002-LSR-Study/

Documents the results of an analysis of the four dams on the lower Snake River and their effects on four lower Snake River salmon and steelhead stocks listed for protection under the Endangered Species Act. Presents four alternatives to evaluate the best way to improve juvenile salmon migration through Lower Snake River Project.

Watson, J. M., S. M. Coghlan, J. Zydlewski, D. B. Hayes, and I. A. Kiraly. 2018. Dam removal and fish passage improvement influence fish assemblages in the Penobscot River, Maine. Transactions of the American Fisheries Society 147(3):525-540. https://doi.org/10.1002/tafs.10053

Surveys the fish assemblages in the Penobscot River, Maine, and its tributaries after two dam removals. Finds an increased number of anadromous fish and a greater diversity in the assemblage.

Whittum, K. A., J. D. Zydlewski, S. M. Coghlan, D. B. Hayes, J. Watson, and I. Kiraly. 2023. Fish assemblages in the Penobscot River: a decade after dam removal. Marine and Coastal Fisheries 15(1):e10227. https://doi.org/10.1002/mcf2.10227

Surveys the fish assemblages in the Penobscot River, Maine, and its tributaries after two dam removals. Noted the most dramatic shifts occurred immediately after the dam removals, lacustrine species remain more common upstream, while anadromous fish remain most abundant downstream.

Wippelhauser, G. 2021. Recovery of diadromous fishes: a Kennebec River case study. Transactions of the American Fisheries Society 150(3):277-290. https://doi.org/doi/10.1002/tafs.10292

Examines the long-term response of multiple fish species in the Kennebec River, Maine, to the removal of two hydropower dams and the installation of upstream fish passage facilities that restored access to historic habitat.

Wippelhauser, G. S., G. B. Zydlewski, M. Kieffer, J. Sulikowski, and M. T. Kinnison. 2015. Shortnose sturgeon in the Gulf of Maine: Use of spawning habitat in the Kennebec system and response to dam removal. Transactions of the American Fisheries Society 144(4):742-752. https://doi.org/10.1080/00028487.2015.1037931

Assesses spawning behavior of shortnose sturgeon, finds that they are spawning in the restored Kennebec River, Maine, after the removal of a 162-year-old dam in 1999.

Politics, Policy, and Society

Amos, A. L. 2014. Dam removal and hydropower production in the United States - ushering in a new era. Journal of Environmental Law and Litigation 29. https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/17841/Amos.pdf?sequence=1&isAllowed=y

Lecture concerning shifts in policy and practice on hydropower production how this must be balanced with environmental concerns. Reviews FERC involvement in river restoration, and focuses on the Klamath River as an exemplar.

Baish, S. K., S. D. David, and W. L. Graf. 2002. The complex decisionmaking process for removing dams. Environment: Science and Policy for Sustainable Development 44(4):20-31. https://doi.org/10.1080/00139150209605779

Reviews the state of policymaking for dam removal decisions, proposes a step-by-step decision-making process can help identify possible effects of a dam's removal on the environment, the local and regional economy, and surrounding communities.

Becker, D. H. 2006. The challenges of dam removal: the history and lessons of the Condit Dam and potential threats from the 2005 federal power act amendments. Environmental Law 36(3):811-868. https://law.lclark.edu/live/files/257-363becker

Describes procedural rights granted to utilities by the passage of the 2005 Federal Power Act to oppose fish passage dams and potential ways that challenges to federal fish passage projects could play out.

Blumm, M. C., and A. B. Erickson. 2012. Dam removal in the Pacific Northwest: lessons for the nation. Environmental Law Review 42:1043-1120. https://lawcommons.lclark.edu/cgi/viewcontent.cgi?article=1250&context=faculty_articles

Surveys successful and proposed dam removals in the Pacific Northwest, namely the Elwha and White Salmon rivers in Washington, the Rogue and Sandy rivers in Oregon, and the Klamath River in Oregon and California.

Blumm, M. C., L. J. Lucas, D. B. Miller, D. J. Rohlf, and G. H. Spain. 1998. Saving Snake River water and salmon simultaneously : the biological, economic, and legal case for breaching the lower Snake River dams, lowering John Day Reservoir, and restoring natural riverflows. Northwest Water Law & Policy Project, Portland, Oregon. https://catalog.cbfwl.org/cgi-bin/koha/opac-detail.pl?biblionumber=4509

Argues that breaching the four lower Snake River dams and lowering John Day Reservoir will simultaneously save Snake River salmon and water. The study provides a comprehensive review of the major scientific and economic studies addressing this option and a thorough analysis of the legal imperative to restore salmon.

Boucher, Z., and P. F. Hudson. 2023. Troubled waters: riparian ecosystem services and community opposition to the largest dam removal project in Europe, Vezins Dam, France. Geoforum 147: 103906. https://doi.org/10.1016/j.geoforum.2023.103906

Retrospective on the removal of Vezins Dam on the Sélune River, France. Examines the French government's approaches to removing the dam as well as opposition to the removal, posits that the French Government failed to address the concerns of those near the dam and river, which resulted in a lack of community support.

Bowman, M. B. 2002. Legal perspectives on dam removal. BioScience 52(8):739-747. https://doi.org/10.1641/0006-3568(2002)052[0739:LPODR]2.0.CO;2

Considers the legal issues associated with both decisions about whether or not to remove a dam and decisions about how to remove a dam; also, how implementation of environmental restoration activities such as dam removal fits into our existing legal system and how environmental laws may need to evolve to address the increasing interest in environmental restoration.

Brewitt, Peter. 2019. Same river twice: the politics of dam removal and river restoration. Oregon State University Press, Corvallis. https://search.worldcat.org/title/1125324624

Examines the history and removal of the Elwha, Glines Canyon, Savage Rapids, and Marmot Dams with an emphasis on the political processes that led to each dam's removal.

Doyle, M. W., J. M. Harbor, and E. H. Stanley. 2003. Toward policies and decision-making for dam removal. Environmental Management 31(4):453-465. https://doi.org/10.1007/s00267-002-2819-z

Outlines practices for federal and state agencies to assess dam removals based on the development and adoption of a prioritization scheme for what constitutes an important dam removal, and the establishment of minimum levels of analysis prior to decision-making about a dam removal.

Doyle, M. W., E. H. Stanley, J. M. Harbor, and G. S. Grant. 2003. Dam removal in the United States: emerging needs for science and policy. Eos, Transactions American Geophysical Union 84(4):29-33. https://doi.org/10.1029/2003EO040001

Lays out the emergence of dam removal as a critical issue, contemporary gaps in policy and the need for further scientific research to inform future policy.

Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. "You kill the dam, you are killing a part of me": dam removal and the environmental politics of river restoration. Geoforum 70:93–104. https://doi.org/10.1016/j.geoforum.2016.02.013

Examines political conflicts and micropolitics of dam removals in New England. Suggests that the historical geography of New England and associated cultural values also play a role in conflicts over dam removals.

Gowan, C., K. Stephenson, and L. Shabman. 2006. The role of ecosystem valuation in environmental decision making: Hydropower relicensing and dam removal on the Elwha River. Ecological Economics 56(4):508–523. https://doi.org/10.1016/j.ecolecon.2005.03.018

Describes the technical analysis that was employed and how such analysis contributed to the Elwha Dam removal decision.

Grabowski, Z. J., A. Denton, M. A. Rozance, M. Matsler, and S. Kidd. 2017. Removing dams, constructing science: coproduction of undammed riverscapes by politics, finance, environment, society, and technology. Water Alternatives 10(3): 769-795. https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1081&context=geog_fac

Argues for the construction of an interdisciplinary framework to integrate knowledge relevant to decision-making on dam removal.

Habel, M., K. Mechkin, K. Podgorska, M. Saunes, Z. Babiński, S. Chalov, D. Absalon, Z. Podgórski, and K. Obolewski. 2020. Dam and reservoir removal projects: a mix of social-ecological trends and cost-cutting attitudes. Scientific Reports 10: 19210. https://doi.org/10.1038/s41598-020-76158-3

Attempts to construct a general framework for dam removals, the stakeholders, their perspectives, and arguments towards dam removal projects. Focuses on Europe and the United States and attempts to compare regional attitudes.

Habel, M., K. Mechkin, I. Wagner, Z. Grabowski, Z. Kaczkowski, D. Absalon, D. Szatten, M. Matysik, S. Pytel, T. Jurczak, and K. Obolewski. 2024. Dammed context: community perspectives on ecosystem service changes following Poland's first dam removal. Land Degradation & Development [Online Version of Record before inclusion in an issue] https://doi.org/10.1002/ldr.5053

Surveys community members on the removal of Wilkówka dam in southern Poland, finds the majority of community members felt the government did not put enough effort in hearing community concerns, and the vast majority of respondents felt the removal was carried out without recognizing or addressing opposition.

Hoenke, K. M., M. Kumar, and L. Batt. 2014. A GIS based approach for prioritizing dams for potential removal. Ecological Engineering 64:27-36. https://doi.org/10.1016/j.ecoleng.2013.12.009

Presents a GIS based approach for prioritizing dams for removal based on eco-hydrologic and social metrics. Results show that highest ranking dams from an ecological prioritization are located on reaches of high habitat quality and longer connected river miles.

Jumani, S., L. Andrews, T. E. Grantham, S. K. McKay, J. Duda, and J. Howard. 2023. A decision-support framework for Dam Removal Planning and its application in Northern California. Environmental Challenges 12:1 00731. https://doi.org/10.1016/j.envc.2023.100731

Presents a hierarchical, multi-disciplinary decision-support framework to prioritize dam removals based on opportunistic factors, hydro-ecological variables, and socio-cultural considerations.

Kuby, M. J., W. F. Fagan, C. S. ReVelle, and W. L. Graf. 2005. A multiobjective optimization model for dam removal: an example trading off salmon passage with hydropower and water storage in the Willamette Basin. Advances in Water Resources 28(8):845-855. https://doi.org/10.1016/j.advwatres.2004.12.015

Introduces a systematic, combinatorial, multiobjective optimization models to analyze ecological-economic tradeoffs of dam removal in the Willamette River Basin, Oregon.

Leisher, C., S. Hess, K. Dempsey, M. L. Payne Wynne, and J. Royte. 2021. Measuring the social changes from river restoration and dam removal. Restoration Ecology 30(1):e13500. https://doi.org/10.1111/rec.13500

Assesses public perception of two dam removals after the fact in Maine. Finds that people reported better perceptions of water quality, swimming, paddling, fishing, and wildlife viewing increased, and the percentage of people saying the river was part of their family's life increased.

Lejon, A. G., B. M. Renöfält, and C. Nilsson. 2009. Conflicts associated with dam removal in Sweden. Ecology and Society 14(2):4. https://www.ecologyandsociety.org/vol14/iss2/art4/

Reviews debates around 17 proposed dam removals in Sweden. Finds that consistent threads of concern around funding, cultural-historic value, and threatened species were brought up in these discussions and could pose obstacles to dam removal.

Magilligan, F. J., C. S. Sneddon, and C. A. Fox. 2017. The social, historical, and institutional contingencies of dam removal. Environmental Management 59(6):982-994. https://doi.org/10.1007/s00267-017-0835-2

Uses a comparative case study approach to assess various attempts, both successful and unsuccessful, to remove dams in New England. Finds that attention to local histories, arbitration, and brokering of compromises are necessary, but that these are not sufficient to guarantee a successful dam removal.

Noda, K., J. Hamada, M. Kimura, and K. Oki. 2018. Debates over dam removal in Japan. Water and Environment Journal 32(3):446-452. https://doi.org/10.1111/wej.12344

Examines discourse around 8 proposed dam removals around Japan. Finds that water rights are a primary concern, while ecological benefit is not relevant to the demolition decision regarding dams conferring public benefit, even if restoration of the river environment was a recognized benefit.

Parent, J. R., A. J. Gold, E. Vogler, and K. A. Lowder. 2024. Guiding decisions on the future of dams: a GIS database characterizing ecological and social considerations of dam decisions. Journal of Environmental Management 351:119683. https://doi.org/10.1016/j.jenvman.2023.119683

Charts the creation of a database that characterizes the ecological benefits of dam removal or modification, in terms of fish passage, and the social dimensions that may need to be considered when engaging a community in discussions about the future of a dam, centers around New England, where many small dam removals have been met with community resistance.

Robbins, J. L., and L. Y. Lewis. 2008. Demolish it and they will come: Estimating the economic impacts of restoring a recreational fishery. JAWRA Journal of the American Water Resources Association 44(6):1488–1499. https://doi.org/10.1111/j.1752-1688.2008.00253.x

Presents the results of a survey of recreational anglers for the lower Kennebec River, post dam removal. Finds significant benefits have accrued to anglers using the restored fishery.

Smith, L. W., E. Dittmer, M. Prevost, and D. R. Burt. 2000. Breaching of a small irrigation dam in Oregon: a case history. North American Journal of Fisheries Management 20(1):205-219. https://doi.org/doi/10.1577/1548-8675%282000%29020%3C0205%3ABOASID%3E2.0.CO%3B2

Describes the biological, technical, and sociological components of the Jackson Street Dam breaching, the sociological factors affecting the collaborative planning process and project implementation, and recommendations for similar efforts.

Wyrick, J. R., B. A. Rischman, C. A. Burke, C. McGee, and C. Williams. 2009. Using hydraulic modeling to address social impacts of small dam removals in southern New Jersey. Journal of Environmental Management 90(s3):S270-S278. https://doi.org/10.1016/j.jenvman.2008.07.027

Analyzes the removal of two small dams in southern New Jersey. The removal of the dams was predicted to have little effect on hydrological and biological characteristics of the stream corridor, but this was a concern for nearby residents who expected drastic shifts to these as well as financial impacts to their property value and social impacts to their recreational activities.

Sediment and Geomorphology

Ahearn, D. S., and R. A. Dahlgren. 2005. Sediment and nutrient dynamics following a low-head dam removal at Murphy Creek, California. Limnology and Oceanography 50(6):1752-1762. https://doi.org/10.4319/lo.2005.50.6.1752

Studied the impacts of a 3-meter low-head dam on Murphy Creek, California on sediment and nitrogen export, both of which increased by an order of magnitude over the previous 2-year mean.

Ashley, J. T., K. Bushaw-Newton, M. Wilhelm, A. Boettner, G. Drames, and D. J. Velinsky. 2006. The effects of small dam removal on the distribution of sedimentary contaminants. Environmental Monitoring and Assessment 114(1-3):287–312. https://doi.org/10.1007/s10661-006-4781-3

Assesses the effects of dam removal on the contaminant redistribution within a Pennsylvania creek, sedimentary concentrations of polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and trace metals.

Burroughs, B. A., D. B. Hayes, K. D. Klomp, J. F. Hansen, and J. Mistak. 2009. Effects of Stronach Dam removal on fluvial geomorphology in the Pine River, Michigan, United States. Geomorphology 110(3–4):96–107. https://doi.org/10.1016/j.geomorph.2009.03.019

Studies sediment transportation after the gradual removal of Stronach Dam on the Pine River, Michigan. Dam removal resulted in progressive headcutting of sediments in the former impoundment, and the study observes an overall increase in river velocity, even as most of the sediment remains.

Cantelli, A., C. Paola, and G. Parker. 2004. Experiments on upstream-migrating erosional narrowing and widening of an incisional channel caused by dam removal. Water Resources Research 40(3): W03304. https://doi.org/10.1029/2003WR002940

Reports on a laboratory investigation of the erosion of a deltaic front induced by the removal of a dam, provides a detailed view of erosional narrowing.

Cantelli, A., M. Wong, G. Parker, and C. Paola. 2007. Numerical model linking bed and bank evolution of incisional channel created by dam removal. Water Resources Research 43(7):W07436. https://doi.org/10.1029/2006WR005621

Presents a morphodynamic model of incision into a reservoir deposit driven by partial or total removal of the associated dam. The model considers the erosional processes upstream of the position of the former dam, rather than downstream deposition.

Cashman, M. J., A. C. Gellis, E. Boyd, M. J. Collins, S. W. Anderson, B. D. McFarland, and A. M. Ryan. 2021. Channel response to a dam-removal sediment pulse captured at high-temporal resolution using routine Gage Data. Earth Surface Processes and Landforms 46(6):1145-1159. https://doi.org/10.1002/esp.5083

Examines how a dam removal caused sediment pulse affected the channel of the Patapsco River, Maryland.

Cheng, F., and T. Granata. 2007. Sediment transport and channel adjustments associated with dam removal: field observations. Water Resources Research 43(3): W03444. https://doi.org/10.1029/2005WR004271

Documents changes in channel geometry, bed level profile, and bed grain size distribution and their relations with the sediment transport at the reach scale, following the removal of a low-head dam.

Chu, C., and G. J. You. 2021. Analytical one-dimensional conceptual model of channel evolution after dam removal based on Diffusion Framework. Water Resources Research 57(5):e2020WR028306. https://doi.org/10.1029/2020WR028306

Examines one-dimensional channel evolution within an infinite channel following dam removal with the aim of providing a method for predictions for bed elevation, sediment volume, and knickpoint positions.

Collins, M. J., A. R. Kelley, and P. J. Lombard. 2020. River channel response to dam removals on the lower Penobscot River, Maine, United states. River Research and Applications 36(9):1778-1789. https://doi.org/10.1002/rra.3700

Studies the effects of dam removals on the Penobscot River, Maine on bed elevations, channel shapes, and channel positions. Finds minimal change and suggests this could be the norm for dam removals in the Northeastern United States.

Collins, M. J., N. P. Snyder, G. Boardman, W. S. L. Banks, M. Andrews, M. E. Baker, M. Conlon, A. Gellis, S. McClain, A. Miller, and P. Wilcock. 2017. Channel response to sediment release: insights from a paired analysis of dam removal. Earth Surface Processes and Landforms 42(11):1636-1651. https://doi.org/10.1002/esp.4108

Studies sediment release and river response over four years associated with dam removal on the Souhegan River in New Hampshire. Finds that two-phase exponential models with changing decay constants fit the erosion data better than single-phase models.

Cui, Y., G. Parker, C. Braudrick, W. E. Dietrich, and B. Cluer. 2006. Dam Removal Express Assessment Models (DREAM). Journal of Hydraulic Research 44(3):291–307. https://doi.org/10.1080/00221686.2006.9521683

Summarizes the Dam Removal Express Assessment Models (DREAM) developed for simulation of sediment transport following dam removal.

Curran, J. C., and K. C. Coveleski. 2021. How sediment composition and flow rate influence downstream channel morphodynamics upon dam removal. Earth Surface Processes and Landforms 46(12):2437-2447. https://doi.org/10.1002/esp.5187

Laboratory experiments focused on understanding how processes occurring immediately after a sediment release upon dam removal or failure affect the downstream channel bed.

De Graff, J. V., and J. E. Evans, editors. 2013. The challenges of dam removal and river restoration. Geological Society of America, Boulder, Colorado. https://search.worldcat.org/title/824087954

Collection of 14 research papers focusing on current understanding of the geological impacts of removing dams and the role of dam removal in the larger context of river restoration.

Doyle, M. W., E. H. Stanley, and J. M. Harbor. 2003. Channel adjustments following two dam removals in Wisconsin. Water Resources Research 39(1):1011. https://doi.org/10.1029/2002WR001714

Examines channel response following the removal of low-head dams on two low-gradient, fine- to coarse-grained rivers in southern Wisconsin.

Draut, A. E., and A. C. Ritchie. 2013. Sedimentology of new fluvial deposits on the Elwha River, Washington, USA, formed during large-scale dam removal. River Research and Applications 31(1):42-61. https://doi.org/10.1002/rra.2724

Examines the sedimentology of the fluvial deposits and sediment transport associated with the Elwha River, Washington, dam removals.

East, A. E., L. R. Harrison, D. P. Smith, J. B. Logan, and R. M. Bond. 2023. Six years of fluvial response to a large dam removal on the Carmel River, California, USA. Earth Surface Processes and Landforms 48(8):1487-1501. https://doi.org/10.1002/esp.5561

Studies the Carmel River response to dam removal over 8 years, two prior two the dam removal and 6 after. Changes to the river are attributed to flow rather than the increase in sediment supply.

East, A. E., J. B. Logan, M. C. Mastin, A. C. Ritchie, J. A. Bountry, C. S. Magirl, and J. B. Sankey. 2018. Geomorphic evolution of a gravel-bed river under sediment-starved versus sediment-rich conditions: river response to the world's largest dam removal. Journal of Geophysical Research: Earth Surface 123(12):3338-3369. https://doi.org/10.1029/2018JF004703

Reviews the fluvial response to the sediment pulse released by the removal of dams on the Elwha River, in particular rates of geomorphic change and sensitivity to stream power.

East, A. E., G. R. Pess, J. A. Bountry, C. S. Magirl, A. C. Ritchie, J. B. Logan, T. J. Randle, M. C. Mastin, J. T. Minear, J. J. Duda, M. C. Liermann, M. L. McHenry, T. J. Beechie, and P. B. Shafroth. 2015. Large-scale dam removal on the Elwha River, Washington, USA: River Channel and Floodplain Geomorphic change. Geomorphology 228:765-786. https://doi.org/10.1016/j.geomorph.2014.08.028

Investigates downstream effects of sediment transport after the removal of two dams on the Elwha River, Washington by measuring changes in riverbed elevation and topography, bed sediment grain size, and channel planform.

Fields, J., C. Renshaw, F. Magilligan, E. Dethier, and R. Rossi. 2021. A mechanistic understanding of channel evolution following dam removal. Geomorphology 395:107971. https://doi.org/10.1016/j.geomorph.2021.107971

Studies the removal of a 4-meter dam in New England to investigate the timing and arc of a channel's return to dynamic equilibrium conditions, using both form- and process-based perspectives.

Ferrer-Boix, C., J. P. Martín-Vide, and G. Parker. 2014. Channel evolution after dam removal in a poorly sorted sediment mixture: experiments and numerical model. Water Resources Research 50(11):8997-9019. https://doi.org/10.1002/2014WR015550

Experimental results demonstrating the rate at which the sediment is released depends on the height of the removed dam, the water discharge, and the maximum potential volume of sediment to be eroded.

Gartner, J. D., F. J. Magilligan, and C. E. Renshaw. 2015. Predicting the type, location and magnitude of geomorphic responses to dam removal: role of hydrologic and geomorphic constraints. Geomorphology 251:20-30. https://doi.org/10.1016/j.geomorph.2015.02.023

Examines sediment transport dynamics after a dam removal on the Ashuelot River in southern New Hampshire.

Gelfenbaum, G., A. W. Stevens, I. Miller, J. A. Warrick, A. S. Ogston, and E. Eidam. 2015. Large-scale dam removal on the Elwha River, Washington, USA: coastal geomorphic change. Geomorphology 246:649-668. https://doi.org/10.1016/j.geomorph.2015.01.002

Details measurements of beach topography and nearshore bathymetry after the Elwha River dam removals, charts the changes to the river delta and associated nearshore geomorphology.

Gilet, L., F. Gob, C. Virmoux, E. Gautier, N. Thommeret, and N. Jacob-Rousseau. 2021. Morpho-sedimentary dynamics associated to dam removal. the Pierre Glissotte dam (central France). Science of The Total Environment 784:147079. https://doi.org/10.1016/j.scitotenv.2021.147079

Presents hydromorphological observations for four years following the removal of the Pierre Glissotte dam on the Yonne River, France. Shows that intense morpho-sedimentary dynamics in the reservoir does not necessarily lead to changes in the downstream conditions.

Harrison, L. R., A. E. East, D. P. Smith, J. B. Logan, R. M. Bond, C. L. Nicol, T. H. Williams, D. A. Boughton, K. Chow, and L. Luna. 2018. River response to large-dam removal in a Mediterranean hydroclimatic setting: Carmel River, California, USA. Earth Surface Processes and Landforms 43(15):3009-3021. https://doi.org/10.1002/esp.4464

Measures changes in channel topography, grain size, and salmonid spawning habitat throughout dam removal and subsequent major floods before, during, and after the removal of a high-head dam on the Carmel River, California.

Kibler, K., D. Tullos, and M. Kondolf. 2011. Evolving expectations of dam removal outcomes: downstream geomorphic effects following removal of a small, gravel-filled dam. JAWRA Journal of the American Water Resources Association 47(2):408-423. https://doi.org/10.1111/j.1752-1688.2011.00523.x

Studies the sediment transport associated with the removal of the Brownsville Dam from the Calapooia River, Oregon. Finds that because of the larger sediment behind the dam, there was less of an impact further downstream.

Lambing, J. H., and S. K. Sando. 2009. Estimated loads of suspended sediment and selected trace elements transported through the Milltown Reservoir project area before and after the breaching of Milltown Dam in the upper Clark Fork basin, Montana, water year 2008: U.S. Geological Survey Scientific Investigations Report 2009-5095. https://pubs.usgs.gov/sir/2009/5095/pdf/sir2009-5095.pdf

Presents estimated loads of suspended sediment and selected trace elements transported before and after the breaching of Milltown Dam and quantifies the net gain or loss of suspended sediment and trace elements within the project area during the transition from a reservoir environment to a free-flowing river.

Lorang, M. S., and G. Aggett. 2005. Potential sedimentation impacts related to dam removal: Icicle Creek, Washington, U.S.A. Geomorphology 71(1-2):182-201. https://doi.org/10.1016/j.geomorph.2004.10.013

Measures the total volume of sediment trapped behind the Icicle Creek dams and estimate the potential sedimentation impacts for the lower portion of Icicle Creek should the dams be removed. Finds flushing of the trapped sediments over several years poses very little threat to the water quality and spawning habitats in the lower Icicle Creek.

Magirl, C. S., R. C. Hilldale, C. A. Curran, J. J. Duda, T. D. Straub, M. Domanski, and J. R. Foreman. 2015. Large-scale dam removal on the Elwha River, Washington, USA: Fluvial sediment load. Geomorphology 246:669-686. https://doi.org/10.1016/j.geomorph.2014.12.032

Examines the fluvial sediment load of the Elwha River throughout the Elwha River Restoration project in Washington State.

Major, J. J., A. E. East, J. E. O'Connor, G. E. Grant, A. C. Wilcox, C. S. Magirl, M. J. Collins, and D. D. Tullos. 2017. Geomorphic responses to dam removal in the United States – a two-decade perspective. Pages 355-383 *In* Gravel-Bed Rivers: Processes and Disasters. https://doi.org/10.1002/9781118971437.ch13

This review of the impacts of sediment release after dam removal suggests that rivers can respond quickly to dam removals, especially when the removal is sudden rather than prolonged; and that rivers can evacuate reservoir sediments relatively quickly and achieve stability within the course of months to years.

Major, J. J., J. E. O'Connor, C. J. Podolak, M. K. Keith, G. E. Grant, K. R. Spicer, S. Pittman, H. M. Bragg, J. R. Wallick, D. Q. Tanner, A. Rhode, and P. R. Wilcock. 2012. Geomorphic response of the Sandy River, Oregon, to removal of Marmot Dam. U.S. Geological Survey Professional Paper 1792. https://pubs.usgs.gov/pp/1792/pp1792_text.pdf

Study using direct measurements of sediment transport, photogrammetry, lidar surveys, and repeat ground surveys of the reservoir reach and channel downstream, to monitor the erosion, transport, and deposition of this sediment in the hours, days, and months following dam removal.

Major, J. J., K. R. Spicer, A. Rhode, J. E. O'Connor, H. M. Bragg, D. Q. Tanner, C. W. Anderson, J. R. Wallick, and G. E. Grant. 2008. Initial fluvial response to the removal of Oregon's Marmot Dam. Eos, Transactions American Geophysical Union 89(27):241-242. https://doi.org/10.1029/2008EO270001

Reviews the initial fluvial response of the Sandy River, Oregon, to the removal of the Marmot Dam and the temporary cofferdam along the river.

Papanicolaou, A. N., and B. D. Barkdoll, editors. 2011. Sediment dynamics upon dam removal. American Society of Civil Engineers, Reston, Virginia. https://archive.org/details/sedimentdynamics0000unse_y8b2/mode/2up

Provides guidance, documentation, and field results for the numerical and physical modeling of sediment movement when dams are removed from waterways.

Pace, K. M., D. Tullos, C. Walter, S. Lancaster, and C. Segura. 2016. Sediment pulse behaviour following dam removal in gravel-bed rivers. River Research and Applications 33(1):102-112. https://doi.org/10.1002/rra.3064

Analyzes bathymetric data from four field sites in Oregon to investigate sediment pulses, and whether low Froude number, fine pulse grain size, small pulse sizes, and large peak discharge characterize pulses that translate downstream.

Pearson, A. J., N. P. Snyder, and M. J. Collins. 2011. Rates and processes of channel response to dam removal with a sand-filled impoundment. Water Resources Research 47(8):W08504. https://doi.org/10.1029/2010WR009733

Uses a low-head dam removal on the Souhegan River in southern New Hampshire to measure processes and rates of channel evolution in a sand-filled impoundment over four years.

Pizzuto, J. 2002. Effects of dam removal on river form and process. Bioscience 52(8):683–691. https://doi.org/10.1641/0006-3568(2002)052[0683:EODROR]2.0.CO;2

Compares the geomorphic effects of different engineering strategies for dam removals both upstream and downstream from the dams.

Poeppl, R. E., T. Coulthard, S. D. Keesstra, and M. Keiler. 2019. Modeling the impact of dam removal on channel evolution and sediment delivery in a multiple dam setting. International Journal of Sediment Research 34(6):537-549. https://doi.org/10.1016/j.ijsrc.2019.06.001

Attempts to model effects of dam removal such as bank erosion processes and lateral migration, to better understand geomorphic responses to dam removal beyond post-removal channel changes.

Randle, T. J., J. A. Bountry, A. Ritchie, and K. Wille. 2015. Large-scale dam removal on the Elwha River, Washington, USA: erosion of reservoir sediment. Geomorphology 246:709-728. https://doi.org/10.1016/j.geomorph.2014.12.045

Investigates reservoir sediment response to the phased and concurrent drawdown of two reservoirs on the Elwha River, Washington. Finds that while significant amounts of sediment were transferred down river, sediment terraces within the reservoir landscape remain.

Ritchie, A. C., J. A. Warrick, A. E. East, C. S. Magirl, A. W. Stevens, J. A. Bountry, T. J. Randle, C. A. Curran, R. C. Hilldale, J. J. Duda, G. R. Gelfenbaum, I. M. Miller, G. R. Pess, M. M. Foley, R. McCoy, and A. S. Ogston. 2018. Morphodynamic evolution following sediment release from the world's largest dam removal. Scientific Reports 8:13279. https://doi.org/10.1038/s41598-018-30817-8

Evaluates geomorphic evolution during and after the sediment pulse, presenting a 5-year sediment budget and morphodynamic analysis of the Elwha River, Washington and its delta.

Sando, S. K., and Lambing, J. H., 2011. Estimated loads of suspended sediment and selected trace elements transported through the Clark Fork basin, Montana, in selected periods before and after the breach of Milltown Dam (water years 1985–2009). U.S. Geological Survey Scientific Investigations Report 2011-5030. https://purl.fdlp.gov/GPO/gpo8315

Presents estimated loads of suspended sediment and selected trace elements transported before and after the breaching of Milltown Dam and quantifies the net gain or loss of suspended sediment and trace elements within the basin during the transition from a reservoir environment to a free-flowing river.

Sawaske, S. R., and D. L. Freyberg. 2012. A comparison of past small dam removals in highly sediment-impacted systems in the U.S. Geomorphology 151-152:50-58. https://doi.org/10.1016/j.geomorph.2012.01.013

Utilizes data collected from past dam removals to develop an additional tool for predicting the rate and volume of sediment deposit erosion. Model shows parameters such as median grain size, level of cohesion, spatial variability of the deposit, and removal timeline are among the most influential factors in determining the rate and volume of sediment erosion.

Stanley, E. H., and M. W. Doyle. 2002. A geomorphic perspective on nutrient retention following dam removal: geomorphic models provide a means of predicting ecosystem responses to dam removal. BioScience 52(8):693-701. https://doi.org/10.1641/0006-3568(2002)052[0693:AGPONR]2.0.CO;2

Examines the roles of agriculture and other human activities on river basins, proposes geomorphic models as a means of predicting ecosystem responses to dam removals.

Stillwater Sciences. 2000. Evaluation of geomorphic effects of removal of Marmot and Little Sandy Dams and potential impacts on anadromous salmonids: preliminary final. Report to Portland General Electric, Portland, Oregon. http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/64e83168-4853-4822-bff7-13bcd7e7d232

Evaluates the geomorphic effects of removing Marmot Dam, on the Sandy River, Oregon, and Little Sandy Dam, on the Little Sandy River, and the potential associated effects on anadromous salmonid habitats and populations.

Stillwater Sciences. 2009. Effects of sediment release following dam removal on the aquatic biota of the Klamath River: final technical report. Prepared for State Coastal Conservancy, Oakland, California. https://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/9b64c8d2-48e5-4bd8-86d4-620b3b872877

Presents analyses of the physical properties and concentrations of suspended sediment likely to result from sediment releases and potential biological effects of sediment release on aquatic habitats and species if the dams were to be removed.

Walter, C., and D. D. Tullos. 2010. Downstream channel changes after a small dam removal: Using aerial photos and measurement error for context; Calapooia River, Oregon. River Research and Applications 26(10):1220-1245. https://doi.org/10.1002/rra.1323

Evaluates aerial photos as substitutes for multiple-year pre-removal field data to assess downstream channel changes associated with the removal of the Brownsville Dam on the Calapooia River, Oregon.

Wang, H. W., and W. C. Kuo. 2015. Geomorphic responses to a large check-dam removal on a mountain river in Taiwan. River Research and Applications 32(5):1094-1105. https://doi.org/10.1002/rra.2929

Describes the geomorphic changes associated with the removal of a 13-meter dam on Chijiawan Creek, Taiwan. The removal of the dam did not see an immediate release of sediment, but higher streamflow in following months did lead to more sediment being transported downstream.

Warrick, J. A., J. A. Bountry, A. E. East, C. S. Magirl, T. J. Randle, G. Gelfenbaum, A. C. Ritchie, G. R. Pess, V. Leung, and J. J. Duda. 2015. Large-scale dam removal on the Elwha River, Washington, USA: source-to-sink sediment budget and synthesis. Geomorphology 246:729-750. https://doi.org/10.1016/j.geomorph.2015.01.010

Provides a source-to-sink sediment budget of the Elwha Dam removal sediment release during the first two years of the project and synthesizes the geomorphic changes that occurred to downstream fluvial and coastal landforms.

Warrick, J. A., A. W. Stevens, I. M. Miller, S. R. Harrison, A. C. Ritchie, and G. Gelfenbaum. 2019. World's largest dam removal reverses coastal erosion. Scientific Reports 9:13968. https://doi.org/10.1038/s41598-019-50387-7

Reveals patterns and trends of beach accretion following the restoration of sediment supply from the removal of dams on the Elwha River, Washington.

Wells, R. R., E. J. Langendoen, and A. Simon. 2007. Modeling pre- and post-dam removal sediment dynamics: the Kalamazoo River, Michigan. JAWRA Journal of the American Water Resources Association 43(3):773-785. https://doi.org/10.1111/j.1752-1688.2007.00062.x

Evaluates the erosion, transport, and deposition of sediments over a 37.3-year period using the channel evolution model in three simulation scenarios: dams in, dams out, and design for the Kalamazoo River, Michigan.

Warrick, J. A., J. J. Duda, C. S. Magirl, and C. A. Curran. 2012. River turbidity and sediment loads during dam removal. Eos, Transactions American Geophysical Union 93(43):425-426. https://doi.org/10.1029/2012EO430002

Reviews the impacts of the dam removals on the Elwha River on the river's turbidity and sediment loads, and efforts taken to moderate the effects of the dam removal.

Wilcox, A. C., J. E. O'Connor, and J. J. Major. 2014. Rapid reservoir erosion, hyperconcentrated flow, and downstream deposition triggered by breaching of 38 m tall Condit Dam, White Salmon River, Washington. Journal of Geophysical Research: Earth Surface 119(6):1376-1394. https://doi.org/10.1002/2013JF003073

Examines the response of sediment release upstream and downstream from the Condit Dam on the White Salmon River, Washington after its rapid breach.

Yantao, C., J. K. Wooster, C. A. Braudrick, and B. K. Orr. 2014. Lessons learned from sediment transport model predictions and long-term postremoval monitoring: Marmot Dam removal project on the Sandy River in Oregon. Journal of Hydraulic Engineering 140(9):04014044. https://doi.org/10.1061/(ASCE)HY.1943-7900.0000894

Assesses sediment load models for the removal of the Marmot Dam from the Sandy River, Oregon, finds that pre-removal models overestimated the amount of sediment transported downriver, and underpredicted immediate levels of suspended sediment, but that the model correctly predicted the suspended sediment would not increase long term.

Vegetation

Brown, R. L., C. C. Thomas, E. S. Cubley, A. J. Clausen, and P. B. Shafroth. 2022. Does large dam removal restore downstream riparian vegetation diversity? Testing predictions on the Elwha River, Washington, USA. Ecological Applications 32(6): e2591. https://doi.org/10.1002/eap.2591

Examines whether the Elwha River dams were associated with lower downstream plant diversity and altered species composition across riparian landforms pre-dam removal, and whether dam removal has begun to restore downstream diversity and composition.

Cubley, E. S., and R. L. Brown. 2016. Restoration of hydrochory following dam removal on the Elwha River, Washington. River Research and Applications 32(7):1566-1575. https://doi.org/10.1002/rra.2999

Studies seed dispersal along the river after the removal of dams on the Elwha River, finds that levels of seed dispersal along the upper river did not change, but the lower river now matched and sometimes exceeded seeds collected upriver.

Chenoweth, J., J. D. Bakker, and S. A. Acker. 2021. Planting, seeding, and sediment impact restoration success following dam removal. Restoration Ecology 30(3):e13506. https://doi.org/10.1111/rec.13506

Studies the revegetation of the former reservoir of the Glines Canyon Dam, on the Elwha River. Seeding and planting were able to contribute to the revegetation of the reservoir, and also prevent the spread of invasive plants, the authors suggest accounting for sediment texture in revegetation plans.

Cortese, A. M., and R. A. Bunn. 2016. Availability and function of arbuscular mycorrhizal and ectomycorrhizal fungi during revegetation of dewatered reservoirs left after dam removal. Restoration Ecology 25(1):63-71. https://doi.org/10.1111/rec.12406

Assesses the availability of arbuscular mycorrhizal and ectomycorrhizal for plants colonizing dewatered reservoirs following a dam removal project on the Elwha River, Washington.

Doyle, M. W., E. H. Stanley, and J. M. Harbor. 2002. Geomorphic analogies for assessing probable channel response to dam removal. JAWRA Journal of the American Water Resources Association 38(6):1567-1579. https://doi.org/10.1111/j.1752-1688.2002.tb04365.x

Examines the impacts of dam removal within the context of the geomorphic analogies of channel evolution models and sediment waves. Sediment transported downstream after removal of other dams suggests that reservoir sediment may be translated downstream either as a distinct wave or gradually eroded away.

Glover, H., A. S. Ogston, I. M. Miller, E. F. Eidam, S. P. Rubin, and H. D. Berry. 2019. Impacts of suspended sediment on nearshore benthic light availability following dam removal in a small mountainous river: in situ observations and statistical modeling. Estuaries and Coasts 42:1804-1820. https://doi.org/10.1007/s12237-019-00602-5

Reviews the effects of downstream sediment transport associated with the removal of dams on the Elwha River, Washington, on macroalgae. Proposes the mass die-off of macroalgae was caused by a reduction in benthic light availability due to increased turbidity.

Lisius, G. L., N. P. Snyder, and M. J. Collins. 2018. Vegetation community response to hydrologic and geomorphic changes following dam removal. River Research and Applications 34(4):317-327. https://doi.org/10.1002/rra.3261

Studies the revegetation after a small dam removal on the Souhegan River in New Hampshire. The six vegetation response was greatest in areas with the largest geomorphic and hydrologic change.

Orr, C. H., and E. H. Stanley. 2006. Vegetation development and restoration potential of drained reservoirs following dam removal in Wisconsin. River Research and Applications 22(3):281-295. https://doi.org/10.1002/rra.891

Examines the vegetation processes of former reservoirs at 30 dam removal sites in southern Wisconsin. Two of these sites were actively restored, and 13 were able to revegetate on their own; finds that this revegetation was already apparent in the first year.

Ravot, C., M. Laslier, L. Hubert-Moy, S. Dufour, D. Le Coeur, and I. Bernez. 2019. Large dam removal and early spontaneous riparian vegetation recruitment on alluvium in a former reservoir: Lessons learned from the pre-removal phase of the Sélune River Project (France). River Research and Applications 36(6):894-906. https://doi.org/10.1002/rra.3535

Analyzes spontaneous vegetation and whether in can ecologically restore the riparian zone of a former reservoir and help maintain fine sediment post dam removal on the Sélune River. Characterizes the established species pools, and longitudinal patterns of vegetation colonization.