Berkshire Environmental Action Team's "Stop Stocking" Campaign

Ecological Impacts of Fish Stocking: Scientific Literature and Resources (*Summarized*)

Updated July 28, 2026

Impacts of Non-native Trout on Native Brook Trout

1. McKenna, J. E., Slattery, M. T., & Clifford, K. M. (2013). Broad-scale patterns of brook trout responses to introduced brown trout in New York. *North American Journal of Fisheries Management*, 33(6), 1221–1235. https://doi.org/10.1080/02755947.2013.830998
   This study examined the relative roles of brown trout, habitat conditions, and stocking practices in the decline of native brook trout across New York. The authors found that while brook trout were often absent where brown trout occurred, **the strongest driver of brook trout declines was repeated stocking of brown trout rather than direct competition or habitat differences**. Simulations suggested that intensive annual stocking of brown trout could eliminate resident brook trout populations in less than a decade, whereas lower-intensity stocking strategies may allow both species to coexist.

2. Kirk, M. A., Rosswog, A. N., Ressel, K. N., & Wissinger2018, S. A. (2018). Evaluating the Trade-Offs between Invasion and Isolation for Native Brook Trout and non-native Brown Trout in Pennsylvania Streams. *Transactions of the American Fisheries Society*. https://doi.org/10.1002/tafs.10078
   This study found that non-native brown trout negatively affected native brook trout populations in Pennsylvania, with **brook trout populations coexisting with brown trout exhibiting lower densities and fewer age classes than populations without brown trout**. The presence of downstream barriers greatly increased the likelihood of brook trout persistence by preventing brown trout invasion, suggesting that strategically placed barriers can provide important refuges for native brook trout while balancing the need to maintain connectivity among populations.

3. Trout Unlimited (2006). *Eastern Brook Trout: Status and Threats.* Produced by Trout Unlimited for the Eastern Brook Trout Joint Venture. https://easternbrooktrout.org/science-data/reports/eastern-brook-trout-status-and-threats%20%282006%29/view
   This report **assessed the status of brook trout across more than 11,000 subwatersheds in the eastern United States** and **identified the primary threats** to their persistence. It found that **intact brook trout populations remain in only 5% of subwatersheds**, while brook trout have been extirpated or greatly reduced across nearly half of their historical range and now persist primarily as fragmented headwater populations. The **most**

widespread threats to brook trout and their habitat were poor land management (especially agriculture), elevated water temperatures, road-related sedimentation, **non-native fish**, urbanization, degraded riparian habitat, **brown trout**, stream fragmentation from roads and dams, and forestry.

4. Johnson, K. (2011). *Evaluating Trout Stream Restoration Benefits: A Case Study at Pine Creek, Wisconsin*. Trout Unlimited Kiap-TU-Wish Chapter. https://www.kiaptuwish.org/wp-content/uploads/2020/03/Pine-Creek-Case-Study_Final-Presentation-Manuscript_Wild-Trout-Symposium_0917.pdf
This study evaluated the effects of stream restoration on a Wisconsin brook trout stream and found that while habitat conditions improved—including cooler water, reduced bank erosion, deeper pools, and improved substrate—**brook trout populations declined by 70% after restoration**. In contrast, **brown trout abundance increased more than 30-fold**, suggesting that **habitat restoration alone may unintentionally favor non-native brown trout** and emphasizing the need for restoration strategies that specifically protect and enhance native brook trout where the two species coexist.

5. Hitt, N. P., Snook, E. L., & Massie, D. L. (2016). Brook trout use of thermal refugia and foraging habitat influenced by brown trout. *Canadian Journal of Fisheries and Aquatic Sciences*. https://cdnsciencepub.com/doi/10.1139/cjfas-2016-0255
This study found that both brook trout and brown trout increasingly relied on cold groundwater upwelling areas as stream temperatures warmed, highlighting the importance of thermal refugia for brook trout persistence. **Brown trout altered brook trout behavior by restricting their use of foraging habitats outside these refuges, suggesting that competition from introduced brown trout can reduce brook trout viability** and that **brown trout removal may improve brook trout persistence** and expansion in suitable habitats.

6. Isely, J. J., & Kempton, C. (2000). Influence of Costocking on Growth of Young-of-Year Brook Trout and Rainbow Trout. *Transactions of the American Fisheries Society*, *129*(2), 613-617. https://doi.org/10.1577/1548-8659(2000)129%3C0613:IOCOGO%3E2.0.CO;2
This laboratory study found that **hatchery-reared brook trout grew larger than rainbow trout when raised separately**, but their **growth was significantly reduced when the two species were reared together**. Rainbow trout consistently outgrew brook trout under all feeding levels in mixed groups, suggesting that **behavioral interactions and competition with rainbow trout can suppress brook trout growth** even when food availability is high.

7. Huntsman, B. M., Merriam, E. R., Rota, C. T., & Petty, J. T. (2023). Non-native species limit stream restoration benefits for brook trout. *Restoration Ecology*, *31*(1), e13678. https://doi.org/10.1111/rec.13678

This study found that stream **habitat restoration increased brook trout occupancy <u>only</u> in restored reaches where non-native brown trout were absent**. The results indicate that **habitat restoration alone may not benefit native brook trout if it also improves conditions for brown trout**, emphasizing that effective brook trout conservation should address invasive trout alongside habitat restoration.

8. Trego, C. T., Merriam, E. R., & Petty, J. T. (2019). Non-native trout limit native brook trout access to space and thermal refugia in a restored large-river system. *Restoration Ecology*, *27*(4), 892-900. https://doi.org/10.1111/rec.12925
This study found that **non-native brown and rainbow trout displaced brook trout from preferred habitats within restored stream pools**, forcing them into shallower, faster, and less thermally suitable areas. The authors concluded that **habitat restoration in large rivers may provide limited benefits for native brook trout unless non-native trout are also removed**, as invasive trout can dominate the highest-quality restored habitats.

9. Fausch, K. D., & White, R. J. (1981). Competition Between Brook Trout (*Salvelinus fontinalis*) and Brown Trout (*Salmo trutta*) for Positions in a Michigan Stream. *Canadian Journal of Fisheries and Aquatic Sciences,* 38, 1220-1227. https://doi.org/10.1139/f81-164
This study found that **brown trout displaced brook trout from preferred resting habitats**, particularly larger brook trout, which occupied higher-quality, shaded resting positions after brown trout were removed. The authors concluded that **competition for limited habitat, combined with factors such as predation on juvenile brook trout, angling pressure, and environmental stressors, likely contributes to brook trout declines** and brown trout expansion in streams where the two species coexist.

10. Hitt, N. P., Snook, E. L., & Massie, D.L. (2016). Brook trout use of thermal refugia and foraging habitat influenced by brown trout. *Canadian Journal of Fisheries and Aquatic Sciences.* https://doi.org/10.1139/cjfas-2016-0255
This study found that brook trout increasingly relied on cold groundwater refuges as stream temperatures rose, but the **presence of non-native brown trout limited native brook trout movement and access to foraging habitat** outside these refuges. The authors concluded that removing brown trout could improve brook trout population viability and allow native populations to expand into downstream habitats, particularly where cold groundwater refuges are available.

11. Alexander, G.R. (1977). Consumption of small trout by large predatory brown trout in the North Branch of the Au Sable River, Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1855.
https://www2.dnr.state.mi.us/publications/pdfs/DNRFishLibrary/ResearchReports/RR1801-RR1900/RR1855.pdf

This study found that large **brown trout preyed heavily on small trout, particularly brook trout, making them the most significant natural predator of trout in the study river**. The authors concluded that while brown trout predation may help regulate dense populations of small trout and support growth of trophy-sized brown trout, it is likely detrimental to brook trout populations where conservation of native brook trout is a primary management objective.

12. Hoxmeier, R. J. H., & Dieterman, D. J. (2012). Demographic Responses of Brook Trout to Removal of Brown Trout from a Driftless Area Stream in Minnesota. Minnesota Department of Natural Resources, Final Report STUDY 677. https://files.dnr.state.mn.us/areas/fisheries/lanesboro/research/677report.pdf
This field study found that **removing brown trout led to increased brook trout abundance**, primarily through greater recruitment, immigration, and growth, while also increasing the proportion of larger brook trout in the population. These results provide **evidence that brown trout can suppress brook trout populations in natural streams and suggest that reducing brown trout abundance can improve brook trout population size and structure**.

13. U.S. Geological Survey. (2020). *Effects of introduced species on native brook trout: A guide to the scientific literature.* U.S. Geological Survey. https://www.usgs.gov/centers/chesapeake-bay-activities/science/effects-introduced-species-native-brook-trout-a-guide
This USGS literature review concluded that introduced trout, particularly **brown trout and rainbow trout, can reduce the growth, abundance, and occurrence of native brook trout**, although the magnitude of these effects varies with region and environmental conditions. The review also found evidence that non-native trout can interact with disease and climate change to further threaten brook trout populations, and **highlighted the removal of brown trout as a promising management strategy to support native brook trout conservation**.

14. Hudy, M., Thieling, T. M., Gillespie, N., & Smith, E. P. (2008). Distribution, status, and land use characteristics of subwatersheds within the native range of brook trout in the eastern United States. *North American Journal of Fisheries Management,* 28(4), 1069–1085. https://doi.org/10.1577/M07-017.1
This study found that **self-sustaining brook trout populations have been substantially reduced across their native range**, with only 31% of subwatersheds retaining more than half of their historical brook trout habitat and 28% having lost self-sustaining populations entirely. The authors identified habitat degradation associated with land use and **the presence of naturalized non-native fishes as major threats to remaining brook trout**

populations, emphasizing that conserving forested watersheds and limiting invasive species are critical for brook trout conservation.

15. Marschall, E. A., & Crowder, L. B. (1996). Assessing population responses to multiple anthropogenic effects: A case study with brook trout. *Ecological Applications*, 6(1), 152–167. https://doi.org/10.2307/2269561
This modeling study found that **brook trout populations are affected by multiple human-caused stressors, including non-native rainbow trout**, acidification, siltation, and fishing pressure, but that some factors have much greater impacts than others. The authors concluded that **reduced growth and survival caused by non-native trout**, acid deposition, and severe siltation **can substantially reduce brook trout populations**, whereas increased fishing pressure alone was unlikely to cause population collapse.

16. Larson, G. L., & Moore, S. E. (1985). Encroachment of Exotic Rainbow Trout into Stream Populations of Native Brook Trout in the Southern Appalachian Mountains. *Transactions of the American Fisheries Society*, *114*(2), 195-203. https://doi.org/10.1577/1548-8659(1985)114%3C195:EOERTI%3E2.0.CO;2
This study found that **native brook trout have been progressively displaced by introduced rainbow trout in the southern Appalachian Mountains**, with brook trout largely restricted to upper headwater reaches while rainbow trout dominate lower stream sections. The authors concluded that **competition with rainbow trout forces brook trout into less favorable habitats** and, without management intervention, will likely continue to **reduce brook trout to isolated headwater refuges and eliminate them from many streams**.

Impacts of Stocked Non-Native Fish on Native Species Other than Brook Trout

17. Gimenez, M., & Cucherousset, J. (2024). Can habitat enhancement limit the ecological impacts of predatory fish stocking? An experimental approach. *Knowledge & Management of Aquatic Ecosystems*. https://doi.org/10.1051/kmae/2024004
This mesocosm* experiment found that **stocking a predatory fish altered zooplankton community structure**, but habitat enhancement with coarse woody habitat partially reduced these impacts, particularly when wood was contained within cages. However, **habitat enhancement alone was not sufficient to fully offset the ecological effects of fish stocking, indicating that habitat restoration cannot completely mitigate stocking impacts on aquatic ecosystems**.
**a small-scale, experimental ecosystem that simulates natural environmental conditions in a controlled setting*

18. Holmes, T. G., Tonn, W. M., Paszkowski, C. A., & Scrimgeour, G. J. (2017). Limited effects of non-native trout on microcrustacean zooplankton in boreal foothills lakes: comparisons of stocked, unstocked, and fishless lakes. *Canadian Journal of Fisheries and Aquatic Sciences*, 74(4), 598-608. https://doi.org/10.1139/cjfas-2015-0495
This study found that **introducing non-native trout into lakes already containing native fish had relatively little additional effect on zooplankton communities beyond the impacts of existing fish populations**. In contrast, fishless lakes supported distinctly different zooplankton communities, suggesting that native fish had already shaped these ecosystems and that **trout stocking produced comparatively minor additional ecological changes in lakes where fish were already presen**t.

19. Houde, A. L. S., Smith, A. D., Wilson, C. C., Peres-Neto, P. R., & Neff, B. D. (2014). Competitive effects between rainbow trout and Atlantic salmon in natural and artificial streams. Ecology of Freshwater Fish, 25(2), 248-260. https://doi.org/10.1111/eff.12206
This study found that **the presence of non-native rainbow trout reduced the growth, condition, and habitat quality of juvenile Atlantic salmon by displacing them into less favorable habitats**. The authors concluded that restoration of native salmonids is more likely to succeed when reintroduced populations are selected for strong competitive ability and when restoration occurs in habitats free of non-native competitors.

20. Matthews, K. R. (2001). The influence of introduced trout on native aquatic invertebrate communities in a paired watershed study of High Sierran streams. University of California. https://escholarship.org/uc/item/1tr6k62h
This study found that **introduced trout altered the structure and function of high-elevation stream ecosystems** in the Sierra Nevada by reducing the abundance of many native aquatic invertebrates—particularly endemic species—and increasing algal biomass and certain prey taxa. The authors concluded that **non-native trout can negatively affect stream biodiversity and recommended trout removal, coupled with long-term monitoring, as a strategy to restore native invertebrate communities and ecological function**.

21. Gall, B. G., & Mathis, A. (2009). Innate predator recognition and the problem of introduced trout. Ethology, 116(1), 47–58. https://doi.org/10.1111/j.1439-0310.2009.01718.x
This study found that **larval eastern hellbenders recognized and responded to chemical cues from native fish predators but failed to recognize introduced brown trout and rainbow trout as threats**. The authors concluded that this lack of innate predator recognition may increase predation by non-native trout and **could contribute to declines of native hellbender populations where these introduced fish occur**.

22. Epanchin, P. N., Knapp, R. A., & Lawler, S. P. (2010). Non-native trout impact an alpine-nesting bird by altering aquatic-insect subsidies. *Ecology*, *91*(8), 2406-2415. https://doi.org/10.1890/09-1974.1
This study found that **introduced trout dramatically reduced emerging aquatic insects**, with fish-containing lakes producing 98% fewer mayflies than fishless lakes, thereby reducing an important food subsidy to terrestrial wildlife. As a result, Gray-crowned Rosy-Finches were nearly six times more abundant at fishless lakes, **demonstrating that trout introductions can have cascading ecological effects that extend beyond aquatic ecosystems and negatively affect terrestrial species**.

23. Whiting, D. P., Paukert, C. P., Healy, B. D., & Spurgeon, J. J. (2014). Macroinvertebrate prey availability and food web dynamics of non-native trout in a Colorado River tributary, Grand Canyon. *Freshwater Science*, *33*(3), 872-884. https://doi.org/10.1086/676915
This study found that **non-native brown and rainbow trout consumed large numbers of aquatic invertebrates and, in the case of larger brown trout, native fish**, **while also overlapping in diet with native fish species**. The authors concluded that suppressing non-native trout populations could benefit native fishes by reducing both predation and competition for food resources.

24. Schilling, E. G., Loftin, C. S., & Huryn, A. D. (2009). Effects of introduced fish on macroinvertebrate communities in historically fishless headwater and kettle lakes. *Biological Conservation*, *142*(12), 3030-3038. https://doi.org/10.1016/j.biocon.2009.08.003
This study found that **fish stocking significantly altered macroinvertebrate communities in historically fishless lakes by reducing species richness and eliminating taxa characteristic of fishless ecosystems**. In headwater lakes, these effects occurred rapidly—within three years of brook trout introduction—and became more severe with prolonged stocking, leading the authors to recommend protecting remaining fishless lakes and restoring those that have been stocked.

25. Burrell, H. L. A. (2004). *The Effect Of Introduced Trout On Native, Non-Game Fish In The Watauga River, NC* [Graduate Thesis, College of Arts and Sciences]. https://appstate.figshare.com/articles/thesis/The_Effect_Of_Introduced_Trout_On_Native_Non-Game_Fish_In_The_Watauga_River_NC/29866766?file=57041819
This study found that **stocking non-native trout caused significant declines in the abundance of nearly all native non-game fish species in the study reach, with cyprinid species showing the greatest declines, despite little change in overall community composition**. The results **suggest that both direct predation and predator-induced behavioral changes (causing native fish to avoid or leave stocked areas) contributed to these declines**, leading the author to recommend against trout stocking in waters supporting threatened or endangered native fish species.

26. Miller, R. R., Williams, J. D., & Williams, J. E. (1989). Extinctions of North American Fishes During the Past Century. *Fisheries. 14*(6), 22-38. DOI:10.1577/1548-8446(1989)014<0022:EONAFD>2.0.CO;2
This review documented **the extinction of 43 native fish taxa in North America over the previous century** and found that most extinctions were caused by multiple interacting threats. Habitat alteration was the most common contributing factor, but **introduced species were implicated in 68% of extinctions, highlighting non-native species as one of the leading drivers of native fish declines alongside habitat degradation**.

27. Alexiades, A.V., & Kraft, C.E. (2017). Effects of stocked trout on stream invertebrate communities, *Journal of Freshwater Ecology*, 32:1, 95-102, DOI: 10.1080/02705060.2016.1248502
This study found that **stocking brown trout significantly altered stream macroinvertebrate community structure within just two months of stocking**, despite the fact that nearly all stocked trout died or were harvested within a year. The results **demonstrate that even short-term pulses of stocked trout can produce measurable ecological changes in aquatic invertebrate communities**.

28. Sowersby, W., Thompson, R.M. & Wong, B.B.M. (2016). Invasive predator influences habitat preferences in a freshwater fish. *Environ Biol Fish* 99, 187–19. https://doi.org/10.1007/s10641-015-0466-5
This study found that **native riffle galaxiids altered their behavior in response to introduced rainbow trout**, avoiding them when only simple sand habitat was available but not when complex cobble habitat was present. The authors concluded that structurally complex habitats may provide refuge from invasive trout, allowing native fish to coexist despite the presence of a non-native predator.

29. Hatch Magazine. (2023). 50 years of research overwhelmingly shows hatcheries are harmful to trout, salmon, char, and more. *Hatch Magazine,* https://hatchmag.com/articles/50-years-research-overwhelmingly-shows-hatcheries-are/7715778
This article highlights **a global review of more than 50 years of peer-reviewed research on hatchery salmonids**, reporting that **83% of studies found hatcheries negatively affected wild salmonid populations**, while only 3% found beneficial effects. The review concluded that hatcheries should be used cautiously and only for clearly defined conservation purposes, as they can **reduce the abundance, fitness, genetic diversity, and resilience of wild fish populations when used to supplement existing wild populations.**

Ecological Impacts of Fish Stocking

30. Alexiades, A. V., Flecker, A. S., & Kraft, C. E. (2017). non-native fish stocking alters stream ecosystem nutrient dynamics. *Ecological Applications*, *27*(3), 956-965. https://doi.org/10.1002/eap.1498
This study found that **stocking hatchery-raised brown trout at high densities created** a **substantial** but **short-lived nutrient pulse in streams**, **supplying enough ammonium to meet up to 85% of in-stream nitrogen demand** for approximately **6–8 weeks after stocking**. The results demonstrate that fish stocking can significantly alter stream nutrient cycling by increasing nutrient availability, even though these effects diminish as stocked fish die or are harvested.

31. Eby, L. A., Roach, W. J., Crowder, L. B., & Stanford, J. A. (2006). Effects of stocking-up freshwater food webs. *Trends in Ecology & Evolution*, 21(10), 576–584. https://doi.org/10.1016/j.tree.2006.06.016
This review found that **stocking non-native game fish can alter freshwater ecosystems far beyond their direct effects on native species** by **strengthening top-down predation**, **changing nutrient cycling**, and **disrupting ecological connections between aquatic and terrestrial environments**. The authors argue that fisheries management should consider these ecosystem-wide consequences when evaluating fish stocking practices rather than focusing solely on recreational fisheries.

32. Haubrock, P. J., Novello, M., Abreo, N. A., Błońska, D., Sampaio Franco, A. C., Soto, I., Castaldelli, G., Katsanevakis, S., Kouba, A., Balzani, P., Kurtul, I., Tarkan, A. S., Briski, E., & Britton, J. R. (2025). A global account of established non-native fish species. *Global Change Biology,* 31(8), e70451. https://doi.org/10.1111/gcb.70451
This global review identified **1,535 established non-native fish species across 193 countries** and found that the primary pathways of introduction include the aquarium trade, aquaculture, fishery enhancement (stocking), and artificial waterways. Where ecological impacts have been studied, **non-native fishes most commonly threaten native biodiversity through competition and predation**, underscoring the need for stronger prevention and management strategies to reduce the impacts of fish introductions.

33. Crone, E. R., Sauer, E. L., & Preston, D. L. (2023). Non-native fish facilitate non-native snails and alter food web structure in experimental pond communities. *Functional Ecology*, 37(4), 947–958. https://doi.org/10.1111/1365-2435.14274
This study found that **introduced goldfish had strong direct and indirect effects on aquatic ecosystems**, increasing water turbidity, reducing native amphibians, snails, zooplankton, and algae, and altering food web dynamics. Goldfish also **facilitated the success of another invasive species**, the Chinese mystery snail, by increasing its

reproductive success, providing experimental evidence that interactions among non-native species can amplify their ecological impacts.

34. Koel, T. M., Tronstad, L. M., Arnold, J. L., Gunther, K. A., Smith, D. W., Syslo, J. M., & White, P. J. (2019). Predatory fish invasion induces within and across ecosystem effects in Yellowstone National Park. *Science Advances*, 5(3), eaav1139. https://doi.org/10.1126/sciadv.aav1139
This long-term study found that introducing **predatory lake trout caused cascading ecological changes** throughout the Yellowstone Lake ecosystem by dramatically **reducing native cutthroat trout** populations, **altering plankton communities,** and **decreasing nutrient transport to tributary streams**. These **impacts extended beyond the lake**, reducing food availability for bears and ospreys, altering bald eagle diets, and demonstrating that introduced predatory fish can fundamentally disrupt both aquatic and terrestrial ecosystems.

35. Rocha, B. S., Rodrigues, A. C., & Granzotti, R. V. (2025). Widespread freshwater non-native fishes exhibit synchronized population dynamics with functionally similar natives. *Scientific Reports*, 15, Article 19753. https://doi.org/10.1038/s41598-025-04587-z
This global study found that **non-native fish species** were **more likely to exhibit population dynamics similar to native species** with comparable ecological and morphological traits, suggesting that functionally **similar invaders can integrate into and influence native communities**. The authors concluded that these similarities **may increase ecological synchrony and reduce community stability**, highlighting the long-term ecological risks posed by non-native fish invasions.

36. Adams, M. J., Pearl, C. A., & Bury, R. B. (2003). Indirect facilitation of an anuran invasion by non-native fishes. *Ecology Letters*, 6(4), 343–351. https://doi.org/10.1046/j.1461-0248.2003.00435.x
This study found that **one invasive species can facilitate the success of another**: introduced sunfish increased the survival of invasive bullfrog tadpoles by reducing native dragonfly predators. The authors **concluded that positive interactions among non-native species can amplify biological invasions through indirect ecological mechanisms**, providing experimental support for the **invasional meltdown hypothesis**.

37. Hagen, I. J., Jensen, A. J., Bolstad, G. H., et al. (2019). Supplementary stocking selects for domesticated genotypes. *Nature Communications,* 10, Article 199. https://doi.org/10.1038/s41467-018-08021-z
This study found that **stocking can unintentionally increase the spread of domesticated genes** in wild Atlantic salmon populations when broodstock are already genetically introgressed with farmed fish. The authors showed that **hatchery conditions favored introgressed fish**, which produced up to four times more returning adult offspring than

non-introgressed broodstock, **potentially reducing the long-term fitness of wild populations.**

38. Bekkevold, D., Besnier, F., Frank-Gopolos, T., Nielsen, E. E., & Glover, K. A. (2024). Introgression affects Salmo trutta juvenile life-history traits generations after stocking with non-native strains. *Evolutionary Applications*, 17(7), e13725. https://doi.org/10.1111/eva.13725
This study found that **stocking with non-native hatchery brown trout led to persistent genetic introgression** that increased growth in wild populations, with these effects remaining detectable even after several generations in the wild. The authors concluded that **hatchery introgression can alter traits linked to local adaptation and may have long-term ecological and conservation consequences**, particularly as warming temperatures may further favor introgressed fish.

39. Araki, H., Berejikian, B. A., Ford, M. J., & Blouin, M. S. (2008). Fitness of hatchery-reared salmonids in the wild. *Evolutionary Applications*, 1(2), 342–355. https://doi.org/10.1111/j.1752-4571.2008.00026.x
This review found that **hatchery fish generally have lower reproductive success and survival in the wild than wild fish**, with fitness declines occurring after as little as one or two generations in captivity. The authors concluded that **rapid domestication in hatcheries can reduce the fitness of stocked populations,** particularly when captive breeding alters multiple traits under selection, and that **even hatchery programs using local wild broodstock may produce fish that perform worse** than naturally reproducing wild fish.

40. Cavalcante L.L., Occhi T.V.T., Olden J.D., Padial A.A. (2025). Non-native species drive the global loss of freshwater fish beta-diversity. *NeoBiota* 97: 257-277. https://doi.org/10.3897/neobiota.97.126607
This study found that **non-native fish introductions have significantly altered global freshwater fish diversity by reducing the uniqueness of fish communities across watersheds**, leading to increasing **biotic homogenization**. The authors concluded that watersheds with high numbers of endemic and threatened native species are particularly important for maintaining freshwater biodiversity and that preventing non-native species introductions is critical for conserving distinct fish communities.

41. Cucherousset, J., & Olden, J. D. (2011). Ecological Impacts of Non-native Freshwater Fishes. *Fisheries*, *36*(5), 215-230. https://doi.org/10.1080/03632415.2011.574578
This review found that **non-native freshwater fishes can have widespread ecological, evolutionary, and economic impacts**, **affecting organisms from zooplankton to mammals and altering biological processes from the genetic to ecosystem level**. The

authors conclude that **invasive fishes are a major threat to freshwater biodiversity** and emphasize **the need for more geographically, taxonomically, and methodologically diverse research** to better understand and manage their impacts.

42. Moi, D. A., Alves, D. C., Figueiredo, B. R. S., Antiqueira, P. A. P., Teixeira de Mello, F., Jeppesen, E., Romero, G. Q., Mormul, R. P., & Bonecker, C. C. (2021). Non-native fishes homogenize native fish communities and reduce ecosystem multifunctionality in tropical lakes over 16 years. *Science of The Total Environment*, *769*, 144524. https://doi.org/10.1016/j.scitotenv.2020.144524
This long-term study found that **increasing richness and biomass of non-native fish were associated with declining native fish diversity, greater biotic homogenization, and reduced ecosystem multifunctionality** in tropical lakes. The authors concluded that non-native fishes can diminish ecosystem functioning by replacing native species and emphasized the importance of long-term monitoring to understand the ecological consequences of biological invasions.

43. Araki, H., Berejikian, B. A., Ford, M. J., & Blouin, M. S. (2008). Fitness of hatchery-reared salmonids in the wild. *Evolutionary Applications*, *1*(2), 342-355. https://doi.org/10.1111/j.1752-4571.2008.00026.x
This review found that **hatchery fish generally have lower fitness in the wild than wild fish**, with declines occurring after as little as one or two generations of captive breeding. The authors concluded that hatchery fish derived from local wild populations typically perform better than nonlocal hatchery stocks but often still have lower survival and reproductive success than wild fish, likely due to rapid domestication selection acting on multiple traits.

Impacts of Hatchery Practices and Operations

44. Conservation Law Foundation. (2022). *EPA Joins CLF Lawsuit Against New Hampshire Fish Hatchery*. https://www.clf.org/newsroom/epa-joins-clf-lawsuit-against-new-hampshire-fish-hatchery/
This article reports that the U.S. Environmental Protection Agency intervened in a Clean Water Act lawsuit alleging that **New Hampshire's Powder Mill Fish Hatchery discharged excessive phosphorus pollution into the Merrymeeting River, contributing to toxic algal blooms and water quality degradation**.

45. Nappier, S. P., Liguori, K., Ichida, A. M., Stewart, J. R., & Jones, K. R. (2020). Antibiotic Resistance in Recreational Waters: State of the Science. *International Journal of Environmental Research and Public Health*, *17*(21). https://doi.org/10.3390/ijerph17218034

46. Skretting Impact Report 2024. www.skretting.com/siteassets/global/sustainability/pdfs/skretting-impact-report-2024.pdf?v=49d72b#page=13

47. Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., Eshel, G., Golden, C. D., Halpern, B. S., Hornborg, S., Jonell, M., Metian, M., Mifflin, K., Newton, R., Tyedmers, P., Zhang, W., Ziegler, F., & Troell, M. (2021). Environmental performance of blue foods. *Nature*, *597*(7876), 360-365. https://doi.org/10.1038/s41586-021-03889-2

48. MacLeod, M. J., Hasan, M. R., Robb, D. H. F., et al. (2020). Quantifying greenhouse gas emissions from global aquaculture. *Scientific Reports*, 10, Article 11679. https://doi.org/10.1038/s41598-020-68231-8

49. Liu, X., Wang, Y., Liu, H., Zhang, Y., Zhou, Q., Wen, X., Guo, W., & Zhang, Z. (2024). A systematic review on aquaculture wastewater: Pollutants, impacts, and treatment technology. *Environmental Research*, 262(Part 1), Article 119793. https://doi.org/10.1016/j.envres.2024.119793

50. Kashem, A. H. M., Das, P., Hawari, A. H., et al. (2023). Aquaculture from inland fish cultivation to wastewater treatment: A review. *Reviews in Environmental Science and Biotechnology*, 22, 969–1008. https://doi.org/10.1007/s11157-023-09672-1
This review found that **aquaculture wastewater contains nutrients and other pollutants that can contribute to eutrophication and the spread of antimicrobial-resistant organisms** if discharged untreated. The authors conclude that effective physical, chemical, and biological wastewater treatment technologies are essential for reducing environmental impacts, enabling water reuse, and supporting more sustainable aquaculture practices.

51. Li, Y., Shang, J., Zhang, C., et al. (2021). The role of freshwater eutrophication in greenhouse gas emissions: A review. *Science of the Total Environment*, 768, Article 144582. https://doi.org/10.1016/j.scitotenv.2020.144582

52. Cañedo-Argüelles, M., Kefford, B., & Schäfer, R. (2018). Salt in freshwaters: Causes, effects and prospects - introduction to the theme issue. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *374*(1764), 20180002. https://doi.org/10.1098/rstb.2018.0002

53. Beketov, M. A., Kefford, B. J., Schäfer, R. B., & Liess, M. (2013). Pesticides reduce regional biodiversity of stream invertebrates. *Proceedings of the National Academy of Sciences*, *110*(27), 11039-11043. https://doi.org/10.1073/pnas.1305618110

54. Kaushal, S.S., Likens, G.E., Pace, M.L. *et al.* (2021). Freshwater salinization syndrome: from emerging global problem to managing risks. *Biogeochemistry* 154, 255–292. https://doi.org/10.1007/s10533-021-00784-w

Additional References and Supporting Resources

55. Benbow, M. E., Receveur, J. P., & Lamberti, G. A. (2020). Death and decomposition in aquatic ecosystems. *Frontiers in Ecology and Evolution*, 8, Article 17. https://doi.org/10.3389/fevo.2020.00017
This review found that **animal carcasses are an important** but **often overlooked source of nutrients and energy in aquatic ecosystems,** with **decomposition influencing nutrient cycling, food webs, and ecosystem processes across a wide range of freshwater and marine environments**. The authors conclude that both natural and human-caused pulses of carrion—including fish die-offs and introduced spawning fish—can **have substantial and lasting ecological effects**, and that these nutrient subsidies should be more fully considered in aquatic ecosystem management.

56. Commonwealth of Massachusetts. (2023). Executive Order No. 618: Biodiversity conservation in Massachusetts. https://www.mass.gov/doc/executive-order-no-618-biodiversity-conservation-in-massachusetts

57. Mass Audubon. (2025). Q & A with Department of Fish & Game Commissioner Tom O'Shea, massaudubon.org

58. Childress, E. S., Demarest, E. D., Wofford, J. E. B., Hitt, N. P., & Letcher, B. H. (2024). Strong variation in brook trout trends across geology, elevation, and stream size in Shenandoah National Park. *Transactions of the American Fisheries Society*, 153(2), 250–263. https://doi.org/10.1002/tafs.10460
This study found that **brook trout abundance declined substantially across Shenandoah National Park over a 27-year period**, with **roughly 70% of monitored streams losing at least half of their populations** and **several streams experiencing apparent local extirpations**. The authors concluded that warming stream temperatures were the primary driver of these declines, although brook trout populations increased in some acid-sensitive watersheds as water quality improved following reductions in acid deposition.

59. White, S. L., Miller, W. L., Dowell, S. A., Bartron, M. L., & Wagner, T. (2018). Limited hatchery introgression into wild brook trout (Salvelinus fontinalis) populations despite reoccurring stocking. *Evolutionary Applications*, 11(9), 1618–1631. https://doi.org/10.1111/eva.12646
This study found that **hatchery brook trout contributed relatively little genetic introgression into wild brook trout populations**, with over 93% of sampled wild fish showing no evidence of hatchery ancestry despite repeated stocking. However, **the authors caution that even low levels of introgression could affect the long-term fitness and adaptive potential of wild populations**, supporting a precautionary approach to stocking until its genetic consequences are better understood.

60. Manstan, S. E., Sullivan, C. J., & Vokoun, J. C. (2025). Movement and survival of stocked brown trout in a climate-altered fifth-order river. *North American Journal of Fisheries Management*, 45(2), 283–296. https://doi.org/10.1093/najfmt/vqaf013
This study found that most **stocked brown trout either disappeared from the stocking area or had low apparent survival**, particularly after a major flood event, **with spring-stocked fish surviving better than fall-stocked fish**. The authors concluded that environmental conditions, including discharge, water temperature, and access to deep pools and thermal refuges, strongly influence the movement and survival of stocked brown trout, highlighting the challenges of maintaining stocking programs in warming, highly variable river systems.

61. Massachusetts Division of Fisheries and Wildlife. (n.d.). Swift River fisheries research*.* https://www.mass.gov/info-details/swift-river-fisheries-research#2021-research-and-results

62. Kautza, A. (2023). Massachusetts wild trout fisheries [Video]. YouTube. https://www.youtube.com/watch?v=rG_HCRuGGFg
This presentation was delivered by MassWildlife fish biologist Adam Kautza at BEAT's speaker series, *Berkshire Green Drinks.* During the presentation, Kautza notes the high mortality rate among stocked trout due to travel shock and their inability to forage since they have been pellet-fed their entire lives. Kautza also acknowledges the lack of research on how trout stocking affects native brook trout populations or the broader ecosystem.

63. Nobre, R. L., Carneiro, L. S., Panek, S. E., González, M. J., & Vanni, M. J. (2019). Fish, including their carcasses, are net nutrient sources to the water column of a eutrophic lake. *Frontiers in Ecology and Evolution*, 7, Article 340. https://www.doi.org/10.3389/fevo.2019.00340
This study found that **fish populations can strongly influence nutrient cycling**, with **nearly all nitrogen and phosphorus contained in fish carcasses eventually being returned to the water column through decomposition**. Although fish temporarily stored nutrients in their biomass, nutrient excretion greatly exceeded nutrient sequestration over the long term, making the **fish population a net source of nutrients to the lake's pelagic ecosystem.**

64. U.S. Environmental Protection Agency. (2025, February 7). Nutrients and eutrophication*.* EPA CADDIS. https://www.epa.gov/caddis/nutrients-and-eutrophication

65. Wood, C. (2020, September 18). Native and Wild. Trout Unlimited. https://tu.org/magazine/from-the-president/native-and-wild
This article, written by the President & Chief Executive Officer of Trout Unlimited, argues that fisheries management should prioritize protecting and restoring self-sustaining wild and native trout populations over stocking hatchery fish, except where natural reproduction

is not feasible. It cites scientific evidence that stocking hatchery or non-native trout can lead to competition, disease transmission, hybridization, and genetic impacts on wild populations, while advocating habitat restoration as the preferred long-term conservation strategy.

66. Cardoza, J. E. (2015). The Massachusetts Division of Fisheries and Wildlife: 1866-2012. https://www.mass.gov/doc/a-history-of-masswildlife-1866-2012-complete-text/download

67. MassWildlife Annual Reports https://www.mass.gov/info-details/masswildlife-annual-reports

68. Smithsonian Environmental Research Center. Myxobolus cerebralis: Whirling Disease. https://invasions.si.edu/nemesis/chesreport/species_summary/myxobolus%20cerebralis#:~:text=The%20suspected%20source%20of%20the,(Bergersen%20and%20Anderson%201997).

69. Massachusetts Department of Public Health (December 2025). Freshwater Fish Consumption Advisory List. https://www.mass.gov/doc/public-health-freshwater-fish-consumption-advisories-2025-0/download

70. Enforcement and Compliance History Online (ECHO) https://echo.epa.gov/facilities/facility-search/results

71. International Union for Conservation of Nature (IUCN). Global Invasive Species Database: 100 of the World's Most Invasive Alien Species. https://www.iucngisd.org/gisd/100_worst.php
The IUCN Invasive Species Database lists **rainbow trout and brown trout as two of the most harmful invasive species worldwide**.

72. Wildlife For All. (2026, March 22). State agencies' dependence on fish stocking reveals need for updated funding structure. https://wildlifeforall.us/fish-stocking-funding/
This article argues that **widespread stocking of non-native sport fish is driven in part by funding structures that incentivize recreational fishing**, often **at the expense of ecosystem health**. It c**ites scientific research indicating that stocked fish can displace native species, alter food webs, affect amphibians and birds, and reduce genetic integrity,** and advocates for wildlife management policies that prioritize habitat restoration and biodiversity over continued fish stocking.

73. Conniff, Richard. (November 2017). Gone Fishing. *Scientific American Magazine*, 317(5), pg 42. https://www.scientificamerican.com/article/the-trouble-with-fish-stocking/
This article **reviews scientific evidence that widespread stocking of non-native fish has contributed to declines in native fish, amphibians, and other aquatic species through competition, predation, hybridization, and ecosystem disruption**. It also describes a

growing shift in fisheries management toward reducing stocking in ecologically sensitive waters, restoring native habitats, and prioritizing conservation of self-sustaining native fish populations.

74. Mallard, Bob. (March 2023). Stop Stocking Over Wild Native Fish. *Northwoods Sporting Journal,* pages 25 & 27. https://sportingjournal.s3.amazonaws.com/2023-3/index.html#page=24
This article, written by the Executive Director of the Native Fish Coalition, argues that stocking hatchery fish over existing wild native fish populations is both biologically unsound and economically inefficient because it can disrupt natural reproduction, increase competition, introduce diseases and parasites, and reduce the genetic integrity of wild populations. It advocates prioritizing habitat protection and restoration over stocking where self-sustaining native fish populations already exist, while acknowledging that hatcheries may still have a role in restoring extirpated native populations.

75. Center for Biological Diversity. (N.d.) Fish-Stocking Reform. https://www.biologicaldiversity.org/campaigns/fish-stocking_reform/index.html