NFHP'S National Assessment of Fish Habitat

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[1] U.S. Geological Survey

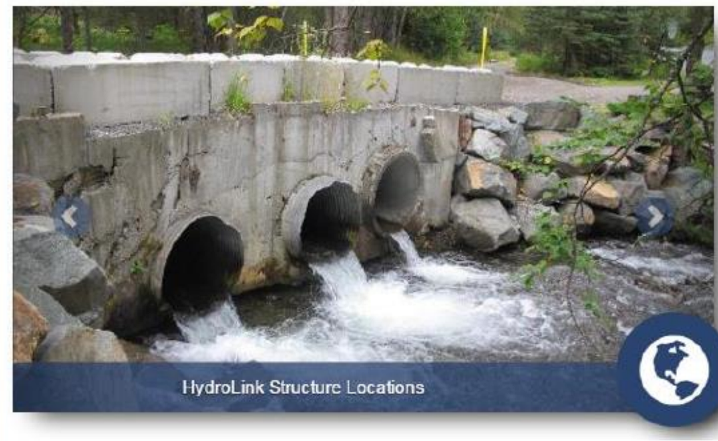
[2] Michigan State University

[3] Michigan Department of Natural Resources

April 24th, 2018

Instream Flow Council 2018

U.S. Department of the Interior
U.S. Geological Survey



Outline

- Through A Fish’s Eye
  - Intro
  - Estuary Assessments
  - Stream Assessments
  - Data Availability
- National Assessment Next Steps
- Building From NFHP Data and Spatial Framework – FLOW Related Examples

Through A Fish's Eye

http://assessment.fishhabitat.org

NATIONAL FISH HABITAT PARTNERSHIP

THROUGH A FISH'S EYE:
THE STATUS OF FISH HABITATS IN THE UNITED STATES 2015

This report summarizes the results of an unprecedented nationwide assessment of human effects on fish habitat in the rivers and estuaries of the United States. The assessment assigns a risk of current habitat degradation scores for watersheds and estuaries across the nation and within 14 sub-regions. The results also identify some of the major sources of habitat degradation.

Navigate this report by:

Explore the Assessment

Explore Regions

Last Update: 2017-08-01

Photo Credit: Katrina Mueller

National Fish Habitat Partnership (NFHP)

Collaboration of agencies, states, and non-profits working to: Protect, restore, and enhance the nation’s fish and aquatic communities through partnerships that foster fish habitat conservation

National Assessment of Fish Habitats stems from objectives outlined in NFHP’s action plan

USGS

Through A Fish's Eye

http://assessment.fishhabitat.org/#578a9a77e4b0c1aacab897e9/578a9a77e4b0c1aacab897e9SingleItem

NATIONAL FISH HABITAT PARTNERSHIP **Introduction** Report Authors and Citation

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These threats led to the 2006 development of the National Fish Habitat Partnership, a coalition of anglers, conversation groups, scientists, state and federal agencies, and industry leaders focused on improving America's fish habitat that will result in better fish populations. This group's Action Plan is a strategy for making the most effective use of conservation dollars to protect, restore, and enhance key fish habitats.

The objects of the first Action Plan in 2006 were to:

1. Conduct a condition analysis of all fish habitat within the United States by 2010.
2. Prepare a "Status of Fish Habitats in the United States" report in 2010 and every five years thereafter.
3. Identify priority fish habitats and establish Fish Habitat Partnerships targeting these habitats by 2010.
4. Establish 12 or more Fish Habitat Partnerships throughout the United States by 2010.
5. Protect all intact healthy fish habitats by 2015.

Through A Fish's Eye

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NATIONAL FISH HABITAT PARTNERSHIP

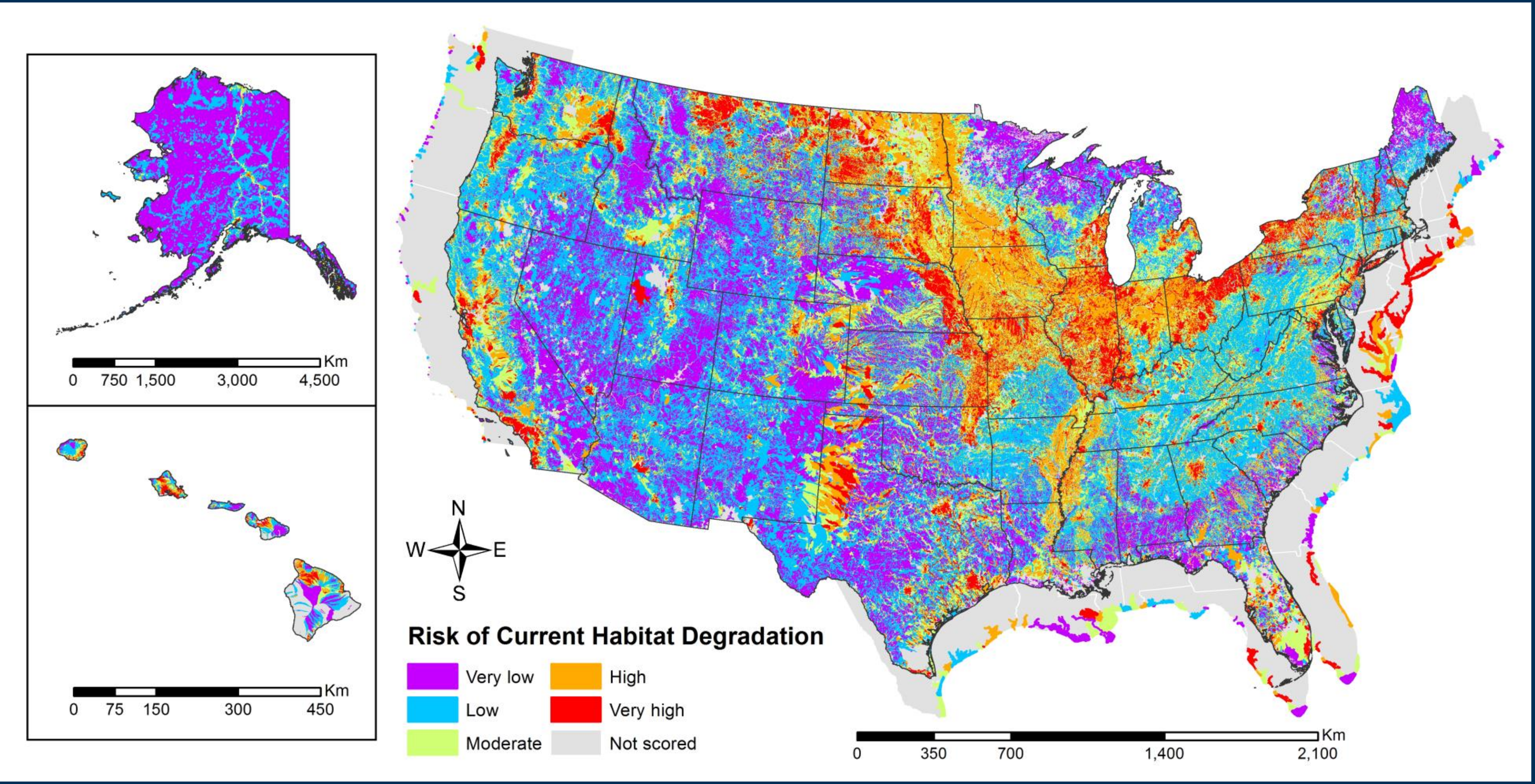
Introduction

The Action Plan was updated in 2012 with following objectives:

1. Achieve measurable habitat conservation results through strategic actions of Fish Habitat Partnerships that improve ecological condition, restore natural processes, or prevent the decline of intact and healthy systems leading to better fish habitat conditions and increased fishing opportunities.
2. Establish a consensus set of national conservation strategies as a framework to guide future actions and investment by the Fish Habitat Partnerships by 2013.
3. Broaden the community support for fish habitat conservation by increasing fishing opportunities, fostering the participation of local communities - especially young people – in conservation activities, and raising public awareness of the role healthy fish habitats play in the quality of life and economic well-being of local communities.
4. Fill gaps in the National Fish Habitat Assessment and its associated database to empower strategic conservation action supported by broadly available scientific information, and integrate socio-economic data in the analysis to improve people's lives in a manner consistent with fish habitat conservation goals.
5. Communicate the conservation outcomes produced collectively by Fish Habitat Partnerships as well as new opportunities and voluntary approaches for conserving fish habitat to the public and conservation partners.

Through A Fish's Eye

Inland Assessment of Streams: Conterminous U.S, Hawaii, and Alaska
Estuary Assessment: National and Gulf of Mexico



Estuary Assessment Team

National Estuary Assessment

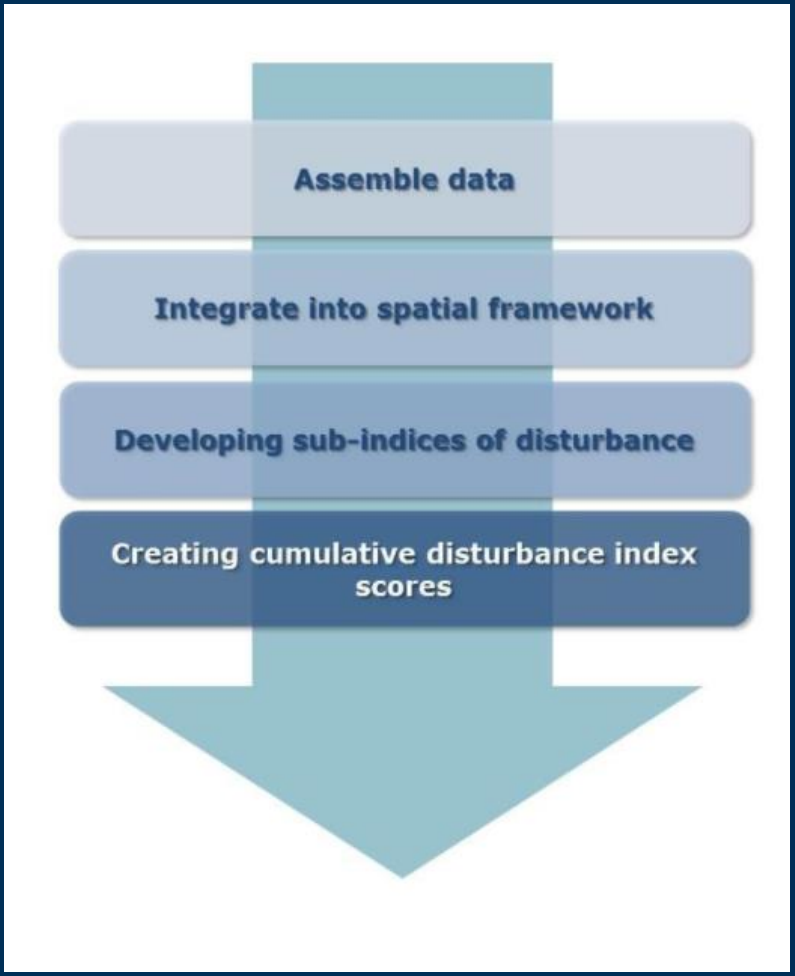
PI: Kristen Blackhart - NOAA

Through A Fish's Eye: National Estuary Assessment

http://assessment.fishhabitat.org/#578a9a43e4b0c1aacab89763/578a9a38e4b0c1aacab8973e

Spatial Framework:

Figure 7: Spatial units used to analyze the effects of variables on estuaries.



28 Disturbance Metrics

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Spatial Units

Habitat Condition Indices

Through A Fish's Eye: National Estuary Assessment

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Disturbance Category	Variable	Units	Scale	Date	Source
Land Use / Land Cover	Agriculture	%	Shoreline	2010	C-CAP[1]
	Agriculture	%	EDA[2]	2010	C-CAP[1]
	Development	Intensity score	Shoreline	2010	C-CAP[1]
	Development	Intensity score	EDA[2]	2010	C-CAP[1]
	Estuarine	% change	Shoreline	2006-10	C-CAP[1]
	Estuarine	% change	EDA[2]	2006-10	C-CAP[1]
	Palustrine	% change	Shoreline	2006-10	C-CAP[1]
	Palustrine	% change	EDA[2]	2006-10	C-CAP[1]
	Undeveloped	% change	Shoreline	2006-10	C-CAP[1]
	Undeveloped	% change	EDA[2]	2006-10	C-CAP[1]
	Impervious surface[3]	%	Watershed	2011	MRLC[4]
	Population[3]	$\#/km^2$	EDA[2]	2010	U.S. Census[5]
Alteration of River Flows	Mean annual discharge	m^3/s	Watershed	2015	USGS; IBWC; EC[6]
	7-day minimum discharge	m^3/s	Watershed	2015	USGS; IBWC; EC[6]
	7-day maximum discharge	m^3/s	Watershed	2015	USGS; IBWC; EC[6]
	Low pulse duration	Days	Watershed	2015	USGS; IBWC; EC[6]
	High pulse duration	Days	Watershed	2015	USGS; IBWC; EC[6]
	Trend in minimum discharge	$m^3/s/year$	Watershed	2015	USGS; IBWC; EC[6]
	Trend in maximum discharge	$m^3/s/year$	Watershed	2015	USGS; IBWC; EC[6]
	Trend in low pulse duration	Days/year	Watershed	2015	USGS; IBWC; EC[6]
	Trend in high pulse duration	Days/year	Watershed	2015	USGS; IBWC; EC[6]
	Dam density[7]	$\#/km^2$	Watershed	2010	NID[8]
	Total water withdrawals[3]	mgal/year	EDA[2]	2005	USGS[9]
Sources of Pollution	Mines and mineral plants[7]	$\#/km^2$	Watershed	2003	USGS[10]
	EPA pollution sites	$\#/km^2$	Watershed	2015	EPA[11]
	Roads[3]	m/km^2	Shoreline	2015	U.S. Census[12]
	Roads[3]	m/km^2	EDA[2]	2015	U.S. Census[12]
Estuary Eutrophication	Overall eutrophic condition[13]	Categorical score	Estuary	1999; 2007	NEEA[14]

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Through A Fish's Eye: Gulf of Mexico Estuary Assessment

Detailed Methods: http://assessment.fishhabitat.org/#578a9a43e4b0c1aacab89763/578a9a38e4b0c1aacab8973e

Spatial Framework:

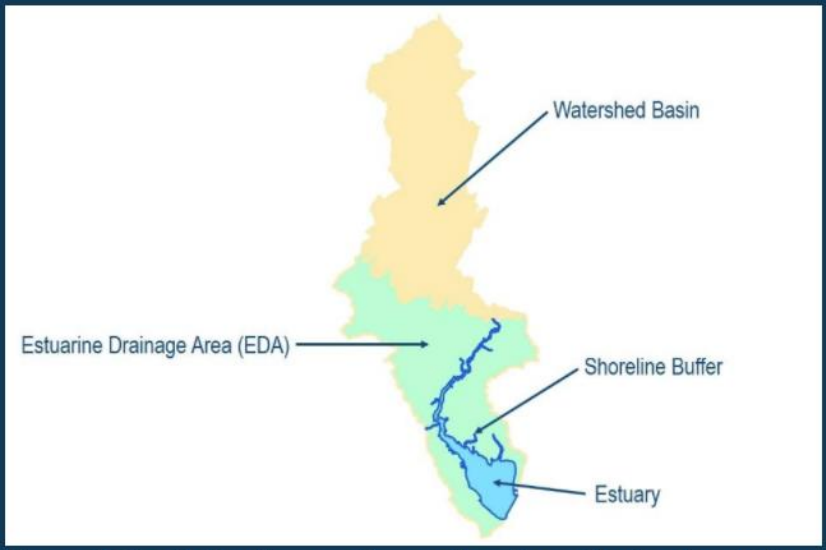

Figure 7: Spatial units used to analyze the effects of variables on estuaries.

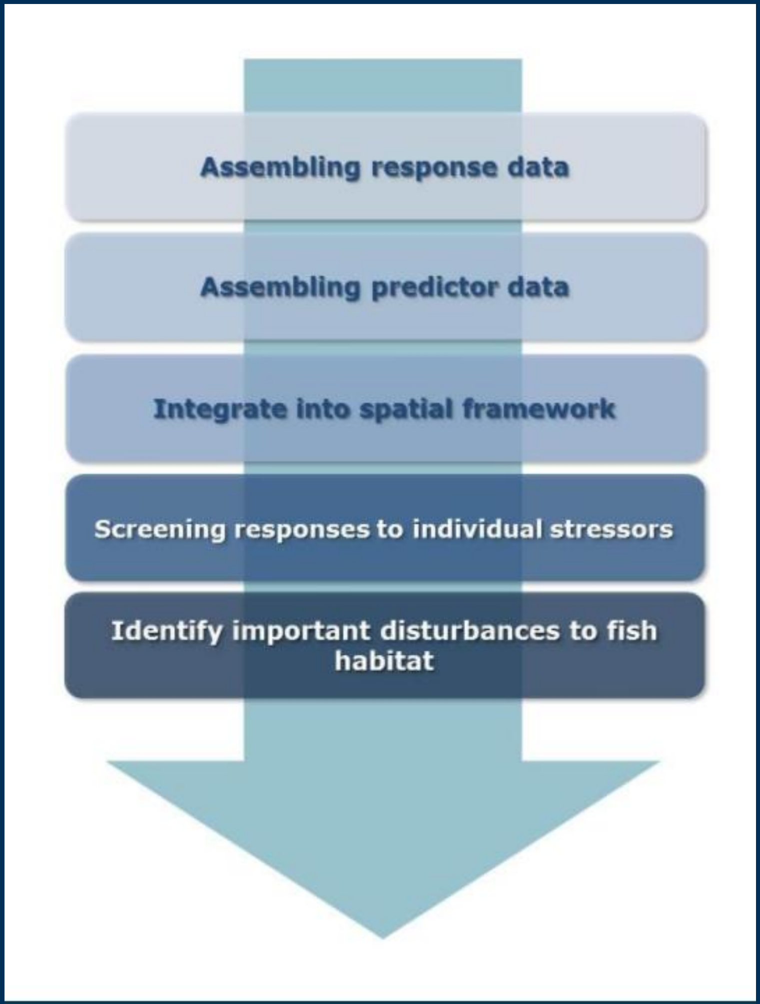

Figure9: Steps used for the 2015 Regional Estuary

87 estuary-level predictor variables

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Spatial Units

Habitat Condition Indices

Through A Fish's Eye: Gulf of Mexico Estuary
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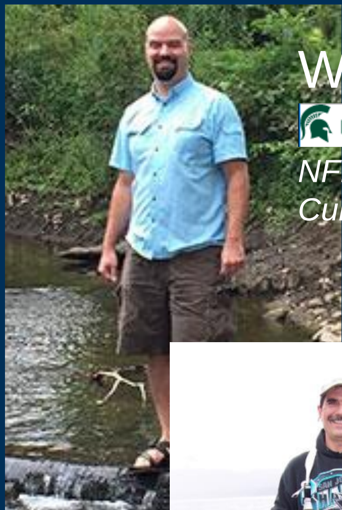
Variable	Unit	Normalization Factor					
		None	Estuary Area	Flow	Volume	Exchange	Land Area
Watershed Factors							
Shoreline Urban	km^2		*				*
Shoreline Hard	km^2		*				*
Shoreline Crop	km^2		*				*
Shoreline Agriculture	km^2		*				*
Shoreline Developed	km^2		*				*
Shoreline Wetlands	km^2		*				*
EDA Urban	km^2		*	*	*	*	*
EDA Hard	km^2		*	*	*	*	*
EDA Crop	km^2		*	*	*	*	*
EDA Agriculture	km^2		*	*	*	*	*
EDA Developed	km^2		*	*	*	*	*
Basin Urban	km^2		*	*	*	*	*
Basin Hard	km^2		*	*	*	*	*
Basin Crop	km^2		*	*	*	*	*
Basin Agriculture	km^2		*	*	*	*	*
Basin Developed	km^2		*	*	*	*	*
EDA Toxic Releases	#		*	*	*	*	
EDA NPDES Sites	#		*	*	*	*	
EDA Population	#		*	*	*	*	
Basin population	#		*	*	*	*	
N Load	kg/d		*	*	*	*	
Estuary Condition							
Estuary Salinity	%	*					
Estuary Openness	%	*					
Hypoxic Condition	I[1]	*					
Toxic Algal Condition	I[1]	*					
Eutrophication Condition	I[1]	*					

[1]"I" indicates a categorical variable on a 1 to 3 scale.

Inland Assessment Team



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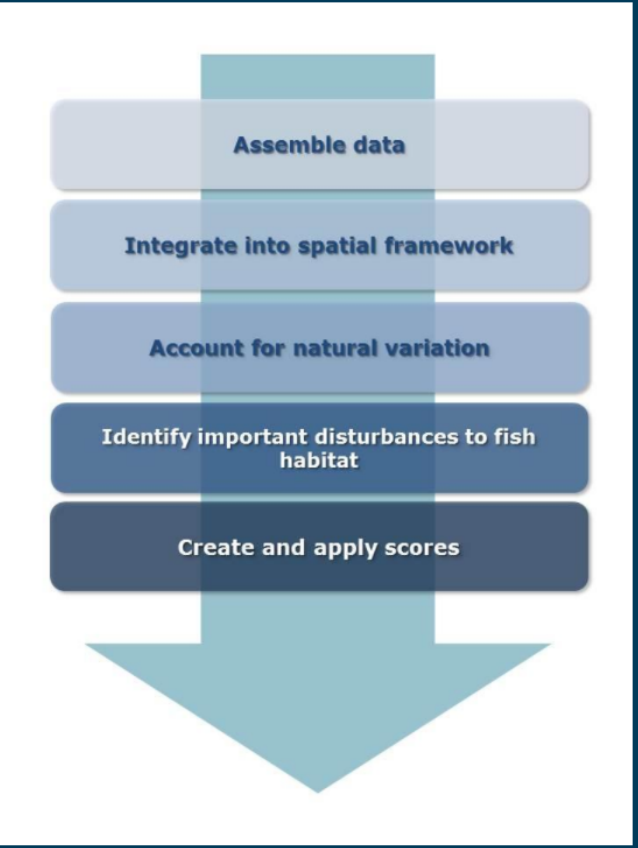
Through A Fish's Eye: Inland Assessment

http://assessment.fishhabitat.org/#578a9a48e4b0c1aacab8976c/578a99f4e4b0c1aacab89699

Detailed Methodology for Inland Stream Assessment for the Conterminous United States

Key elements of the 2015 national assessment of stream fish habitats follow the 2010 assessment, including: 1) the idea that fishes reflect the quality of habitat in which they live; and 2) human landscape factors pose a risk to the condition of stream habitat, and indirectly, to fishes. The assessment followed five broad steps (Figure 1), and each are described in detail below.



Through A Fish's Eye: Inland Assessment

Conterminous U.S.

Detailed Methods: http://assessment.fishhabitat.org/#578a9a43e4b0c1aacab89763/578a99f4e4b0c1aacab89699

*****Includes 4 spatial scales (local catchment, local buffer (90m), network catchment, network buffer (90m)**

Spatial Framework: NHDPlusV1 (1:100,000 scale) *** with connections to ecological and jurisdictional units

Community Fish Samples (1990-2012): 39,405
(single pass electrofishing, first pass on multiple pass population estimates)

26 Disturbance Metrics

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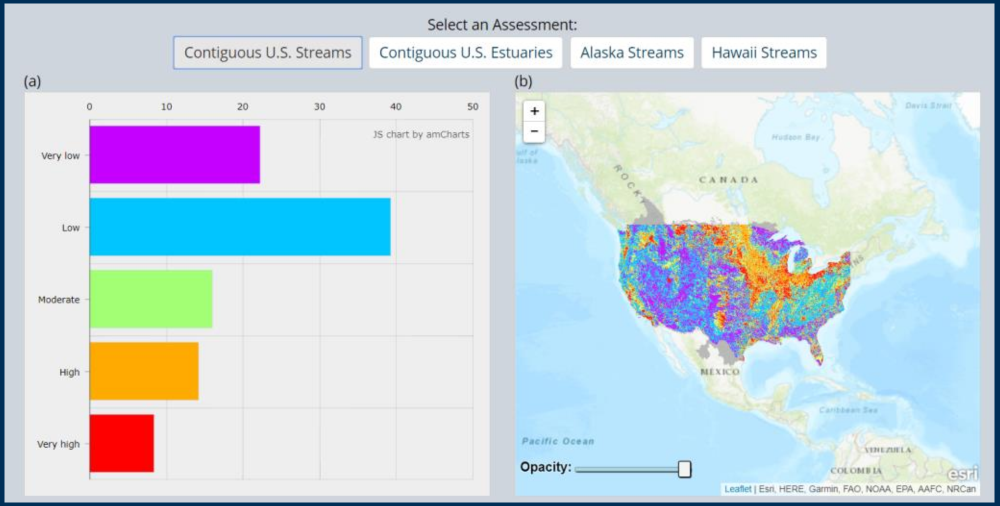
Habitat Condition Indices ***
Limiting Disturbance ***
Disturbance Summaries ***
Stream Fragmentation Statistics
Stream Flow Alteration Statistics



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Detailed Methods: http://assessment ... b0c1aacab89699

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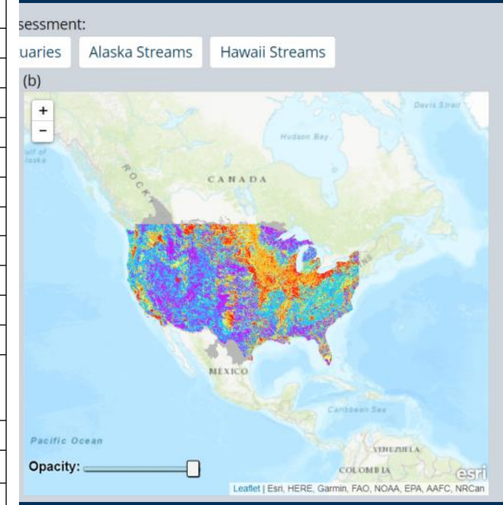
Stream Fragmentatio...

Stream Flow Alteratio...

Super Category	Variable	Units	Scale	Date	Source
Human landscape factors					
Mines	All mines (mineral, coal, uranium mine density)*	#/km^2	NA	2003, 2012	USTRAT[1], MRP[2]
	Coal mine density*	#/km^2	NA	2012	USTRAT[1]
	Mineral mine density*	#/km^2	NA	2003	MRPS[2]
	Uranium mine density*	#/km^2	NA	2003	OAR[3]
Fragmentation by dams	Downstream main-stem dam density*	#/100km	NA	2012	NABD[4], Cooper et al. In Review
	Upstream main-stem dam density*	#/100km	NA	2012	NABD[4], Cooper et al. In Review
Water withdrawal	Domestic water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Industrial water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Thermo-electric water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Agriculture water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Total water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
Human population	Population density$^{\Delta}$	#/km^2	1:100,000	2000	TIGER US Census[6]
Road length and crossings	Road length density$^{\Delta}$	km/km^2	1:100,000	2006	TIGER US Census[6]
	Road crossing density$^{\Delta}$	#/km^2	1:100,000	2006	TIGER US Census[6]
Urban land use	Low intensity urban and open space$^{\Delta}$	%	30m	2006	MRLC[7]
	Medium intensity urban$^{\Delta}$	%	30m	2006	MRLC[7]
	High intensity urban$^{\Delta}$	%	30m	2006	MRLC[7]
Agriculture land use	Pasture/Hay$^{\Delta}$	%	30m	2006	MRLC[7]
	Cultivated crops$^{\Delta}$	%	30m	2006	MRLC[7]
Impervious surface cover	Percent impervious surface$^{\Delta}$	%	30m	2006	MRLC[7]
Nutrient and sediment pollution	Total anthropogenic nitrogen yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
	Total anthropogenic phosphorus yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
	Total anthropogenic sediment yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
Point source pollution	Toxic release inventory site density	#/km^2	NA	2007	EPA[9]
	Comprehensive Environmental Response, Compensation, and Liability Information System site density	#/km^2	NA	2007	EPA[9]
	Permit Compliance System site density	#/km^2	NA	2007	EPA[9]
Natural landscape factors					
	Mean elevation in catchment	m	30m	2005	NED[10]
	Mean slope in catchment	degrees	30	2005	NED[10]
	Ground water contribution to base flow	%	1km	2003	USGS[11]
	Mean annual precipitation	mm	1:250,000	1990-2010	PRISM[12]
	Mean annual air temperature	°C	1:250,000	1990-2010	PRISM[12]

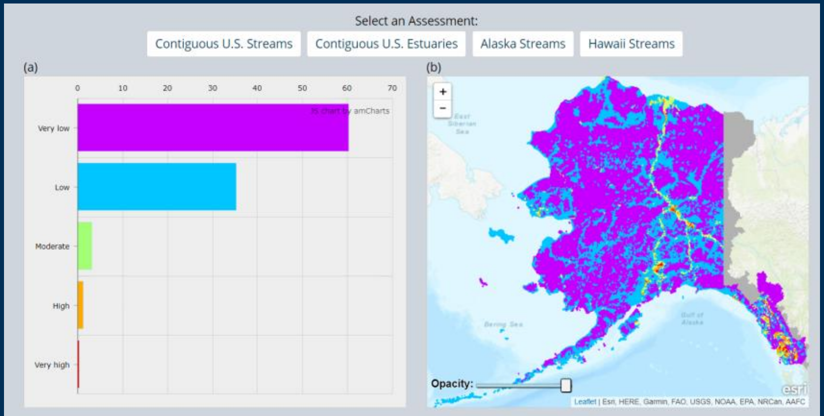


Through A Fish's Eye: Inland Assessment

Alaska Detailed Methods: http://assessment.fishhabitat.org/#578a9a43e4b0c1aacab89763/58ffa76de4b0e85db3a46c4d

Alaska Streams

Spatial Framework: HUC12s
Disturbance Data: 19 Metrics



SE Alaska

Spatial Framework: NHD (1:63,360 scale) w/ NFHP catchments
Disturbance Data: 21 Metrics

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Disturbance Indices
Disturbance Summaries

Through A

Alaska Detailed Methods: ht ... c4d

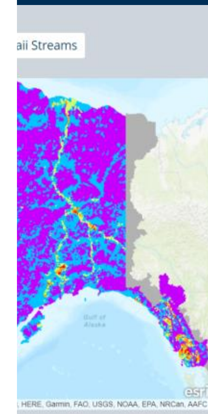
Alaska

Spatial Frame
Disturbance D

Table 1. Human landscape factors used for the 2015 Alaska assessment of stream fish habitat.

Sub-index Category	Variable	Units	Date	Source	Greater Alaska	Southeast Alaska
Urban land use	Population density	#/km^2	2010	US Census	x	x
	Developed open space	%	2011	MRLC[1]	x	x
	Developed low intensity	%	2011	MRLC[1]	x	x
	Developed medium intensity	%	2011	MRLC[1]	x	x
	Developed high intensity	%	2011	MRLC[1]	x	x
Agriculture land use	Pasture/hay	%	2011	MRLC[1]	x	x
	Cultivated crops	%	2011	MRLC[1]	x	x
	Conventional forest harvest	%	2012	USFS[2] and Sealaska		x
Fragmentation	Culvert density	#/km^2	2014	Tongass USFS[2]		x
	Culvert density	#/km2	2014	ADFG[3]	x	x
	Dam density	#/km^2	2012	NABD[4]	x	x
Point source pollution	Toxic release inventory site density	#/km^2	2013	EPA[5]	x	x
	Comprehensive environmental response, compensation, and liability information system site density site density	#/km^2	2013	EPA[5]	x	x
	Permit compliance system site density	#/km^2	2013	EPA[5]	x	x
	Contaminated site database	#/km^2	2015	AK DEC[6]	x	x
	303D impaired waters	% impaired stream km		EPA[5]	x	x
Infrastructure	Road length density	km/km^2	2014	TIGER[7]	x	
	Road length density	km/km^2	2012	Southeast Alaska GIS Library		x
	Railroad length density	km/km^2	2006	ASGDC[8]	x	x
	Pipeline length density	km/km^2	2006	ASGDC[8]	x	x
	Airport/landing strips	#/km^2	2006	ASGDC[8]	x	x
Mines	Active and prospect mines	#/km^2	2008	ASGDC[8]	x	x

[1]Multi-Resolution Land Characteristic Consortium; [2]United States Forest Service; [3]Alaska Department of Fish & Game; [4]National Anthropogenic Barrier Database; [5] Environmental Protection Agency; [6]Alaska Department of Environmental Conservation; [7]Topologically Integrated Geographic Encoding and Referencing; [8]Alaska State Geospatial Data Clearinghouse



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Hawaii Streams

Detailed Methods: http://assessment.fishhabitat.org/#578a9a43e4b0c1aacab89763/578a99d2e4b0c1aacab89650

Spatial Framework: Hawaii Fish Habitat Partnership stream layer (modified 1:24,000 NHD)

Fish Samples (1992-2010): 403 Presence/Absence Locations

Disturbance Data: 27 Metrics

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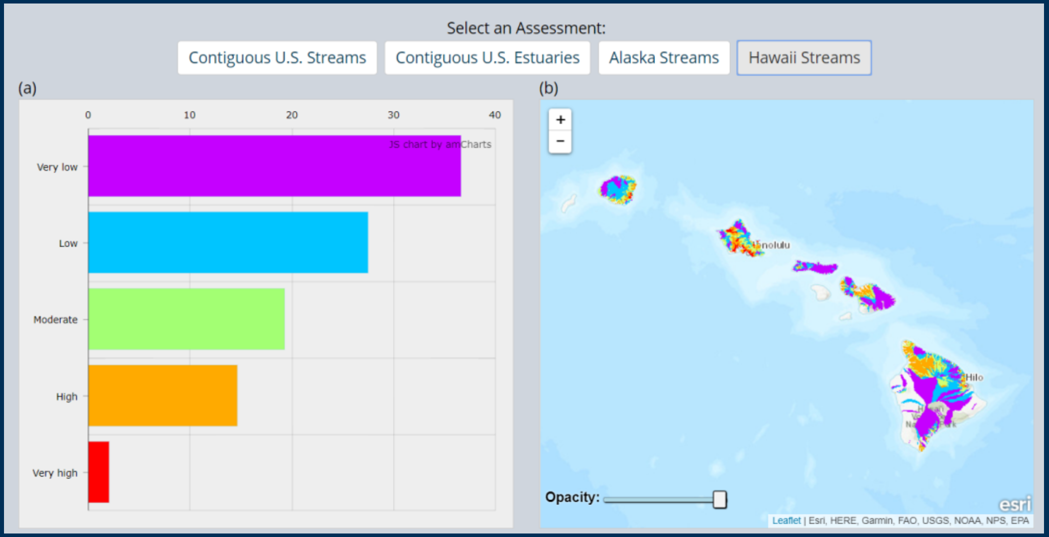
Disturbance Summaries



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Detailed Methods: http://asse acab89650

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Fish Samples (19

Disturbance Data

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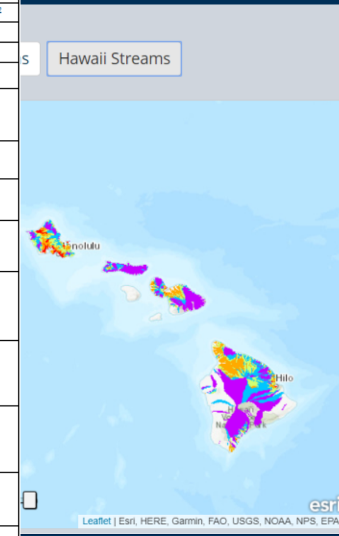
Disturbance Indices
Disturbance Summa

Subindex Category	Variable	Units	Scale	Date	Source
	Human landscape factors				
Agricultural land use					
	Pasture/hay[Δ]	%	30m	2005,2010,2011	CCAP[1]
	Cultivated crops[Δ]	%	30m	2005,2010,2011	CCAP[1]
Urban land use					
	Developed (open)[Δ]	%	30m	2005,2010,2011	CCAP[1]
	Developed (impervious surface)[Δ]	%	30m	2005,2010,2011	CCAP[1]
	Population density[Δ]	#/km^2	1:100,000	2010	TIGER US Census[2]
	Road density[Δ]	km/km^2	1:100,000	2014	TIGER US Census[2]
	Utility pipeline density	m/km^2	1:24,000	1983	Hawaii OP[3]
	Percent of catchment covered by golf courses*	%	N/A	1993	Hawaii OP[3]
Former plantations					
	Percent of catchment that was once used for pineapple production	%	30m	1989	Hawaii OP[3]
	Percent of catchment that was once used for sugarcane production	%	30m	1989	Hawaii OP[3]
Point source pollution					
	Quarry density	#/km^2	N/A	2003	USGS MRP[4]
	Comprehensive Environmental Response, Compensation, and Liability Information System site density[Δ]	#/km^2	N/A	2014	EPA[5]
	Permit Compliance System site density[Δ]	#/km^2	N/A	2014	EPA[5]
	Toxic release inventory site density[Δ]	#/km^2	N/A	2014	EPA[5]
	Underground injection well density	#/km^2	N/A	2010	Hawaii DOH[6]
Density of ditches					
	Ditch density	m/km^2	1:24,000	2004	Hawaii DAR[7]
Stream fragmentation					
	Stream road crossing density[Δ]	#/km^2	1:100000	2014	TIGER US Census[2]
	Dam density	#/km^2	N/A	2010	ACOE[8]
	Ditch intersection density	#/km^2	1:24,000	2004	Hawaii DAR[7]
303d listed streams					
	Percent of upstream river network classified as 303D stream with measured TMDL	%	1:24,000	2012	EPA[9]
	Natural landscape factors				
	Minimum elevation of reach (Local catchment)*	m	10m	2005	NED[10]
	Mean slope of reach (Local catchment)*	%	10m	2005	NED[10]
	Mean slope of downstream reach (Downstream main channel catchment)*	%	10m	2005	NED[10]
	Minimum hydrological soil grouping (Network catchment)*	1-4	1:12,000 -1:63,360	2005	NRCS[11]
	Percent of catchment with wetlands surface cover (Local catchment)*	%	30m	2005,2010,2011	CCAP[1]
	Mean annual rainfall (Network catchment)*	mm/yr	225m	2015	Frazier et al. 2015
	Point locations of waterfalls (Local catchment)*	NA	NA	NA	Tingley et al. in prep



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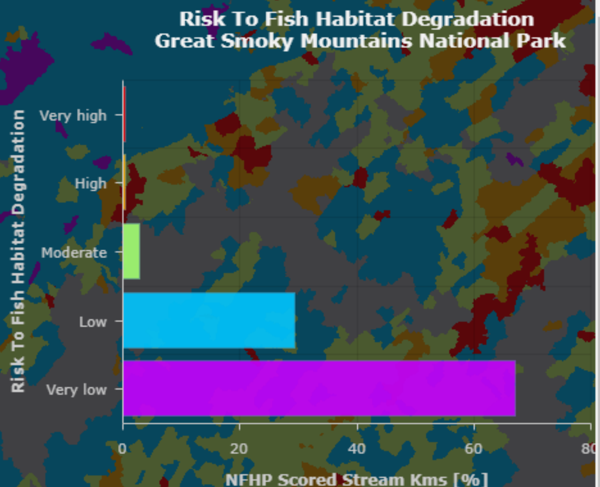
Download example: Contiguous U.S. Inland Assessment of Streams Disturbance Data

COMID	GRID_CODE	AREASQKM	L_POPDENS	L_ROAD_CR	L_ROADLEN	L_TRI	L_CERC	L_PCS	L_URBANL	L_SLOPE	L_ELEVATIO	L_URBANM	L_URBANH	L_PASTURE	L_CROP	LB_URBANL	LB_URBANM	LB_URBANH	LB_PASTURE
4287635	2933415	3.458	20.95474	1.44592	5.62193	0	0	0	8.09474	5.93857	230.05001	0.78084	0	4.11244	16.9443	12.31752	0.72992	0	0.4562
4287281	2933280	2.713	88.41025	0.12786	3.20702	0	0	0	3.38308	7.35224	221.5	1.75788	0.63018	3.21725	1.12769	11.90926	7.3724	3.21361	0
4287299	2933289	8.495	5.53222	0.35314	12.32525	0	0	0	5.77392	5.74383	251.59	0.1695	0	1.63153	16.35767	11.34942	0	0	1.78731
4287305	2933292	4.981	9.36973	0.40152	4.71722	0	0	0	2.22262	4.61691	222.12	0.43368	0	3.25262	6.32454	3.4134	2.02276	0	0
4287289	2933284	5.78	22.55415	1.21107	13.36588	0	0	0	9.31174	5.50296	266.39	4.50016	0.38928	5.01401	10.21489	13.78353	6.84551	0.46253	3.05273
4287287	2933283	2.12	82.67312	1.41509	3.12227	0	0	0	7.47029	3.33659	243.63002	0.80645	0	1.65535	5.17827	4.53333	1.33333	0	0
4287297	2933288	3.58	32.07933	0.55865	3.94498	0	0	0	4.6003	5.23077	288.4	0	0	29.31121	1.03067	2.36613	0	0	35.49191
4287303	2933291	2.659	18.08349	0	0	0	0	0	0	2.22952	194.85001	0	0	1.62492	1.15098	0	0	0	3.29218
4287283	2933281	1.905	84.12021	2.09974	5.58869	0	0	0	11.66745	3.718	230.34	3.40104	0	6.47142	18.28059	23.64964	4.08759	0	1.89781
4287285	2933282	0.751	120.03502	0.10696	0.8758	0	0	0	2.39808	9.23022	249.25	0	0	0.1199	3.83693	7.33945	0	0	0.45871
4287301	2933290	1.126	18.09352	0.03266	2.22374	0	0	0	7.19424	2.47162	159.05	2.39808	0	5.7554	31.255	7.21311	3.60656	0	5.90164
4287315	2933297	7.5	5.5088	0	7.67703	0	0	0	4.60818	2.85023	202.59	0	0	1.45206	17.19669	0	0	0	0
4287307	2933293	5.822	4.62363	0.51528	6.81061	0	0	0	2.50425	4.7185	300.45999	0	0	26.12459	0.81929	3.6643	0	0	17.37589
4287291	2933285	2.776	25.97572	1.08069	4.10242	0	0	0	3.88979	5.32577	291.17001	0	0	13.64668	4.92707	10.86957	0	0	13.71237
4287317	2933298	2.928	15.95376	0.68306	4.50249	0	0	0	3.47372	3.25945	235.37	0	0	8.51522	30.03381	0	0	0	2.43553
4287293	2933286	1.981	47.2476	1.00959	3.36385	0	0	0	11.85825	5.4916	279.69001	0	0	0	6.22444	12.93801	0	0	0
4287321	2933300	3.278	19.75253	0.30506	5.01726	0	0	0	7.24876	3.03542	227.63	0.60406	0	0.79626	12.05382	12.73292	0	0	0
4287309	2933294	2.123	8.97179	0.94206	2.58849	0	0	0	7.07927	5.63162	284.90001	0.84781	0	0	21.15303	7.89022	0	0	0
4287295	2933287	1.335	70.12105	0.05683	1.61833	0	0	0	15.10452	5.96022	213.41999	2.22522	2.15779	8.49629	5.52933	16.31016	1.60428	1.87166	0
724062	2914344	4.57	5.52479	0.43763	5.28095	0	0	0	5.39583	4.91571	285.2	0.31508	0	15.39976	10.71288	8.03383	0.31712	0	13.53066
724484	2914512	1.552	21.64111	1.28866	1.96804	0	0	0	3.7703	3.75174	270.54998	0	0	4.81439	21.80974	3.43249	0	0	5.03432
4287313	2933296	11.092	2.53863	0.27046	11.60263	0	0	0	5.5497	4.99984	274.92999	0.54361	0	10.13387	9.92292	4.30622	0	0	4.38596
4287643	2933419	4.948	10.06738	0.8084	7.79589	0	0	0	4.74718	3.84322	189.81	0.10913	0	3.85595	13.29574	8.20734	0	0	3.67171
724066	2914346	3.693	13.30154	0	0.94737	0	0	0	0.92615	1.16549	221.16999	0	0	3.19279	29.51499	0	0	0	0
4287901	2933547	3.616	7.46792	0.27654	4.03016	0	0	0	4.10652	3.18367	207.16001	0.02488	0	0.69686	2.38925	7.29614	0	0	0
4287311	2933295	1.065	73.81727	0	0	0	0	0	0	9.3415	238.62999	0	0	0	0	0	0	0	0
4287641	2933418	5.021	2.59088	0.39832	6.72361	0	0	0	1.81036	4.418	234.55001	0.14339	0	2.93959	0.96791	3.54691	0.11441	0	0.34324
4287645	2933420	7.997	6.71584	0	2.14943	0	0	0	0.05627	1.99651	225.22999	0	0	0.43894	10.99606	0	0	0	0
724482	2914511	4.285	6.5183	0.46674	5.47626	0	0	0	5.92313	4.35308	280.72001	0.10501	0	6.51124	33.60639	16.43664	0	0	1.00376
724072	2914349	3.837	4.26164	0.26062	2.00179	0	0	0	2.97912	5.20995	252.56	0	0	1.80624	3.00258	2.89634	0	0	0
724064	2914345	2.153	9.1719	0.92893	2.00879	0	0	0	3.34448	4.28303	249.50998	0	0	8.94649	8.44482	3.81166	0	0	7.17489
724488	2914514	1.594	44.54203	0	0.10664	0	0	0	0	1.85884	221.95	0	0	0	10.55901	0	0	0	0
724070	2914348	0.389	70.1527	0	0.69584	0	0	0	12.26852	1.92824	213.72	0	0	0	43.75	26.36364	0	0	0
724486	2914513	0.96	53.41302	0	0	0	0	0	0	1.48641	212.60001	0	0	0	12.6523	0	0	0	0
4287345	2933312	11.857	4.74663	0.07848	10.43348	0	0	0	3.55326	3.11699	193.9427	0.20486	0.06357	9.67788	20.55665	7.22521	0.30745	0	2.7671
4287325	2933302	9.622	6.85349	0.31178	9.08175	0	0	0	4.7236	4.8567	215.95	0.77635	0.18707	2.02039	15.0781	6.28518	2.1576	0	0
724078	2914352	1.536	25.90625	1.30208	1.80999	0	0	0	2.69479	2.38196	219.47999	0	0	5.85823	25.60047	1.81488	0	0	0
724068	2914347	2.948	14.65865	0	2.21972	0	0	0	3.63248	5.08242	242.49001	0	0	7.14286	9.98168	0	0	0	0

NFHP Assessment Next Steps: 2015 Viewer – In Development

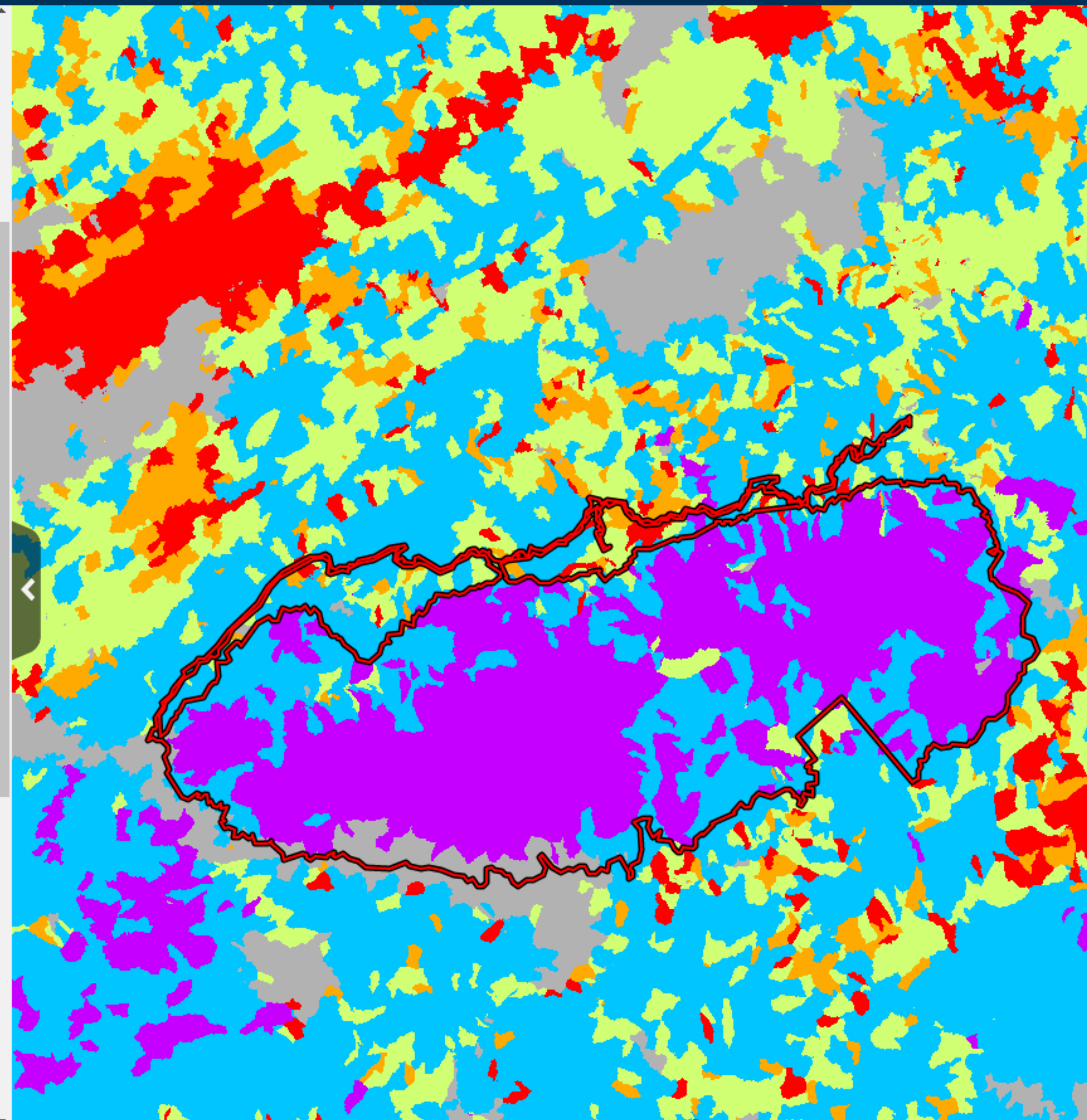
▼ NFHP 2015 Data Summary Visualizations

Fish habitat condition was scored on 1,993 of 2,058 NHDPlusV1 stream kms within Great Smoky Mountains National Park.



Disturbances Influencing Risk to Fish Habitat Condition in Great Smoky Mountains National Park

Disturbance Variable	Local Catchment	Network Catchment	Local Buffer	Network Buffer
Agriculture water withdrawal	NT		NT	NT
All mine density			NT	NT
CERCLIS site density			NT	NT
Coal mine density			NT	NT
Cultivated crops	Significant	Significant	Significant	Significant
Domestic water withdrawal	NT		NT	NT
Downstream mainstem dam density	NT	Significant	NT	NT
High intensity urban	Significant	Significant		Significant

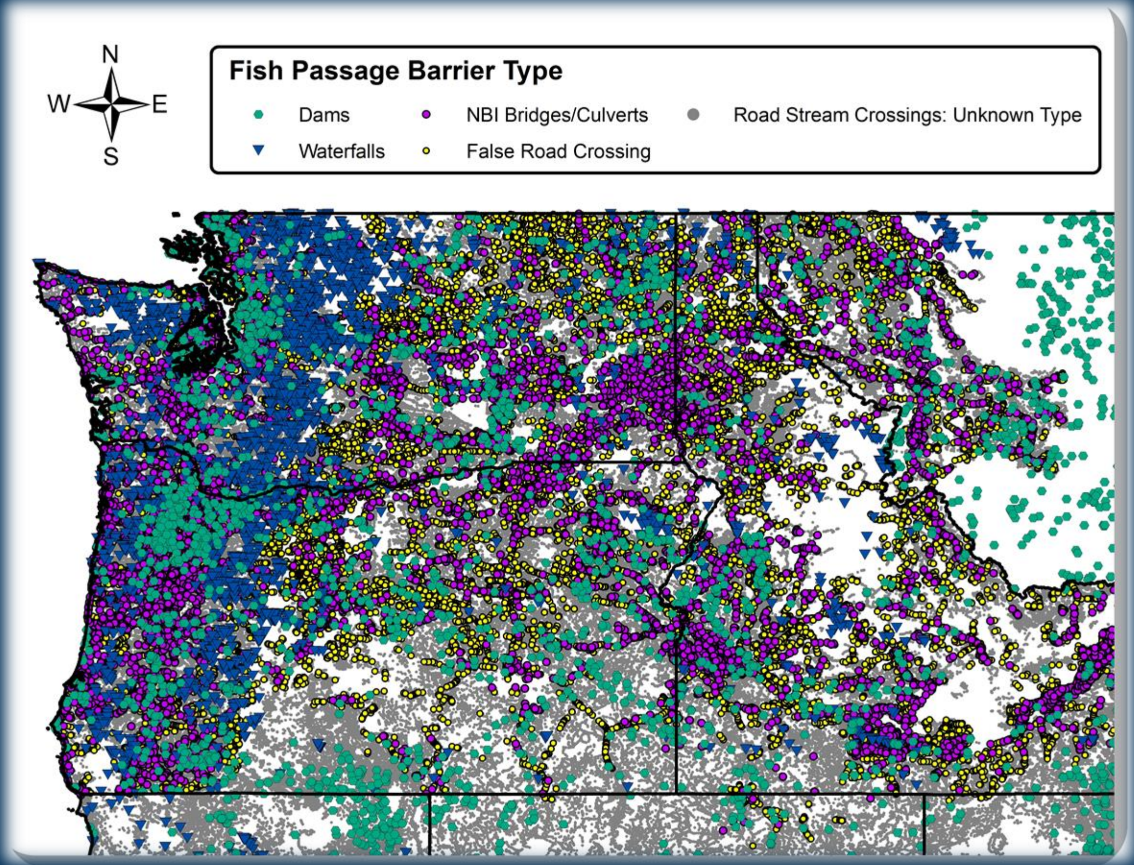


NFHP Assessment Next Steps

Focus on measures and understanding influences:

- Hydrology
- Connectivity

Photo Credit: Katrina Mueller (USFWS)



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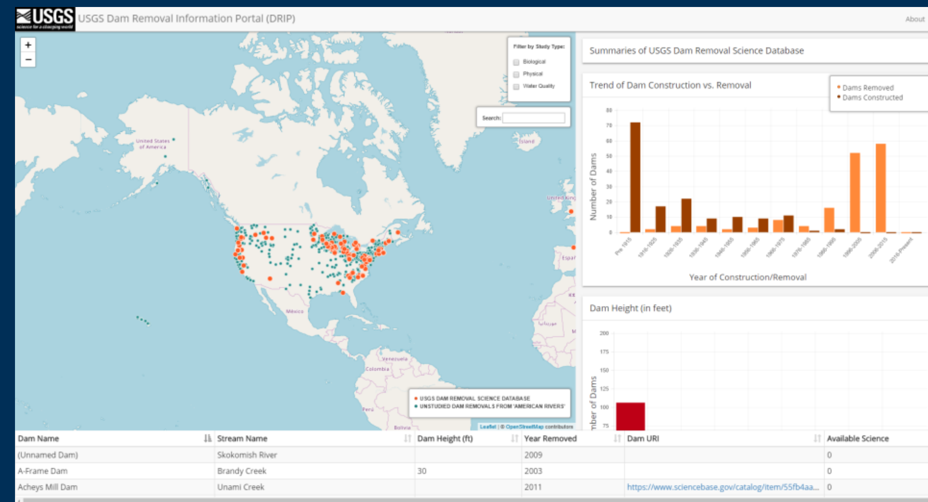
Building Off NFHP Data and Spatial Framework

Both datasets linked to NHDPlus, allowed for quick linkage of information

Dam Removal Information Portal



+

NFHP Variables

Data obtained from the National Fish Habitat Partnership (version 2015)	
Data Type	Data description
*Catchment slope	Mean catchment slope (degrees)
*Catchment elevation	Mean catchment elevation (m)
*Groundwater index	Percent groundwater contribution to stream baseflow
*Precipitation	Mean annual precipitation (mm)
*Air temperature	Mean annual air temperature (C°)
*Habitat Condition Index	Index scoring the risk of habitat degradation for fish (scored as 0–5, with 0 representing very low risk of habitat degradation/very high fish habitat and 5 representing very high risk of habitat degradation/very poor fish habitat)
Population density	Census 2000 average population per catchment density (average population count/km^2)
Road crossings	Road crossing density in the catchment (#/km^2)
Toxic Release sites	Toxic Release Inventory (EPA) sites in the catchment (#/km^2)
Superfund sites	EPA Superfund National Priority in the catchment (#/km^2)
NPDES sites	National Pollutant Discharge Elimination System sites in the catchment

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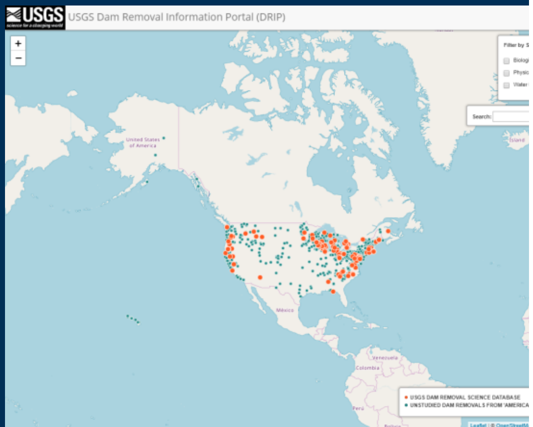
NATIONAL FISH HABITAT PARTNERSHIP

Building Off NFHP: Dam Removal Example

Dam Removal Info



Dam Name	Stream Name	Dam Height (ft)	Yea
(Unnamed Dam)	Skokomish River		200
A-Frame Dam	Brandy Creek	30	200
Acheys Mill Dam	Unami Creek		201

+

NFHP Variables

Data obtained from the National Fish Habitat Partnership (ver	
Data Type	Data description
*Catchment slope	Mean catchment slope (degrees
*Catchment elevation	Mean catchment elevation (m)
*Groundwater index	Percent groundwater contributio
*Precipitation	Mean annual precipitation (mm)
*Air temperature	Mean annual air temperature (C
*Habitat Condition Index	Index scoring the risk of habitat representing very low risk of hab representing very high risk of ha
Population density	Census 2000 average populatio count/km^2)
Road crossings	Road crossing density in the cat
Toxic Release sites	Toxic Release Inventory (EPA) s
Superfund sites	EPA Superfund National Priority
NPDES sites	National Pollutant Discharge Eli

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Landscape context and the biophysical response of rivers to dam removal in the United States

Melissa M. Foley, Francis J. Magilligan, Christian E. Torgersen, Jon J. Major, Chauncey W. Anderson, Patrick J. Connolly, Daniel Wieferich, Patrick B. Shafroth, James E. Evans, Dana Infante, Laura S. Craig

Published: July 10, 2017 • https://doi.org/10.1371/journal.pone.0180107

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Abstract

Dams have been a fundamental part of the U.S. national agenda over the past two hundred years. Recently, however, dam removal has emerged as a strategy for addressing aging, obsolete infrastructure and more than 1,100 dams have been removed since the 1970s. However, only 130 of these removals had any ecological or geomorphic assessments, and fewer than half of those included before- and after-removal (BAR) studies. In addition, this growing, but limited collection of dam-removal studies is limited to distinct landscape settings. We conducted a meta-analysis to compare the landscape context of existing and removed dams and assessed the biophysical responses to dam removal for 63 BAR studies. The highest concentration of removed dams was in the Northeast and Upper Midwest, and most have been removed from 3rd and 4th order streams, in low-elevation (< 500 m) and low-slope (< 5%) watersheds that have small to moderate upstream watershed areas (10–1000 km^2) with a low risk of habitat degradation. Many of the BAR-studied removals also have these characteristics, suggesting that our understanding of responses to dam removals is based on a limited range of landscape settings, which limits predictive capacity in other environmental settings. Biophysical responses to dam removal varied by landscape cluster, indicating that landscape features are likely to affect biophysical responses to dam removal. However, biophysical data were not equally distributed across variables or clusters, making it difficult to determine which landscape features have the strongest effect on dam-removal response. To address the inconsistencies across dam-removal studies, we provide suggestions for prioritizing and standardizing data collection associated with dam removal activities.

Figures

Building Off NFHP Data and Spatial Framework:

Gained insight on

- Landscape level implications to consider for future dam removals

- Data gaps

Cluster (HCI score)	Urban (%)	Forested (%)	Agriculture (%)	Population density (#/km^2)	Road crossings (#/km^2)	Water withdrawal (MGY)	Phosphorus input (kg/km/yr)	Nitrogen input (kg/km/yr)	Sediment input (kg/km/yr)
a–Mountain West (2.9 – moderate risk)	0.02	72.9	1.0	34.3	0.14	30.7	9.0	39.0	2292
b–West (2.1 –high risk)	1.5	63.0	5.2	9.3	0.31	16.6	16.7	58.0	6814
c–Pacific Northwest (2.9 – moderate risk)	1.0	82.1	0.8	10.1	0.17	3.6	7.1	68.1	17738
d–Arizona (3.3 –low risk)	0.1	60.3	0	5.2	0.17	3.6	2.1	8.5	4610
e–Upper Midwest (3.0 – moderate/low risk)	3.2	30.2	48.0	15.9	0.43	13.2	77.8	723	57149
f–New England (2.9 – moderate risk)	5.1	53.8	20.5	44.7	0.57	25.9	97.2	697	85414
g–Midwest (1.1 –high risk)	9.7	19.6	54.1	25.1	0.49	57.6	92.9	1288	71285
h–Southeast (3.0 – moderate/low risk)	2.6	30.7	20.4	77.9	0.44	108.4	49.0	321	51079

Anthropogenic landscape context for before- and after-removal studies clusters.

https://doi.org/10.1371/journal.pone.0180107.t006

USGS

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Building Off NFHP Data and Spatial Framework:

Highlights

- Documented biases such as the lack of representation of gages on small streams and in higher elevations
- Suggestions to account for biases in modeling efforts


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FEATURE

Importance of Understanding Landscape Biases in USGS Gage Locations: Implications and Solutions for Managers

La importancia de comprender el sesgo inducido por el paisaje en el posicionamiento de sensores USGS: implicaciones y soluciones para los administradores

Jefferson Tyrell Deweber, Yin-Phan Tsang, Damon M. Krueger, Joanna B. Whittier, Tyler Wagner, Dana M. Infante & ...show all

Pages 155-163 | Published online: 24 Apr 2014

Download citation | https://doi.org/10.1080/03632415.2014.891503 | Check for updates

Full Article | Figures & data | References | Supplemental | Citations | Metrics | Reprints & Permissions | PDF

In this article: ABSTRACT | INTRODUCTION | METHODS—IDENTIFYING BIASES | RESULTS—IDENTIFIED BIASES | DISCUSSION

ABSTRACT

Flow and water temperature are fundamental properties of stream ecosystems upon which many freshwater resource management decisions are based. U.S. Geological Survey (USGS) gages are the most important source of streamflow and water temperature data available nationwide, but the degree to which gages represent landscape attributes of the larger population of streams has not been thoroughly evaluated. We identified substantial biases for seven landscape attributes in one or more regions across the conterminous United States. Streams with small watersheds (<10 km^2) and at high elevations were often underrepresented, and biases were greater for water temperature gages and in arid regions. Biases can fundamentally alter management decisions and at a minimum this potential for error must be acknowledged accurately and transparently. We highlight three strategies that seek to reduce bias or limit errors arising from bias and illustrate how one strategy, supplementing USGS data, can greatly reduce bias.

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Building off NFHP Data and Spatial Framework

FishTail

A Decision Support Mapper for Conserving Stream Fish Habitats of the NE CSC Region

NE CSC
Northeast Climate Science Center

The FishTail mapper was developed with support from the USGS Northeast Climate Science Center (NE CSC)

Craig Paukert, Dana M. Infante, Jana Stewart, Joanna Whittier, Wesley Daniel, Nick Sievert, Kyle Herreman

To conserve streams from current stressors and future climate changes, managers need region-wide information for decision-making and for developing proactive management strategies. The FishTail project meets those needs by integrating multiple indices characterizing current and future condition of stream fish habitats into a web-based mapper. Indices were developed based on stakeholder-selected priority fish species from throughout the region to ensure that results are most meaningful to management. Three current condition indices describe relative stress to fish habitats from human land use, stream fragmentation by dams and road crossings, and water quality impairments based on EPA 303d listings of waterbodies. FishTail also includes a fourth index that assesses where projected changes in climate from 8 different scenarios may lead to additional changes in stream fish habitats. Results are available in a comparable format for all streams of the 22-state NE CSC region through a spatially-explicit, web-based mapper.

contact: paukertc@missouri.edu and infanted@anr.msu.edu

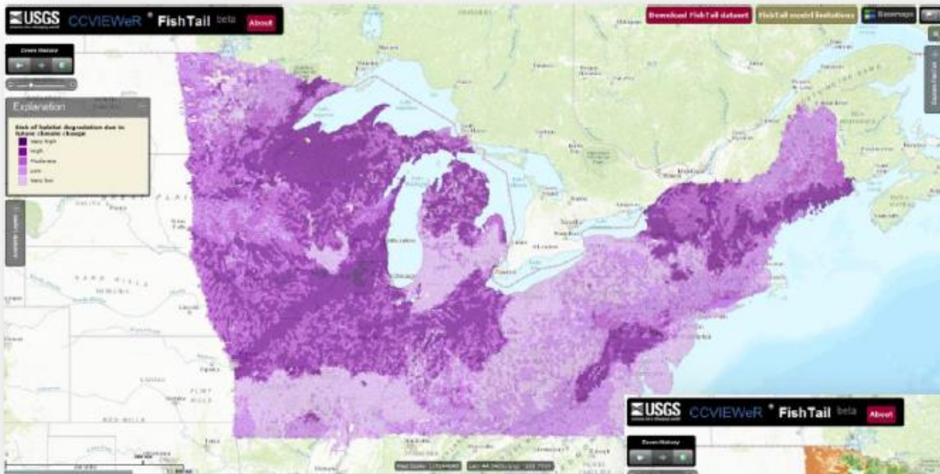
FISHTAIL

- Current and future condition of fish habitats
- Specific indices created for assessment: land use, fragmentation, water quality, climate; allows for decoupling; each reach receives a scores for all of these disturbances
- Based on priority fish species identified by managers, assemblage or species-specific results can be generated
- Decision support mapper

NFHP 2015 INLAND ASSESSMENT

- Current condition of fish habitats
- Cumulative index created for assessment, many landscape disturbances tested, score based on most limiting disturbances
- Based on groups of species (functional traits, game fishes), assemblage or group-specific results can be generated
- Data viewer

Building off NFHP Data and Spatial Framework



Risk of stream fish habitat degradation due to future climate change summarized in HUC 12s

Risk of stream fish habitat degradation due to human land use summarized in catchments

https://ccviewer.wim.usgs.gov/fishtail

- MAP AND DOWNLOAD DATA
- EXPLORE DISTURBANCES: CURRENT LAND USE, FRAGMENTATION, WATER QUALITY, CLIMATE CHANGES
- SEARCH DATA BY ECOREGION, STREAM SIZE, AND HABITAT RESPONSE INDEX

Building off NFHP Data and Spatial Framework

The FishVis mapper is the product of an Upper Midwest and Great Lakes Landscape Conservation Cooperative project

UPPER MIDWEST & GREAT LAKES
LANDSCAPE CONSERVATION COOPERATIVE

FishVis

A Regional Decision Support Tool
for Identifying Vulnerabilities of Riverine Habitat and Fishes to Climate Change

Jana S. Stewart, S. Alex Covert , Nick J. Estes, Stephen M. Westenbroek, Damon Krueger, Daniel J. Wieferich, Michael T. Slattery, John D. Lyons, James E. McKenna, Jr., Dana M. Infante, and Jennifer L. Bruce

Climate change is expected to alter distributions of stream fishes and composition of their communities in the Great Lakes region throughout the 21st century, due in part to altered hydrological systems (stream temperature, streamflow, and stream habitat). The FishVis mapper helps conservation planners visualize, search, and download potential climate-driven responses of 13 fish species in streams across the Great Lakes region, along with changes in stream thermal or flow characteristics important to fishes. The vulnerability (loss) of fish species to climate change was evaluated by comparing predicted species occurrence under current conditions to projected fish species occurrence under future climate conditions for 13 climate models. Results from FishVis analyses can be viewed for the individual stream reach and catchment or summarized at the hydrologic unit scale.

contact: jsstewar@usgs.gov and infanted@anr.msu.edu

Building off NFHP Data and Spatial Framework

FishVis

- Assessment focused on future conditions of habitats for priority fish species
- Natural and anthropogenic landscape factors used to model stream flow and temperature
- Current and projected stream flow and temperature used to model priority species distributions; projections made with variables from multiple climate scenarios
- Changes in species distributions with changes in climate indicate susceptibility of habitats to changes

Building off NFHP Data and Spatial Framework

Change in thermal class in streams of the late century (2081-2100) summarized in catchments

Probability of occurrence (length-weighted) of brook trout (*Salvelinus fontinalis*) in the late century (2081-2100) summarized in HUC 12s

https://ccviewer.wim.usgs.gov/FishVis

- MAP AND DOWNLOAD DATA
- EXPLORE FISH, STREAM TEMPERATURE, STREAMFLOW EXCEEDENCE, AND CLIMATE DATA
- SEARCH DATA TO FIND STREAM REACHES OR CATCHMENTS

MORE DETAILED METHODS ON INLAND ASSESSMENT BELOW

Through A Fish's Eye: Inland Assessment

http://assessment.fishhabitat.org/#578a9a43e4b0c1aacab89763/578a99a6e4b0c1aacab895dd

Assembling data

Data on stream fishes were provided for use in the 2015 assessment from many federal and state agencies and organizations from around the country. For a list of data providers, see Table 2. Due to the cooperation and support of multiple data providers, the 2015 assessment used stream fish assemblage data from 39,405 stream reaches as compared to 26,468 stream reaches in 2010 assessment. Data now reflects abundances of different fish species found in streams throughout the conterminous United States.

Besides fish data, many different human (anthropogenic) landscape factors were assembled and used to characterize habitat condition. These factors include: urban and agricultural land use; intensity of different types of mining activities; impervious surfaces; estimates of nutrient loading to streams; estimates of water withdrawals; major [illegible]

Table1: Table showing human and natural landscape factors used for the 2015 national assessment of stream fish habitat.

Super Category	Variable	Units	Scale	Date	Source
Human landscape factors					
Mines	All mines (mineral, coal, uranium mine density)*	#/km^2	NA	2003, 2012	USTRAT[1], MRP[2]
	Coal mine density*	#/km^2	NA	2012	USTRAT[1]
	Mineral mine density*	#/km^2	NA	2003	MRPS[2]
	Uranium mine density*	#/km^2	NA	2003	OAR[3]
Fragmentation by dams	Downstream main-stem dam density*	#/100km	NA	2012	NABD[4], Cooper et al. In Review
	Upstream main-stem dam density*	#/100km	NA	2012	NABD[4], Cooper et al. In Review
Water withdrawal	Domestic water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Industrial water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Thermo-electric water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Agriculture water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Total water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
Human population	Population density[1]	#/km^2	1:100,000	2000	TIGER US Census[6]
Road length and crossings	Road length density[1]	km/km^2	1:100,000	2006	TIGER US Census[6]
	Road crossing density[1]	#/km^2	1:100,000	2006	TIGER US Census[6]
Urban land use	Low intensity urban and open space[1]	%	30m	2006	MRLC[7]
	Medium intensity urban[1]	%	30m	2006	MRLC[7]
	High intensity urban[1]	%	30m	2006	MRLC[7]
Agriculture land use	Pasture/Hay[1]	%	30m	2006	MRLC[7]
	Cultivated crops[1]	%	30m	2006	MRLC[7]
Impervious surface cover	Percent impervious surface[1]	%	30m	2006	MRLC[7]
Nutrient and sediment pollution	Total anthropogenic nitrogen yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Super Category	Variable	Units	Scale	Date	Source
Human landscape factors					
Mines	All mines (mineral, coal, uranium mine density)*	$\#/km^2$	NA	2003, 2012	USTRAT[1], MRP[2]
	Coal mine density*	$\#/km^2$	NA	2012	USTRAT[1]
	Mineral mine density*	$\#/km^2$	NA	2003	MRPS[2]
	Uranium mine density*	$\#/km^2$	NA	2003	OAR[3]
Fragmentation by dams	Downstream main-stem dam density*	#/100km	NA	2012	NABD[4], Cooper et al. In Review
	Upstream main-stem dam density*	#/100km	NA	2012	NABD[4], Cooper et al. In Review
Water withdrawal	Domestic water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Industrial water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Thermo-electric water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Agriculture water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
	Total water withdrawal*	MGY	HUC12	2005	EPA, USGS[5]
Human population	Population density[Δ]	$\#/km^2$	1:100,000	2000	TIGER US Census[6]
Road length and crossings	Road length density[Δ]	km/km^2	1:100,000	2006	TIGER US Census[6]
	Road crossing density[Δ]	$\#/km^2$	1:100,000	2006	TIGER US Census[6]
Urban land use	Low intensity urban and open space[Δ]	%	30m	2006	MRLC[7]
	Medium intensity urban[Δ]	%	30m	2006	MRLC[7]
	High intensity urban[Δ]	%	30m	2006	MRLC[7]
Agriculture land use	Pasture/Hay[Δ]	%	30m	2006	MRLC[7]
	Cultivated crops[Δ]	%	30m	2006	MRLC[7]
Impervious surface cover	Percent impervious surface[Δ]	%	30m	2006	MRLC[7]
Nutrient and sediment pollution	Total anthropogenic nitrogen yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
	Total anthropogenic phosphorus yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
	Total anthropogenic sediment yield*	kg/km/yr	1:500,000	1992	SPARROW[8]
Point source pollution	Toxic release inventory site density	$\#/km^2$	NA	2007	EPA[9]
	Comprehensive Environmental Response, Compensation, and Liability Information System site density	$\#/km^2$	NA	2007	EPA[9]
	Permit Compliance System site density	$\#/km^2$	NA	2007	EPA[9]
Natural landscape factors					
	Mean elevation in catchment	m	30m	2005	NED[10]
	Mean slope in catchment	degrees	30	2005	NED[10]
	Ground water contribution to base flow	%	1km	2003	USGS[11]
	Mean annual precipitation	mm	1:250,000	1990-2010	PRISM[12]
	Mean annual air temperature	°C	1:250,000	1990-2010	PRISM[12]

Assembling data

Data on stream fishes we... 2015 assessment from m... agencies and organizatio... country. For a list of data... to the cooperation and s... providers, the 2015 asse... assemblage data from 3... compared to 26,468 stre... assessment. Data now re... different fish species fou... the conterminous Unite...

Besides fish data, many ... (anthropogenic) landscap... and used to characterize... factors include: urban an... intensity of different type... impervious surfaces; esti... streams; estimates of wa...

...ble showing human and ...dscape factors used for the ...nal assessment of stream fish

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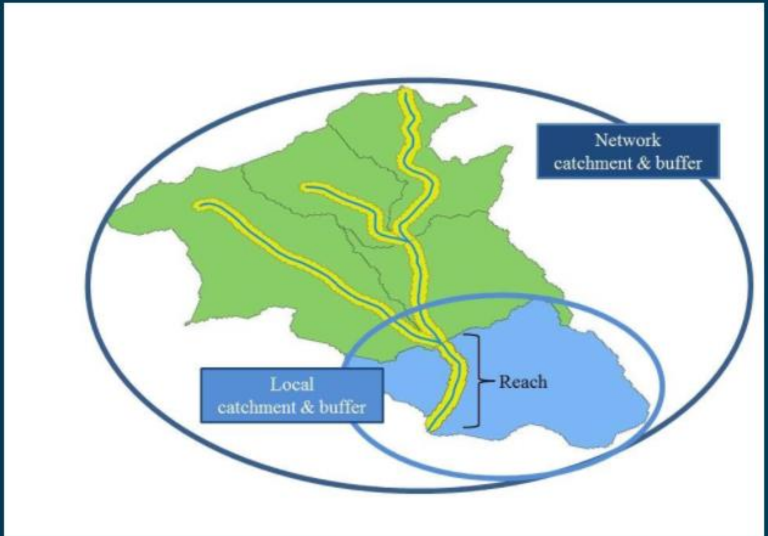
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Integrating data into a spatial framework

After acquiring data, variables were attributed to a national stream coverage for use in assessment following Wang et al. (2011). The National Hydrography Dataset Version 1 (NHDV1) is a 1:100,000 scale representation of streams from throughout the conterminous United States. The NHDV1 identifies stream reaches as sections of streams occurring between confluences (Figure 2). We attributed all data to stream reaches (i.e., fish data, fragmentation metrics by dams) or to local catchments and 90m **buffers** draining to stream reaches (i.e., human land uses, mining activities, **impervious** surfaces, etc.). Local **catchments** (watersheds) and buffers are the land areas draining directly to a stream reach. Using a process described in Tsang et al. (2014), we aggregated landscape information throughout network catchments and buffers, resulting in data available in four **spatial scales** for use in assessment.



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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Conterminous United States (Step 3)

Accounting for natural variation

Besides influences of human landscape factors on fishes, many “natural” landscape factors also affect species composition and their abundances found in different stream habitats. We incorporated multiple analytical steps that accounted for factors like stream catchment area, elevation, and slope; estimates of groundwater contribution to stream baseflow; and mean annual precipitation and air temperature in stream catchments. Also, because of broad differences in distributions of stream fish species in different-sized streams and across the United States, we developed assessment scores specifically for small and large streams and within nine large ecoregions of the country (WSA ecoregions), United States EPA 2006, Figure 3).

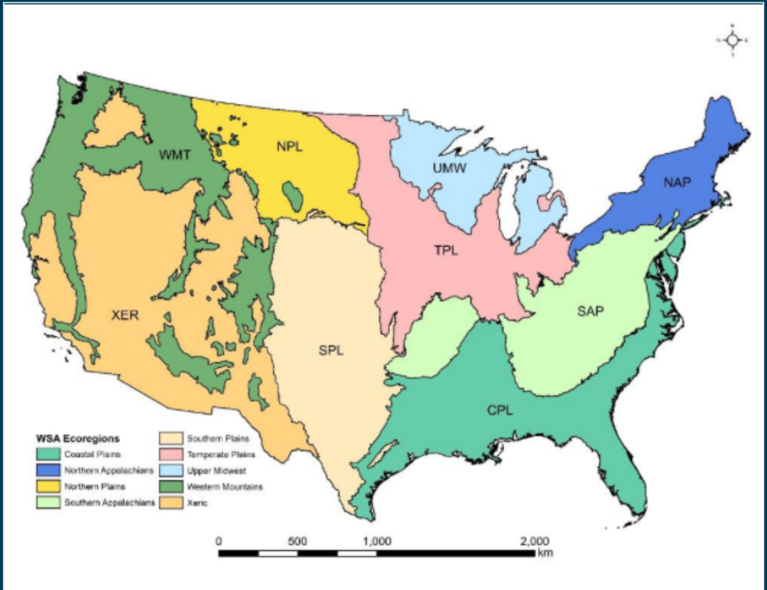

Figure 3: Nine large ecoregions of the conterminous United States used to select fish metrics and conduct the 2015 condition assessment of stream habitats.

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Identifying disturbances to fish habitat

The first step in identifying disturbances to fish habitat involved summarizing stream fish species data into a set of metrics that could be potential indicators of stream habitat condition. Examples of metrics include summaries of fish species by their feeding preferences, reproductive strategies, or tolerance to stressors. While many potential indicators were generated, an analytical process was used to identify a subset of metrics that were the most effective indicators of habitat condition in each of nine large ecoregions (Stoddard et al. 2008). Next, each of the key fish metrics was tested against each of the human landscape factors summarized in watersheds and stream buffers described above. When a key fish metric showed a significant, negative association with a specific human landscape factor (detailed methods described in Daniel et al. 2015), the human landscape factor was identified as a regional risk to stream

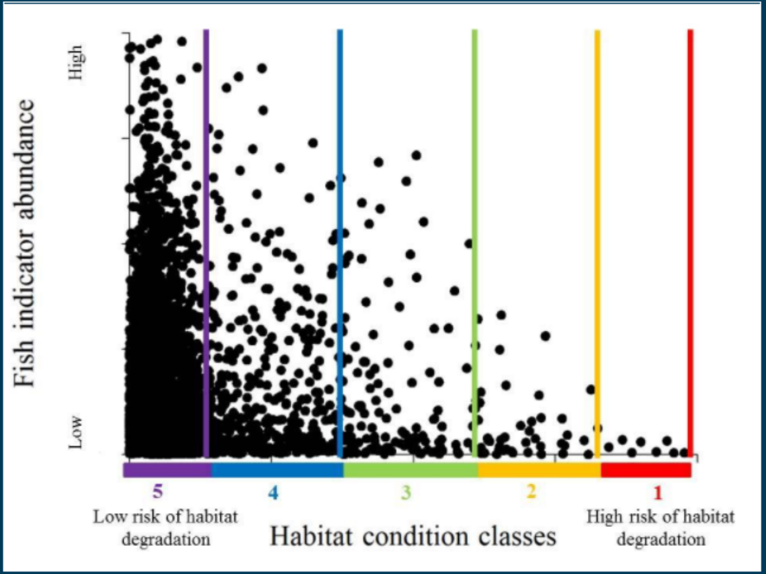

Figure 4: Association between fish indicator (y-axis) and human landscape factor (x-axis). Note that the threshold point occurs at the boundary of condition classes 5 and 4, and the plateau point occurs at the boundary of condition classes 1 and 2.

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Detailed Methodology for Inland Stream Assessment for the Conterminous United States (Step 5)

Creating cumulative habitat condition scores

To create the cumulative habitat condition index (CHCI) for streams of the conterminous United States, associations between multiple fish metrics and multiple human landscape factors were synthesized into a single number using the following scoring process.

5a. For each significant association between a fish metric and a human landscape factor, we evaluated the shape of the relationship to identify two key points. The " threshold point" is the level of a landscape factor associated with a decrease in abundance of a particular fish metric (change in

(a)

	Habitat condition index				
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Local catchment	1.5	5.0	4.8	4.9	3.6
Local buffer	3.8	5.0	3.9	4.9	2.2
Network catchment	1.5	5.0	4.8	4.5	1.0
Network buffer	3.8	5.0	3.9	3.7	3.5
Cumulative Habitat Condition Index	1.5	5.0	3.9	3.7	1.0

(b)

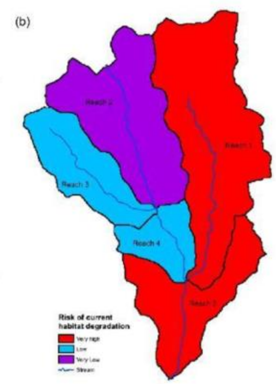

Figure 5: (a) A demonstration of methodology used to generate cumulative habitat condition index (CHCI) scores from habitat condition indices (HCI) for stream reaches. The minimum HCI score generated for a given stream reach is assumed to reflect that stream reach's maximum biological potential, and therefore serves as the CHCI for that stream reach. (b) Risk of current habitat degradation scores for stream reaches mapped to local catchments based off data in (a).