


United States
Department of
Agriculture
Forest Service
Pacific Northwest
Research Station
General Technical
Report
PNW-GTR-213





Models That Predict Standing Crop of Stream Fish From Habitat Variables: 1950-85


Kurt D. Fausch, Clifford L. Hawkes, and Mit G. Parsons

1988

- Reviewed 98 models
- **Reach variables:** discharge, width, depth, velocity, area, pool volume, and % unit types (e.g. pool, riffle, run), fish cover, bank stability, invertebrate drift abundance, substrate, temperature, and water chemistry
- **Watershed variables:** drainage basin area, density & elevation; stream length, order, & gradient

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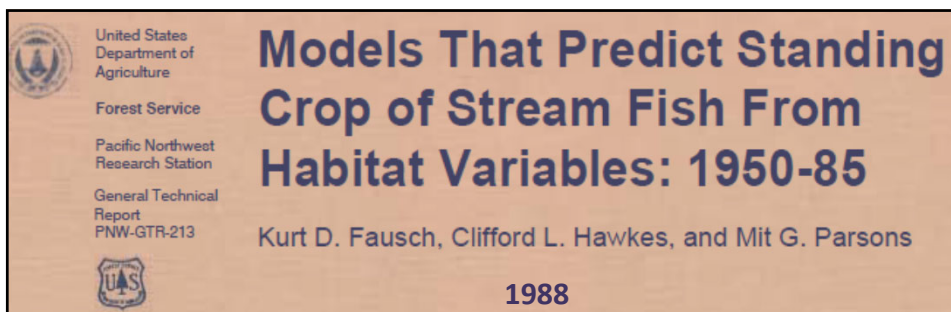
Models That Predict Standing Crop of Stream Fish From Habitat Variables: 1950-85

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1988

- Simple and multiple regressions
- Factor analysis, PCA
- WUA





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**Models That Predict Standing
Crop of Stream Fish From
Habitat Variables: 1950-85**

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1988

- Lack of predictive ability and generality
 - Low sample size
 - Higher r^2 associated with $n < 20$
 - Several variables

Transactions of the American Fisheries Society 108:215-228, 1979
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Quantification of Fluvial Trout Habitat in Wyoming

N. ALLEN BINNS AND FRED M. EISERMAN¹

Models That Predict Standing Crop of Stream Fish From Habitat Variables

- Developed a Habitat Quality Index (HQI) to predict trout standing crop in Wyoming streams.
 - Now called Wyoming Habitat Assessment Methodology (WHAM)
- Measured 22 habitat variables and compared to trout biomass in 36 streams.
- Validated this model on 8 streams.

Transactions of the American Fisheries Society 108:215-228, 1979
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N. ALLEN BINNS AND FRED M. EISERMAN¹

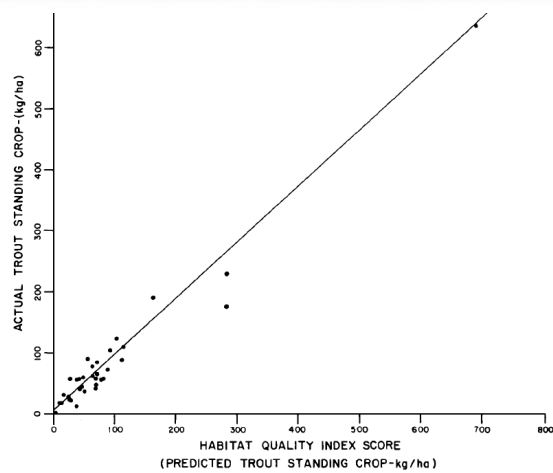


FIGURE 2.—Relationship between HQI score (\hat{Y}) and trout standing crop (Y) at 36 Wyoming streams evaluated with HQI Model II in 1975-1977. The multiple correlation coefficient $R = 0.983$ for the linear relationship: $Y = 5.978 + 0.926(\hat{Y})$.

Transactions of the American Fisheries Society 115:503-514, 1986
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Trout Biomass and Habitat Relationships in Southern Ontario Streams

JAMES N. BOWLBY AND JOHN C. ROFF

Department of Zoology, University of Guelph

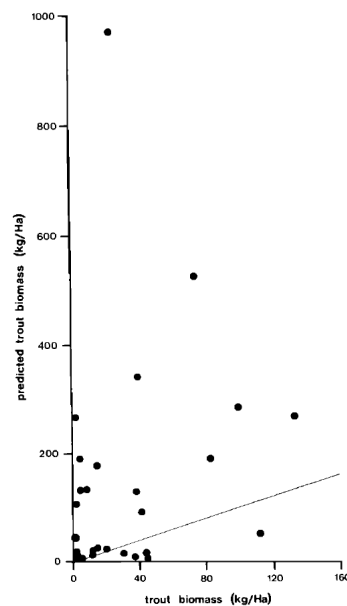



FIGURE 2.—Plot of observed trout biomass in southern Ontario streams versus predicted biomass based on model I of Binns and Eiserman (1979). The diagonal represents observed = predicted.




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1988

- Lack of predictive ability and generality
 - Low sample size
 - Higher r^2 associated with $n < 20$
 - Several variables
- Assumed no measurement error of habitat variables
- High error surrounding fish abundance estimates
- Lack of validation
- Little intermediate scale information



Overcoming limitations to empirical approaches

- Improved data quality and quantity
- 

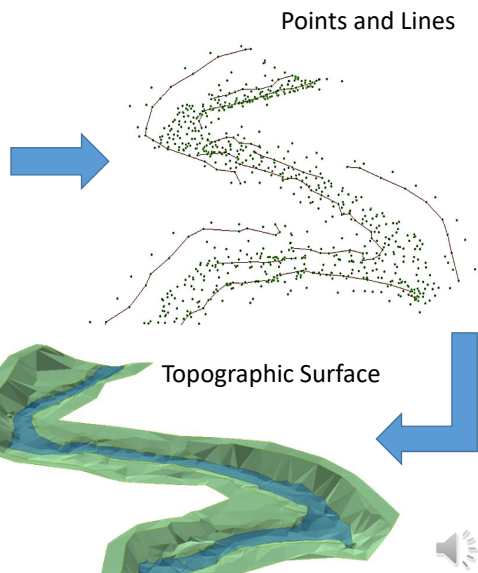
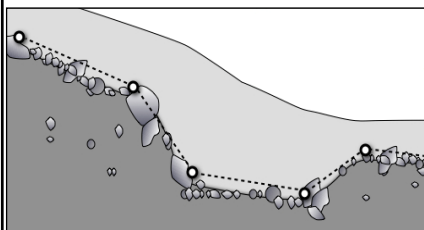
North American Journal of Fisheries Management 30:565–587, 2010
 © Copyright by the American Fisheries Society 2010
 DOI: 10.1577/M09-061.1

**A Comparison of the Performance and Compatibility of
 Protocols Used by Seven Monitoring Groups to Measure
 Stream Habitat in the Pacific Northwest**

Roper et al. 2010

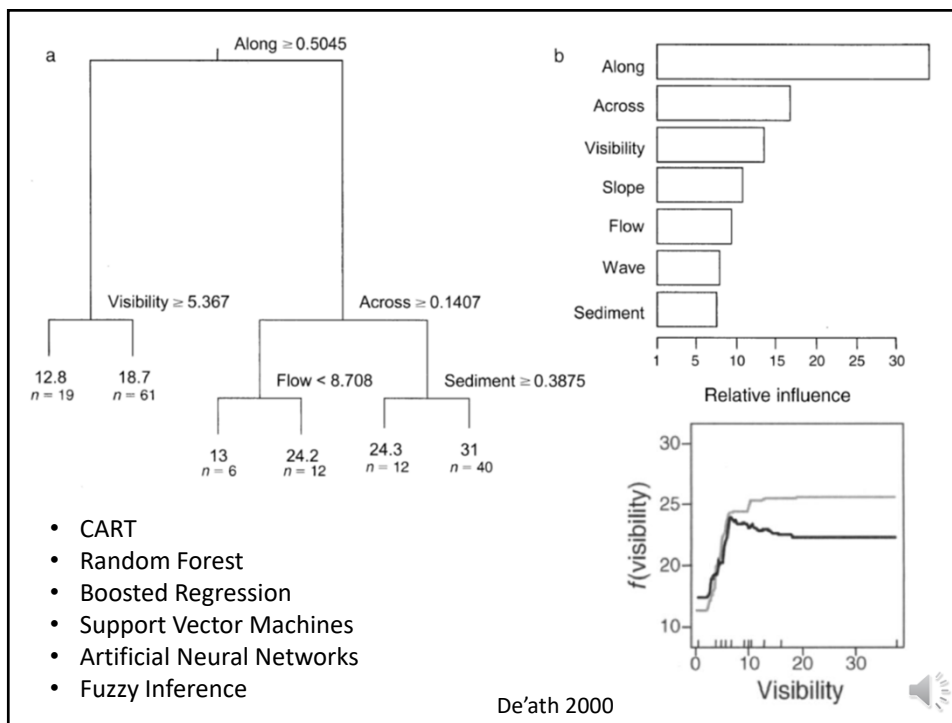
Attribute class	Attribute	Statistic	Monitoring group				
			AREMP	CDFG	EMAP	NIFC	ODFW ...
Reach characteristics	Gradient (%)	Mean	3.35	3.41	3.60	NM	3.48
		RMSE	0.20	1.01	0.49	NM	0.76
		CV	5.9	29.5	13.7	NM	21.9
	Sinuosity	S:N	188.2	4.9	28.7	NM	14.1
		Mean	1.22	NM	1.19	NM	NM
		RMSE	0.04	NM	0.06	NM	NM
Channel cross section	BFW (m)	CV	3.1	NM	5.1	NM	NM
		S:N	13.0	NM	5.5	NM	NM
		Mean	7.40	6.10	5.27	5.90	6.16
	W:D	RMSE	1.63	1.48	1.89	0.83	2.58
		CV	22.0	24.3	35.9	14.0	41.8
		S:N	10.9	6.8	2.5	24.7	2.8
Habitat composition	Percent pools	Mean	15.45	19.80	14.26	19.65	18.09
		RMSE	2.94	5.68	4.30	3.93	3.10
		CV	19.0	28.7	30.1	20.0	17.1
	...	S:N	2.1	1.7	1.7	6.1	3.5
		Mean	37.83	8.37	10.28	23.59	20.99
		RMSE	8.26	6.22	8.30	5.53	7.12
...		CV	21.8	74.2	80.7	23.4	33.9
		S:N	5.2	0.4	1.6	13.5	7.0

Topographic Surveys



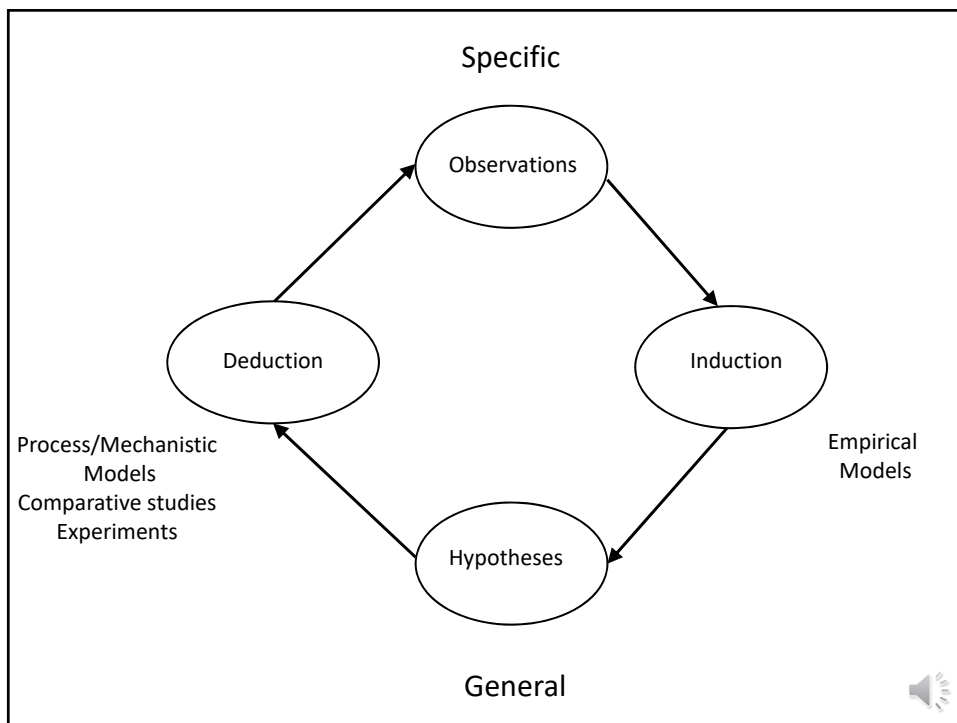
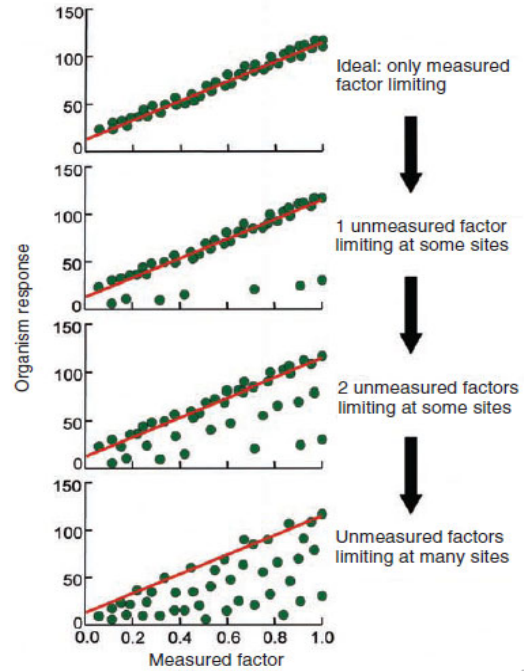
Overcoming limitations to empirical approaches

- Improved data quality and quantity
- Non-linearity
- Higher order interactions
- Threshold effects
- Missing data



Quantile Regressions

Cade and Noon 2003



Habitat Suitability Models

- Make measurements of the abiotic variable of interest where you see the fish
- Make histogram... Fit curve..
- Do inventory of all available habitat (turn into frequency of fish presence)
- Divide to get normalized preference

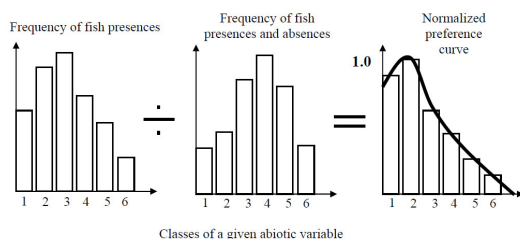
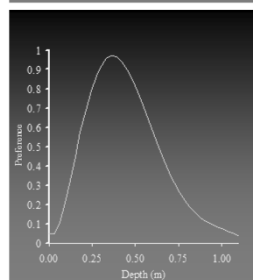
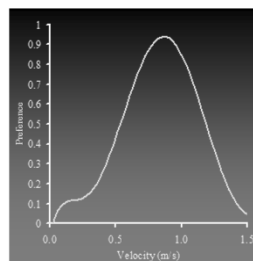
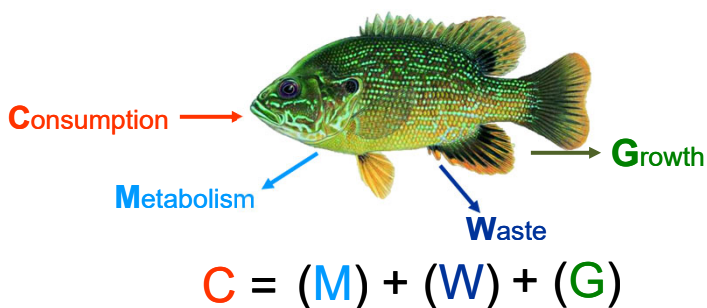
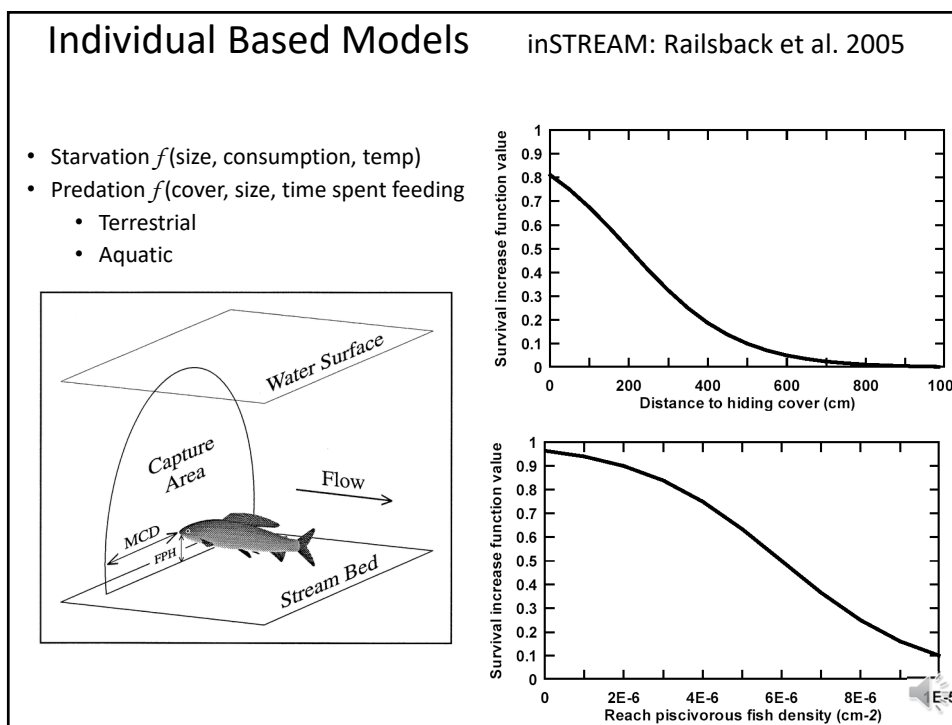
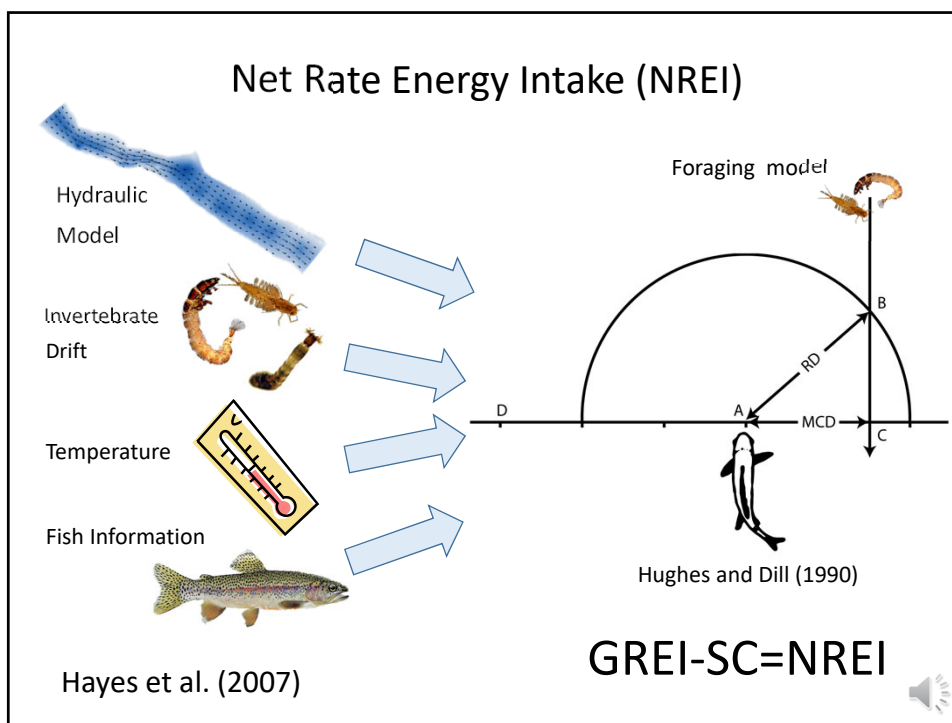


Figure 3 : The general methodology for establishing fish preference curves

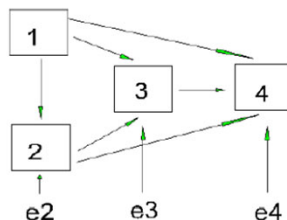


Bioenergetics Models





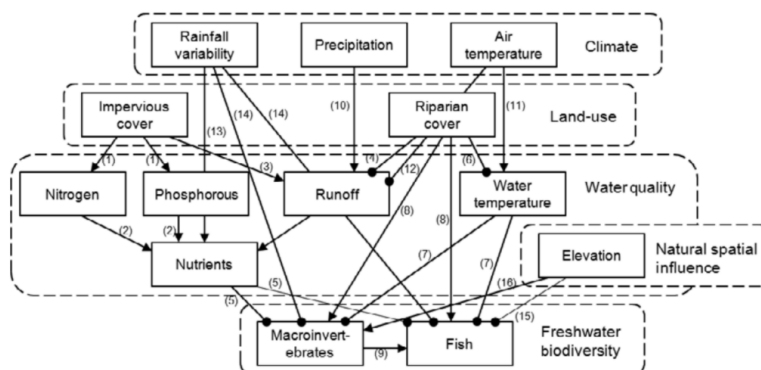
Structural Equation Modeling



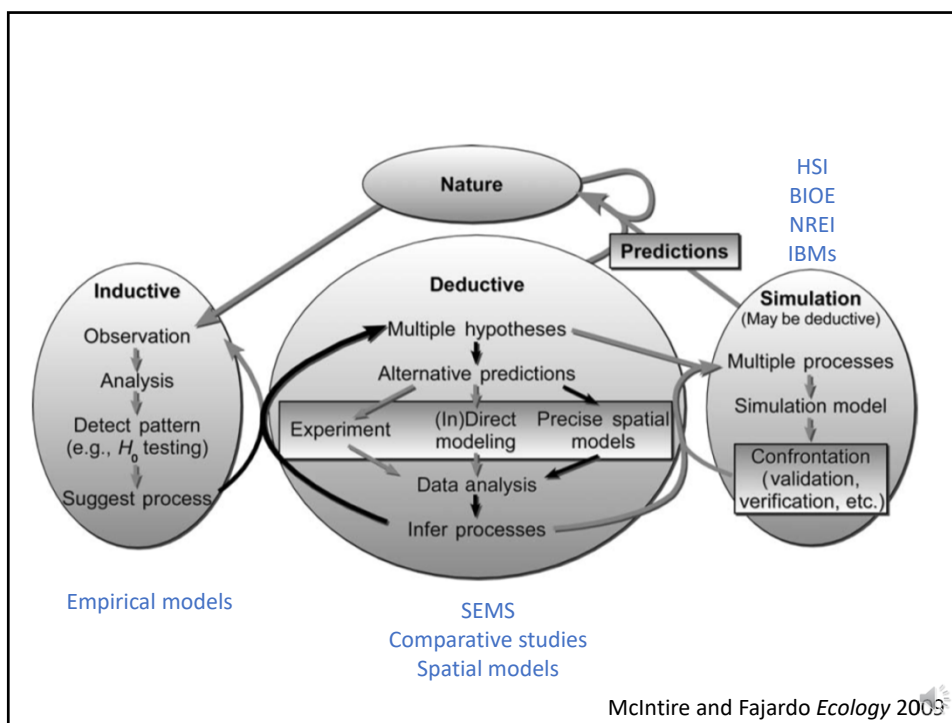
- ❖ Path analysis developed by Sewall Wright (1918, 1921) to understand multiple causes and multiple responses
- ❖ Modern SEM involves analysis of covariance matrix to reveal causal relationships
- ❖ Model building and evaluation best represented graphically

McIntire and Fajardo *Ecology* 2009
Slide from Seth White

Bayesian Belief Networks




Mantyka-Pringle et al. 2014 *Journal of Applied Ecology*



FEATURE

Why It Is Time to Put PHABSIM Out to Pasture



Steven F. Railsback
Department of Mathematics, Humboldt State University, Arcata, CA, and Lang Railsback and Associates, 250 California Avenue, Arcata, CA 95521. E-mail: Steve@LangRailsback.com

720 Fisheries | Vol. 41 • No. 12 • December 2016

- **Preference may not indicate fitness**
- **Dominance hierarchy can push individuals into less favorable environments**
- Does not include other important variables (e.g. temp, food)
- Not transferrable
- Poor selectivity model
- Far better options

COMMENT 2:
WHY IT IS TIME TO PUT PHABSIM OUT TO PASTURE

Don't Throw Out the Baby (PHABSIM) with the Bathwater: Bringing Scientific Credibility to Use of Hydraulic Habitat Models, Specifically PHABSIM

Clair B. Dalnaker, U.S. Geological Survey, Retired, 5415 East County Road 58, Fort Collins, CO 80524.
E-mail: clair.dalnaker@usgs.gov

Jan Chisholm, Minnesota Department of Natural Resources, Ecological and Water Resources Division, River Science Unit Supervisor, Saint Paul, MN

Andrew Paul, Provincial Environmental Flow Specialist, Alberta Environment and Parks, Cochrane, AB, Canada

Is use a good measure of habitat quality?

USE ← SELECTION ← PREFERENCE ← FITNESS

DENSITY AS A MISLEADING INDICATOR OF HABITAT QUALITY

B. VAN HORNE, Department of Biology, University of New Mexico, Albuquerque, NM 87131

J. WILDL. MANAGE. 47(4):893-901

★  Cited by 3142

Research Techniques in
Animal Ecology

Chapter 4

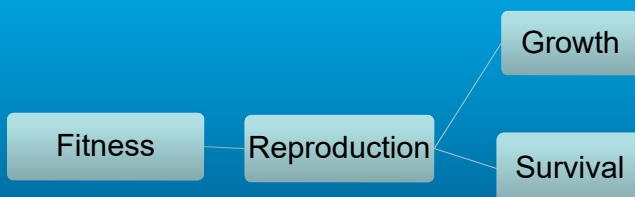
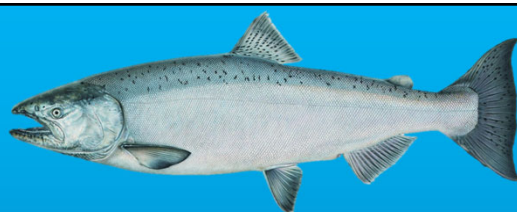
Continuities and Consequences

Delusions in Habitat Evaluation: Measuring Use,
Selection, and Importance

DAVID L. GARSHELIS

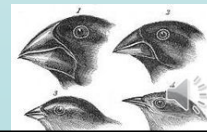
★  Cited by 715

- Very difficult to measure
 - Spatial, temporal var.
- Use = importance?
- Appropriate metrics-
selectivity?
- Dominance hierarchy can
push individuals into less
favorable environments
- Rarely linked to measures
off fitness



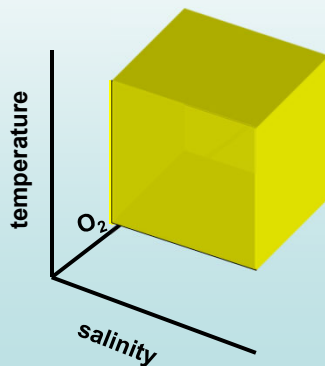
Concept of the niche

- Grinnell (1917,1928)
 - niche describes where an organism lives
 - the niche is the “ultimate distributional unit within which each species is held by its structural and functional limitations”
- Elton (1927), Lotka-Volterra (1925/26) Gause (1934)
 - niche is more what a species does than where it lives
 - competitive exclusion principle: the intensity of competition between species suggests the degree to which their niches overlapped
- Lack (1947)
 - realized that niche relationships could provide a basis for evolutionary diversification of species



The Niche G. Evelyn Hutchinson (1957)

The n -dimensional hypervolume



Ecological space



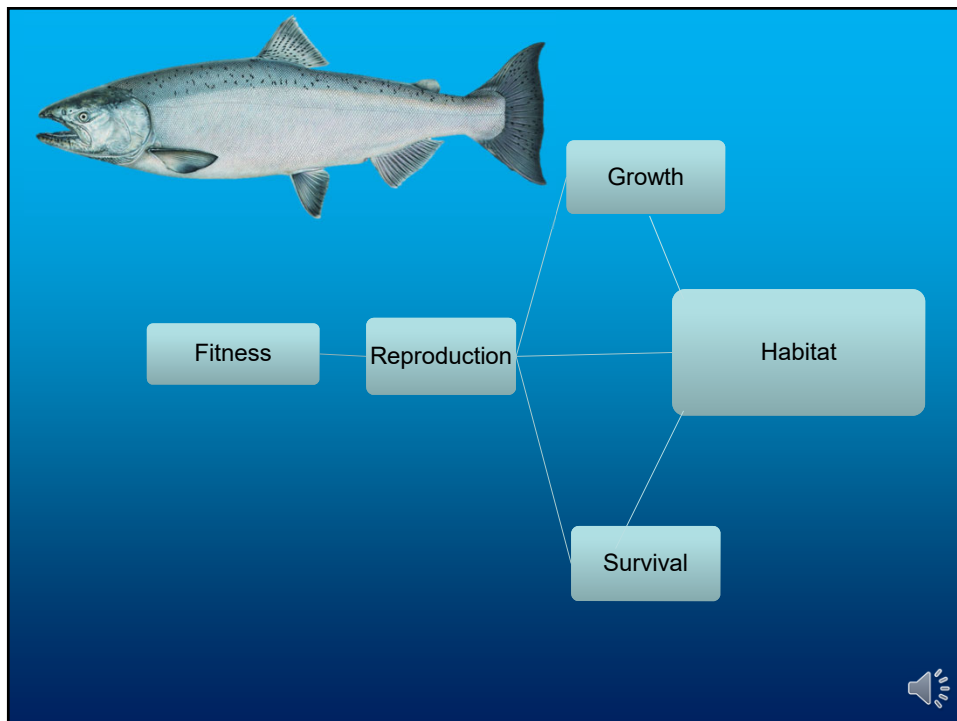
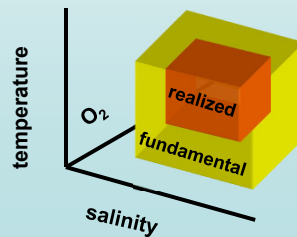
The Niche

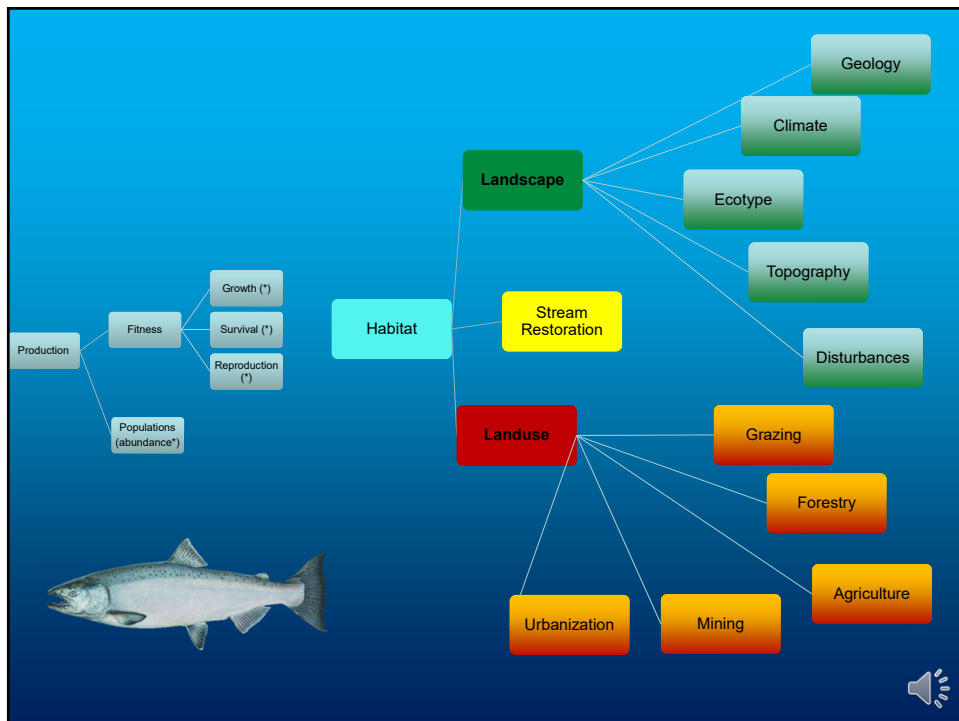
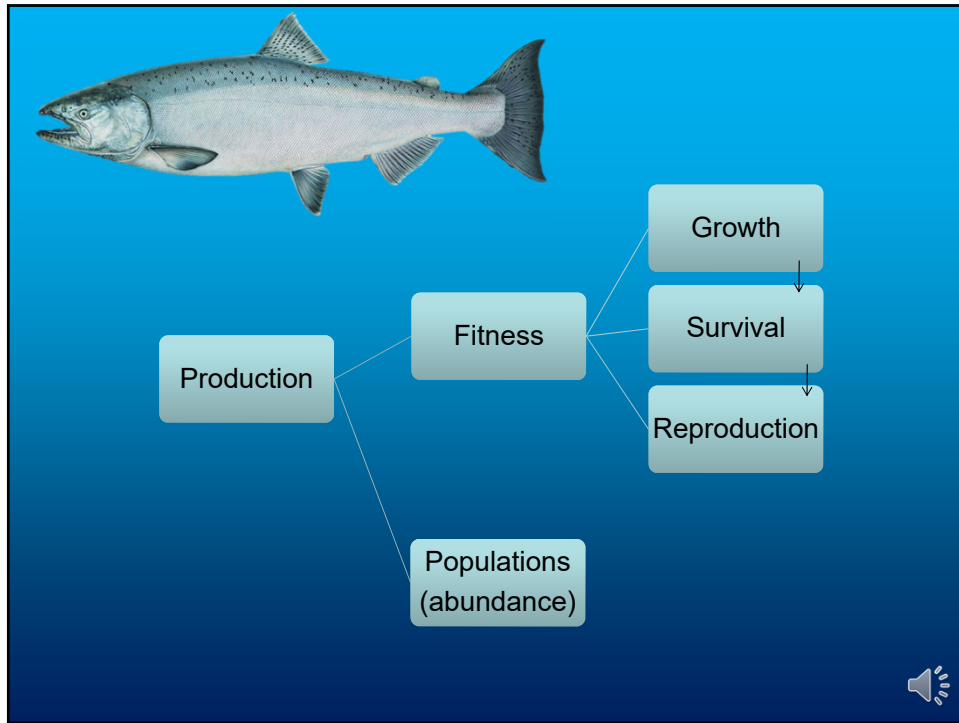
G. Evelyn Hutchinson (1957)

The ecological space in which a species could live is often greater than the space the organism actually occupies

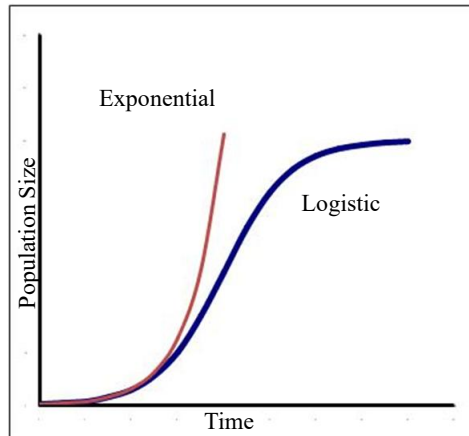
Fundamental niche: all aspects of the n -dimensional hypervolume in the absence of other species.

Realized niche: the part of the fundamental niche to which the species was restricted due to interspecific interactions.





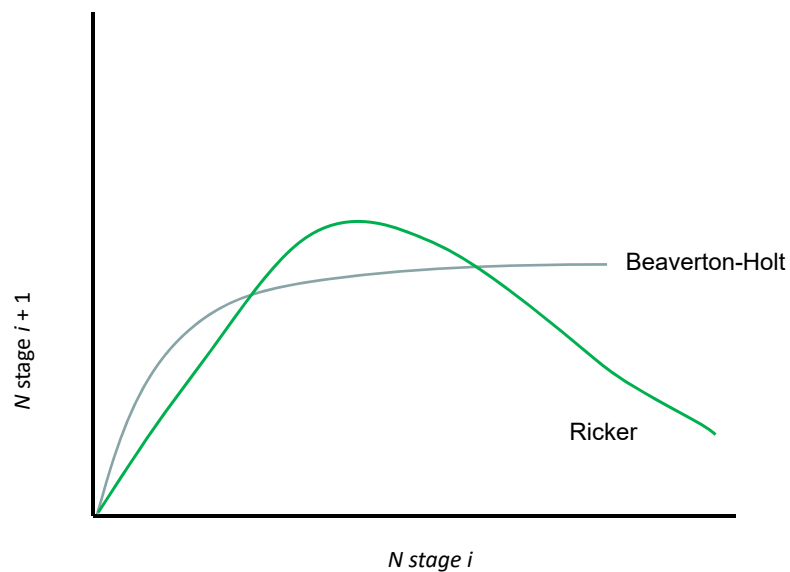
Population growth

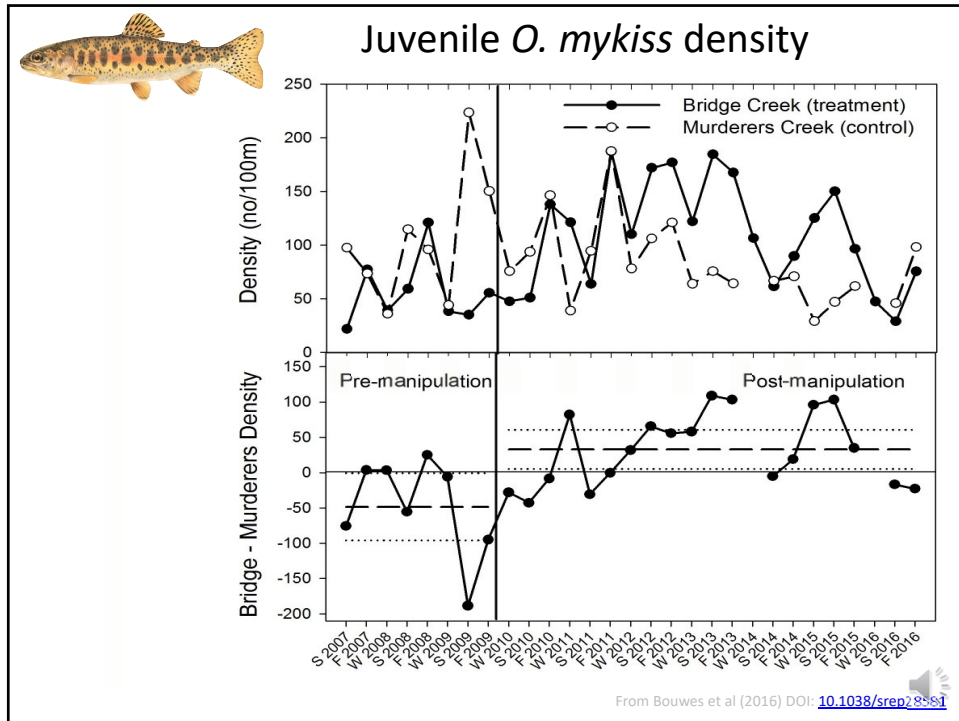


- Malthus (1798)- *Essay on Population*
 - If populations left unchecked they would outstrip their food supply.
 - Because population pressure could never be eliminated, we could not create utopian society where war, famine, and vice were absent.
- Darwin (1859)- *Origin of Species*
 - Overpopulation lead to intense competition, might cause one species to adapt to split into several.
 - The “struggle for existence” included all forms of competition
 - Competition was the main mechanism for evolution.
- Logistic growth- Verhulst (1830s), Pearl (1920s).

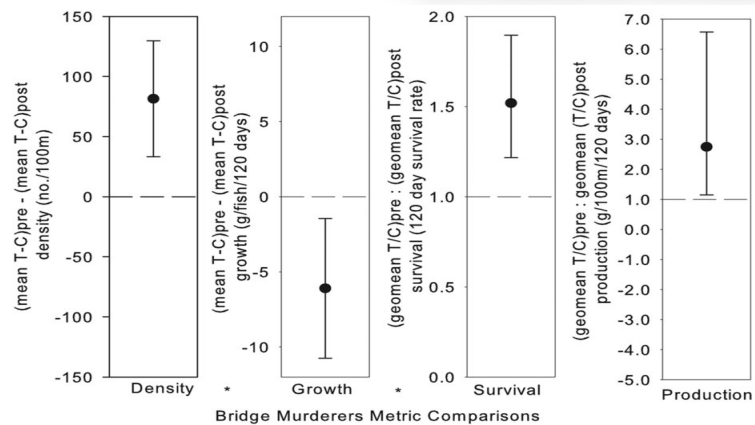
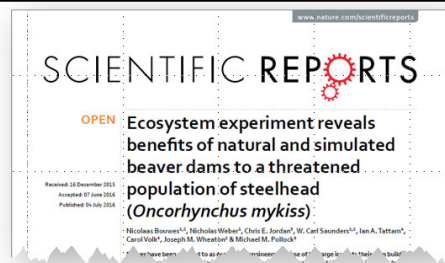


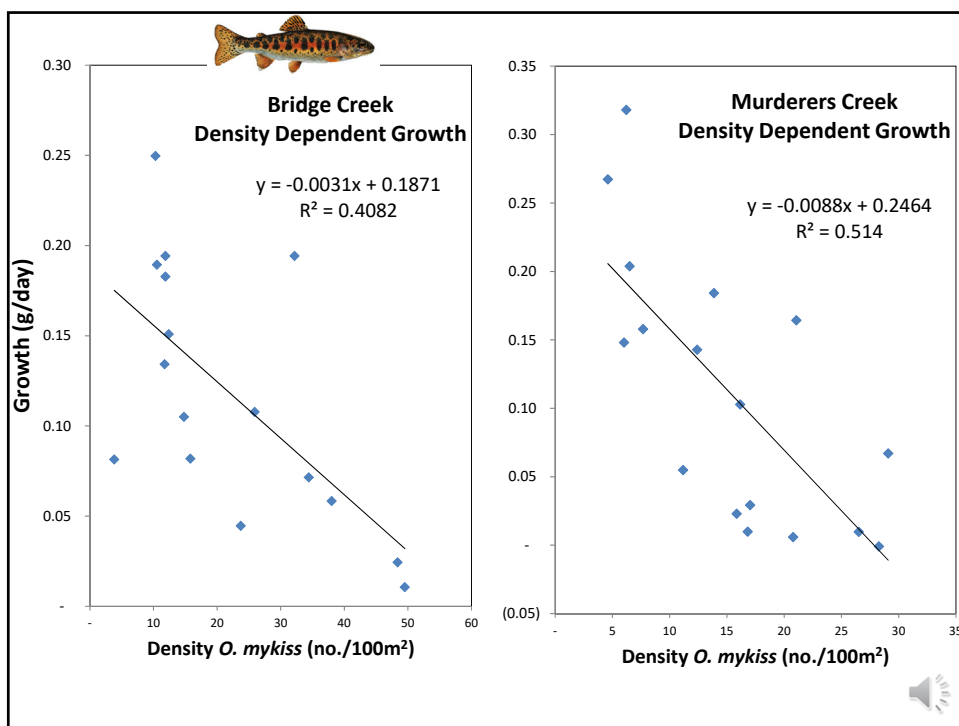
Density Dependent Population Models





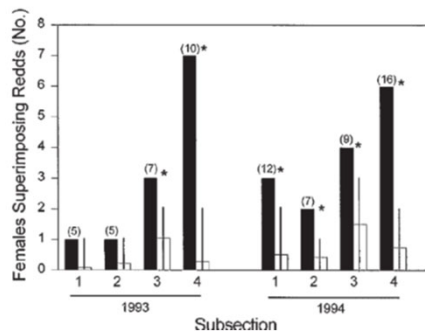
Population Level Response





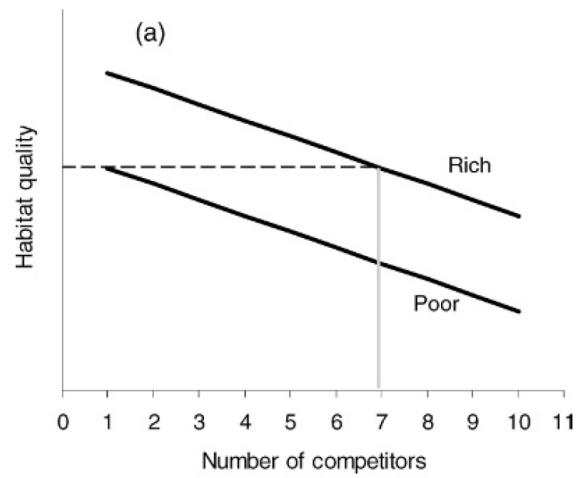
Superimposition-random?

Fig. 2. Observed frequency of brown trout redd superimposition (solid bars) and mean expected frequency (open bars) if females randomly dispersed over available habitat. Lines denote 0.05 and 0.95 percentiles of the expected frequency of superimposition, calculated by performing 1000 simulations of random redd site selection within available habitat. Numbers above bars indicate the total number of females spawning in each subsection. Asterisks denote significant difference between expected and observed superimposition ($P < 0.05$).

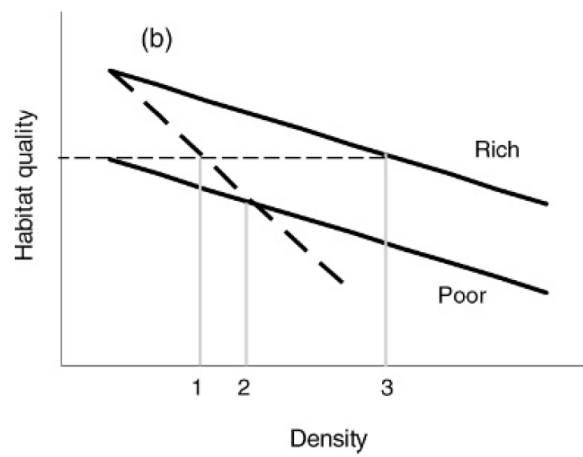


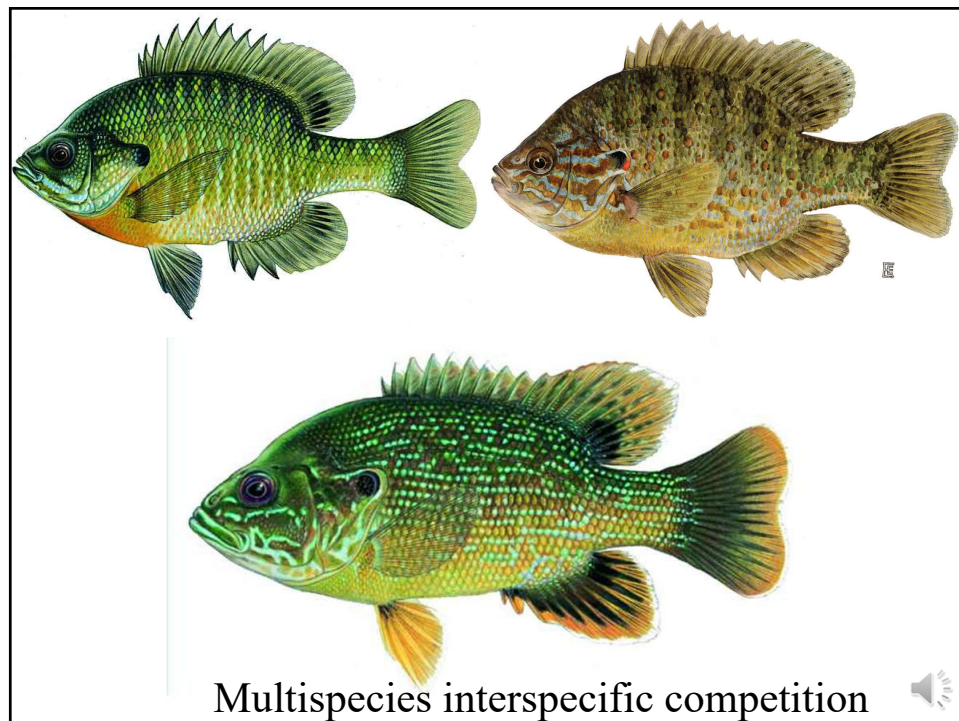
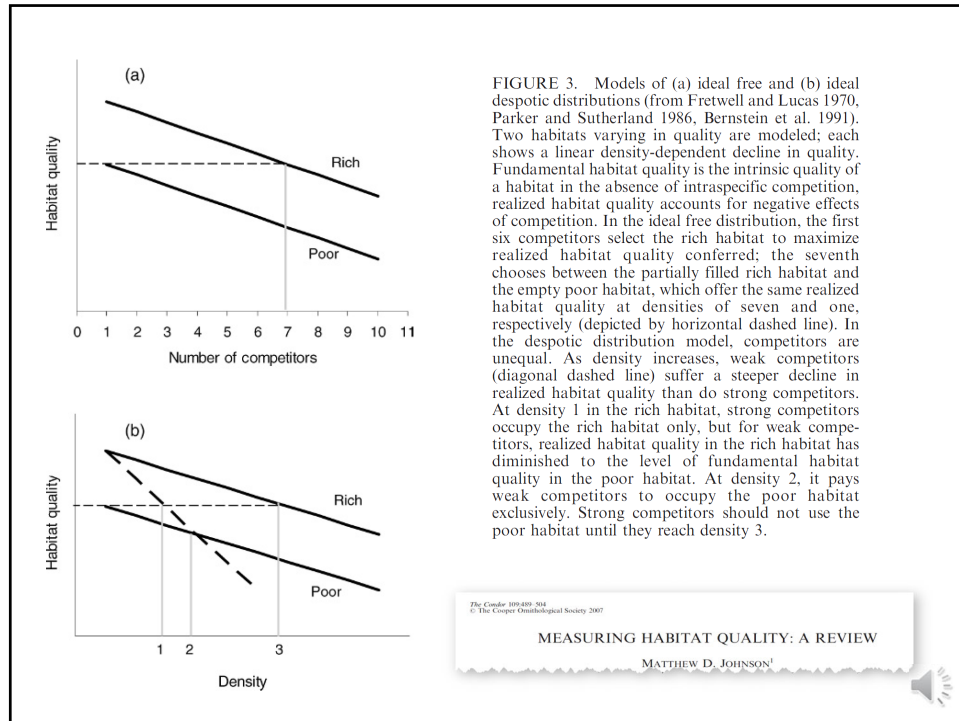
Essington et al 1998

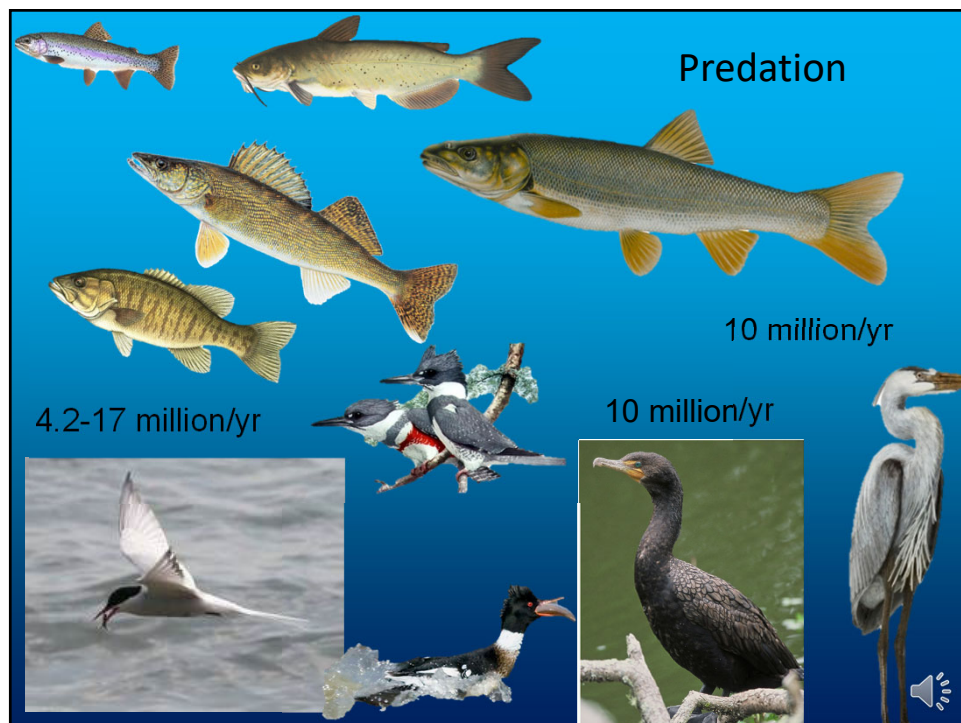
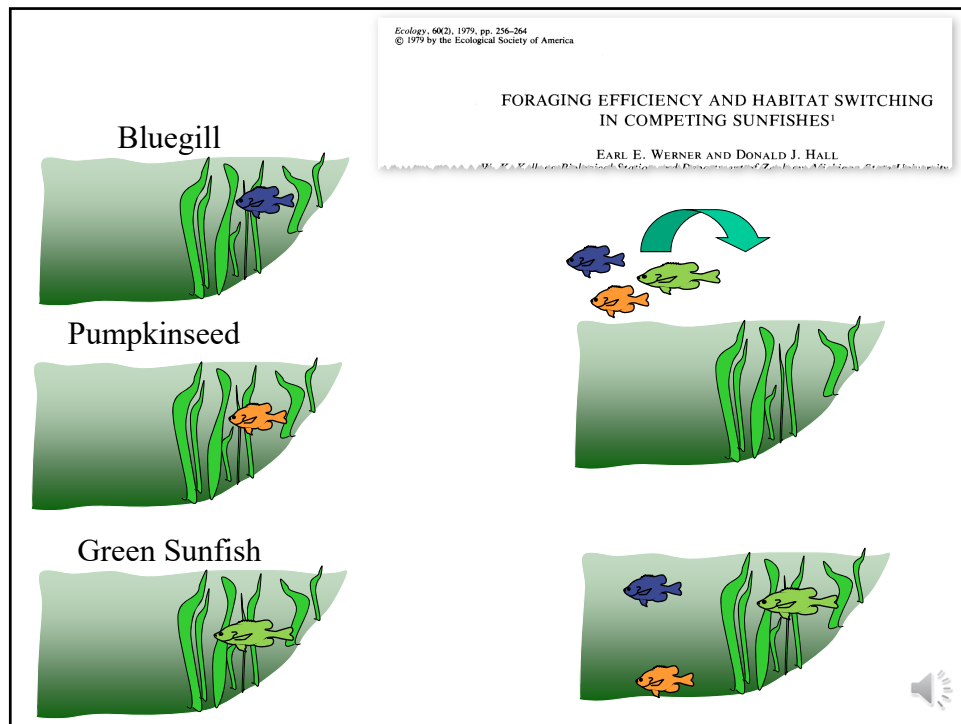
Ideal Free Distribution (IFD)



Ideal Despotic Distribution








FEATURE

Why It Is Time to Put PHABSIM Out to Pasture



Steven F. Railsback
Department of Mathematics, Humboldt State University, Arcata, CA, and Lang Railsback and Associates, 250 California Avenue, Arcata, CA 95521. E-mail: Steve@LangRailsback.com

- Preference may not indicate fitness
- Dominance hierarchy can push individuals into less favorable environments
- **Does not include other important variables (e.g. food, temp, etc.)**
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COMMENT 2:
WHY IT IS TIME TO PUT PHABSIM OUT TO PASTURE

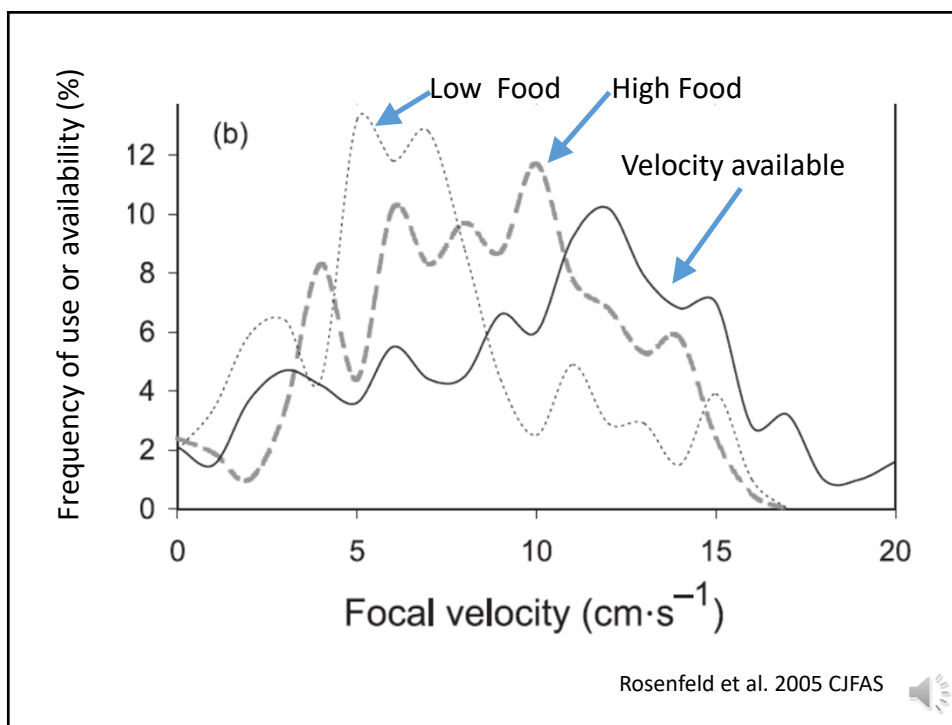
Don't Throw Out the Baby (PHABSIM) with the Bathwater: Bringing Scientific Credibility to Use of Hydraulic Habitat Models, Specifically PHABSIM

Clair B. Stalder, U.S. Geological Survey, Wetland and Aquatic Science Center, 3415 East County Road 58, Fort Collins, CO 80524. E-mail: clair.stalder@usgs.gov

Jan Drouhin, Minnesota Department of Natural Resources, Ecological and Water Resources Division, River Science Supervisor, Saint Paul, MN

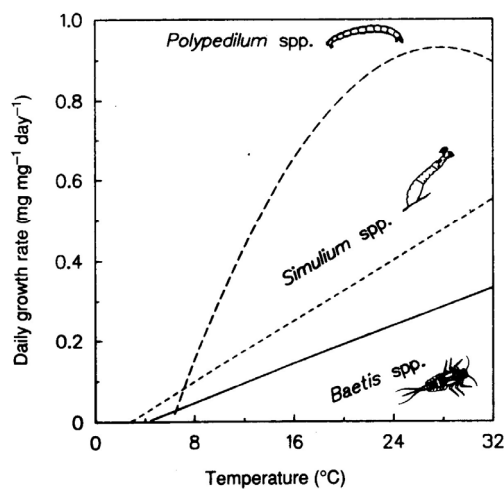
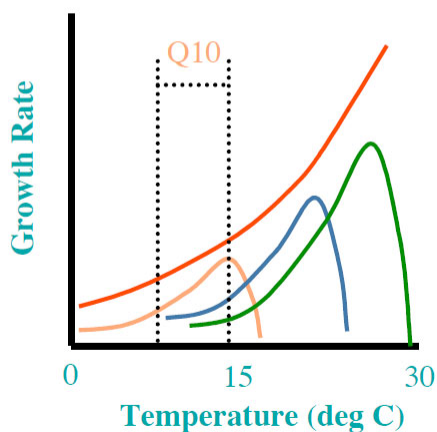
Andrew Paul, Provincial Government of Alberta, Alberta Environment and Parks, Calgary, AB, Canada

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Temperature & Phytoplankton

- Eppley (1972) plotted species growth vs. temp.
- Empirically determined that all phytoplankton fit under a curve



Food
resources and
temperature

FIGURE 3.18 Daily growth rates ($\text{mg mg}^{-1} \text{ day}^{-1}$) as a function of temperature for three aquatic insects found on snag habitat in the Ogeechee River, Georgia, and reared in streamside artificial channels. Insects include the midge *Polypedium*, the black fly *Simulium*, and the mayfly *Baetis*. (From Benke, 1993.)



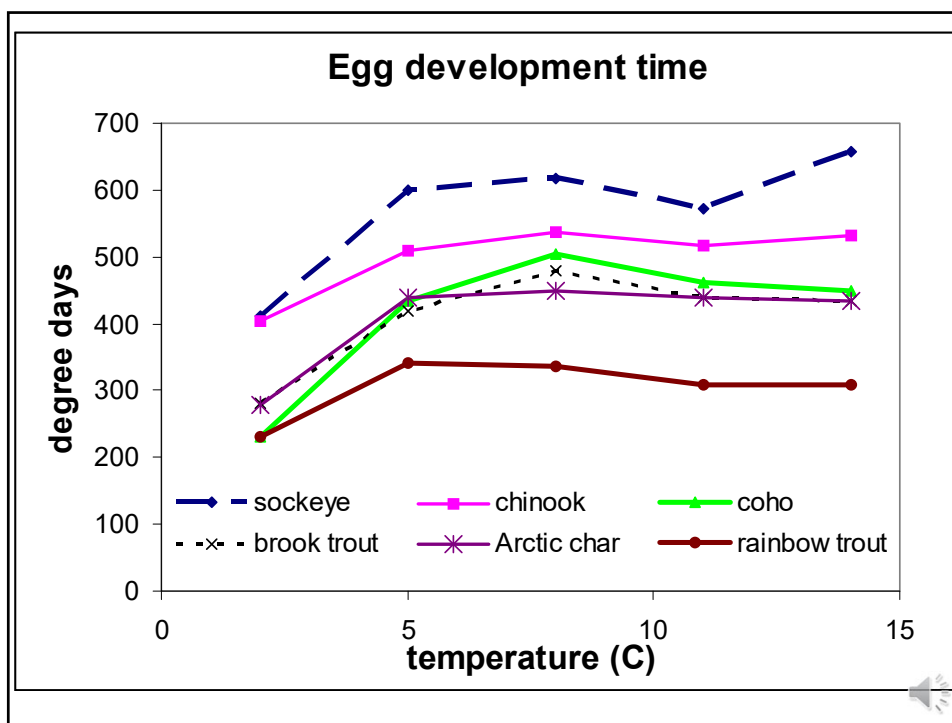
Egg development and temperature



TABLE 8-1. Number of days from fertilization to emergence and from fertilization to hatching for Pacific salmon at constant temperatures, from Murray and McPhail (1988). Data on other species are from Gunnes (1979), Humpesch (1985), Velsen (1987), Crisp (1988), Johnston (2002) and unpublished sources. Methods varied among the studies, and there is also variation among populations, so the values are only generalizations.

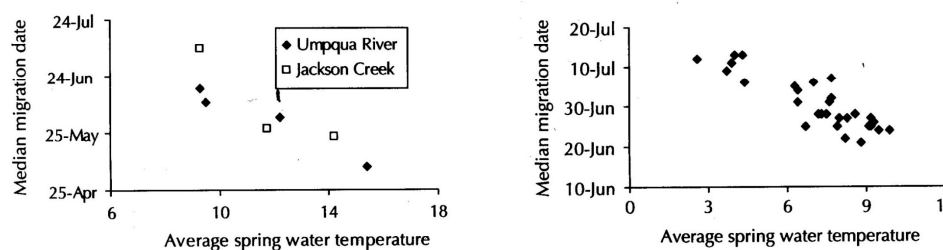
	Temperature (°C)				
	2°	5°	8°	11°	14°
<i>Days to emerge</i>					
sockeye salmon	282	173	121	90	72
chinook salmon	316	191	115	84	63
chum salmon		161	124	98	86
pink salmon		173	120	91	72
coho salmon	228	139	109	74	61
<i>Days to hatch</i>					
sockeye salmon	206	120	77	52	47
chinook salmon	202	102	67	47	38
chum salmon		97	67	52	46
pink salmon		99	72	47	40
coho salmon	115	87	63	42	32
lake trout	155	100	65		
Atlantic salmon		100	63	43	
brook trout	140	84	60	40	31
Arctic char	139	88	56	40	31
brown trout	148	82	57	35	
rainbow trout	115	68	42	28	22
cutthroat trout		61	45	25	
<i>Hucho hucho</i>		55			

Time for egg development under different temperatures (Quinn 2005)

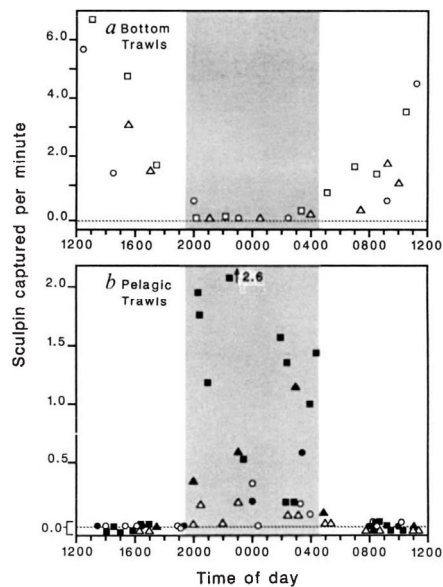


Outmigration timing and temperature

FIGURE 12-4. Relationship between spring water temperature and interannual variation in migration timing of (left) chinook salmon leaving tributaries of the Umpqua River, Oregon (Roper and Scarnecchia 1999), and (right) sockeye salmon leaving Iliamna Lake, Alaska (Alaska Department of Fish and Game annual reports).



Diel Vertical Migration Bear Lake Sculpin



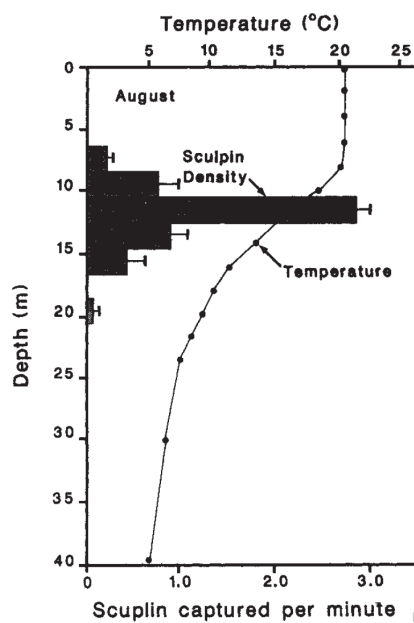
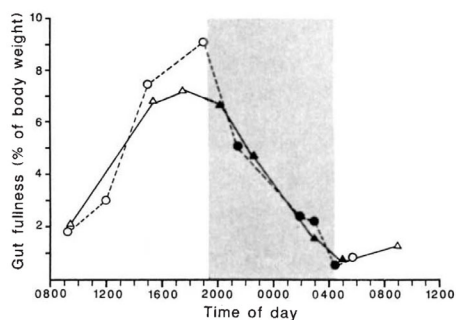
Post-feeding thermotaxis and daily vertical migration in a larval fish

Wayne A. Wurtsbaugh & Darcy Neverman*

Department of Fisheries and Wildlife/Ecology Center,
Utah State University, Logan, Utah 84322-5210, USA

NATURE VOL. 333 30 JUNE 1988

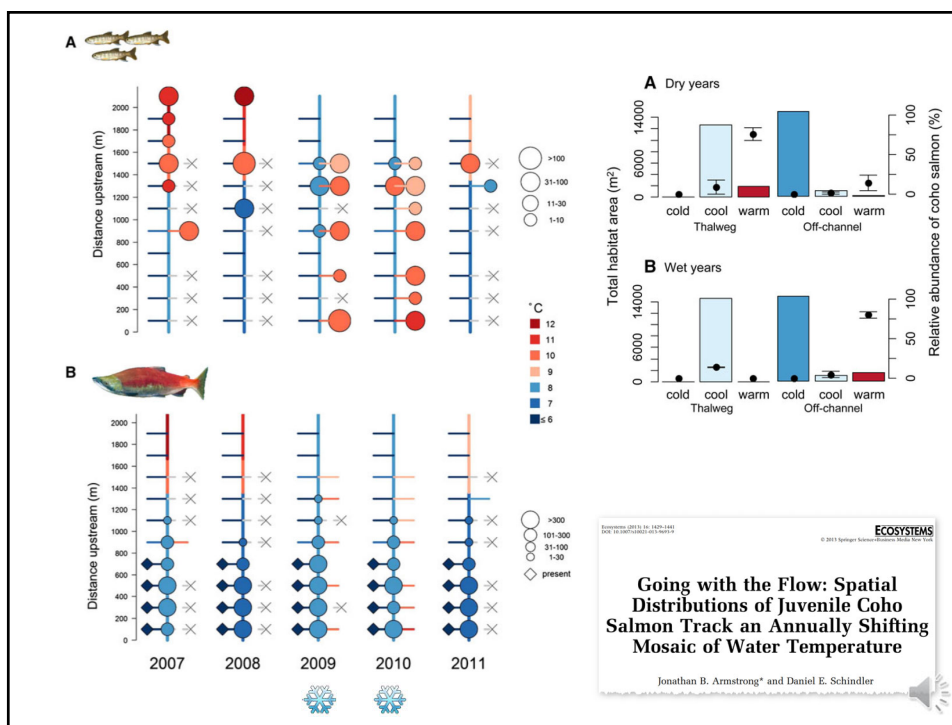
Diel Vertical Migration Bear Lake Sculpin



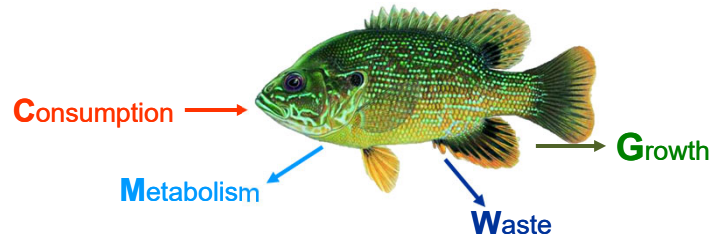
Selecting for optimal temperatures

Table 1 Effects of constant and fluctuating temperatures on feeding and growth rates (dry weight) of juvenile Bear Lake sculpin (*Cottus extensus*) reared in the laboratory

Temperature	Condition simulated	Feeding rate* at 5 °C (strikes per fish min ⁻¹)	Growth rate* (% per day)
5 °C	Hypolimnion	0.22 ± 0.08	0.74 ± 0.30
5–15 °C	Migratory	0.48 ± 0.15	2.15 ± 0.45



Bioenergetics Models



$$C = (M) + (W) + (G)$$

