Woody Habitat Science: Knowns, Unknowns, and Current Studies

Greg G. Sass
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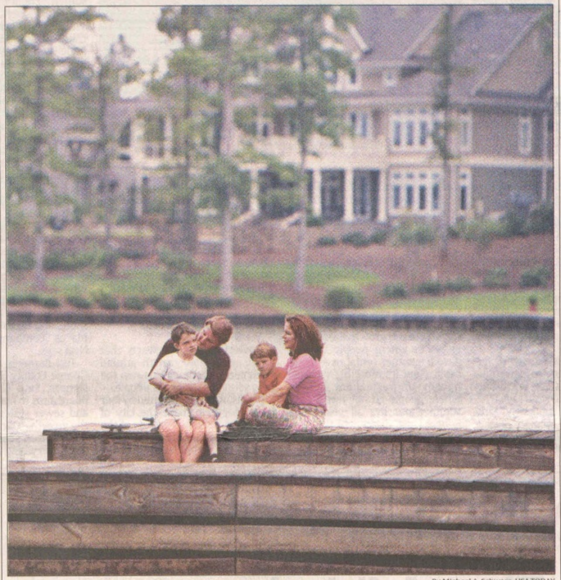
Wisconsin DNR, Bureau of Science Services

Lakeshore Residential Development – United States

USA TODAY

NO. 1 IN THE USA

Recreation, nature lead homeowners to water



By Michael A. Schwarz, USA TODAY

Moved from Atlanta: Frank and Catherine Clark with their sons, Hampton, 7, and Palmer, 5, are among the families realizing their dream of living by a lake. In this case, it's Lake Oconee near Greensboro, Ga.

Growing number of U.S. families are revitalizing their lives — as well as counties — by moving closer to lakes

Cover story

By Larry Copeland
USA TODAY

GREENSBORO, Ga. — Frank and Catherine Clark had lived in Atlanta for more than a decade when they got fed up with city living: The traffic congestion. The high costs and long waiting lists at good private schools. And, critical for him, the near-impossibility of getting into a desirable golf club.

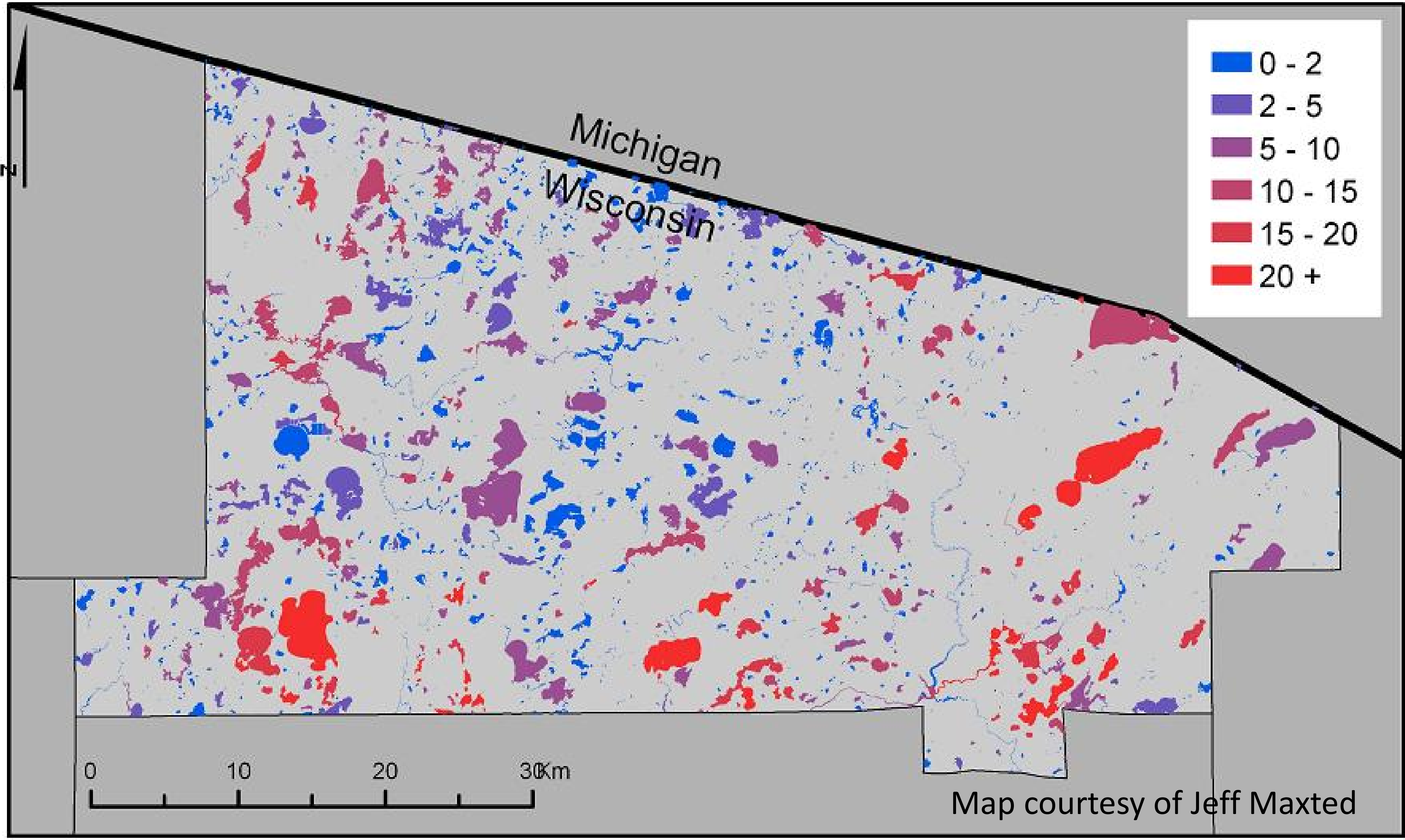
They started looking around and settled here, 75 miles east of Atlanta. Catherine Clark, a flight attendant, says her commute to Hartsfield Atlanta International Airport takes only 10 minutes longer. Their sons, Hampton, 7, and Palmer, 5, can attend private schools costing one-third to one-half what they would pay in their in-town Atlanta neighborhood of Buckhead. Her husband has four golf courses right in their subdivision.

Perhaps best of all, their house is by a lake. "We're happy. We enjoy this way of life," says Frank Clark, 42, a sales manager for a door company. "People out here have a lot of space. It's kind of retro, 'Let's get back to the way things were 60 years ago.'" Adds Catherine Clark, 39: "My parents say Hampton and Palmer have no idea how good they've got it: fishing in the lake, swimming, doing things most people do on their vacation."

The Clarks are among a growing number of Americans fleeing the confines of the big city for the natural beauty, convenience and recreational allure of lakefront living. Many of these

Please see COVER STORY next page ▸

Lakeshore Residential Development



Map courtesy of Jeff Maxted



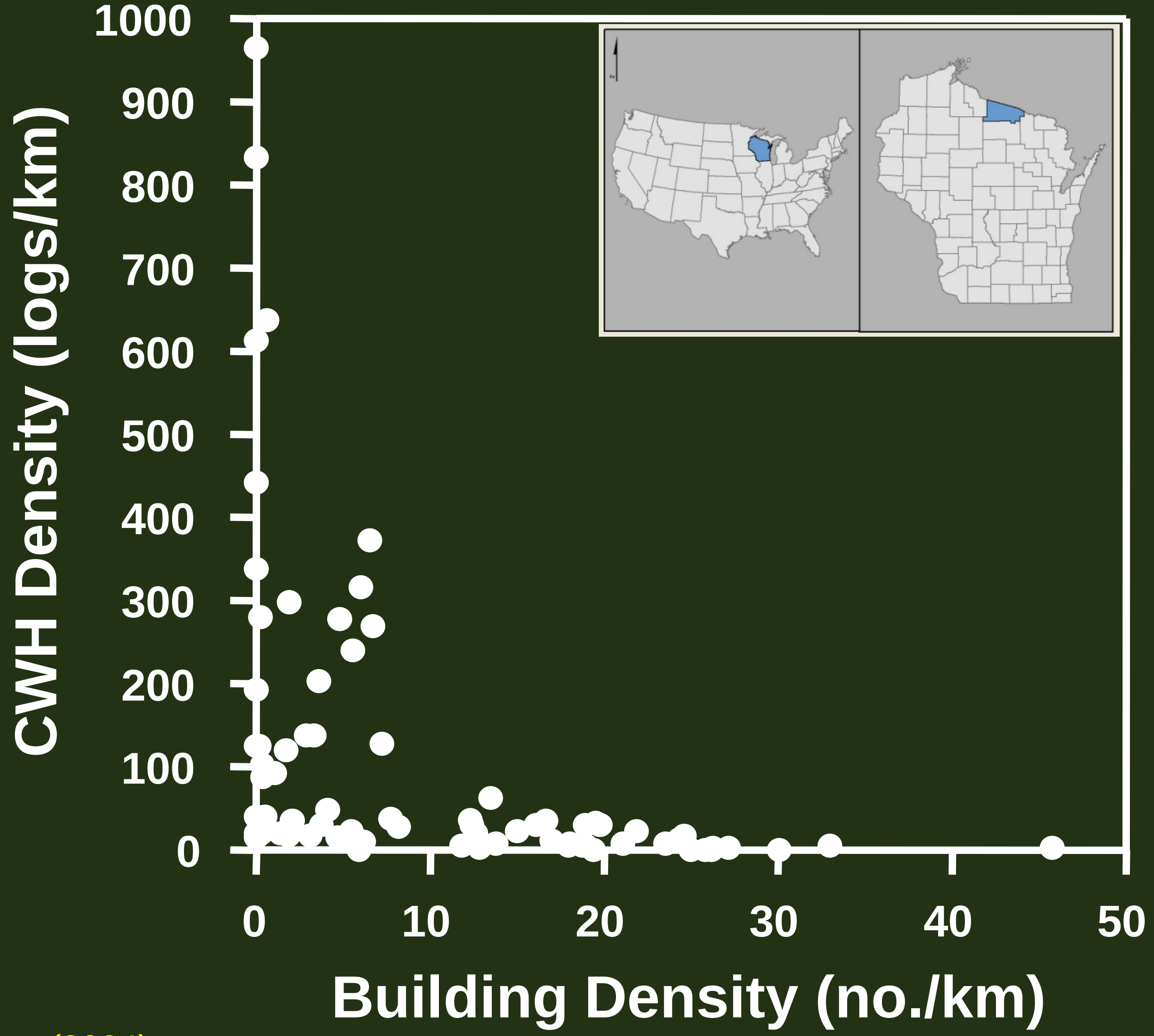

B. Roth


Coarse Woody Habitat (CWH)

-“Trees, logs, branches, and sticks found in lakes, rivers, and streams”

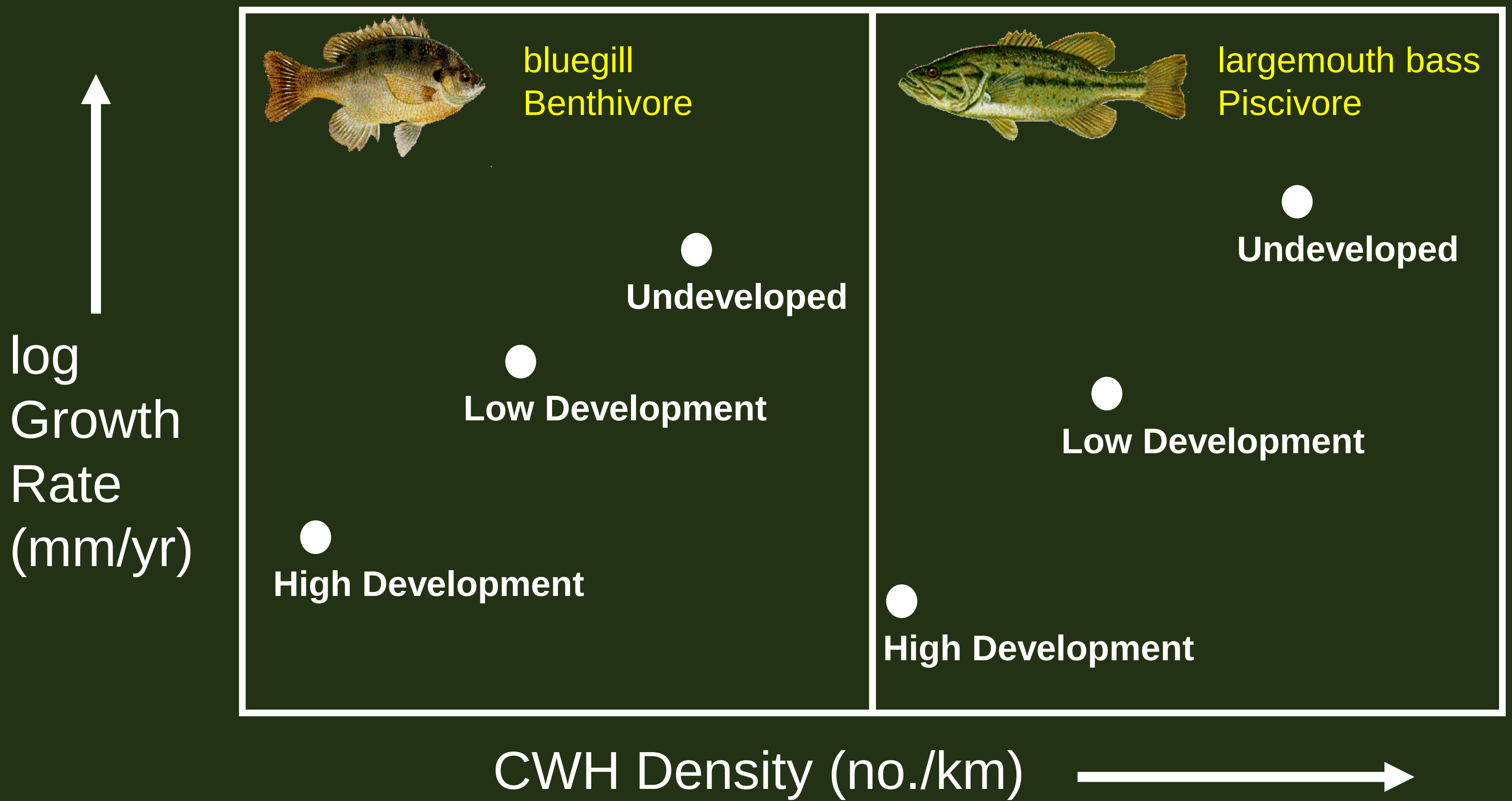
-Also called large woody debris (rivers), coarse woody debris (CWD), wood

CWH and Lakeshore Residential Development



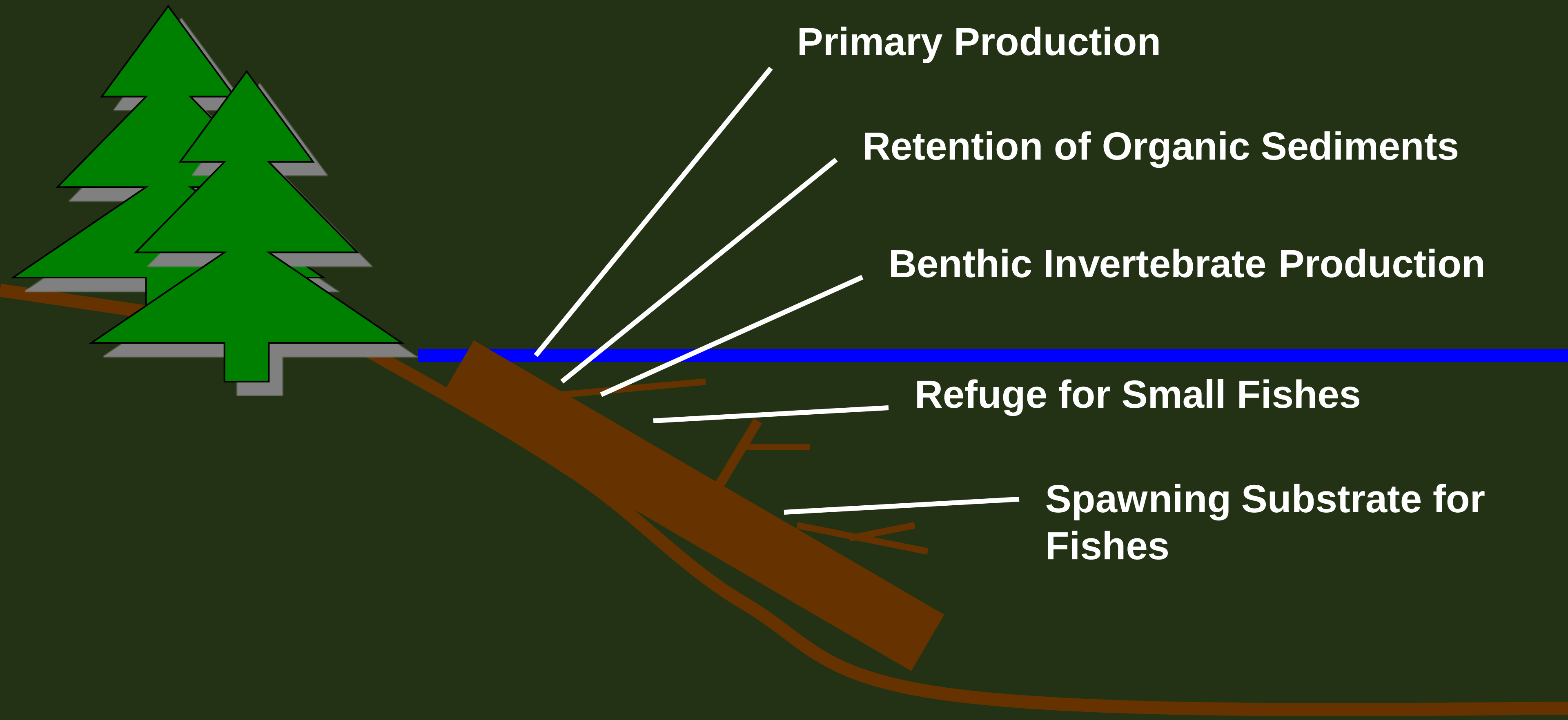
Sugden-Newbery (2004)

Fish Growth and Coarse Woody Habitat

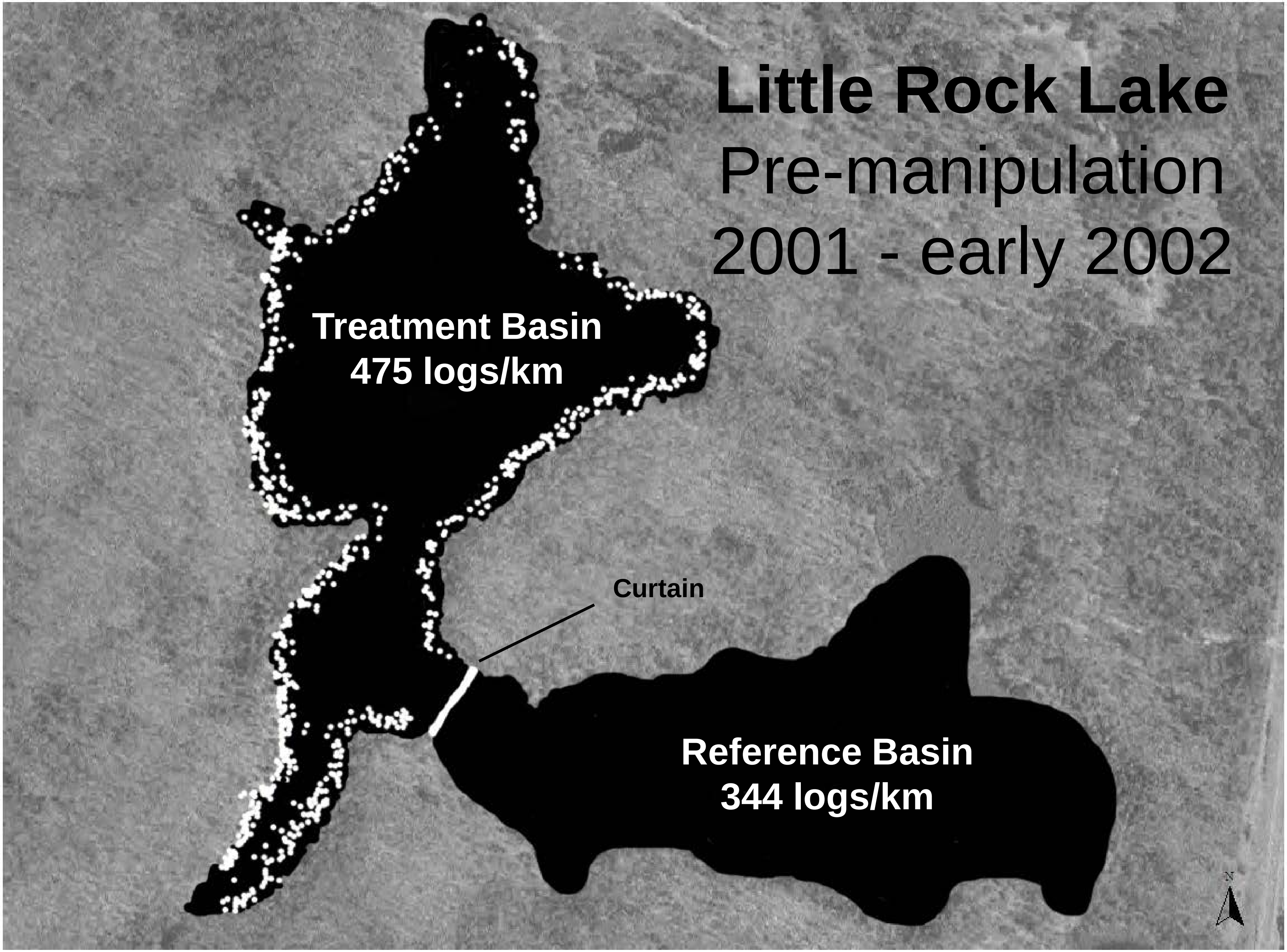


From Schindler et al. (2000); Gaeta et al. (2011)

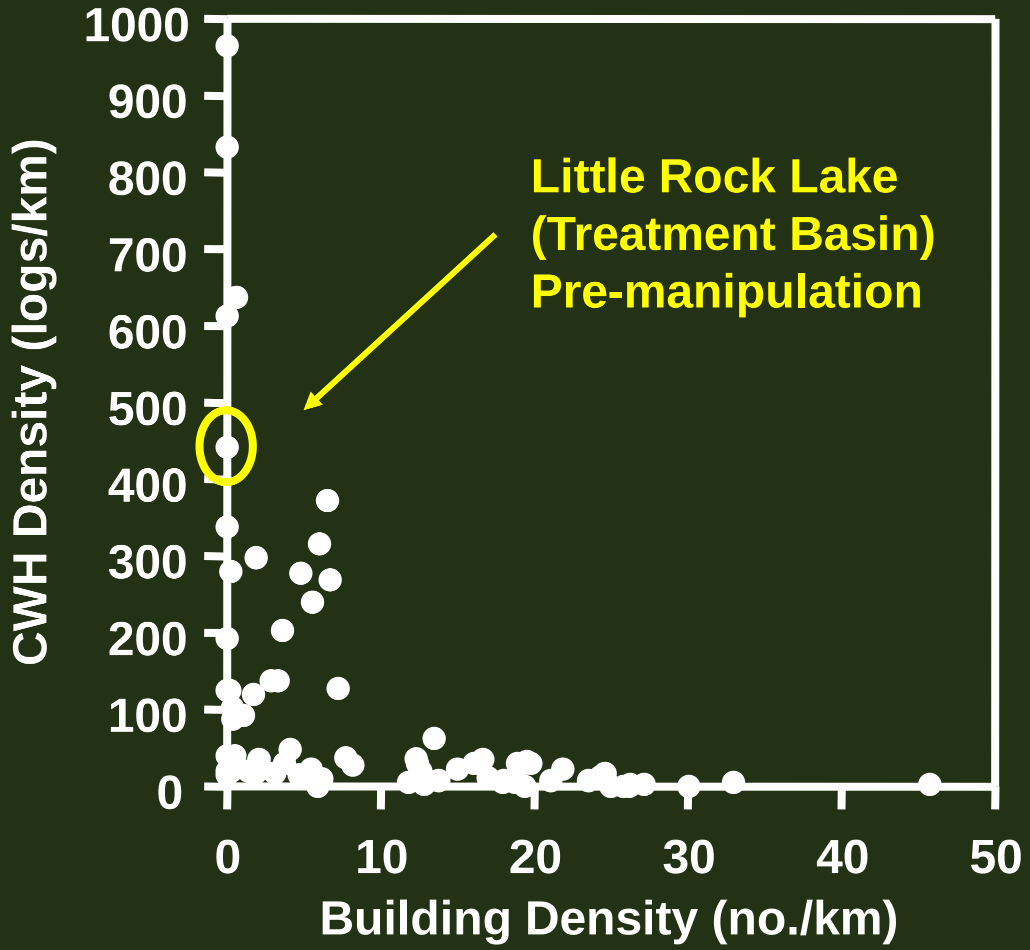
Multiple Roles of CWH




yellow perch
(*Perca flavescens*)
Benthivore
largemouth bass
(*Micropterus salmoides*)
Piscivore

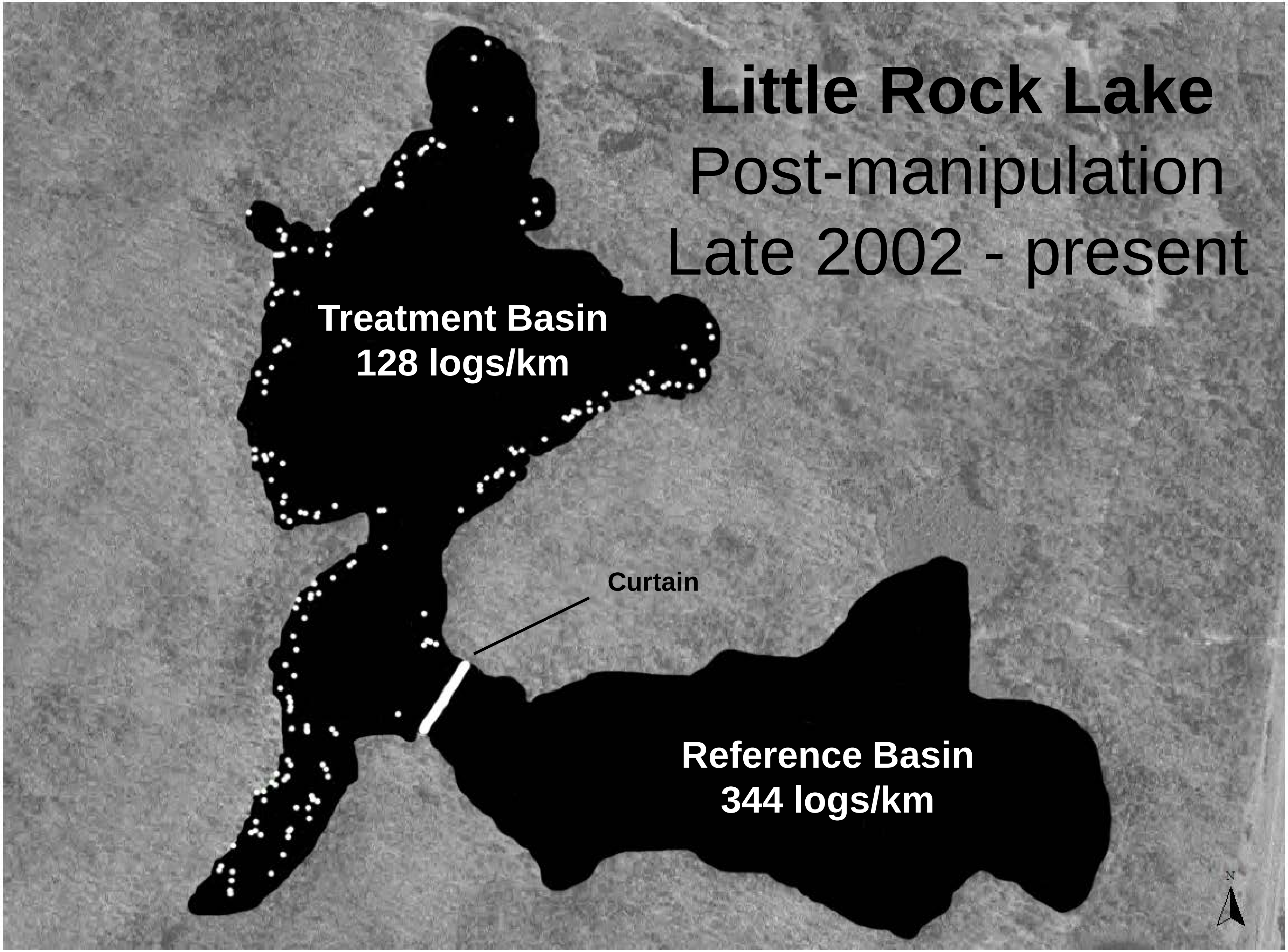

Little Rock Lake
Pre-manipulation
2001 - early 2002
Treatment Basin
475 logs/km
Curtain
Reference Basin
344 logs/km
N

CWH and Lakeshore Residential Development



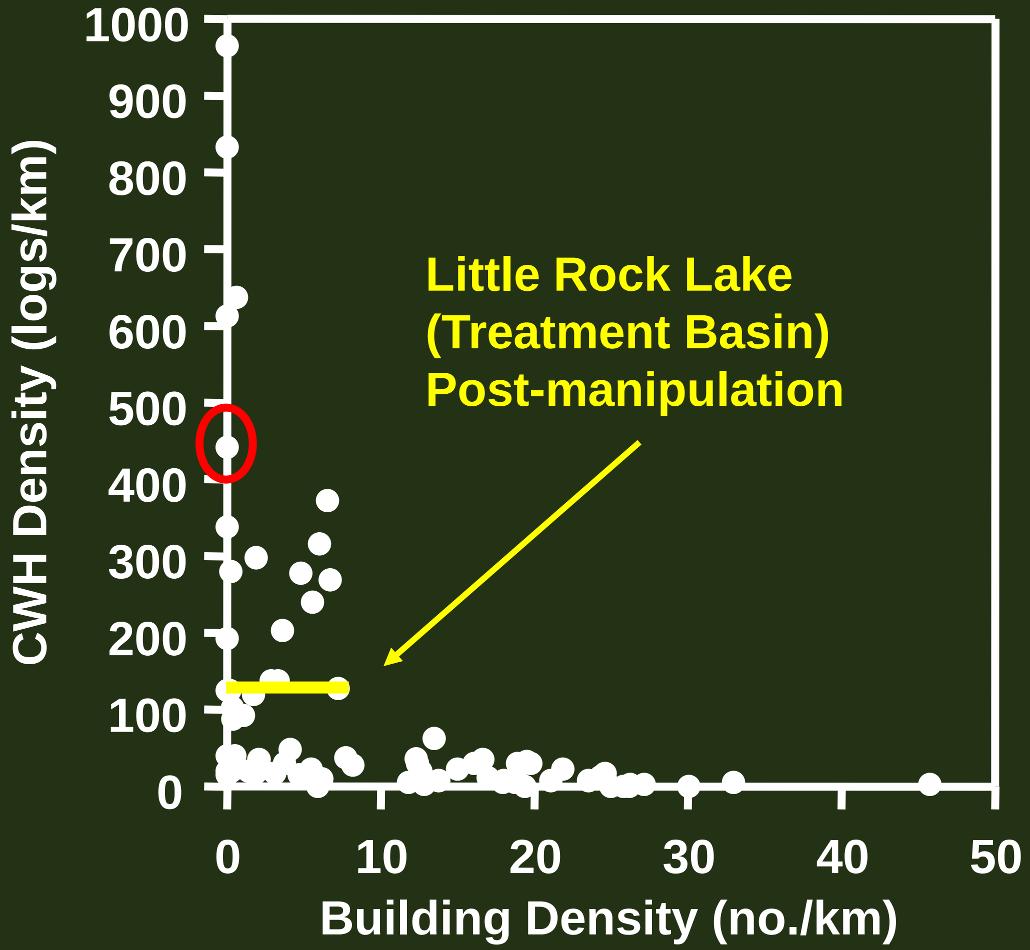
Christensen et al. (1996), Sugden-Newbery (2004)

CWH Removal – July, August 2002



Little Rock Lake
Post-manipulation
Late 2002 - present
Treatment Basin
128 logs/km
Curtain
Reference Basin
344 logs/km
N

CWH and Lakeshore Residential Development



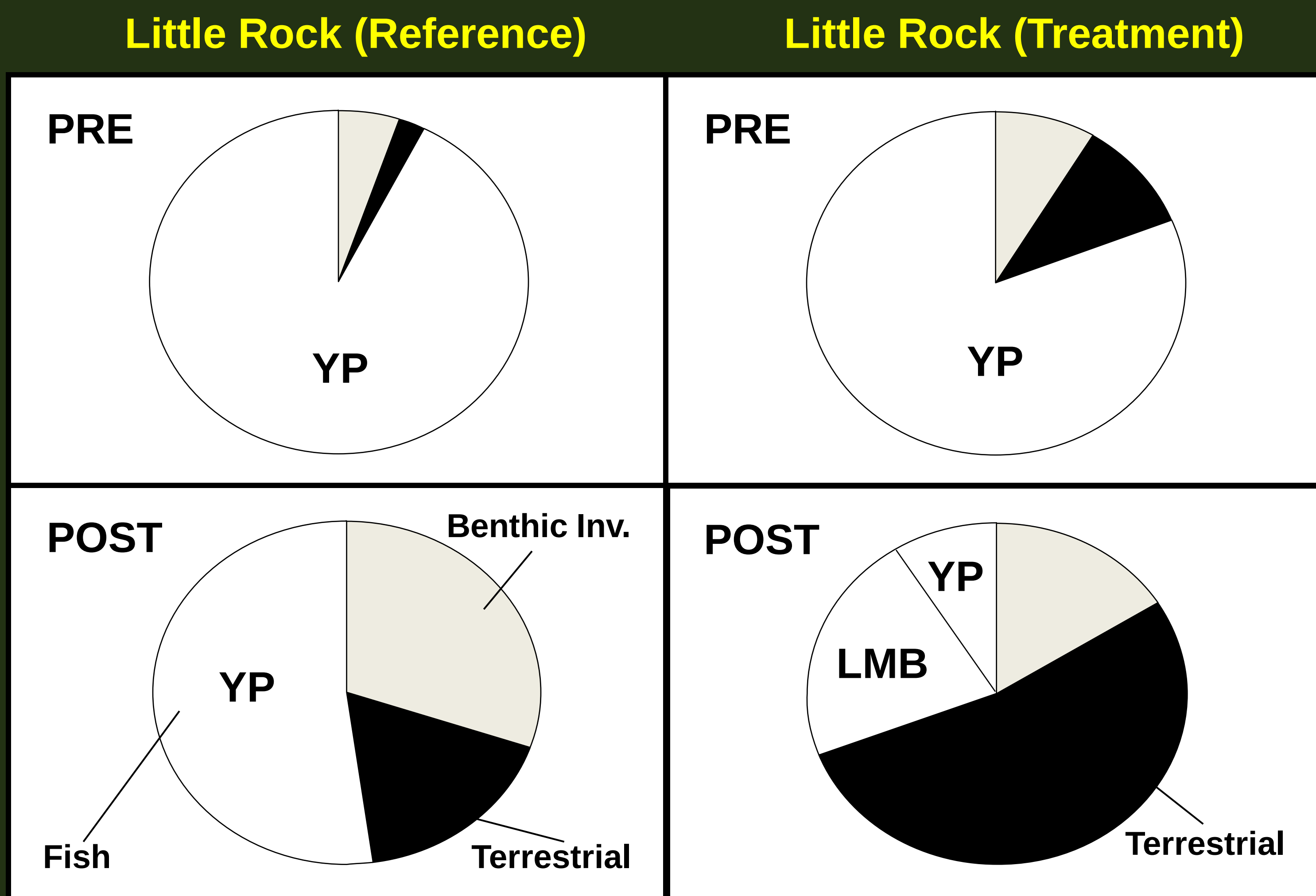
Christensen et al. (1996), Sugden-Newbery (2004)

In the Absence of Development and Fishing, how does CWH Loss Affect…

- Aquatic Food Webs
  - Diets (largemouth bass)
  - Growth rates (largemouth bass)
- Fish Communities
  - Abundance (yellow perch)

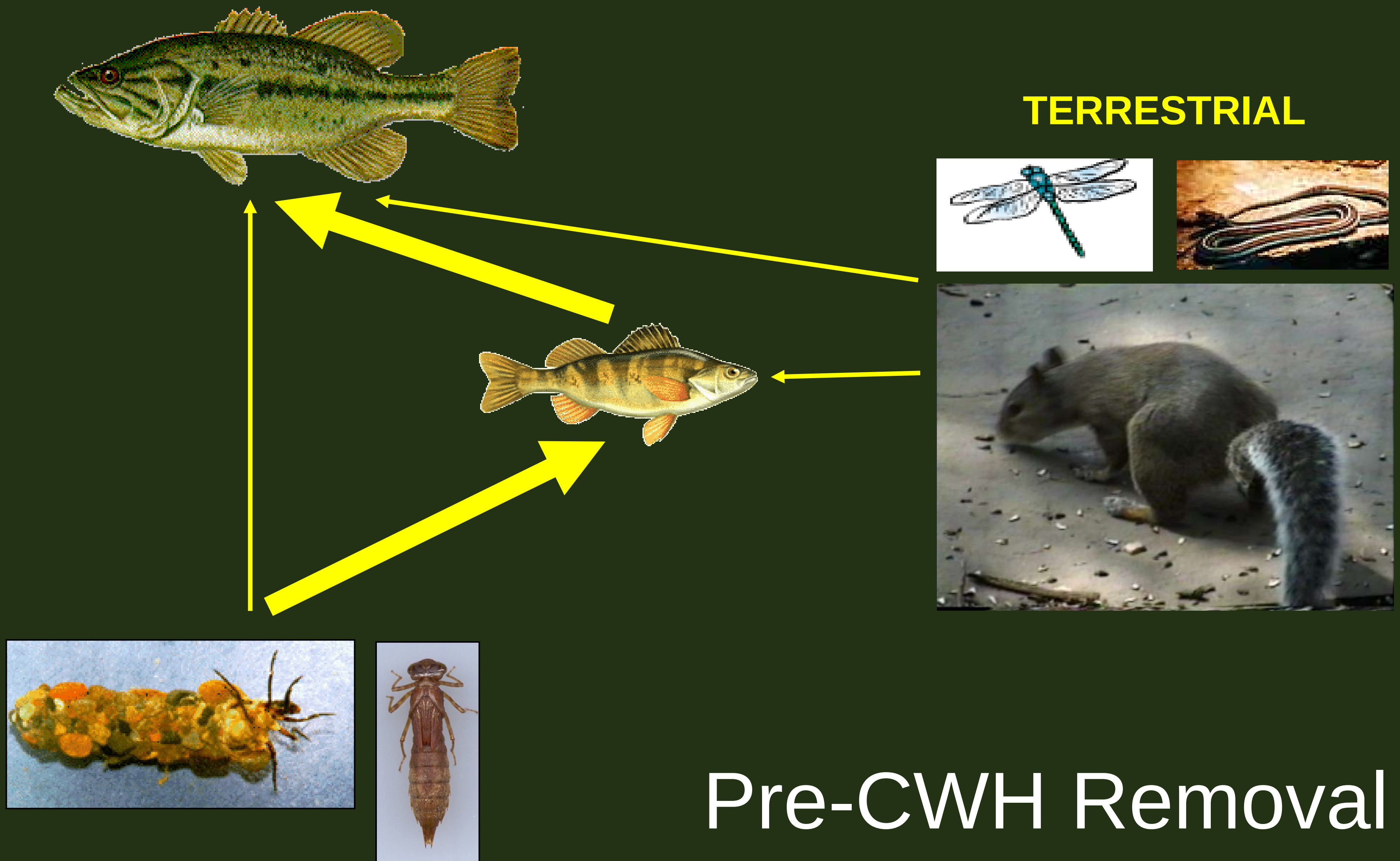
Sass, G.G., J.F. Kitchell, S.R. Carpenter, T.R. Hrabik, A.E. Marburg, and M.G. Turner. 2006. Fish community and food web responses to a whole-lake removal of coarse woody habitat. Fisheries 31:321-330.

Largemouth Bass Diets



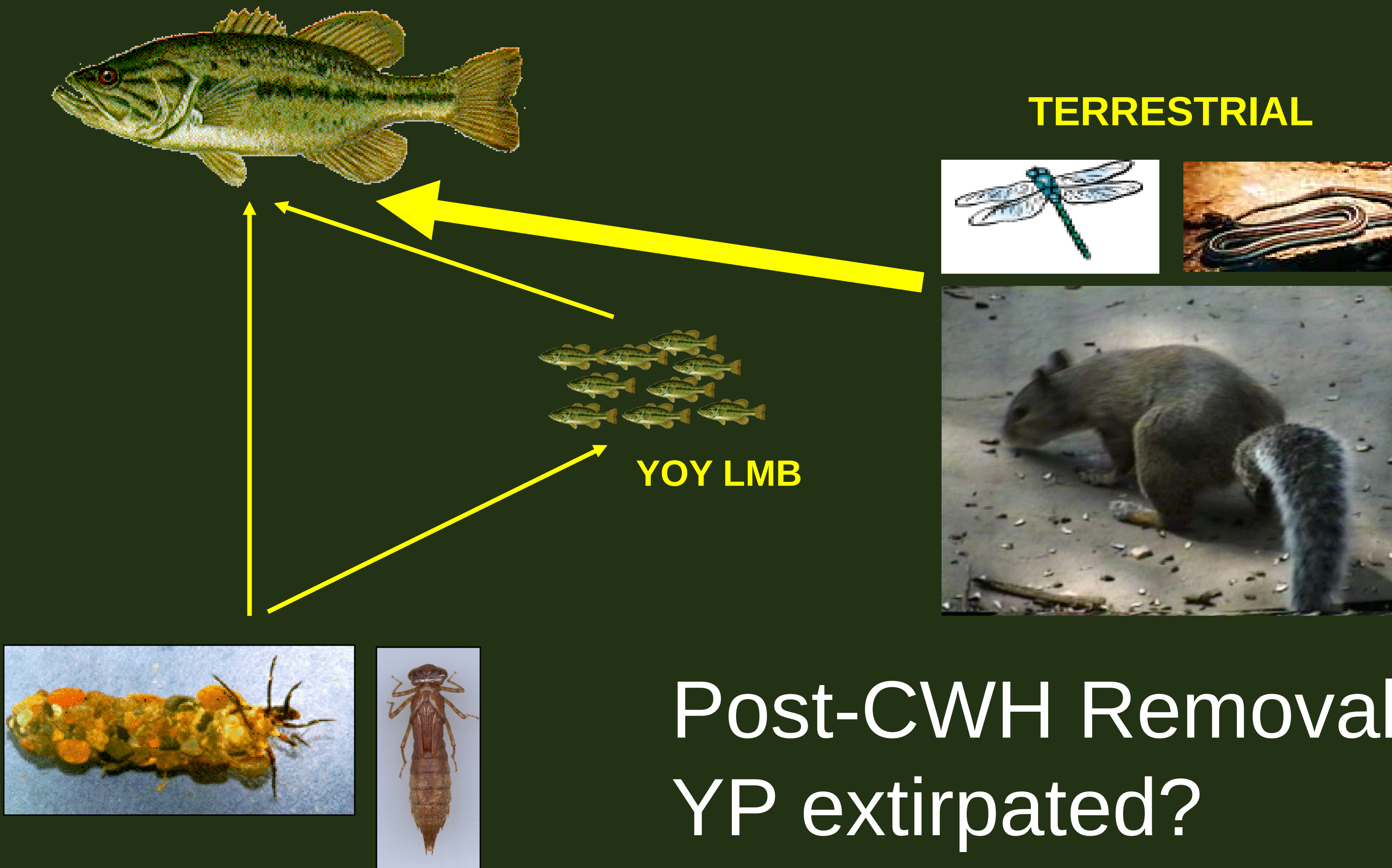
*No diet changes observed in yellow perch

Food Web – Little Rock Lake



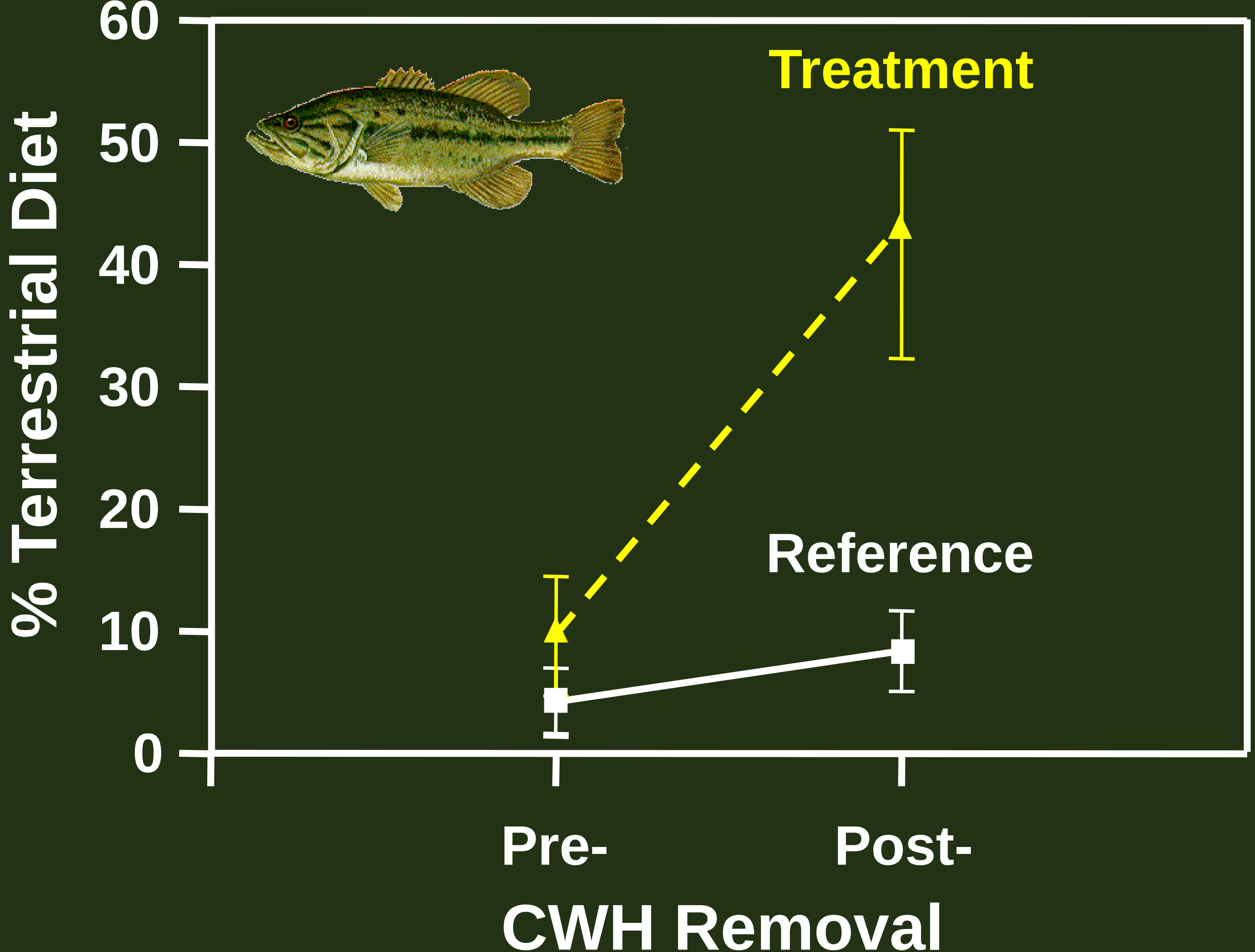
Pre-CWH Removal

Food Web – Treatment Basin

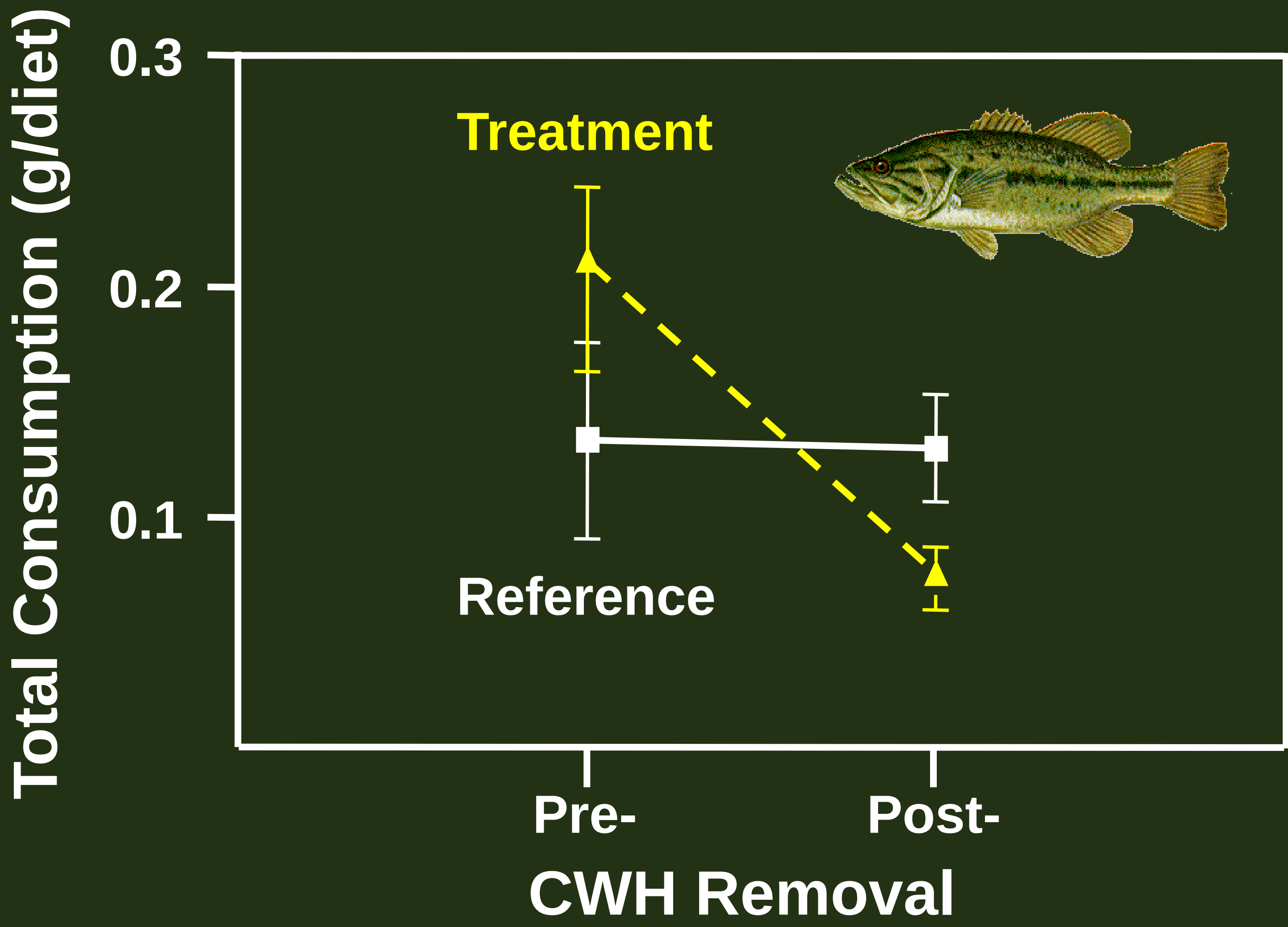


Post-CWH Removal
YP extirpated?

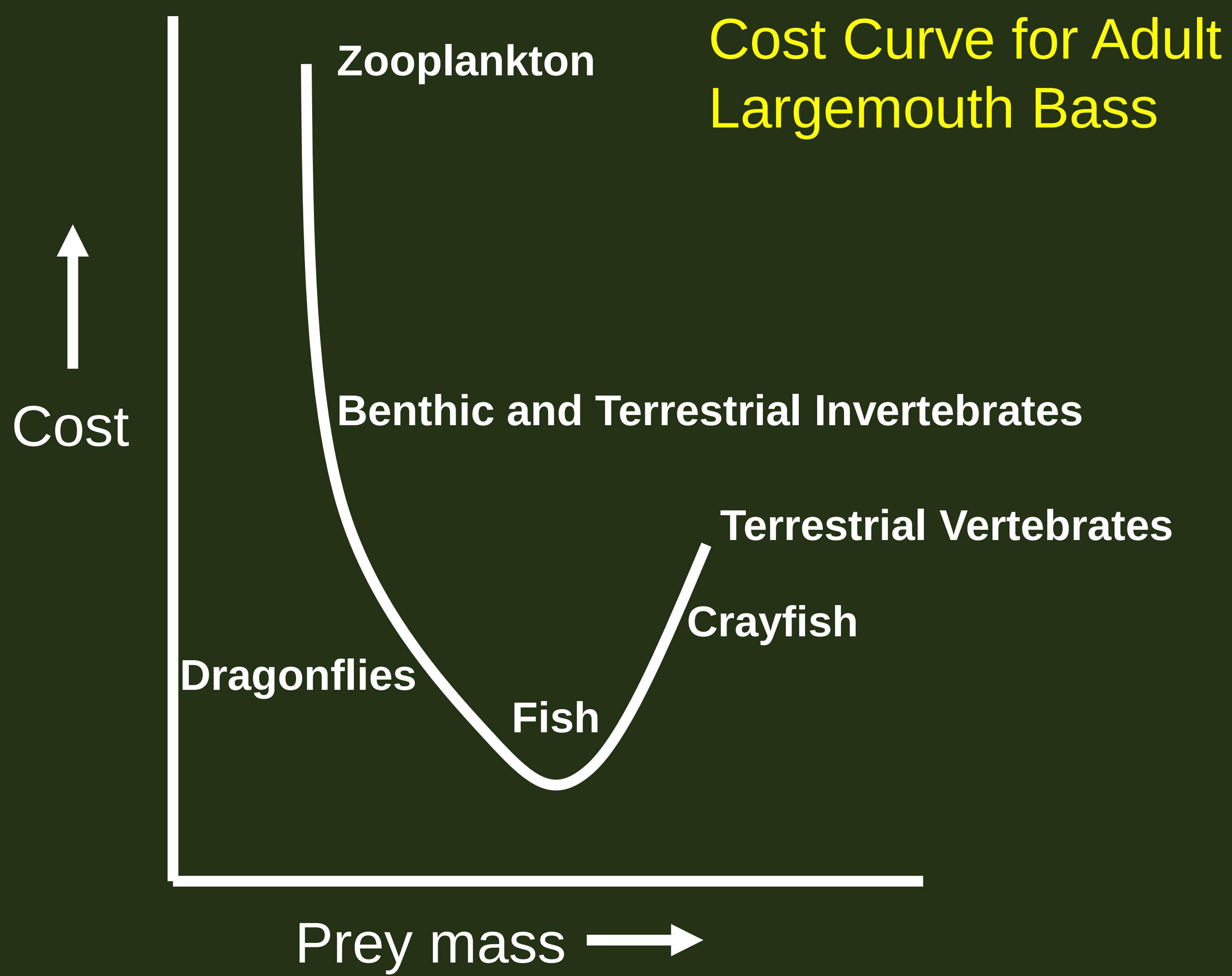
Largemouth Bass % Terrestrial Diet



Largemouth Bass Total Consumption

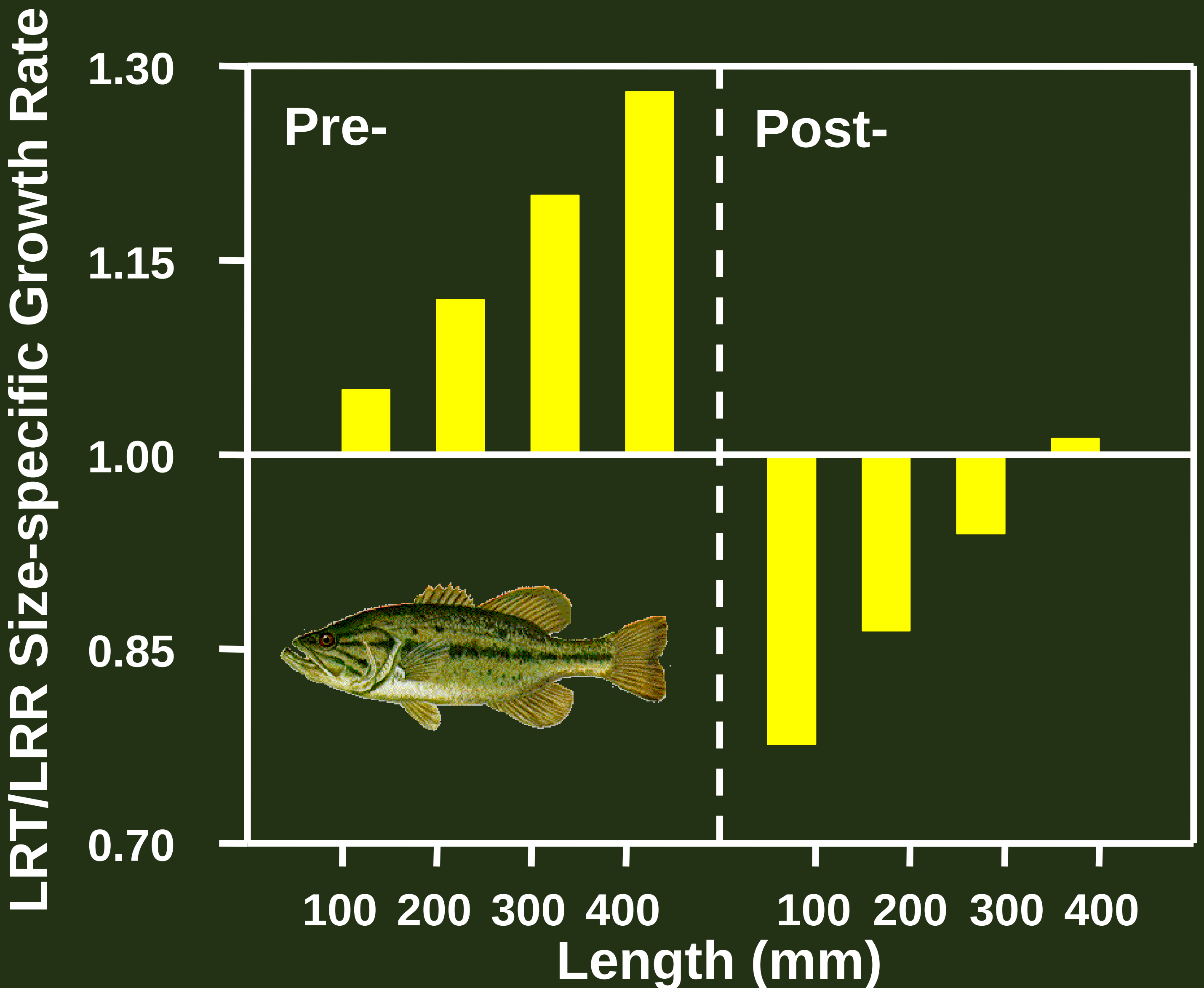


Optimal Foraging

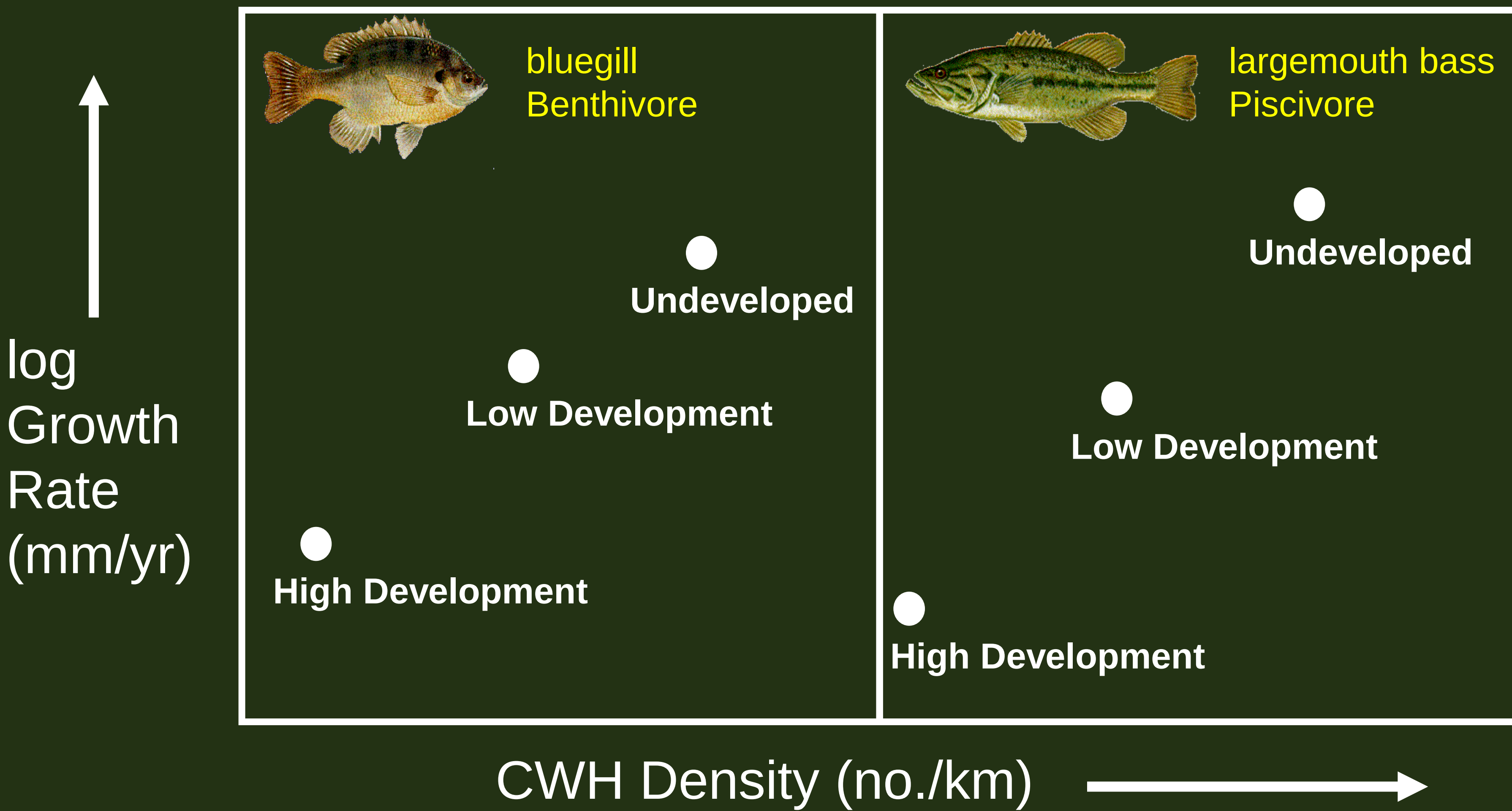


From Werner (1979), Hodgson and Kitchell (1987)

Largemouth Bass Growth Rates



Fish Growth and Coarse Woody Habitat



From Schindler et al. (2000); Gaeta et al. (2011)

In the Absence of Development and Fishing, how does CWH Loss Affect…

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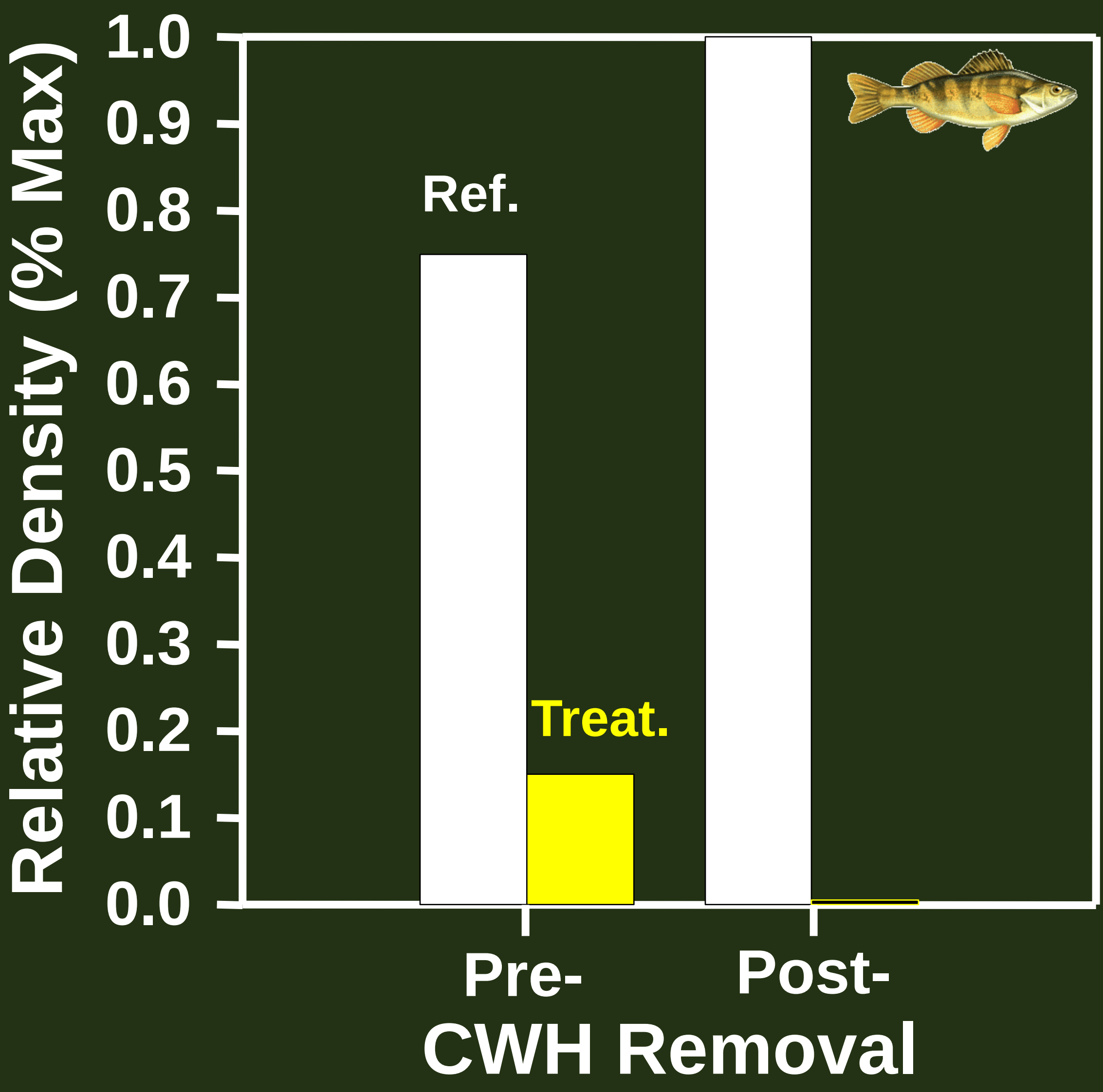
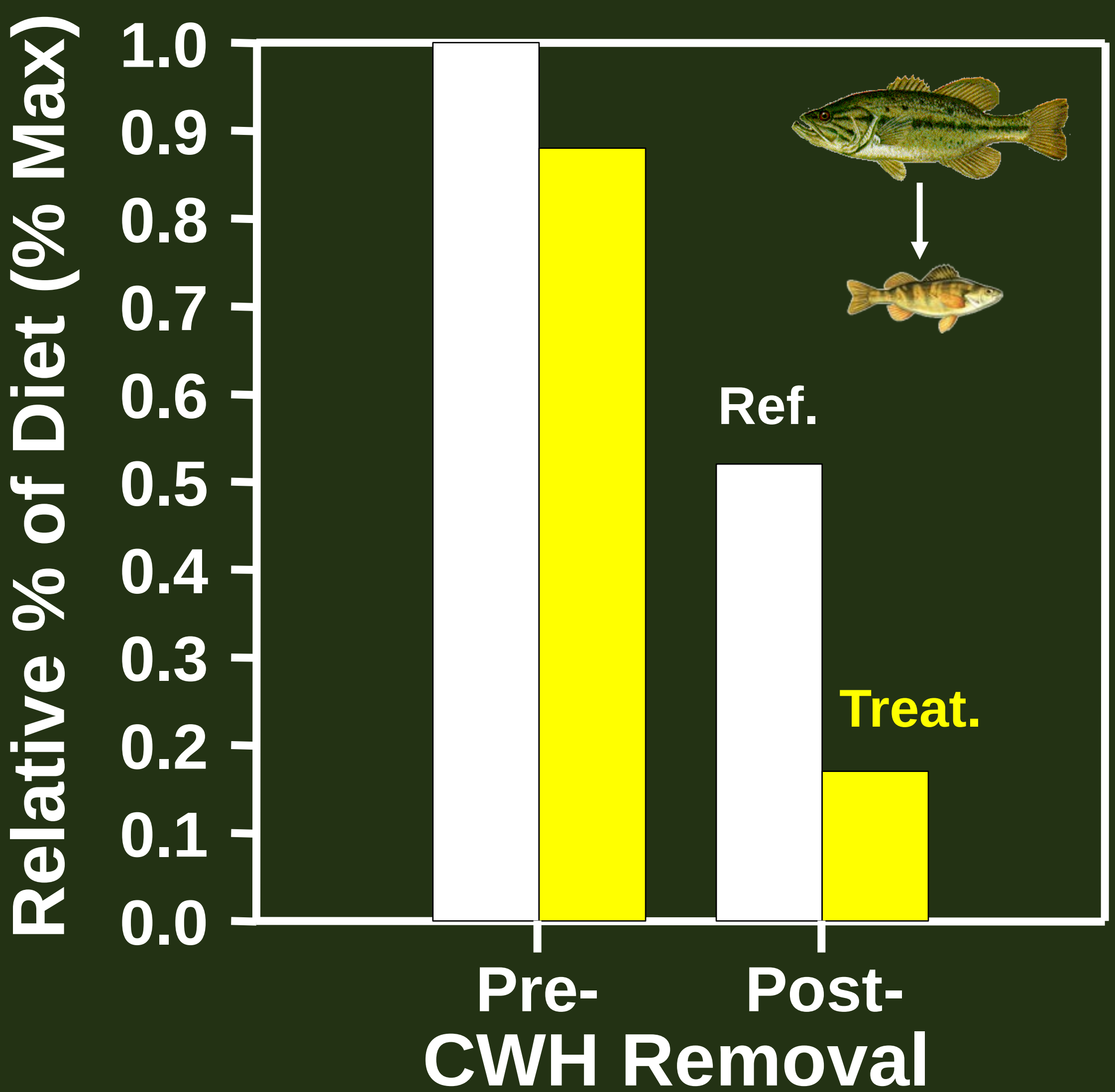
- Fish Communities
  - – Abundance (yellow perch)

Sass, G.G., J.F. Kitchell, S.R. Carpenter, T.R. Hrabik, A.E. Marburg, and M.G. Turner. 2006. Fish community and food web responses to a whole-lake removal of coarse woody habitat. Fisheries 31:321-330.

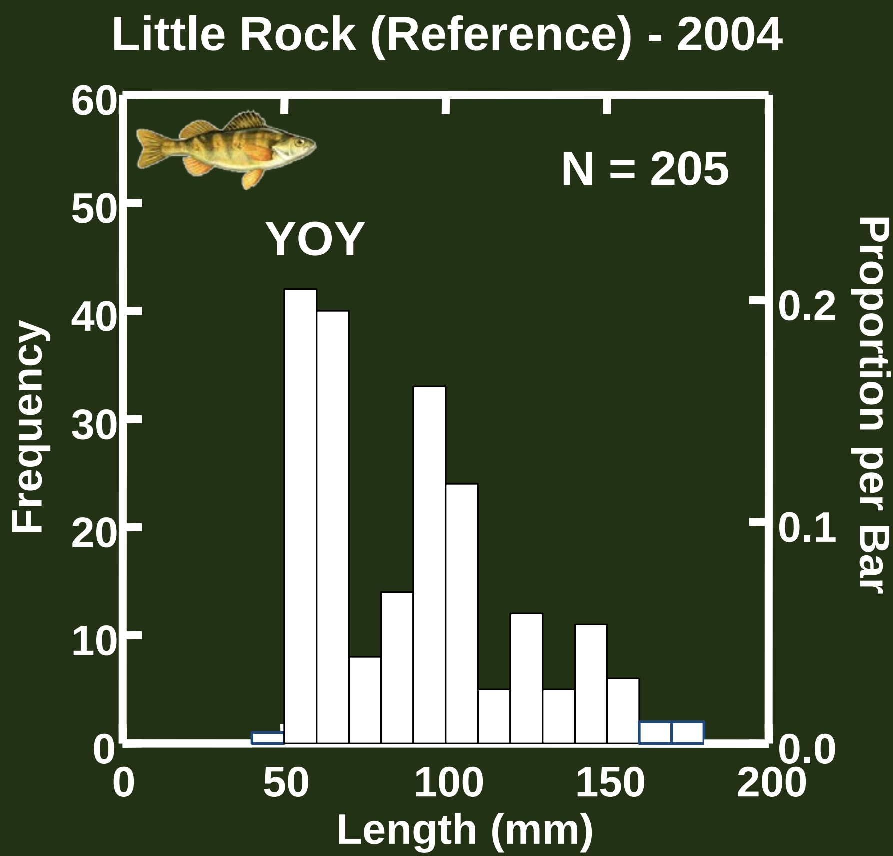
Yellow Perch Abundance
(Population Estimate)

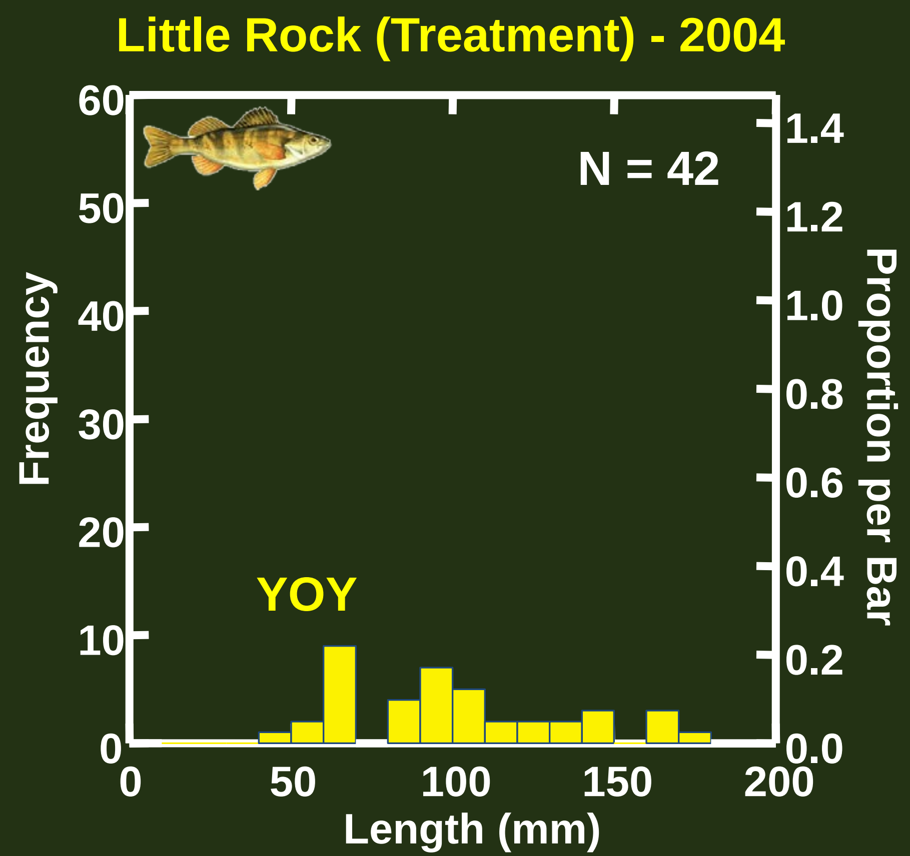


Yellow Perch Abundance
(Largemouth Bass Diets)



Yellow Perch Abundance
(Length-Frequency Distributions)





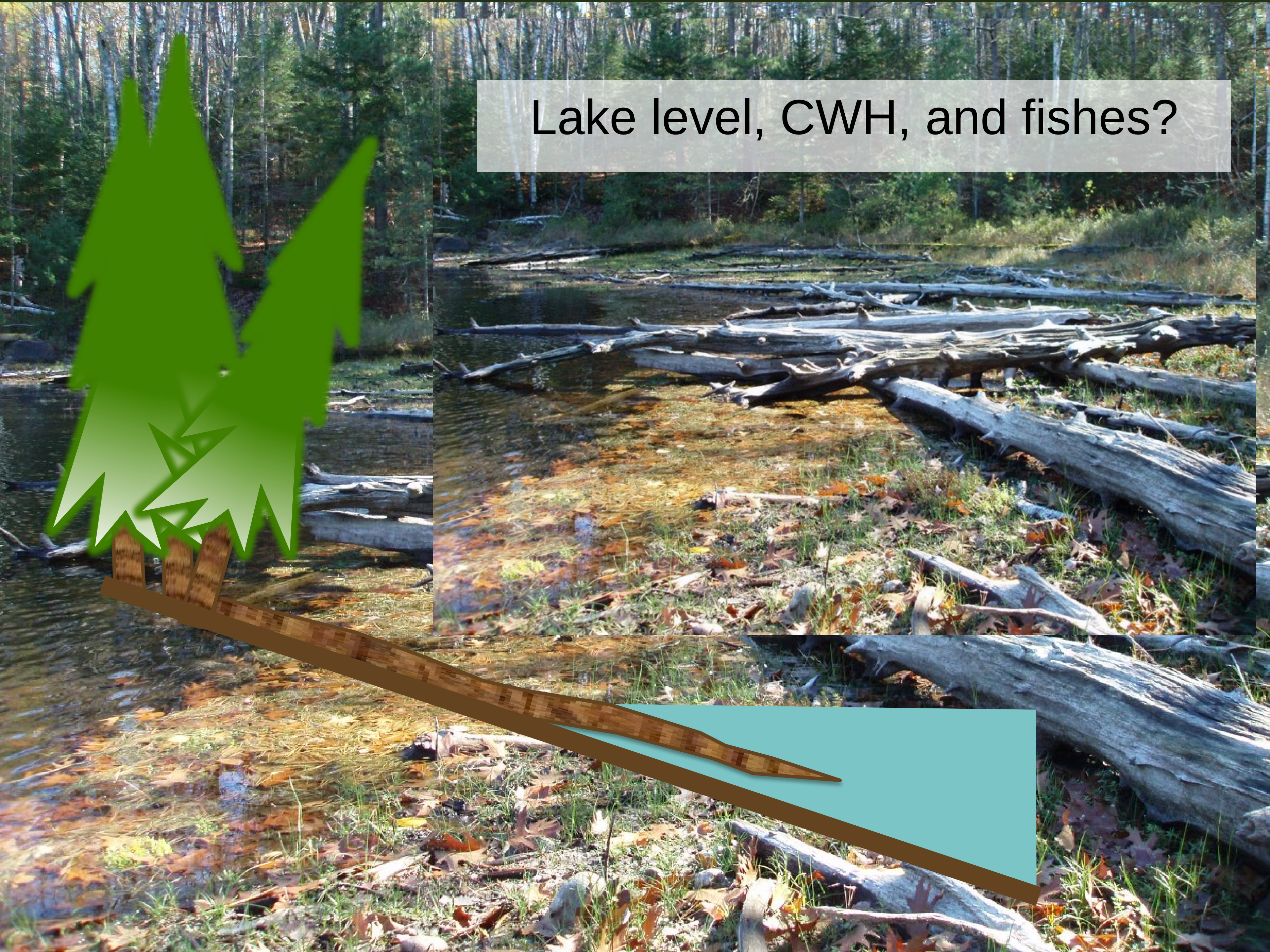
Little Rock Lake – Reference Basin - 2007

Photo by Jereme Gaeta

Drought conditions receive little attention

Up to 1 m lake level reductions observed during drought conditions

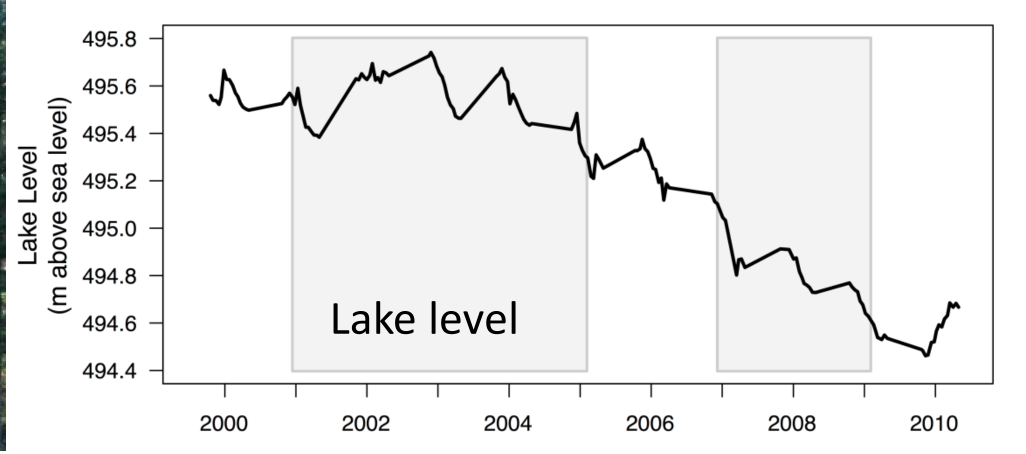
(Magnuson et al. 1997; Watras et al. 2014)

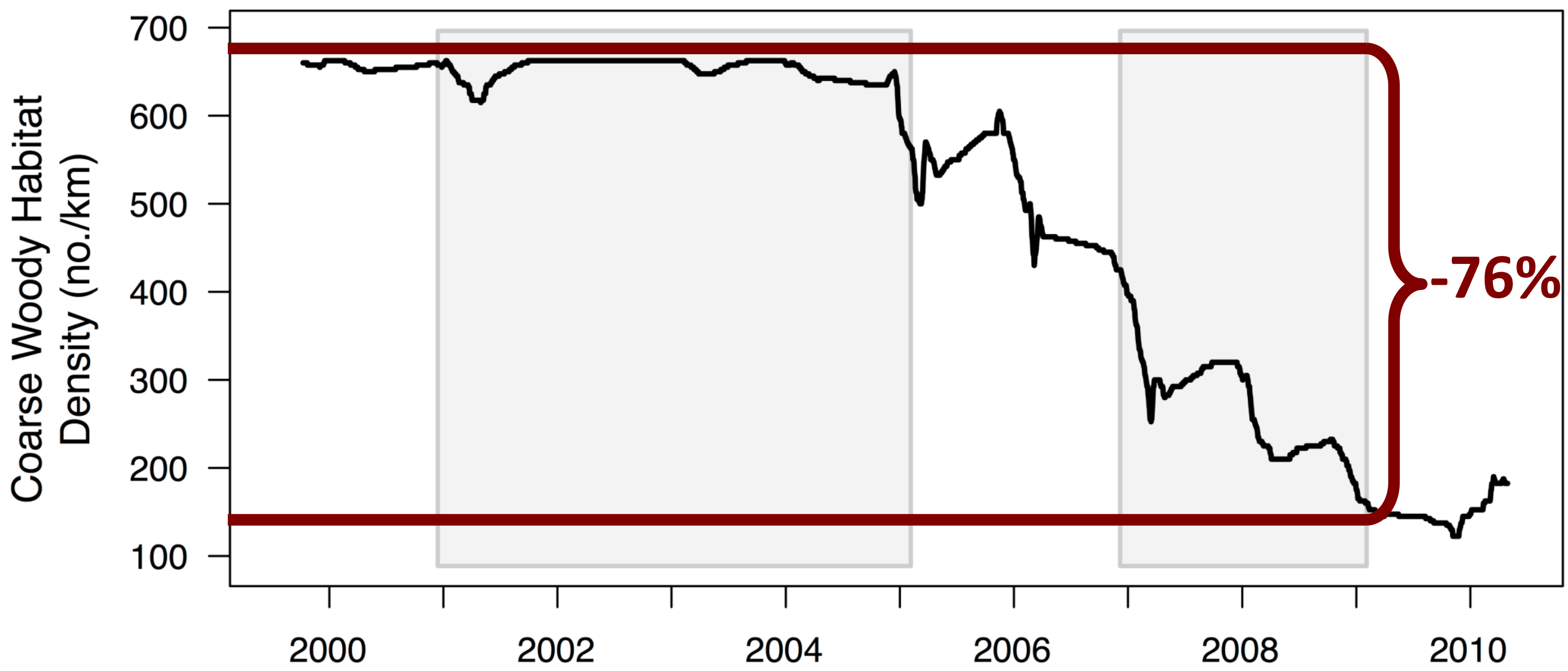

Lake level, CWH, and fishes?

A prolonged drought allowed us to use a northern WI lake as a model system

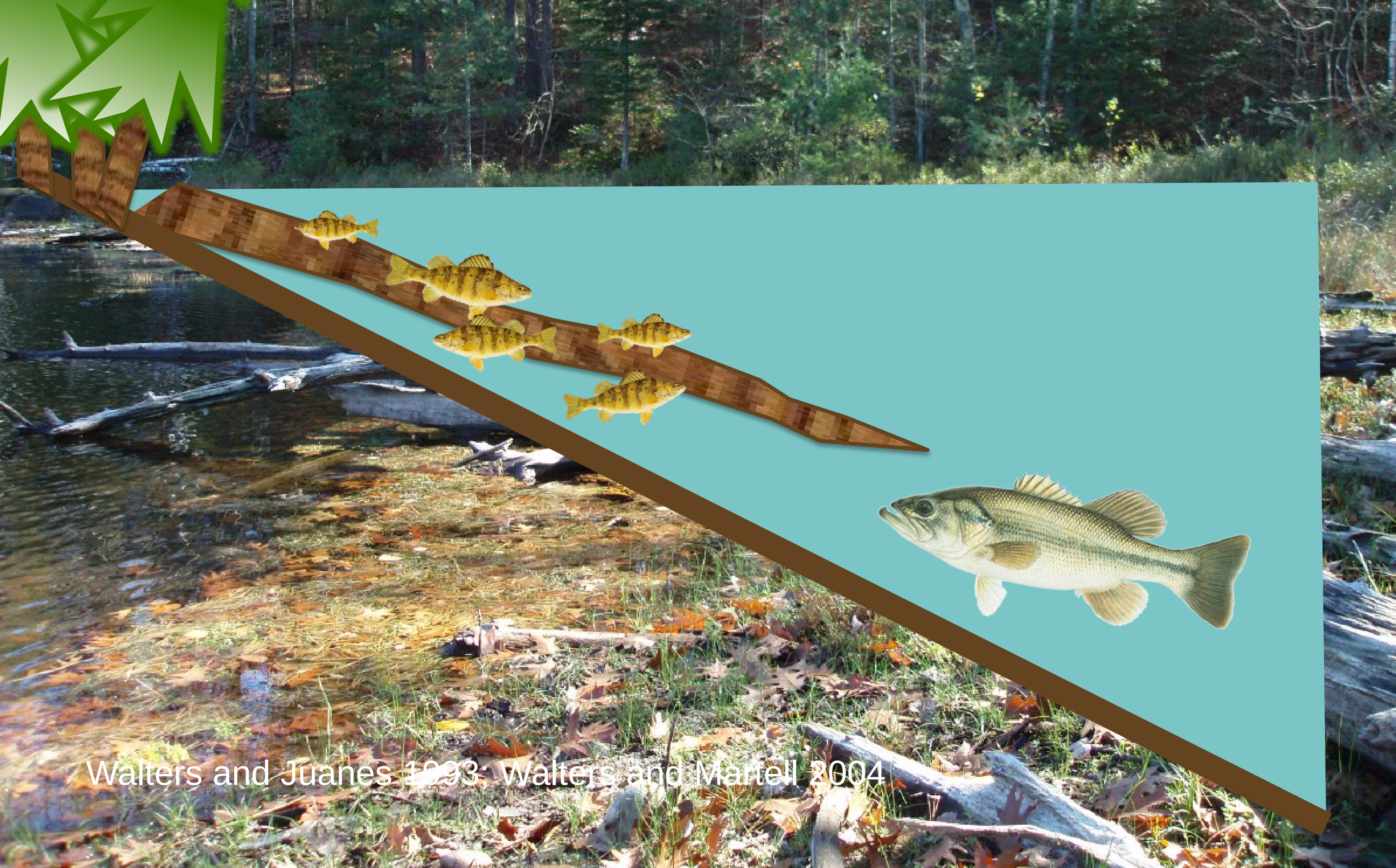
Photo credit: J. Gaeta; LRL; Oct 2007

Corresponding change in CWH





Altered foraging arena

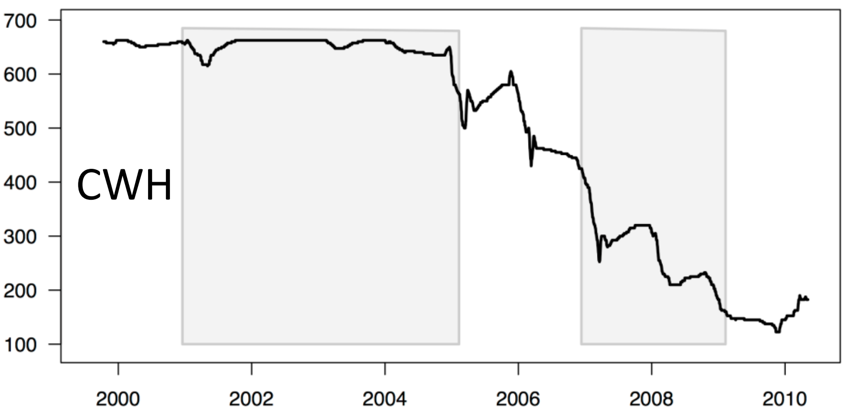


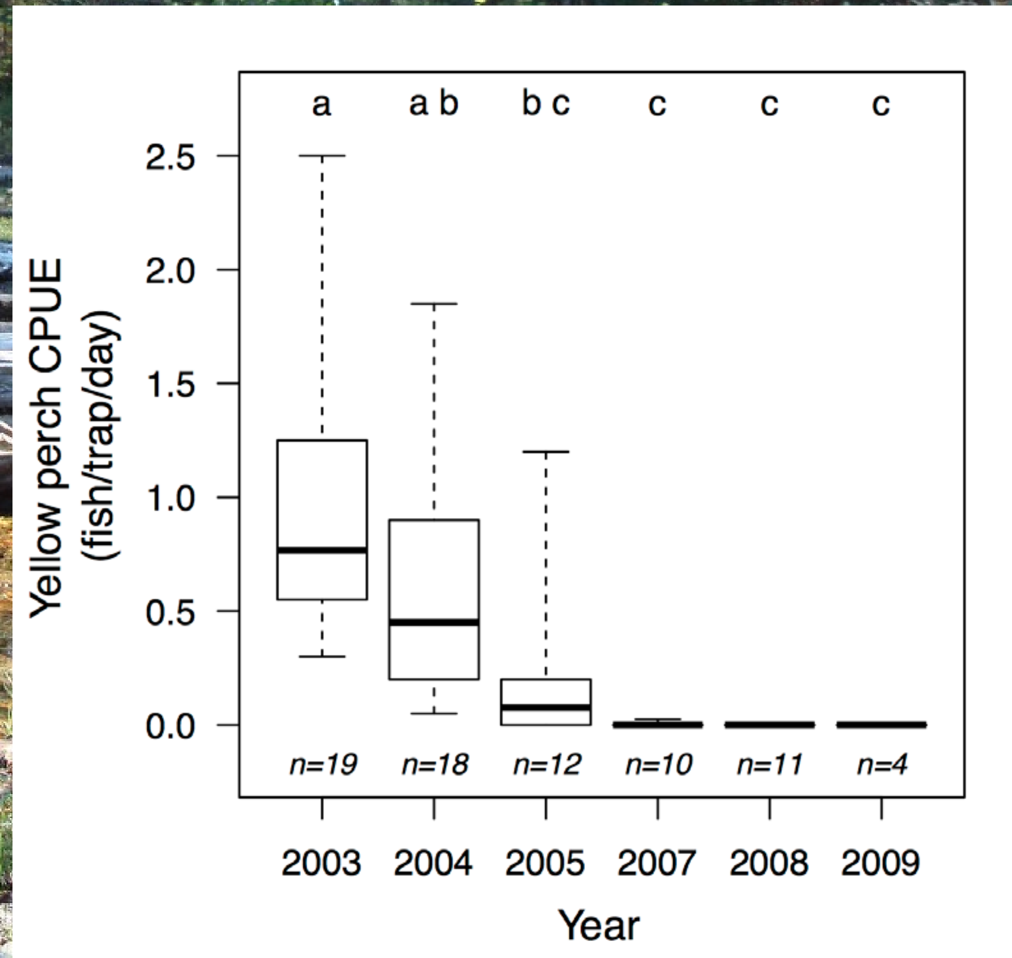
Walters and Juanes 1993; Walters and Martell 2004

Altered foraging arena

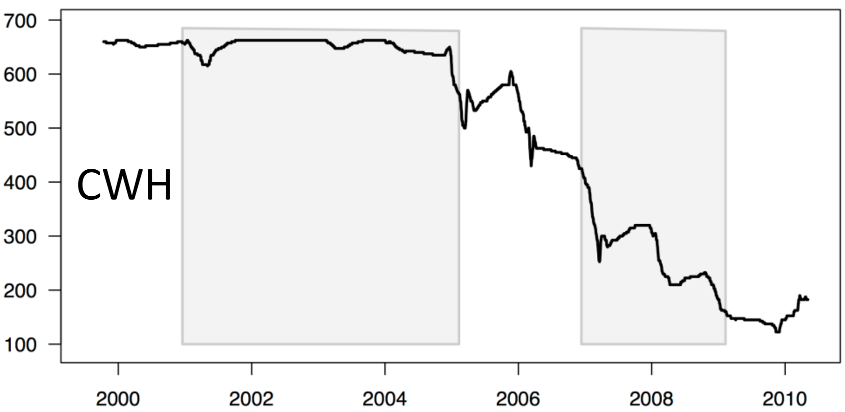
Walters and Juanes 1993; Walters and Martell 2004

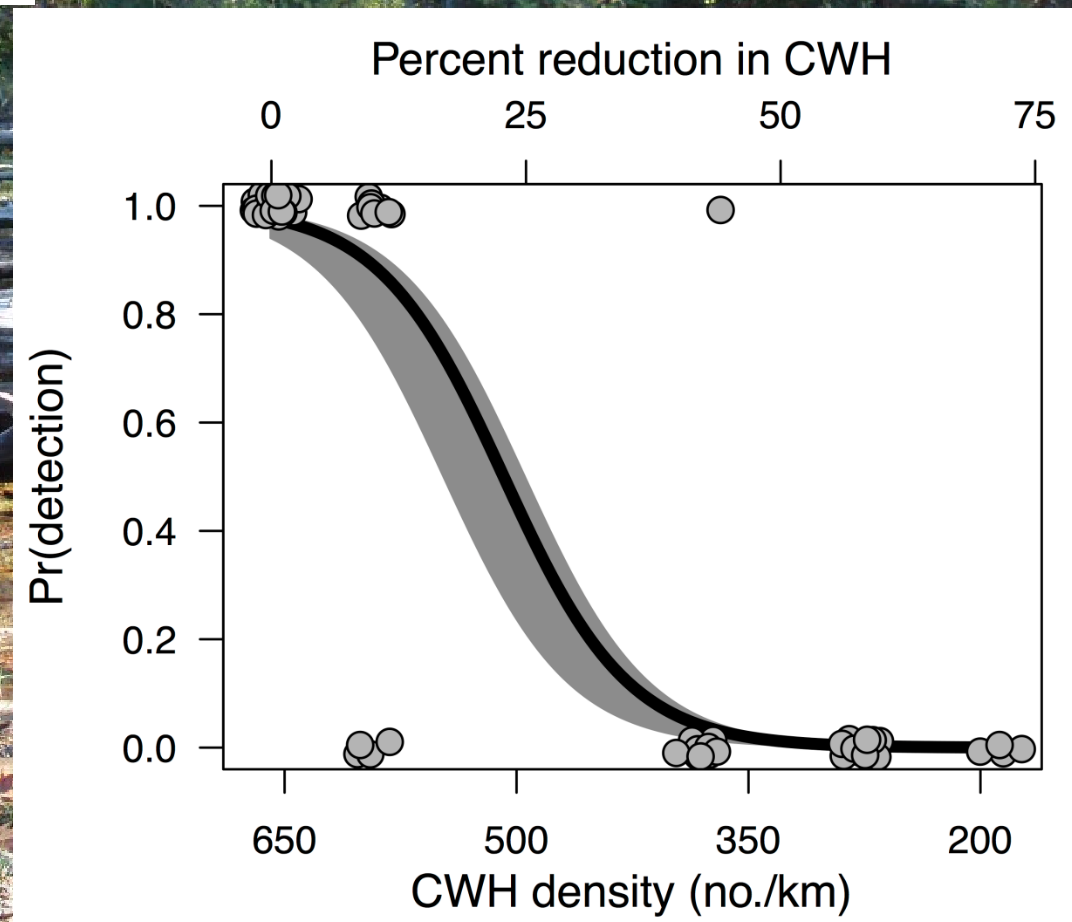
Corresponding change in perch (prey fish)



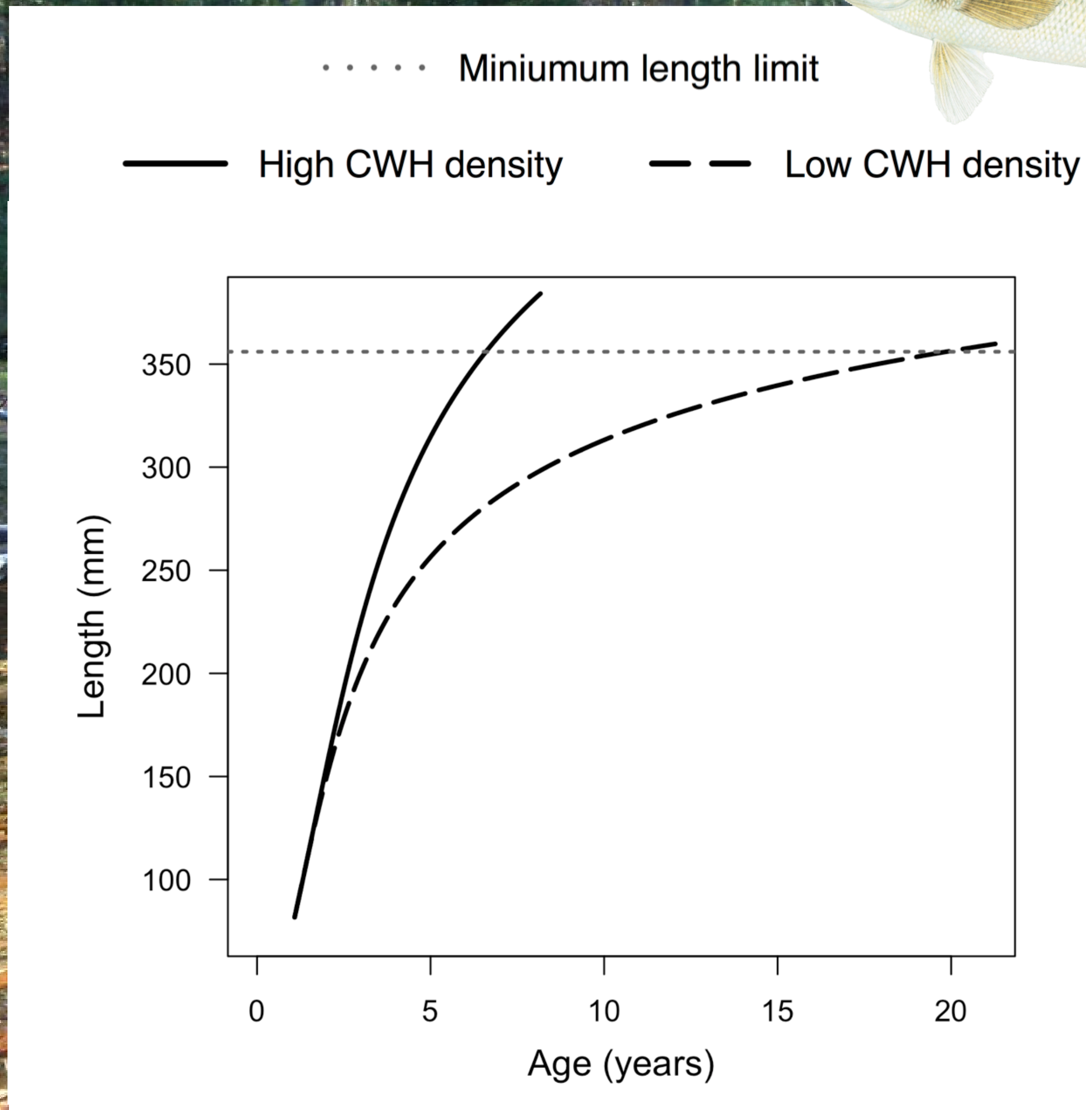


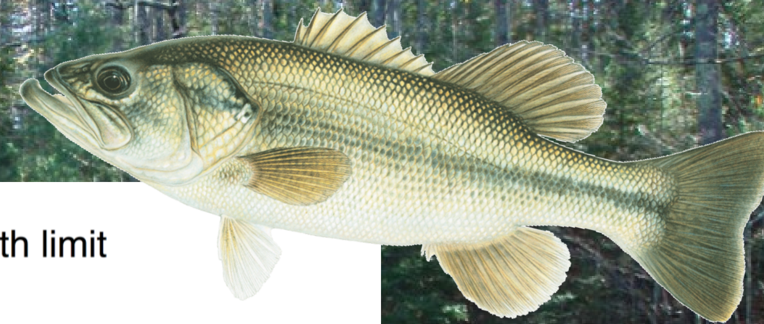
Corresponding change in perch (prey fish)





Growth model simulations





Lessons learned

- Lake level loss decreased CWH and was associated with a major decline in the yellow perch population at the expense of largemouth bass growth

Conclusions

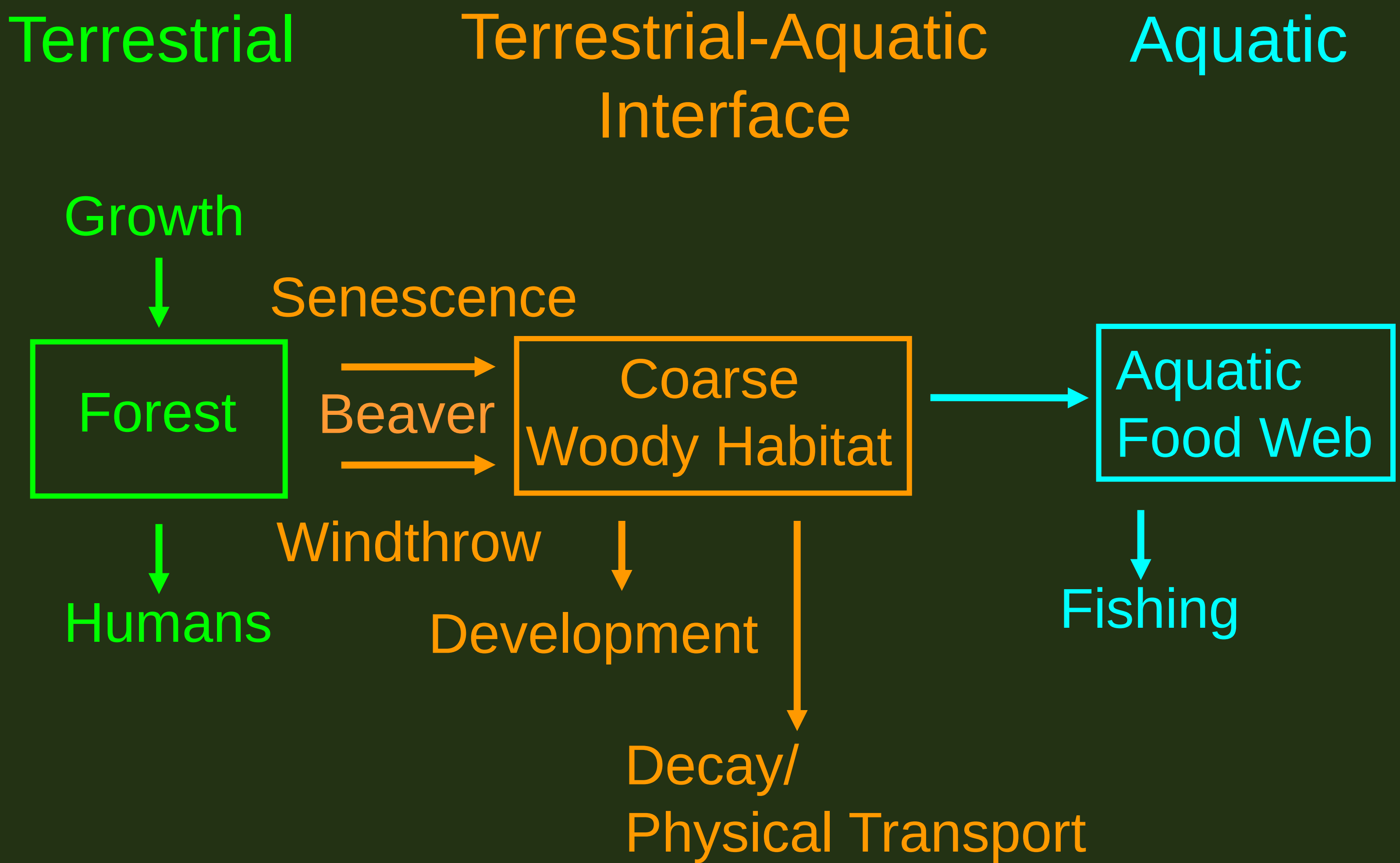
1. Fish growth and food web responses to CWH removal?

   - decreased LMB growth rates, increased reliance on terrestrial food sources, cannibalism, adherence to optimal foraging tenets

2. Yellow perch abundance responses to CWH removal?

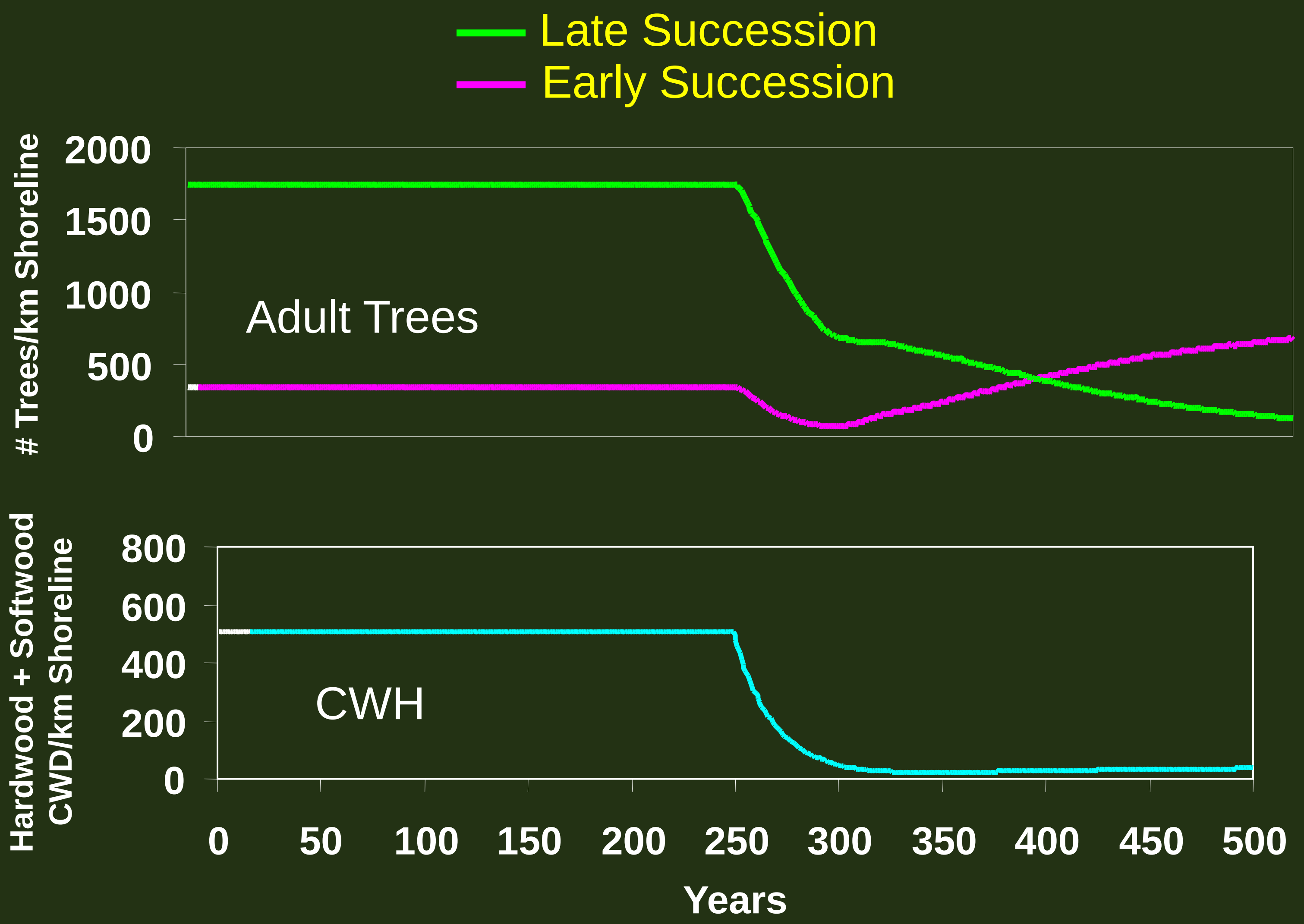
   - functional collapse

3. Long-term effects of lakeshore residential development, CWH removal, and fishing?



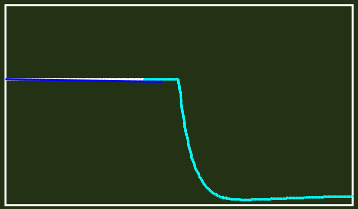
Roth, B.M., I.C. Kaplan, G.G. Sass, P.T. Johnson, A.E. Marburg, A.C. Yannarell, T.V. Willis, M.G. Turner, and S.R. Carpenter. Linking terrestrial and aquatic ecosystems: the role of woody habitat in lake food webs. Ecological Modelling 203:439-452.

Adult Tree and CWH Dynamics During Development



Development and Fishing

CWH



Multiple Roles of CWH

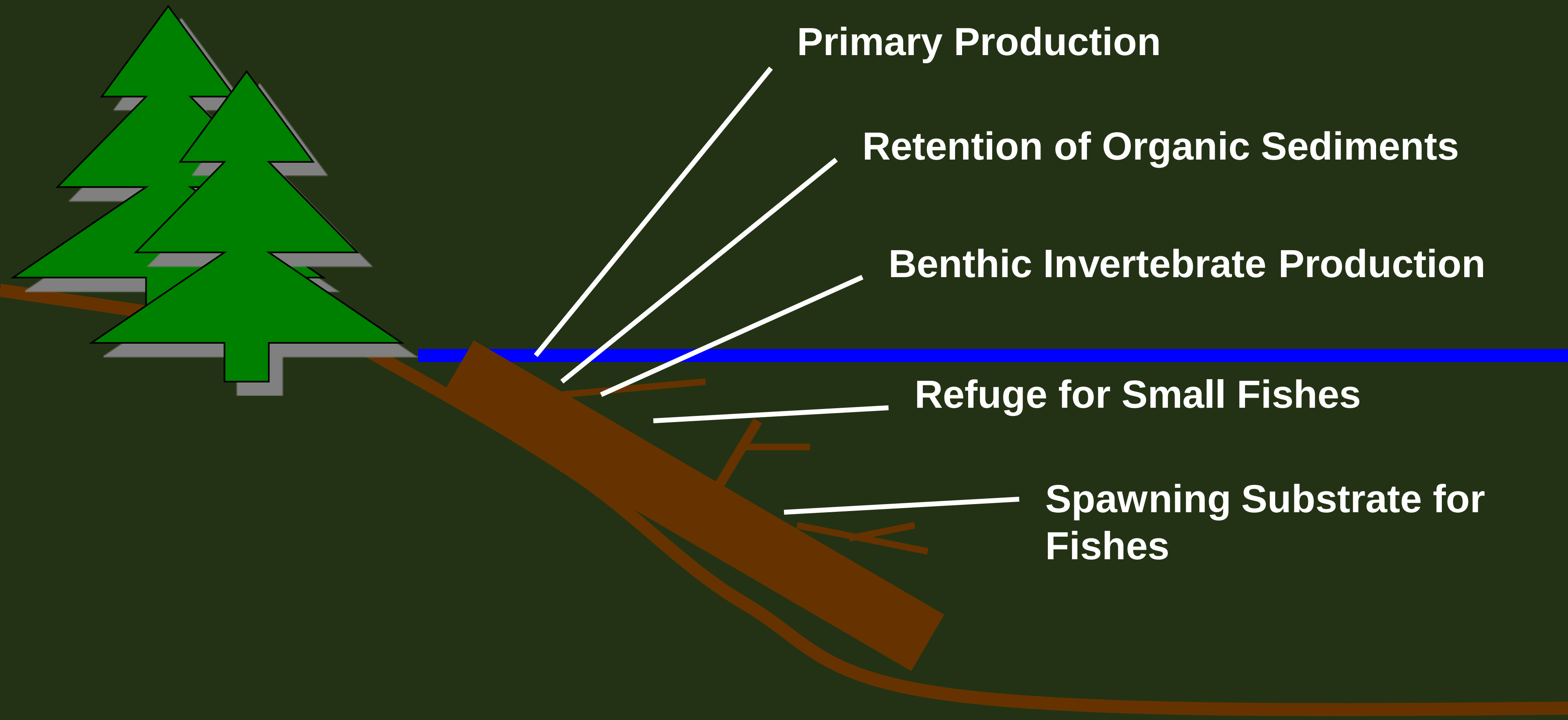
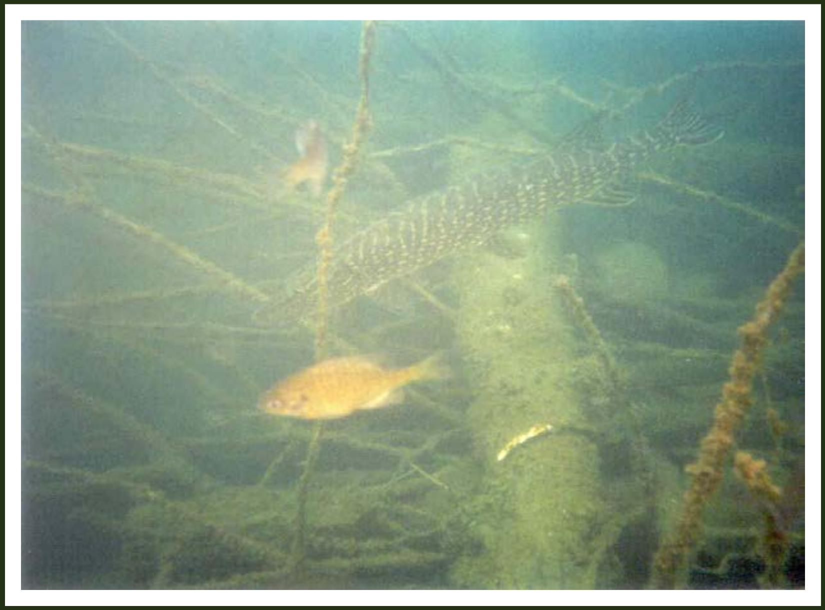



Photo by Matt Helmus

Can CWH addition reverse the negative effects of CWH loss on fish populations?

- Fish abundances, growth, aquatic food webs, habitat use



Northern Highlands Lake District (Vilas County, Wisconsin)

Camp Lake

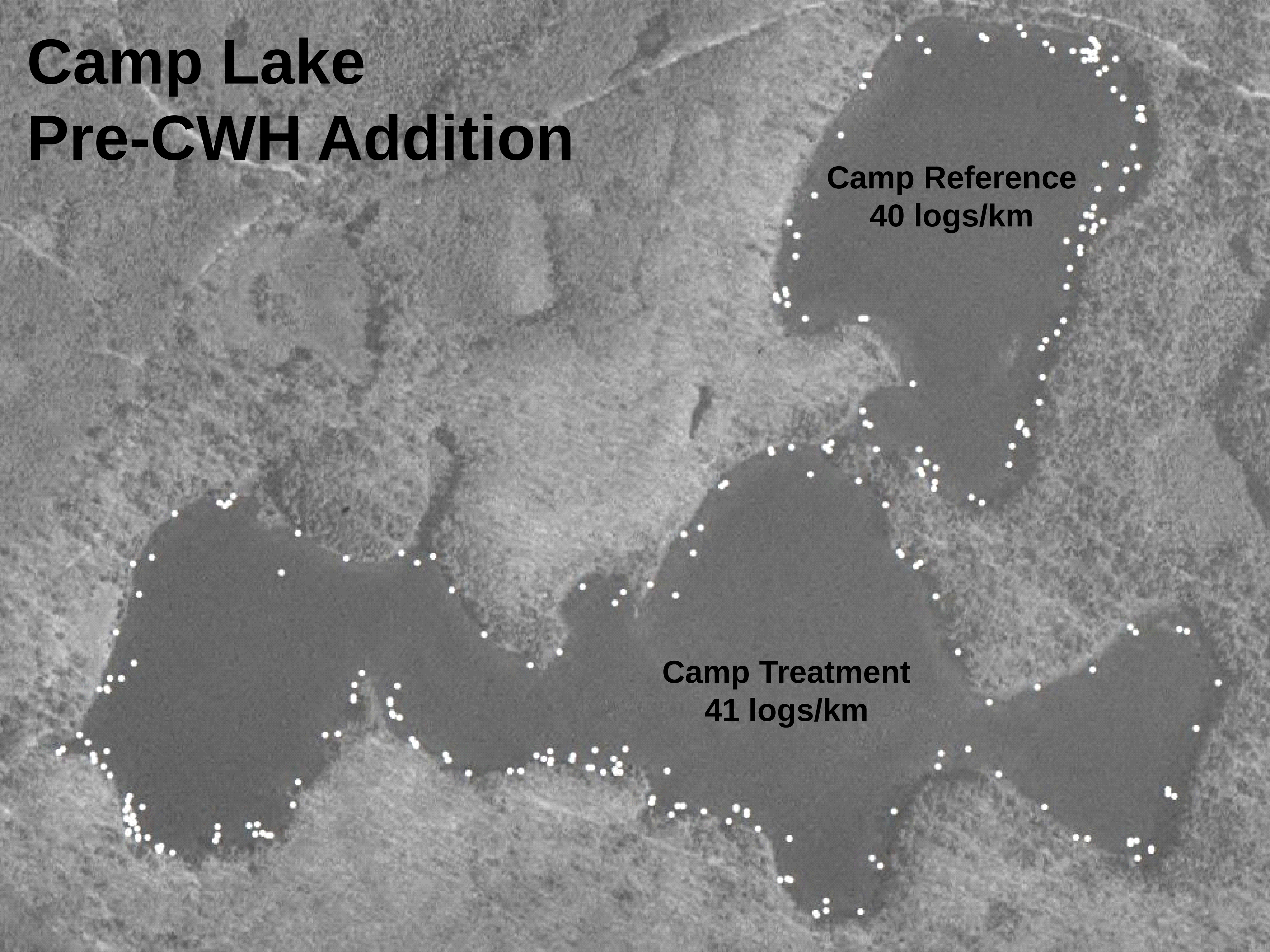
-Treatment basin (17.6 ha)
-Reference basin (8.5 ha)

-Undeveloped
-Minimal fishing pressure

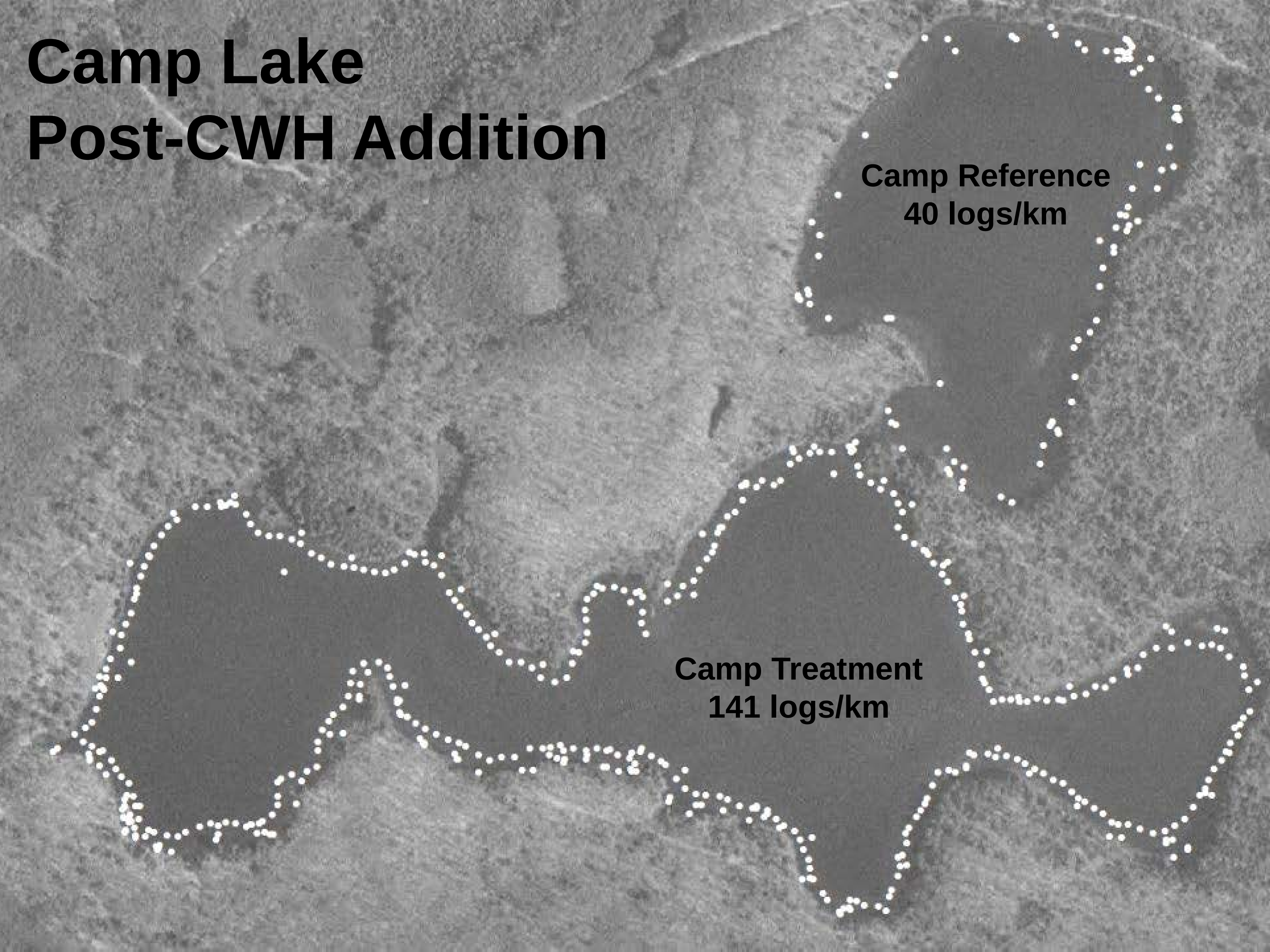
-41 logs/km
-sparse vegetation

-Largemouth bass, bluegill, yellow perch, Iowa darter

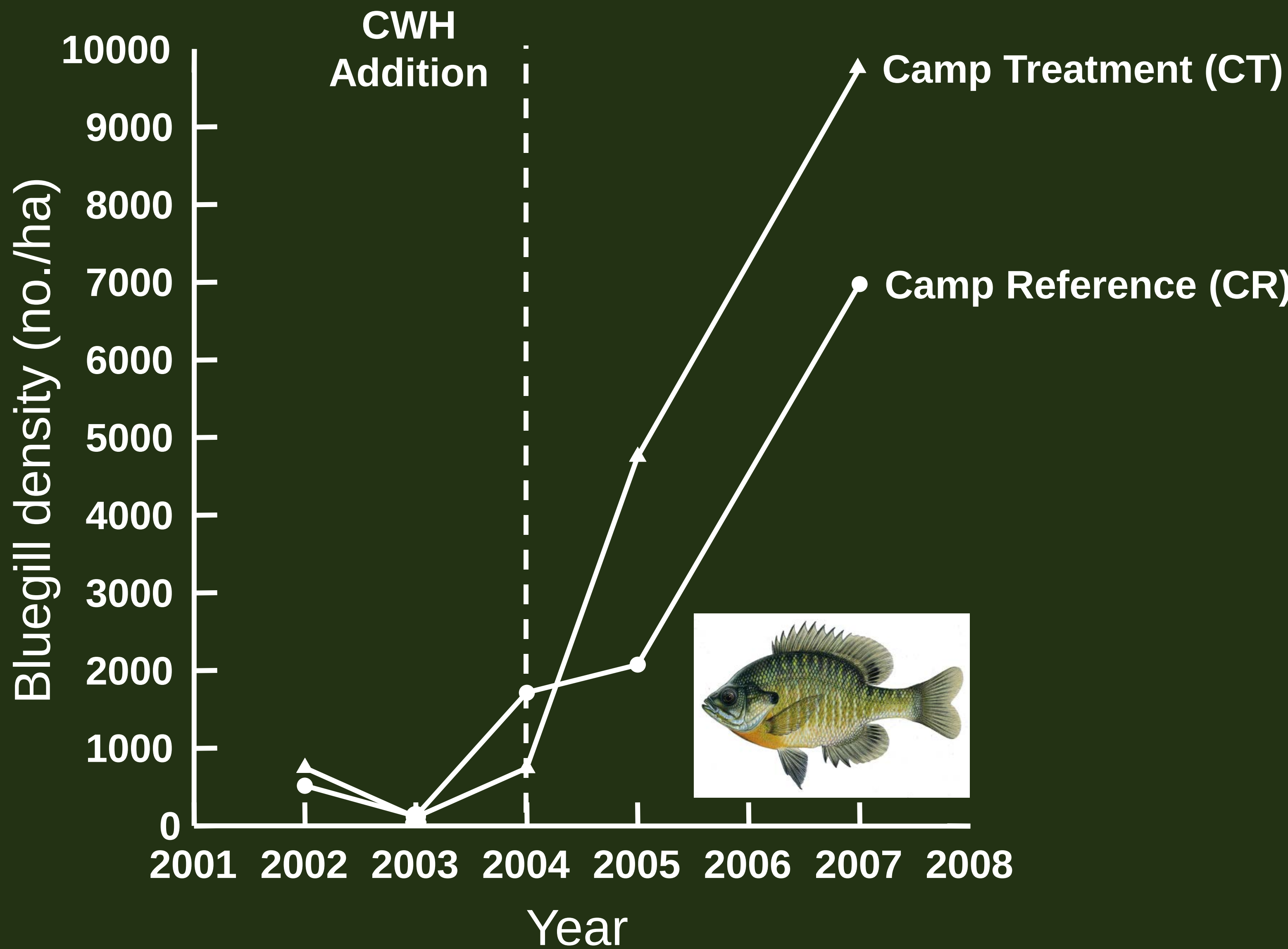
Camp Lake
Pre-CWH Addition



Camp Lake CWH Addition, Spring 2004

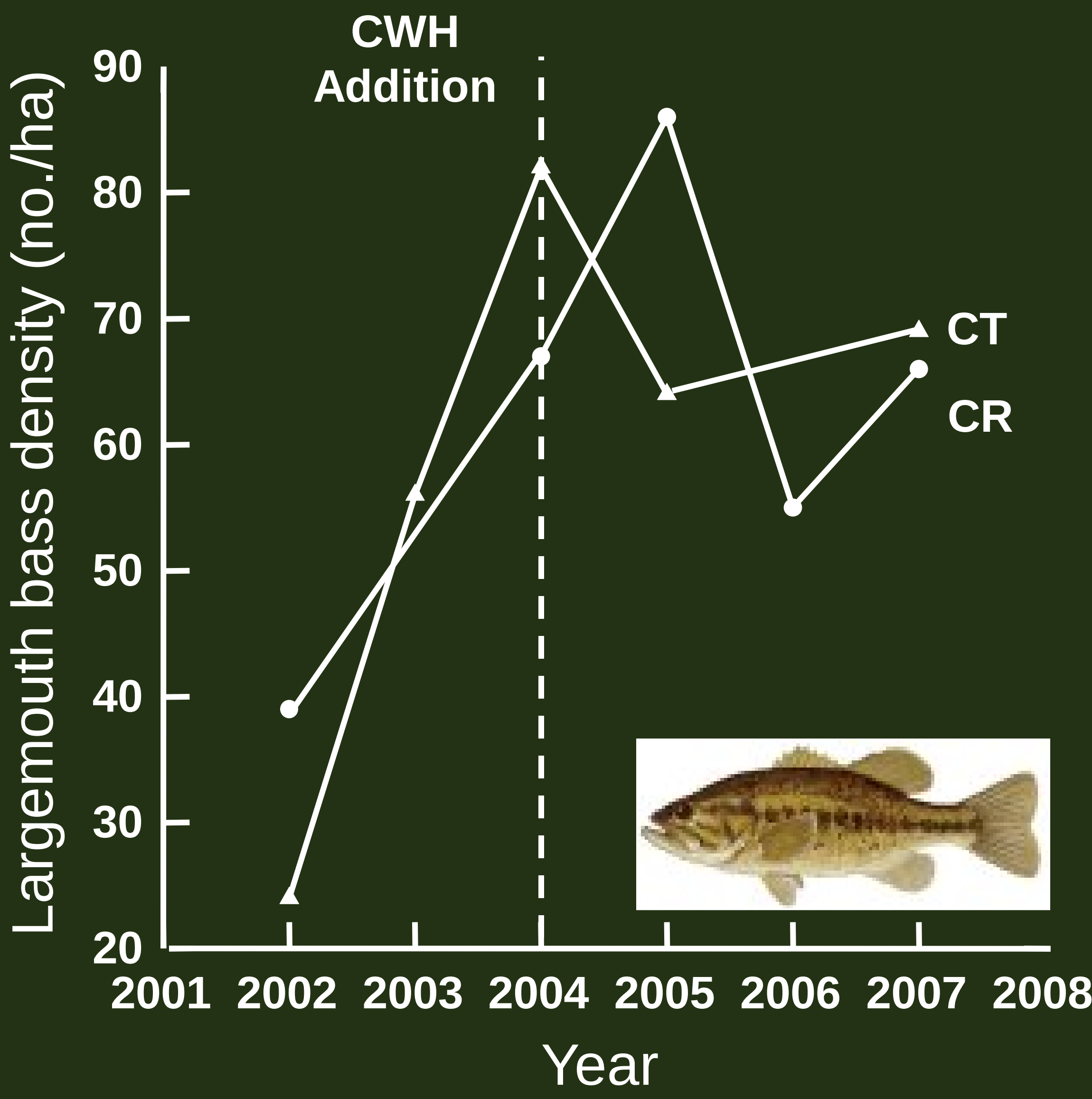

Camp Lake
Post-CWH Addition
Camp Reference
40 logs/km
Camp Treatment
141 logs/km

Camp Lake Fish Abundances



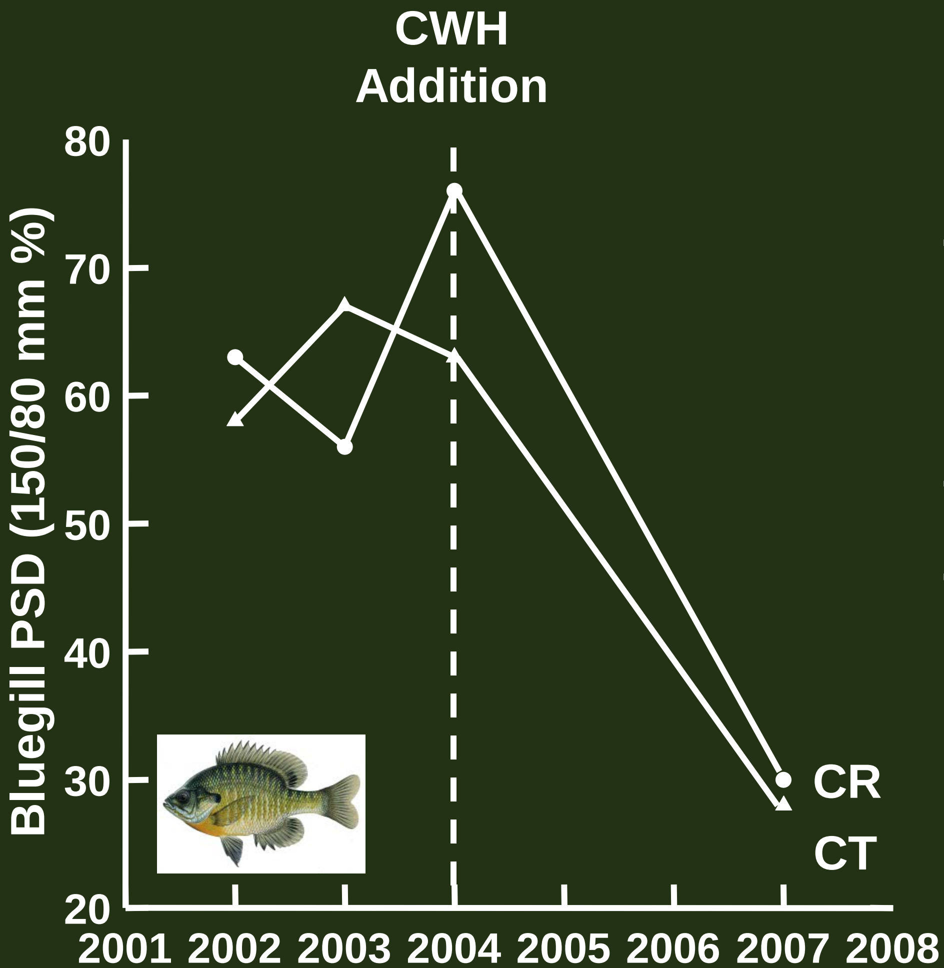
* Note: 95% confidence intervals for population estimates not shown. No significant differences among basins over time.

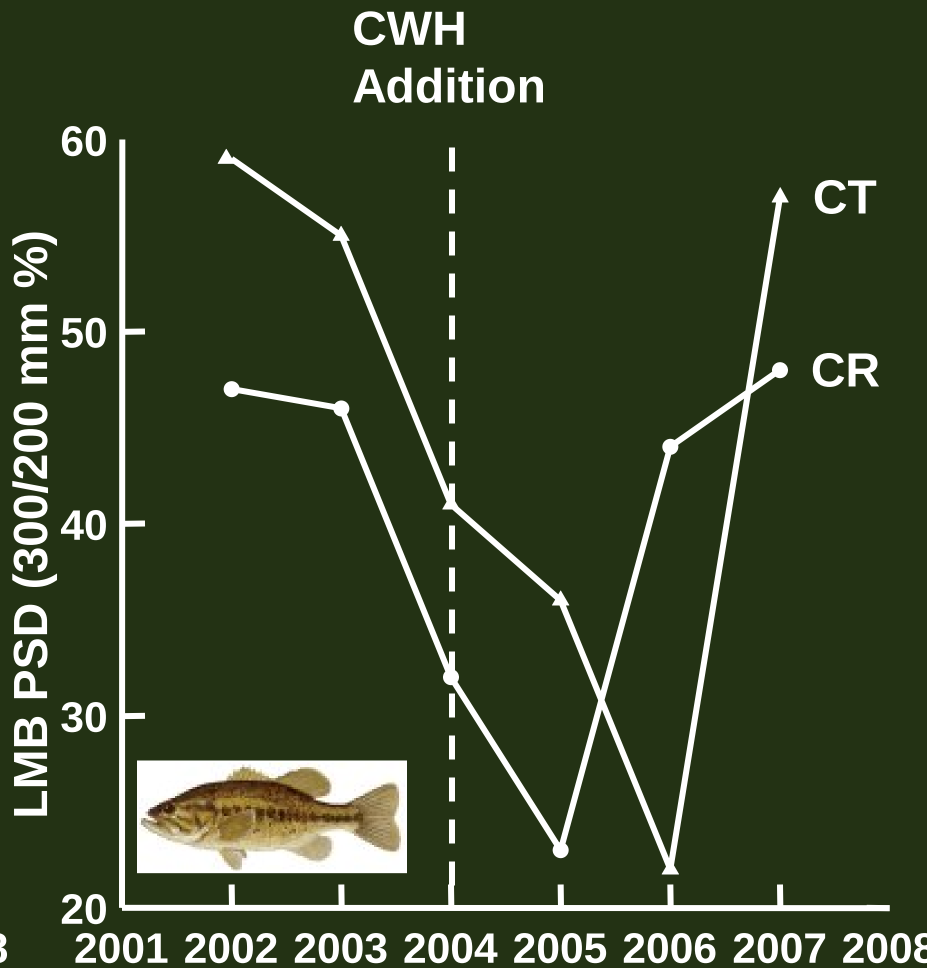
Camp Lake Fish Abundances



* Note: 95% confidence intervals for population estimates not shown. No significant differences among basins over time.

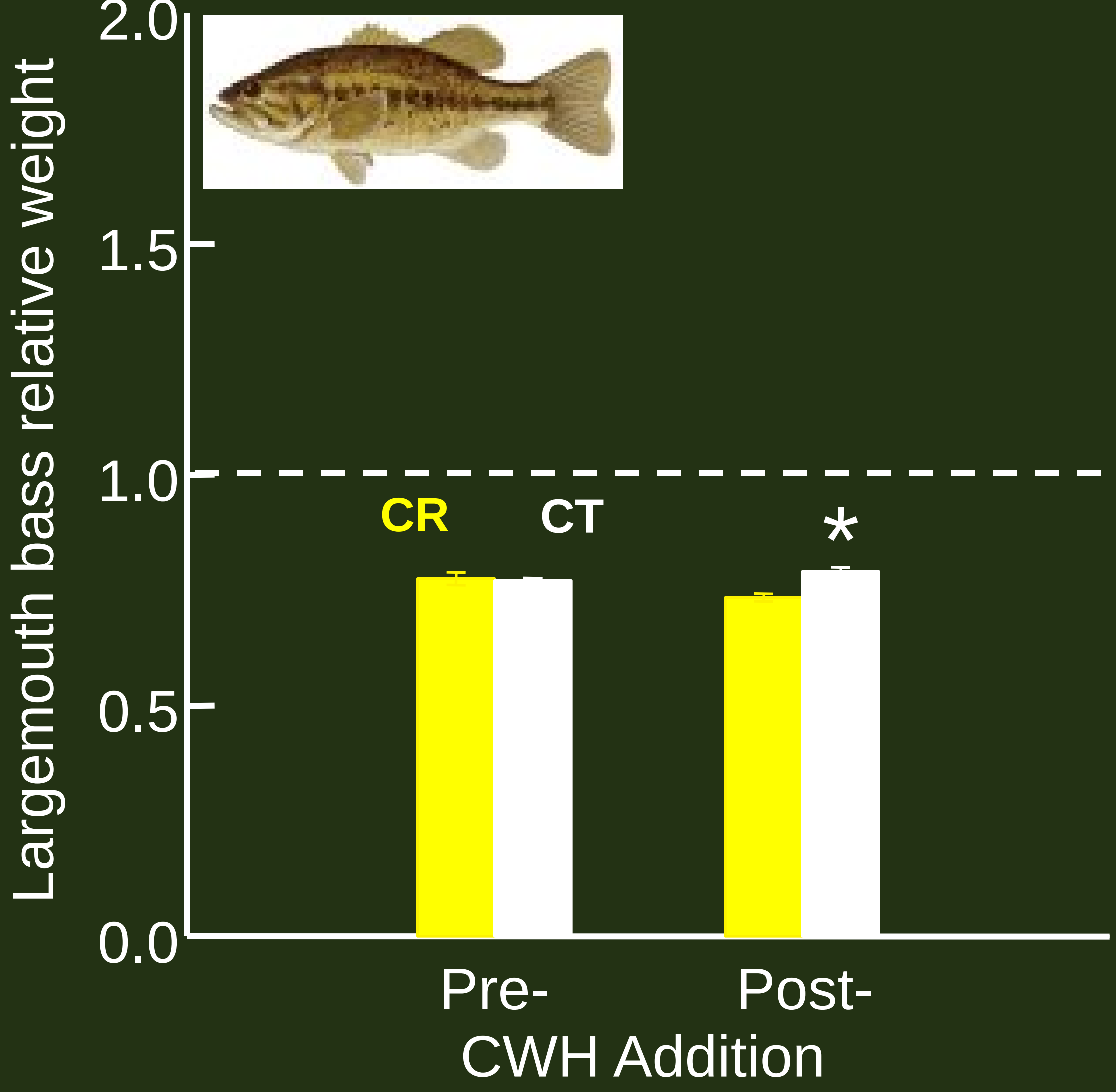
Camp Lake Proportional Size Distributions





Year

Camp Lake Body Condition



-No significant differences within and among basins in bluegill body condition

Camp Lake Mean Size at Age

	CR	LMB		CT	LMB	
Age	Pre-	Post-	+/-	Pre-	Post-	+/-
3	191mm	219mm	+	202mm	215mm	+
4	250	235	-	251	238	-
5	283	261	-	287	270	-
6	313	287	-	319	307	-
7	348	331	-	346	331	-
8	361	338	-	367	359	-
9	375	372	-	407	418	+

- No significant differences in bluegill mean size at age among basins

Camp Lake Size-Specific Growth Rates

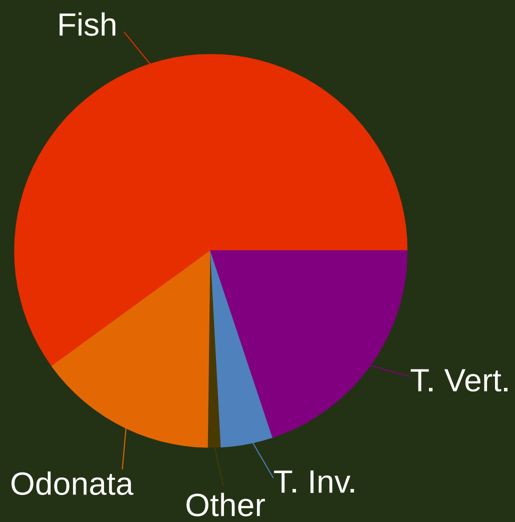
CR LMB **CT LMB**

Size (mm)	Pre-	Post-	+/-	Pre-	Post-	+/-
100	46.15 mm/yr	50.83 mm/yr	+	57.54 mm/yr	51.17 mm/yr	-
200	36.33	36.62	+	39.75	37.83	-
300	28.76	25.67	-	27.58	26.64	-
400	22.9	16.86	-	19.21	17.03	-

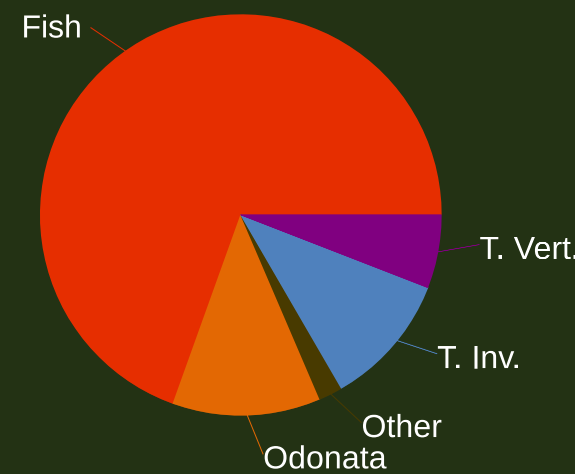
- No significant differences among bluegill size-specific growth rates among basins

Camp Lake Largemouth Bass Diets

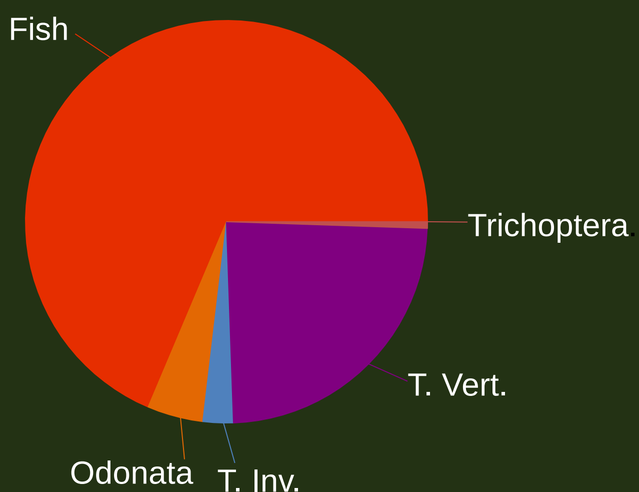
CR Pre-



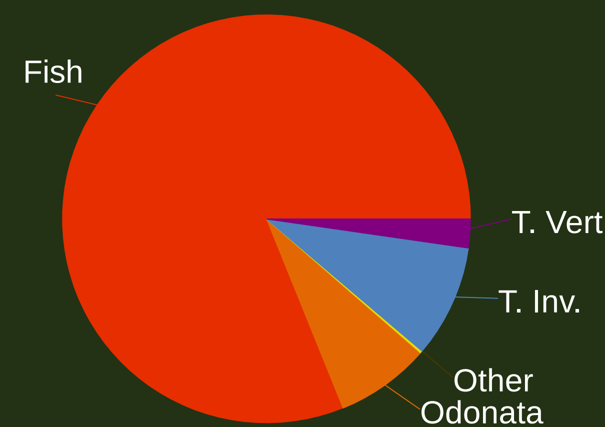
CR Post-



CT Pre-



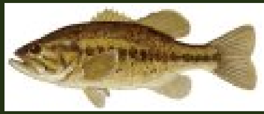
CT Post-



-No significant differences in bluegill diets within and among basins

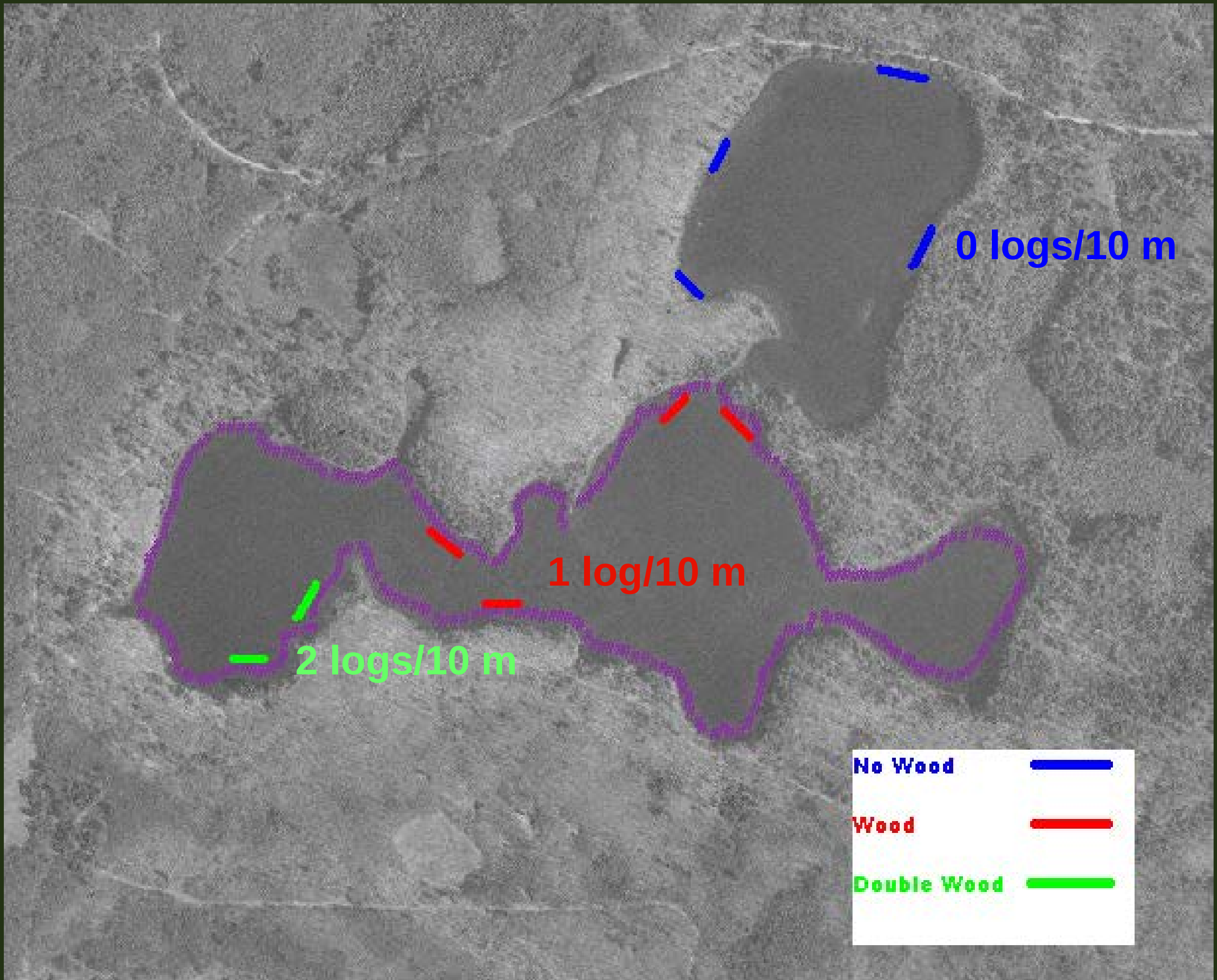
Camp Lake Diet Metrics

	CR Pre-	Post-		CT Pre-	Post-	
Diet breadth	3.08	2.34	-	2.845	2.87	+
% empty	3.75	8.63	+	7.0	7.0	No change
g/diet	0.016	0.009	-	0.021	0.009	-

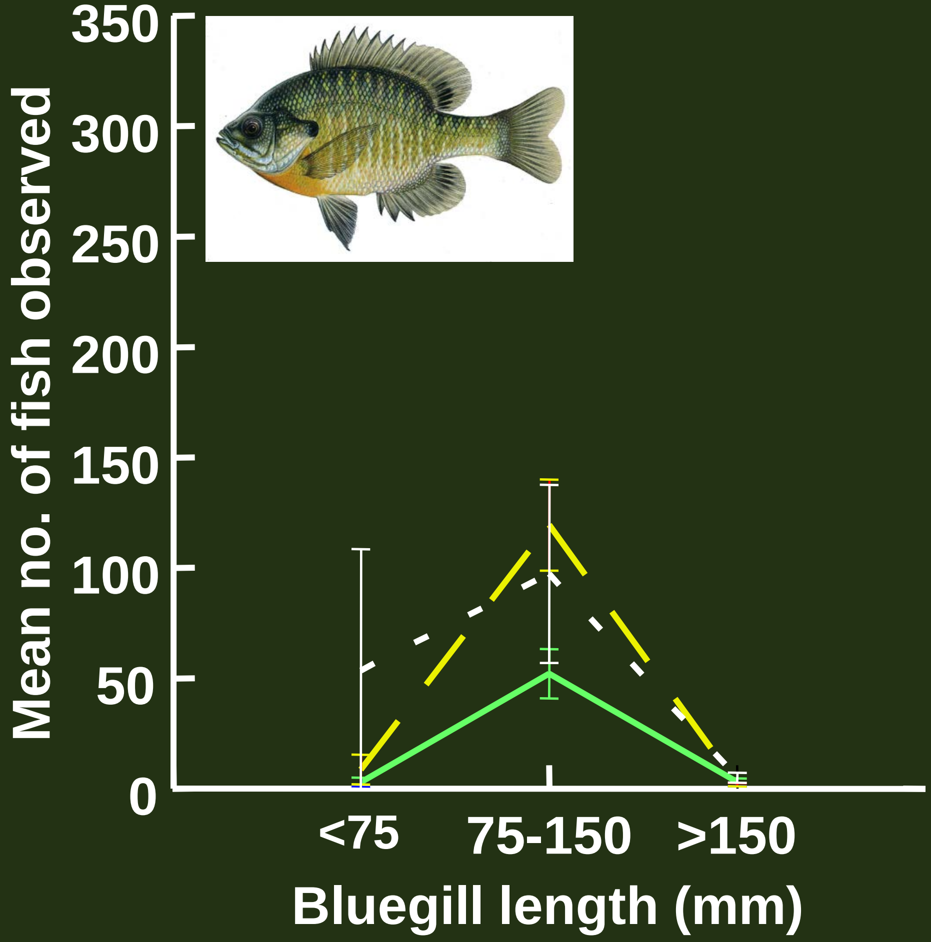


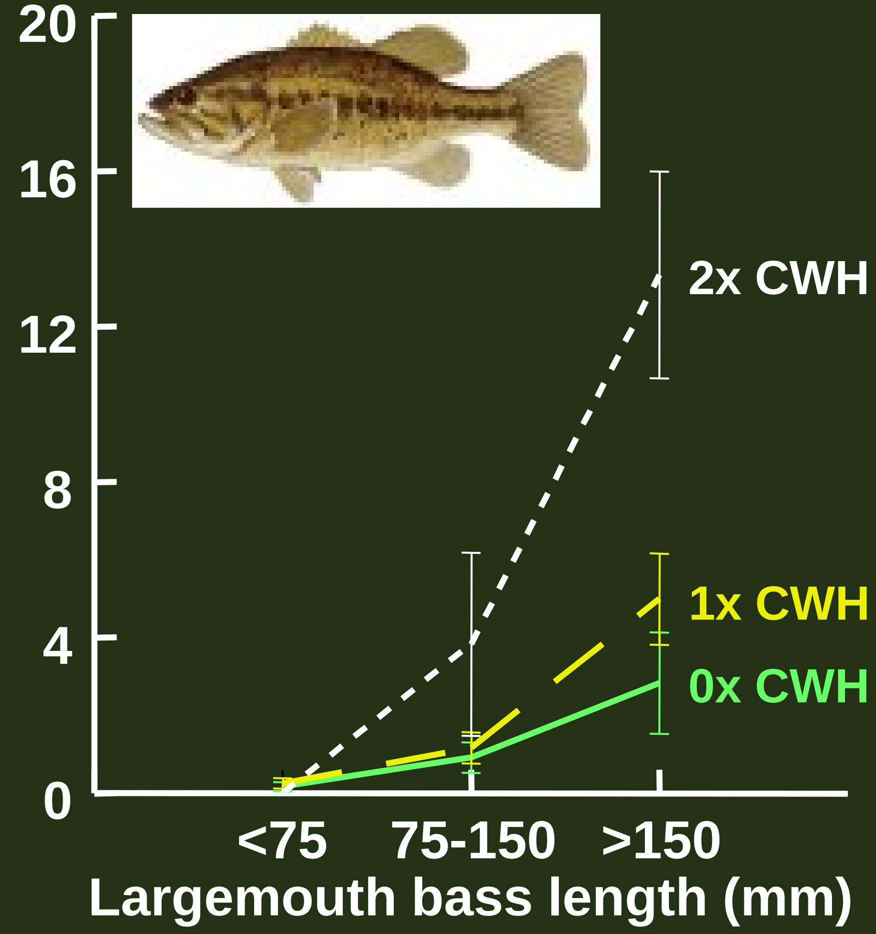
	CR Pre-	Post-		CT Pre-	Post-	
Diet breadth	2.265	1.935	-	1.645	1.868	+
% empty	17.27	23.81	+	31.94	21.6	-
g/diet	0.092	0.051	-	0.13	0.1185	-

Camp Lake CWH Fish Usage

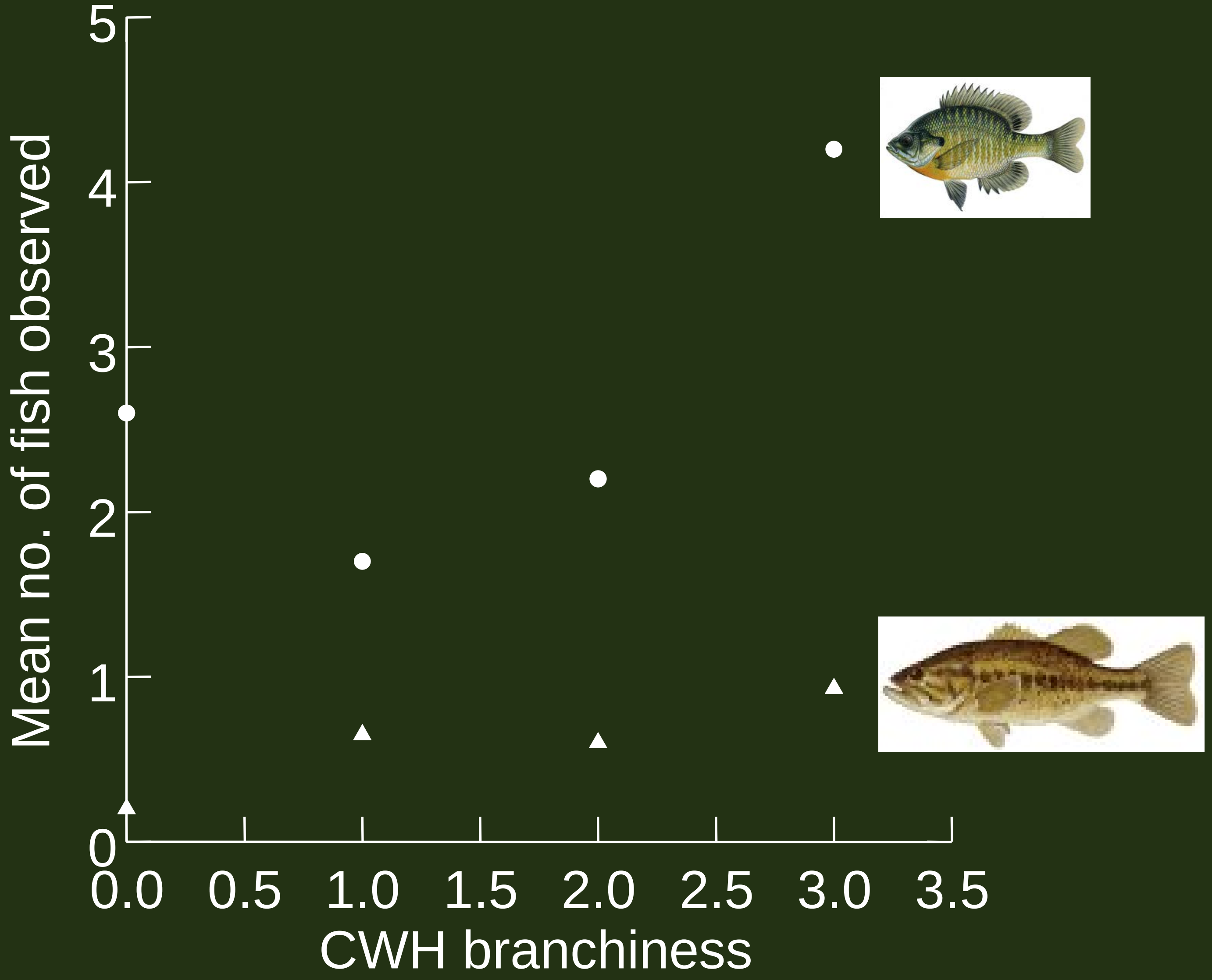


Camp Lake CWH Fish Usage





Camp Lake CWH Fish Usage



-Greater CWH complexity = greater fish usage!

Ahrenstorff, T.D., **G.G. Sass**, and M.R. Helmus. 2009. The influence of littoral zone coarse woody habitat on home range size, spatial distribution, and feeding ecology of largemouth bass (*Micropterus salmoides*). Hydrobiologia 623:223-233.

-5 largemouth bass radio tagged in each basin

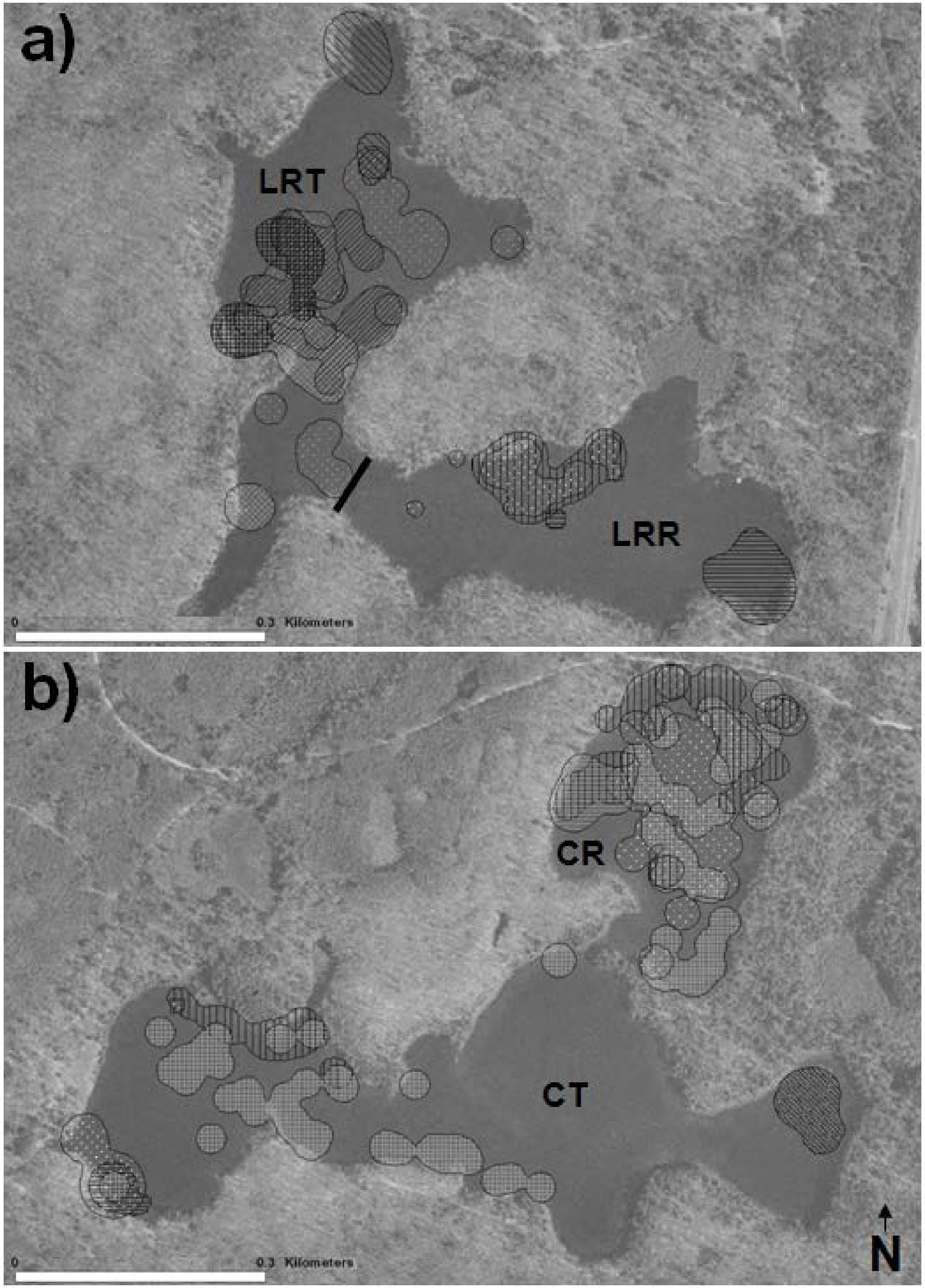
-Each bass located at various time scales (4-12 hours) to determine home range size

-Home range size was significantly less in basins with more CWH

-The presence/absence of CWH appears to influence bass spatial distributions and foraging behavior

- More CWH = sit and wait strategy

- Less CWH = actively searching strategy



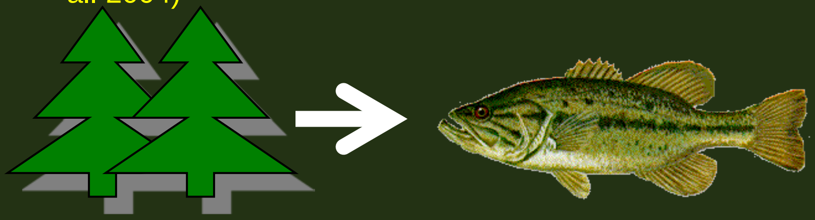
Summary – Camp Lake CWH Addition

- **Fish abundances – bluegill and bass densities increased in both basins over time; larger increases in Camp Treatment**
- **Fish size structure – declines in PSD's for BG and LMB suggest increased reproductive output after CWH addition**
- **Fish growth – minimal effects on fish growth, density-dependence?**
- **Fish diets – little change in BG diets, increased reliance on fish and less on terrestrial sources of food for LMB in Camp Treatment**
- **Fish diets – increased diet breadth and decrease in the % of empty stomachs in Camp Treatment**
- **CWH fish usage – higher abundances of CWH lead to increased use by BG and LMB; greater CWH complexity = more fish usage; CWH presence absence effects LMB home range size**

Coarse Woody Habitat and Fishes

KNOWN:

- Many fishes are attracted to CWH (Newbrey et al. 2005, Sass et al. 2012)
- CWH loss can severely deplete forage fishes and depress largemouth bass growth rates (Sass et al. 2006, Gaeta et al. 2011, 2014)
- Fish behavioral responses are evident with CWH loss or addition (Ahrenstorff et al. 2009, Sass et al. 2012)
- Lakeshore residential development is negatively correlated with CWH (Christensen et al. 1996, Sugden-Newbery 2004, Francis and Schindler 2006)
- A substantial proportion of fish production can derive from terrestrial sources of carbon (Pace et al. 2004)



UNKNOWN:

- Does CWH addition simply attract fishes?
- Does CWH addition increase fish production?
- How do fishes respond to CWH addition….

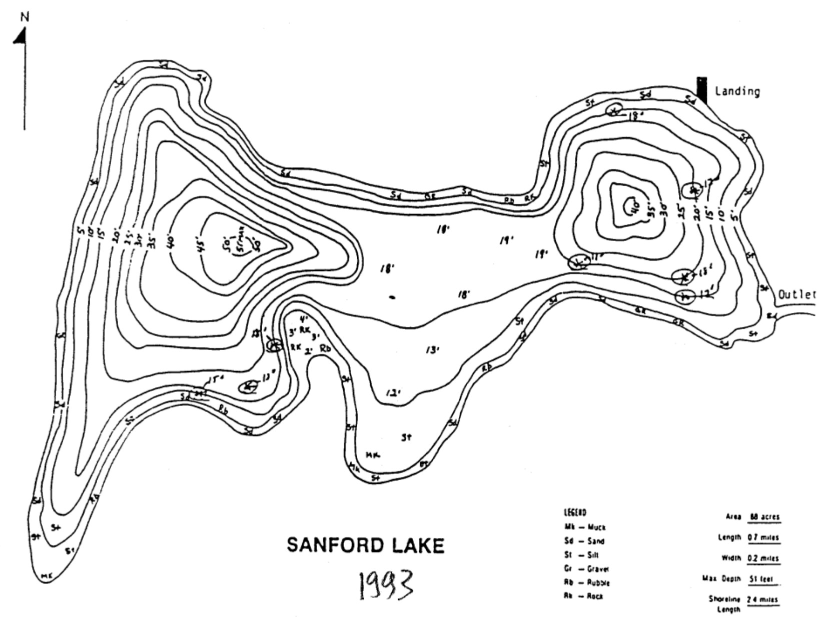
➢ in a more complex fish community

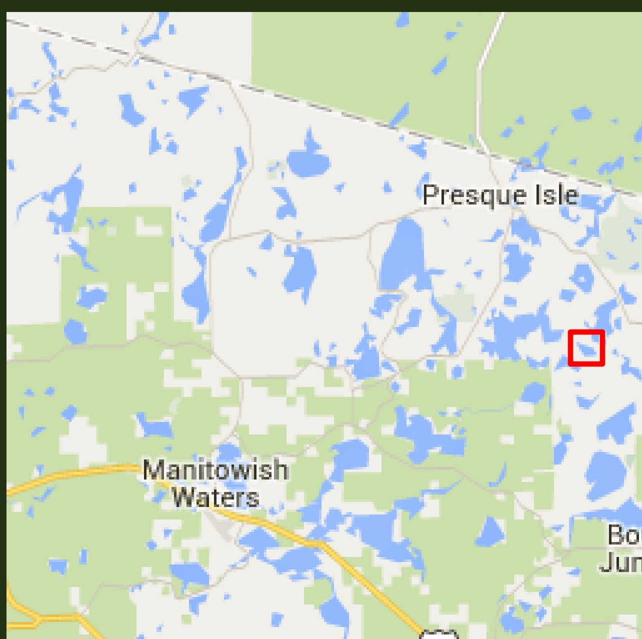
➢ in larger lakes

➢ over extended periods of time (20-25 years)

Sanford Lake - Dairymen's, Inc.

- 88 acres
- Maximum depth of 51 feet
- Undeveloped shoreline

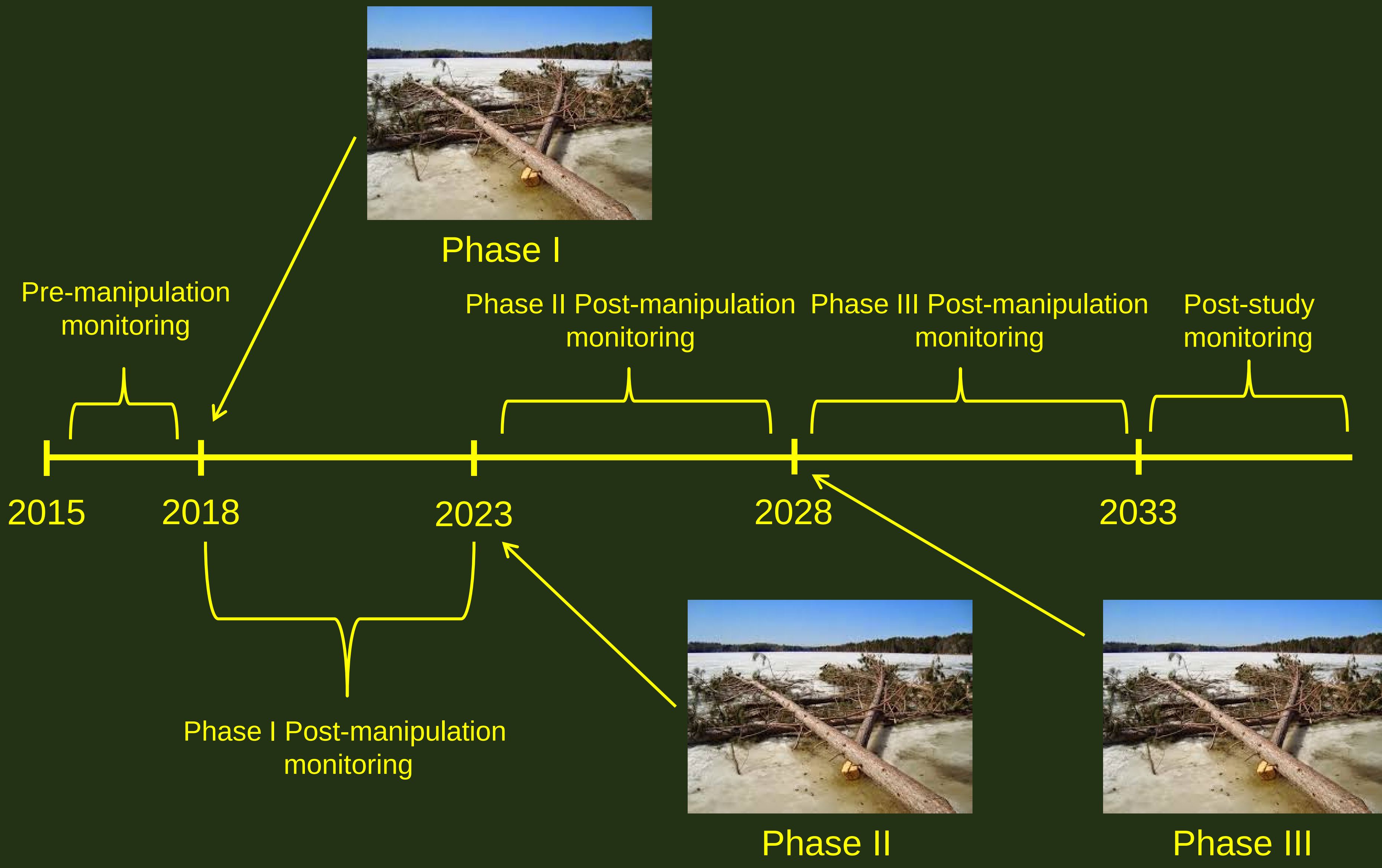




Reference System = Escanaba Lake

Sanford Lake Fish Community

Sanford Lake Study Timeline



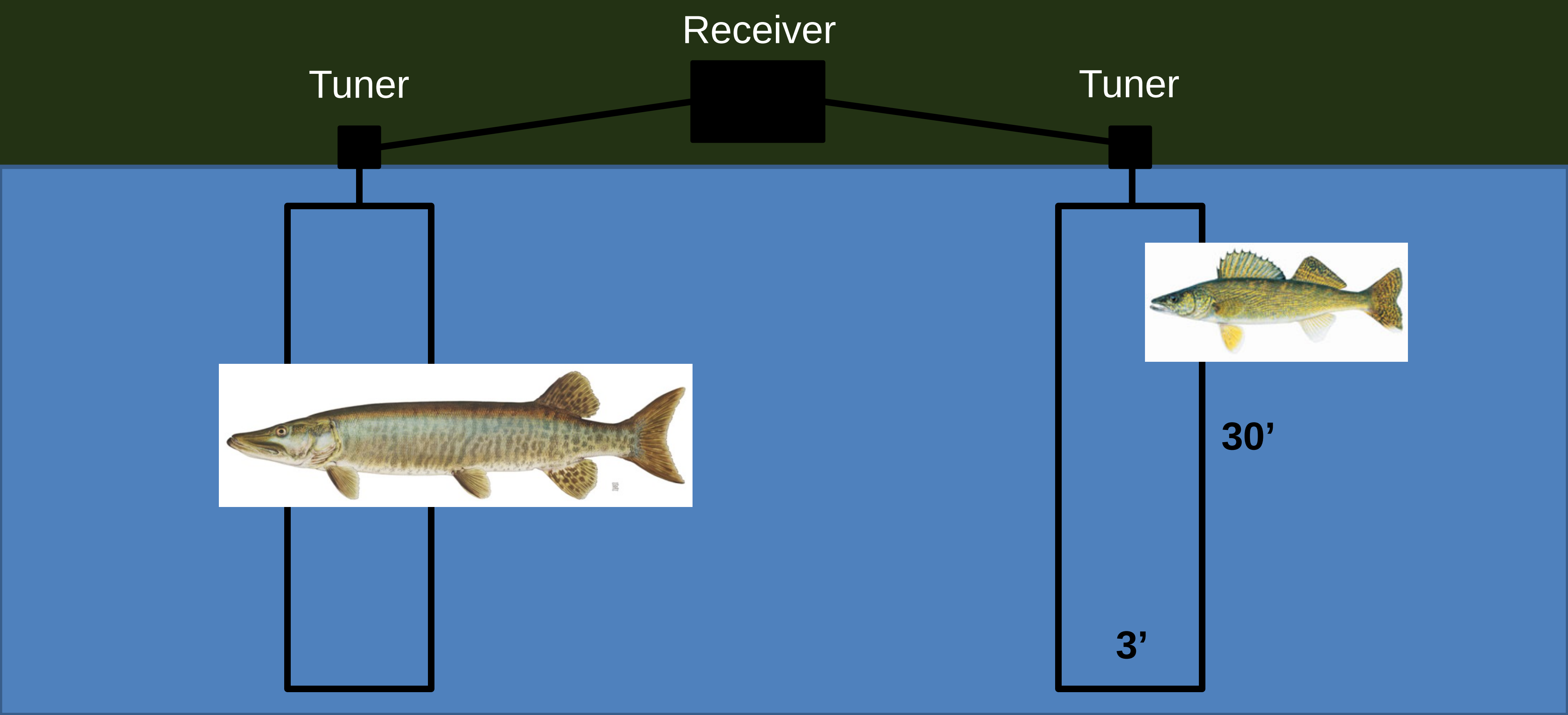
Response Variables

- Fish PE's, growth, condition, diet, production
- Food web structure (stable isotopes)
- Fish nutritional physiology and stress
- CWH habitat use
- Benthic macroinvertebrates
- Zooplankton
- FISH BEHAVIOR AND MOVEMENTS

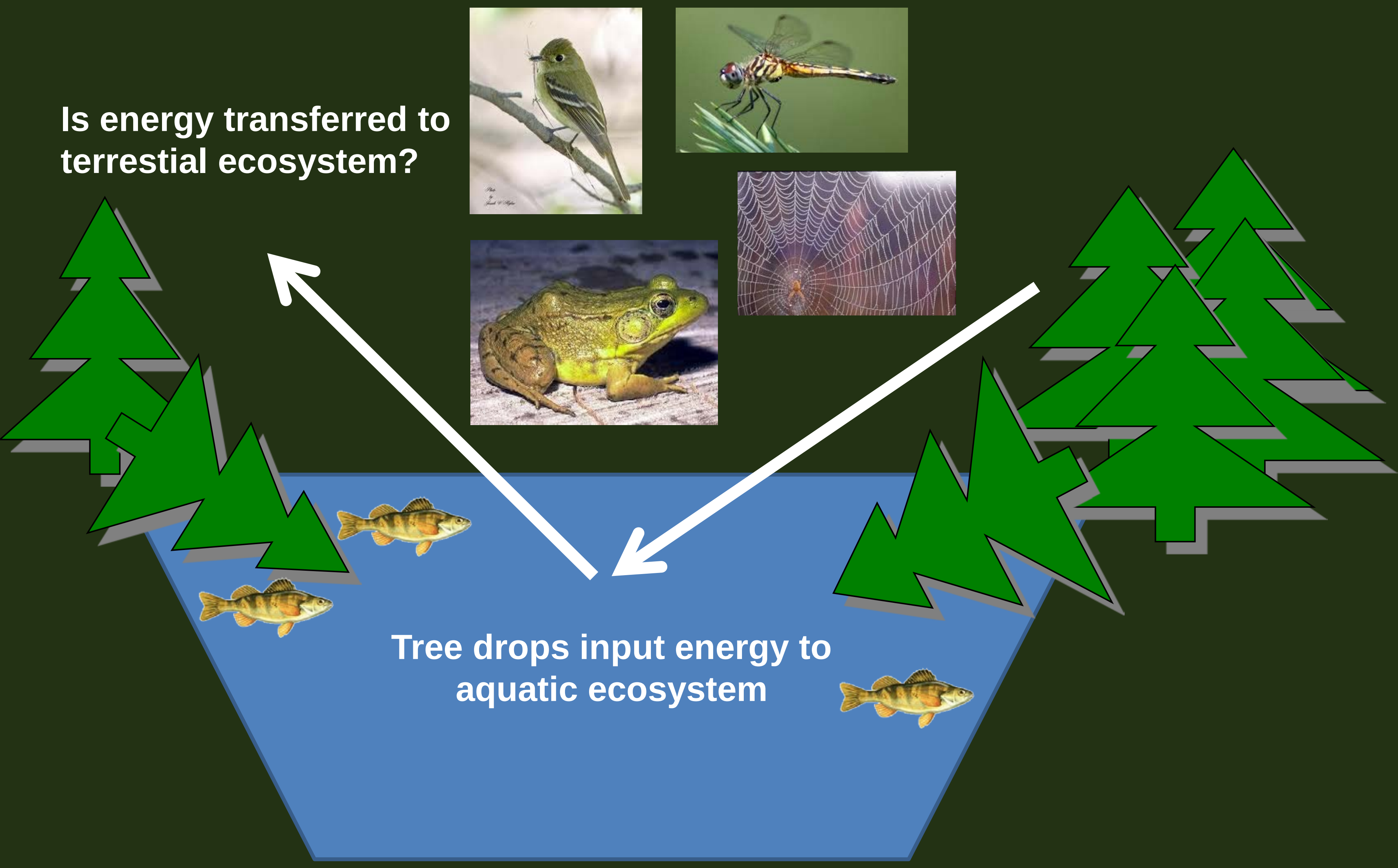
- Temperature/dissolved oxygen profiles
- Periphyton
- CWH abundances
- Riparian forest characteristics
- Chlorophyll *a*, nutrients
- Submersed aquatic vegetation
- Leaf litter
- Angler harvest/catch rates
- ECOTONE RESPONSES

PIT Tag Receivers and Fish Behavior

- Muskellunge, walleye, smallmouth bass = 32 mm PIT tag (3 foot detection)
- Yellow perch, bluegill, rock bass = 12 mm PIT tag (1 foot detection)



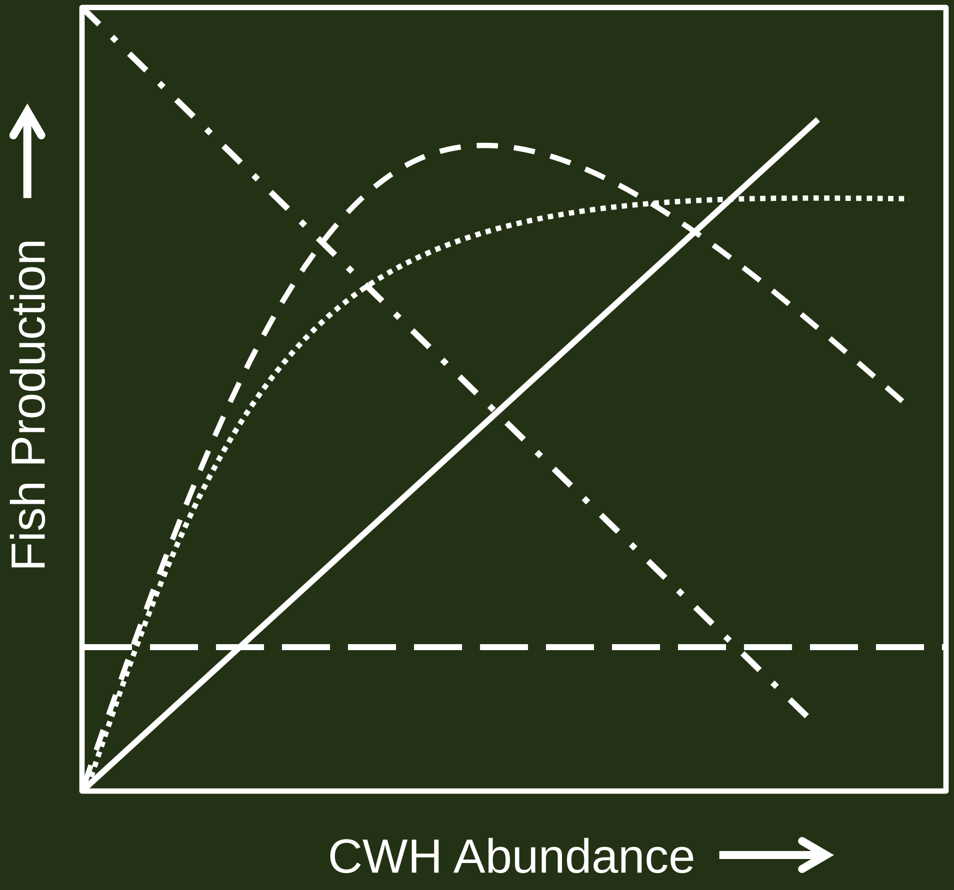
Ecotone Responses



Hypotheses

- Tree drops will increase fish production and energy transferred to the adjacent riparian ecosystem

Surprises?



Final Remarks

CWH Temporal Dynamics

Natural CWH Inputs

Anthropogenic CWH Removals

Very Slow; Decades to Millenia

Very Fast: Days to Years

- In the short term, behavioral responses may be more evident than changes in population dynamics for fish communities subjected to CWH additions

- Hysteresis and irreversibility may prevent reciprocal responses for CWH removals and additions (e.g. species extirpations)

- CWH is a natural feature of many aquatic ecosystems, such that fishes have evolved in the presence of sustained pools of CWH

- Fast removal dynamics of CWH may have long-lasting or permanent consequences

Reservoir Aging vs. “Lake Aging”

Then……

Now……

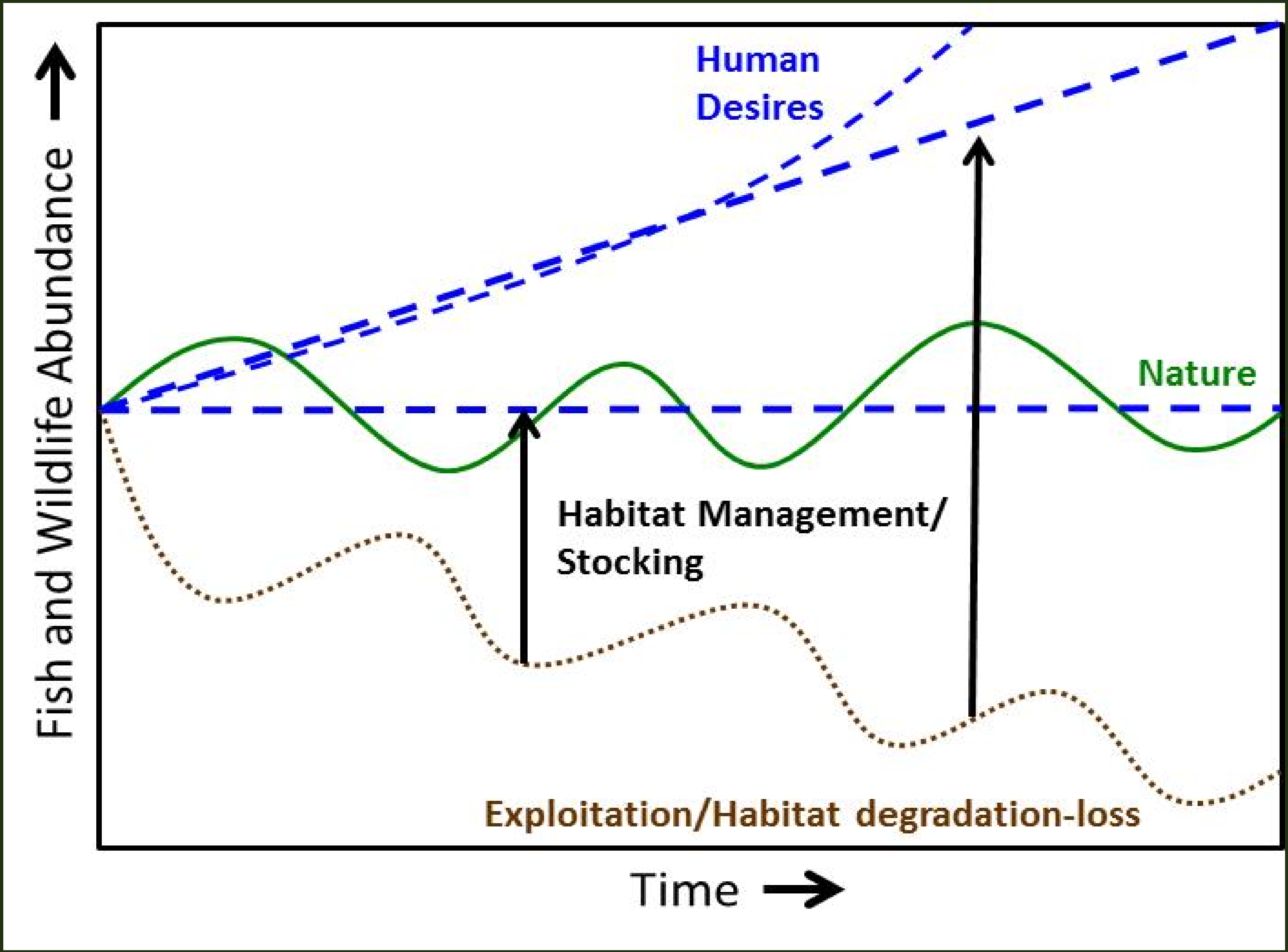
Reservoir Aging vs. “Lake Aging”

Reservoirs

- Built for flood control, water supply, recreational fishing opportunities
- High fish productivity after initial flooding (nutrient loading, complex structure)
- Aging leads to siltation, eutrophication, loss of complex structure, invasive species, development.
- Currently, low productivity and poor fisheries

Natural Lakes

- “Constructed” naturally 10,000 years ago, balanced nutrient and complex structural inputs
- Fish community dictated by “filters” allowing certain species to survive
- Humans have altered these dynamics such that lakes are now aging and “filters” are dictated by human desires
- Human desires of lakeshore residential development, no CWH, clear water, no invasives, only desirable fish



Sass, G.G., A.L. Rypel, and J.D. Stafford. Inland fisheries habitat management: lessons learned from wildlife ecology and a proposal for change. Fisheries (in press).


Questions?
Photo by Matt Helmus