Interactive Effects of Climate Change, Wetlands, and Dissolved Organic Matter on UV Damage to Aquatic Foodwebs

U.S. Environmental Protection Agency's
Global Change and Ecosystem Protection Research
STAR Progress Review Workshop

Nov. 3-4, 2005

Principal Investigators:

- Scott Bridgham[1], Gary Lamberti[2], David Lodge[2], Patricia Maurice[2], Carol Johnston[3], Boris Shmagin[3]

Postdoctoral Associate:

- Paul Frost[2], Kangsheng Wu[3]

Ph.D. Students:

- James Larson[2], Kathryn Young[2]

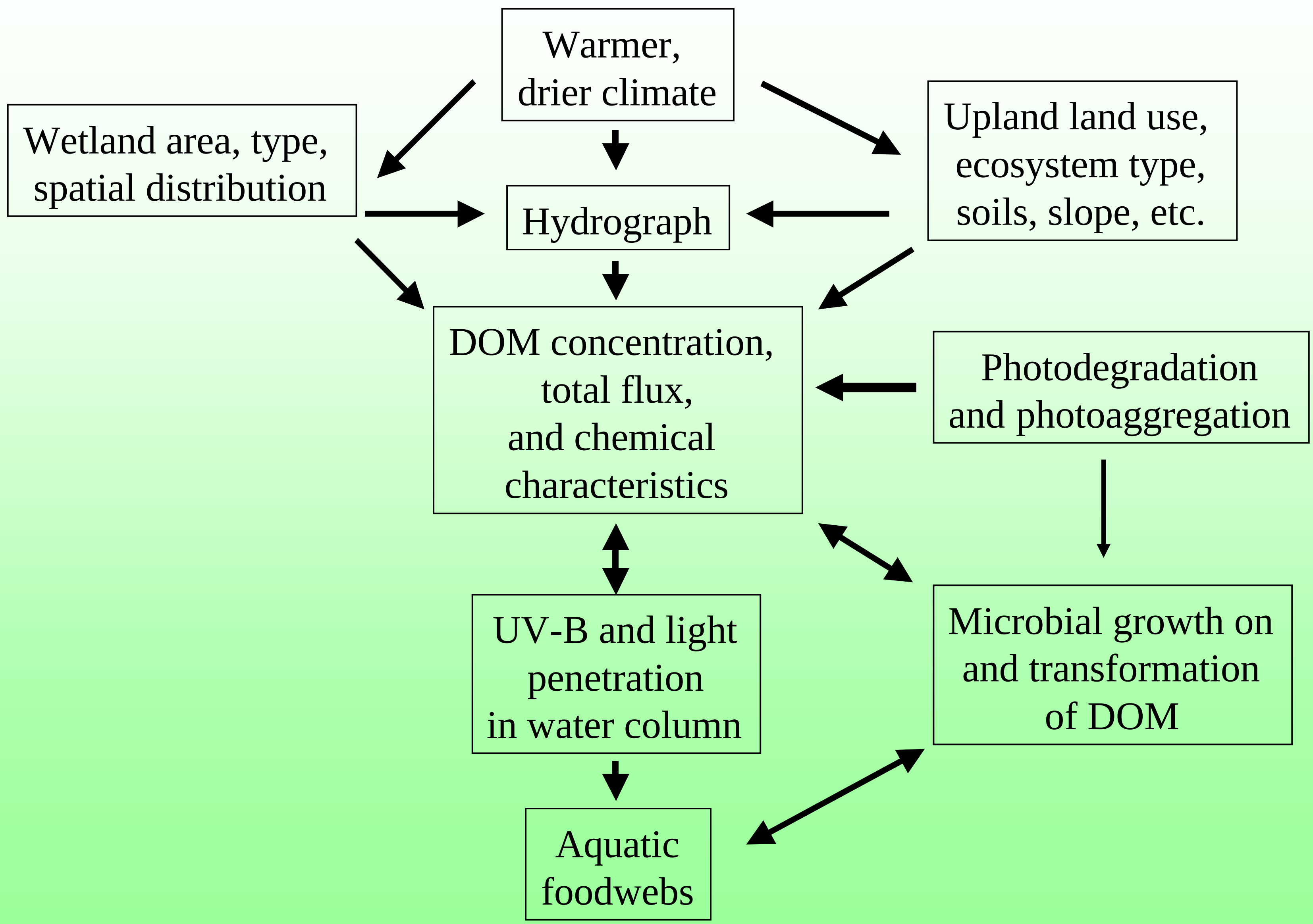
Research Technician:

- Christine Cherrier[1]

[1]Univ. of Oregon, [2]Univ. of Notre Dame, [3]South Dakota State Univ.

Overarching Goal

Provide a better understanding of how land use, climate change, and UVR affect foodweb structure in streams and rivers through their complex interactions with DOM, landscape characteristics, and climate in a northern forested watershed.


Warmer, drier climate
Wetland area, type, spatial distribution
Upland land use, ecosystem type, soils, slope, etc.
Hydrograph
DOM concentration, total flux, and chemical characteristics
Photodegradation and photoaggregation
UV-B and light penetration in water column
Microbial growth on and transformation of DOM
Aquatic foodwebs

Five Main Objectives

1. Determine the extent to which UVR exposure in streams is controlled by DOM concentration and chemistry.

2. Determine the response of stream foodwebs to the interactions among UVR intensity and DOM concentration and type.

Objectives, cont.

3. Determine landscape controls over DOM concentration and chemistry (and, hence, UVR).

4. Determine how in-stream processing of DOM through biodegradation and photodegradation varies spatially within the watershed.

5. Determine how various climate change scenarios will affect discharge and, thus, DOM concentration and UVR exposure.

Study Sites

<u>Ontonagon watershed</u>

-3600 km^2 watershed

-drains into Lake Superior

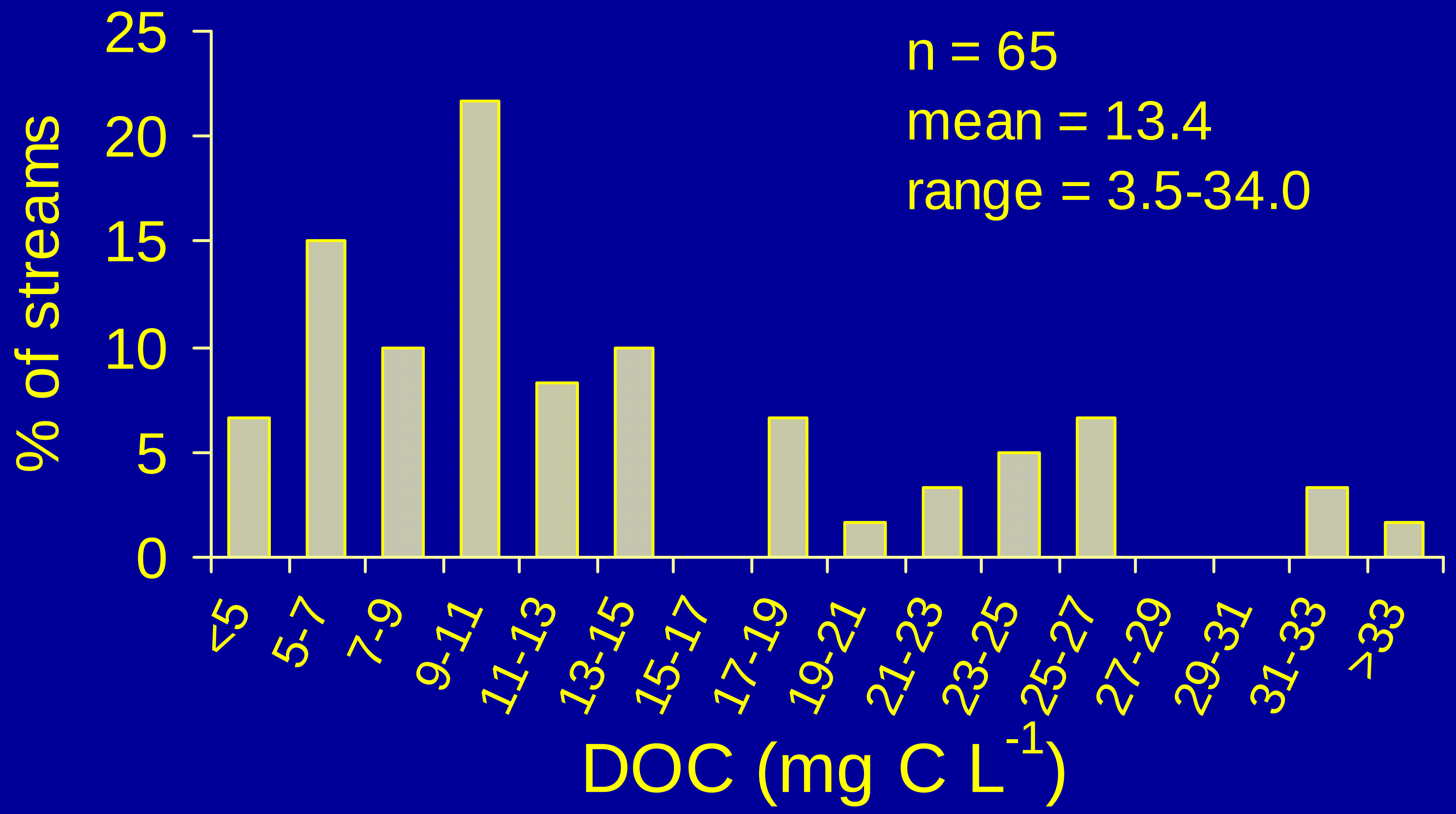
-streams 1st to 6th order

Characteristics of Ontonagon sub-watersheds

Factor	Mean	Min.	Max
% of area in wetland	18.7	0.02	48.1
% of area in lake	4.06	0	22.6
% of area in agriculture	4.93	0.05	62.8
watershed area (km^2)	14.5	0.25	345
total stream length (km)	108	1.35	2628
drainage density ($km\ km^{-2}$)	7.43	1.39	19.5

Photos P. Frost

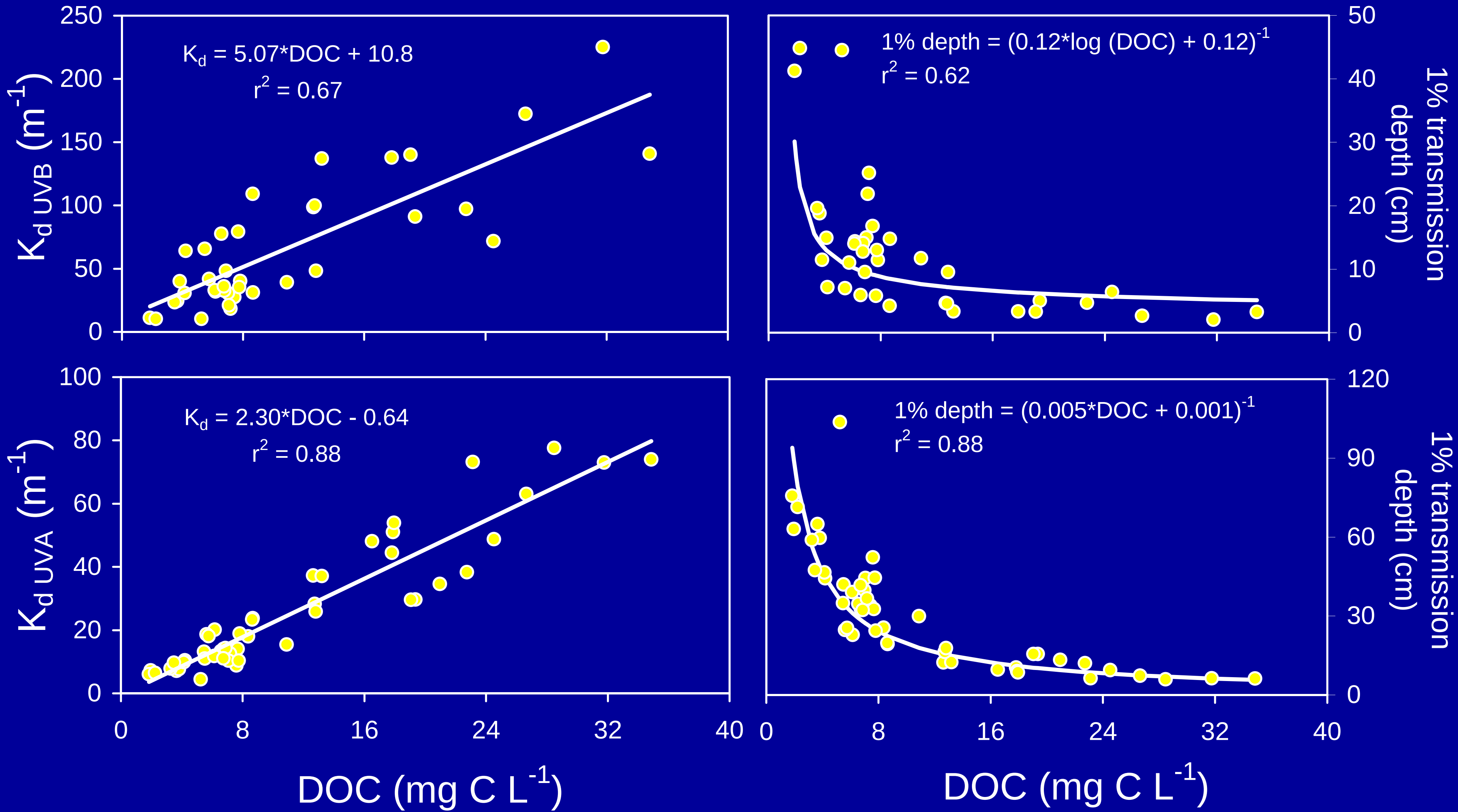
Sept. 2002 Sampling



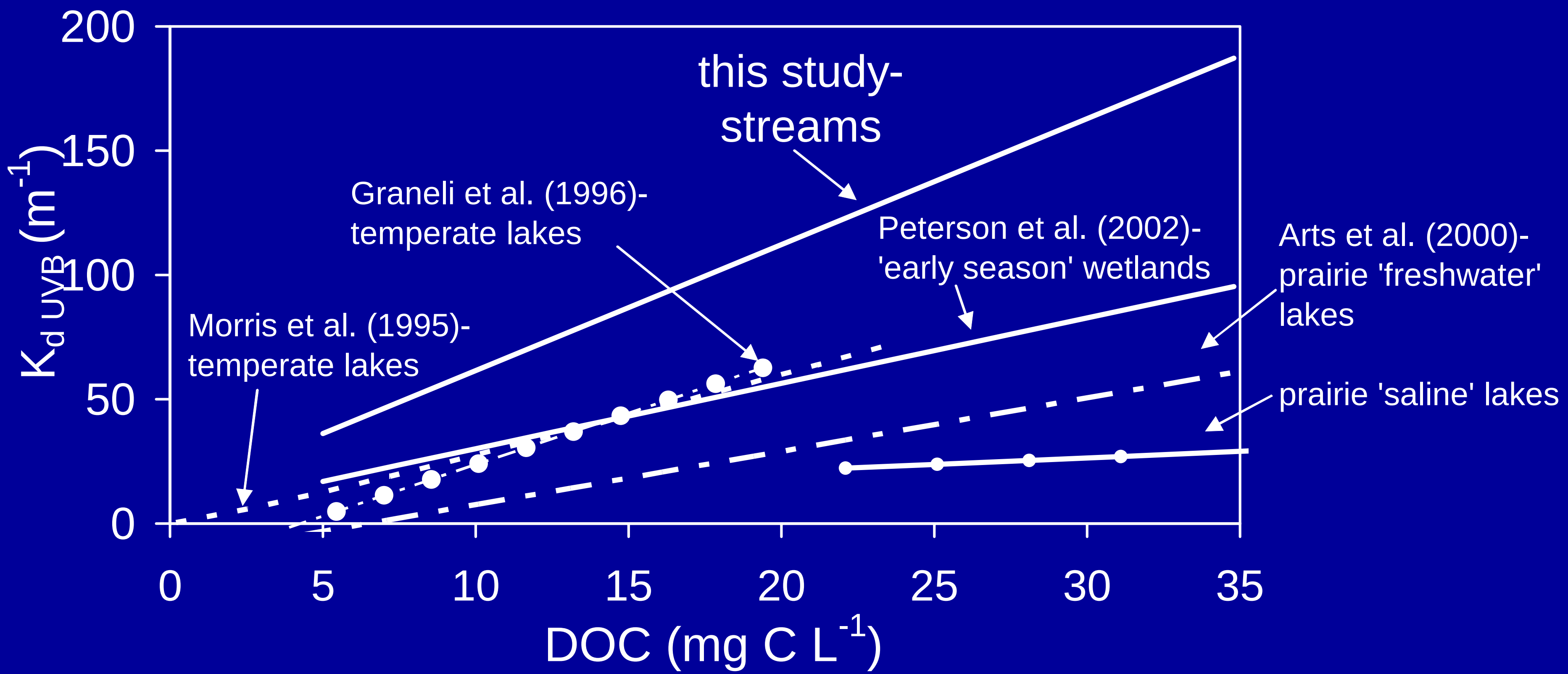
Frost, P. C., J. H. Larson, C. A. Johnston, K. C. Young, P. A. Maurice, G. A. Lamberti, and S. D. Bridgham. *In Press.* Aquatic Sciences.

Objective 1

Determine the extent to which UVR exposure in streams is controlled by DOM concentration and chemistry.

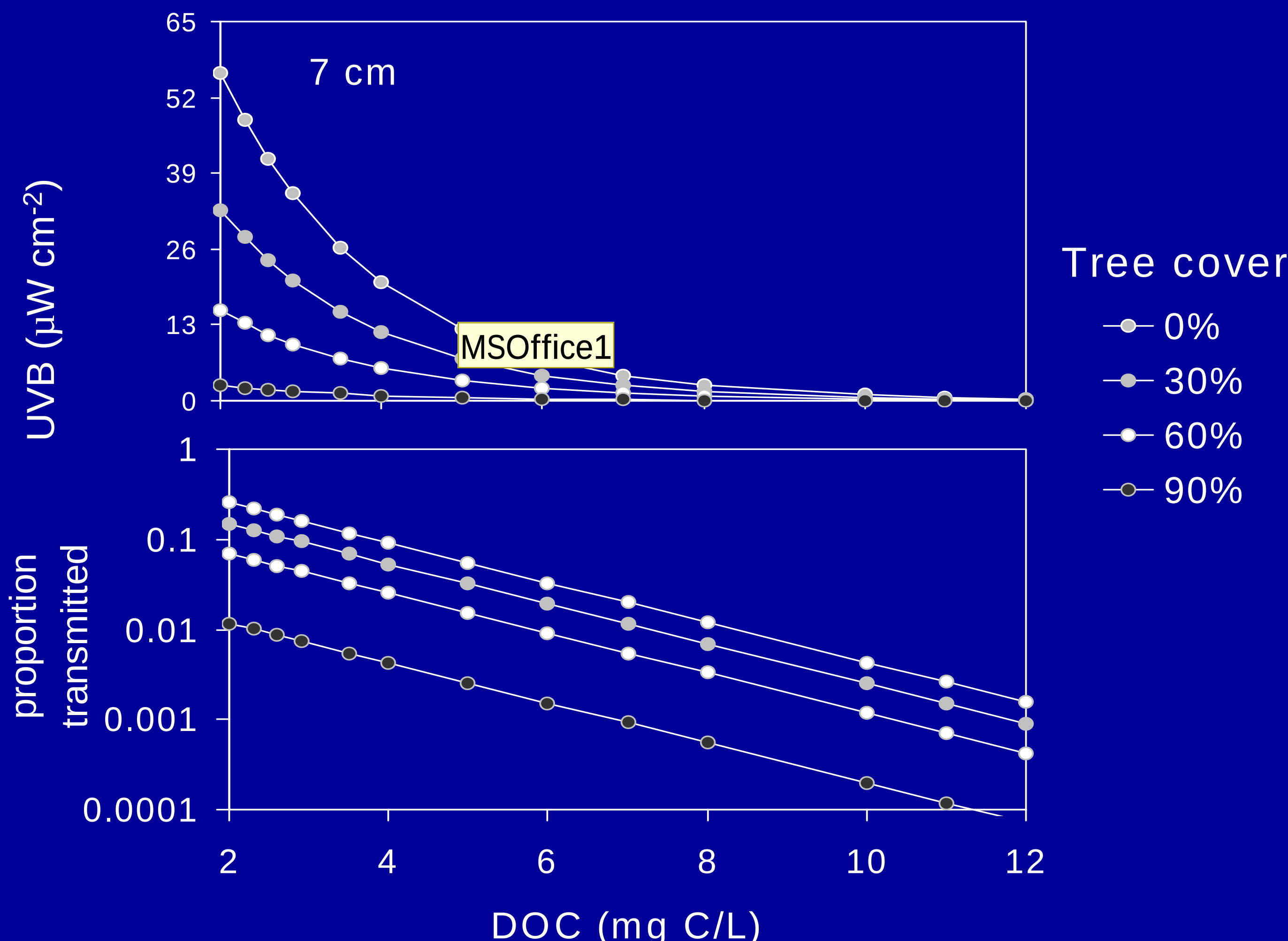


Frost, P. C., J. H. Larson, C. A. Johnston, K. C. Young, P. A. Maurice, G. A. Lamberti, and S. D. Bridgham. *In Press.* Aquatic Sciences.



Frost, P.C., J.H. Larson, G.A. Lamberti, D.M. Lodge, and S.D. Bridgham. 2005. Journal of the North American Benthological Society 24:246-255.

Stream UVB Model



Frost, P.C., J.H. Larson, G.A. Lamberti, D.M. Lodge, and S.D. Bridgham. 2005. Journal of the North American Benthological Society 24:246-255.

MSOffice1 Scott,

I tried to make the eqation below general. Irradiance at top is what is found above the canopy. Irradiance benthos is what reaches 7 cm (in this case). Canopy attenuation was calculated using regression developed btwn % canopy and % UVB removed (from Grant et al. 2002; some terrestrial paper), water attenuation was calculated using the Kd generated by our regression in the before slides. GOOD LUCK!

PF

, 5/4/2004

Objective 1 Conclusions

- UVR exposure to stream biota in this watershed is strongly controlled by DOM concentrations and riparian shading.

Objective 1 Conclusions

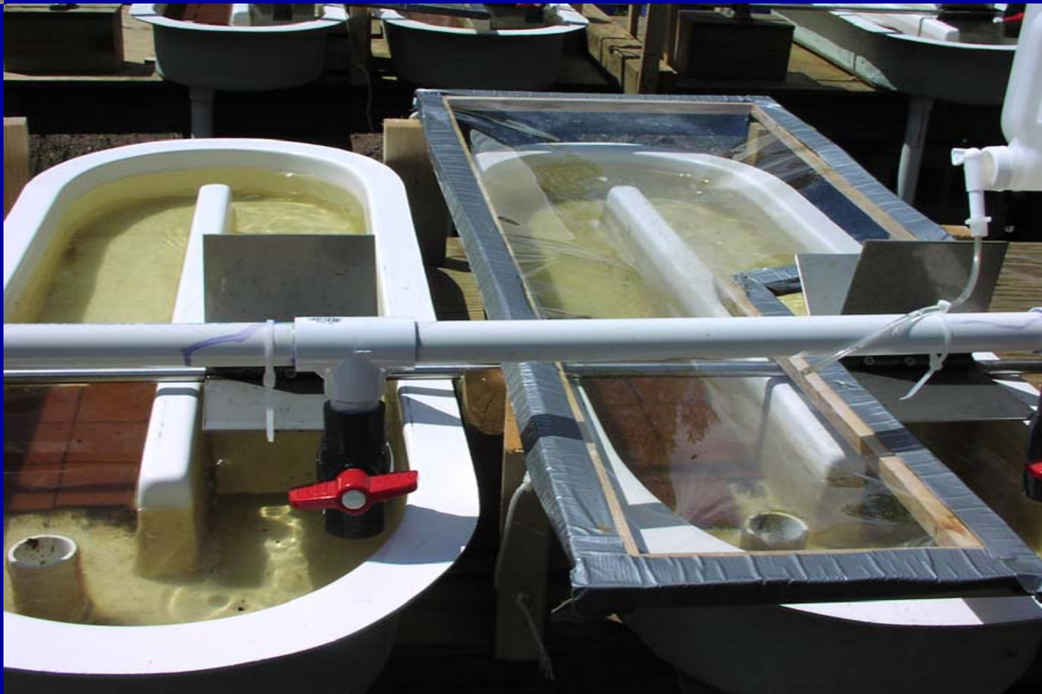
- UVR exposure to stream biota in this watershed is strongly controlled by DOM concentrations and riparian shading.

- Most of the stream biota appear to experience very low UVR exposure because of the high DOM concentrations characteristic of this area.

Objective 2

Determine the response of stream foodwebs to the interactions among UVR intensity and DOM concentration and type.

Controlled experiments to examine the interactive effects of UVR and DOM on stream food web structure



Experiment:

Change UV flux onto periphyton by altering DOM concentration and through the use of plastic UV screens

	w/ plastic	no plastic
plus DOC	no UVB high DOC	low UVB high DOC
no DOC	no UVB low DOC	high UVB low DOC

4 replicates per treatment combination

Objective 2 Conclusions

- Stream periphyton communities are strongly structured by DOM concentration and chemistry.

Objective 2 Conclusions

- Stream periphyton communities are strongly structured by DOM concentration and chemistry.
- UVR has a secondary, if any, effect on periphyton community structure.

Objective 2 Conclusions

- Stream periphyton communities are strongly structured by DOM concentration and chemistry.
- UVR has a secondary, if any, effect on periphyton community structure.
- Microbial community structure and growth rates also strongly reflect DOM concentration and chemistry.

Objective 3

Determine landscape controls over DOM concentration (and, thus, UVR exposure).

Ontonagon Watershed

-3600 km^2 watershed

-60 sampling sites in Sept. 2002

-35 sites sampled ~ 2 months for 2 years

Why the wide range in DOC among these streams?

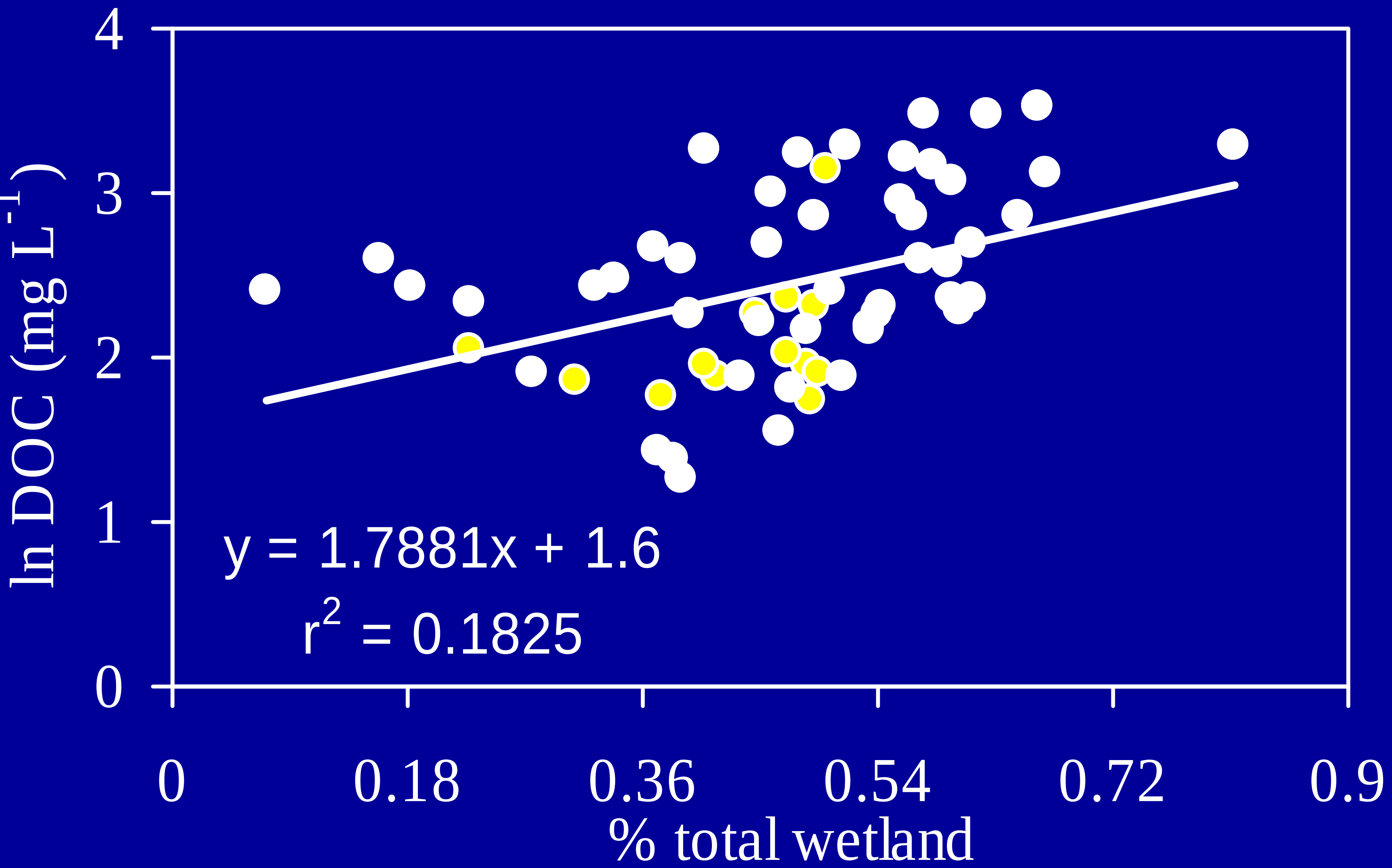
landscape features

- % lake
- % developed
- % evergreen
- % agriculture
- % wetland (by type)
- soil C:N ratio

stream geomorphology

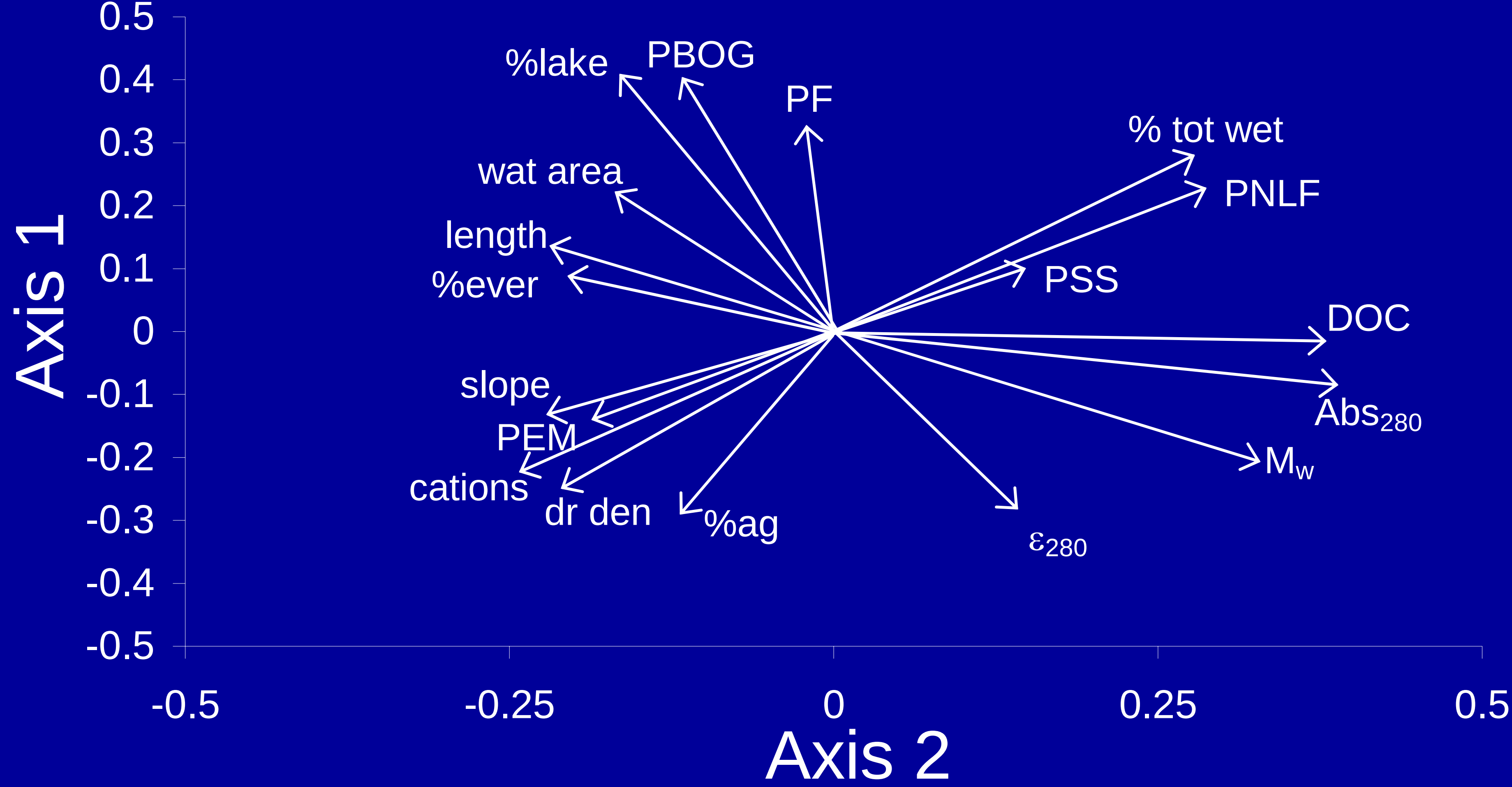
- stream length
- watershed area
- watershed perimeter
- drainage density
- maximum slope
- slope
- discharge

Sept. 2002 Sampling of 60 Sub-watersheds



Frost, P. C., J. H. Larson, C. A. Johnston, K. C. Young, P. A. Maurice, G. A. Lamberti, and S. D. Bridgham. *In Press.* Aquatic Sciences.

Sept. 2002 Sampling of 60 Sub-watersheds



Frost, P. C., J. H. Larson, C. A. Johnston, K. C. Young, P. A. Maurice, G. A. Lamberti, and S. D. Bridgham. *In Press.* Aquatic Sciences.

Ongoing Landscape DOM Projects

- Finish soil C:N ratio analyses.

- Examine how landscape relationships with DOM concentration and chemistry vary with seasonally with ~ bimonthly sampling of stream survey.

Objective 4

Determine how in-stream processing of DOM through biodegradation and photodegradation varies spatially within the watershed.

- Two published papers and one in preparation about how microbial community structure and activity reflects DOM concentration and chemistry.

- Short- and long-term biodegradation experiment with DOM from six streams of varying DOM concentration and chemistry, with and without prior photodegradation and nutrient additions.

Objective 5

Determine how various climate change scenarios will affect discharge and, thus, DOM concentration and UVR exposure.

- Factor analysis has been used at the scale of the conterminous U.S., the Great Lakes region, and the Upper Great Lakes region to determine landscape and climatic correlates of annual and seasonal discharge in streams and rivers.

- Calibrate mechanistic hydrological model (SWAT) for the Ontonagon Watershed.

- Calibrate mechanistic hydrological model (SWAT) for the Ontonagon Watershed.
- Will incorporate our empirically derived landscape and discharge controls over DOM concentration and chemistry and UVR exposure into the model.

- Calibrate mechanistic hydrological model (SWAT) for the Ontonagon Watershed.
- Will incorporate our empirically derived landscape and discharge controls over DOM concentration and chemistry and UVR exposure into the model.
- Will use several climate change scenarios to examine the susceptibility of this watershed to future disruptions in discharge, DOM, and UVR exposure.

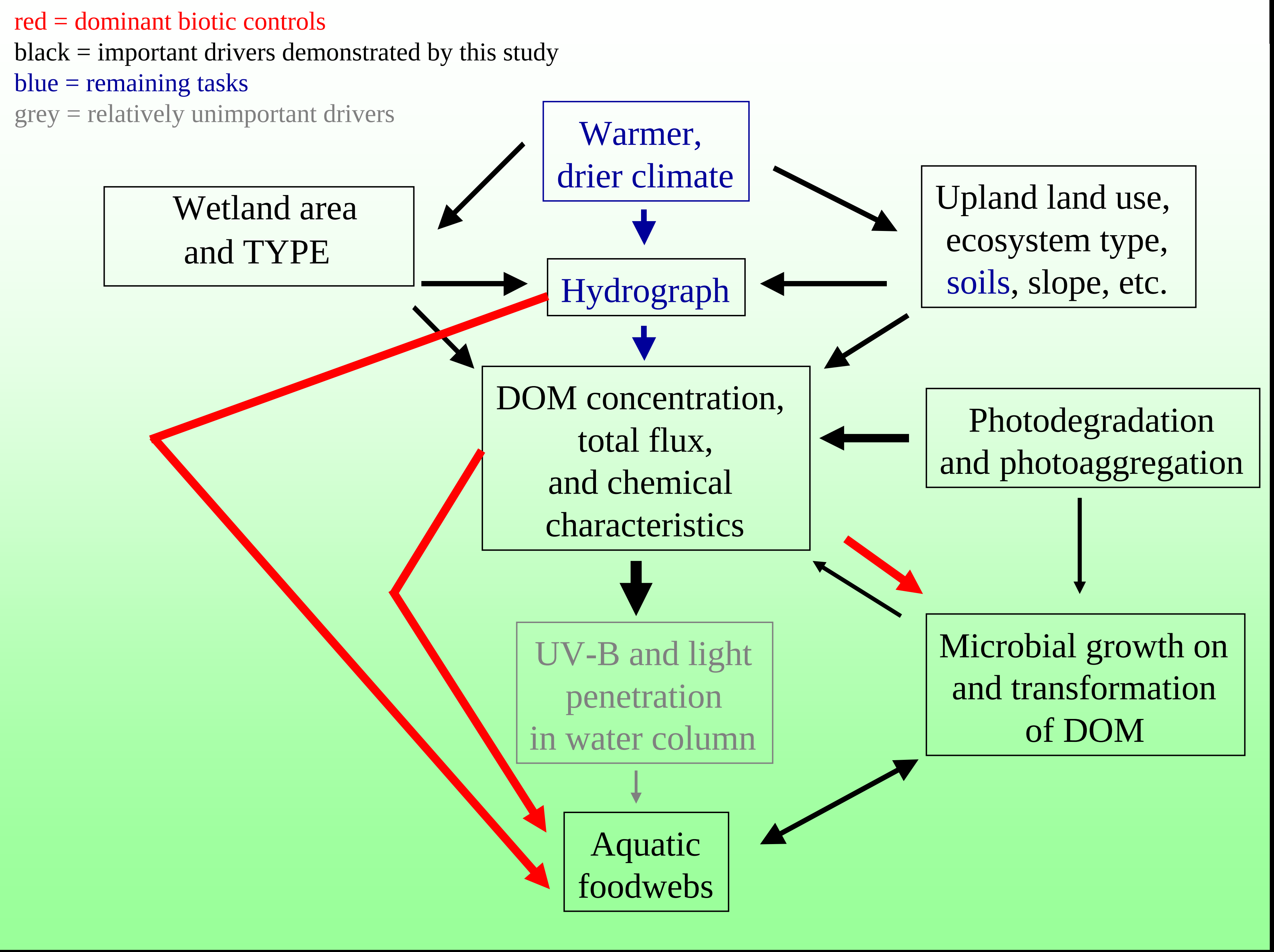
Overall Conclusions

- Only a small area of the streams in this watershed receive high UVR exposure because of the high DOM concentrations.

Overall Conclusions

- Only a small area of this watershed receives high UVR dosages because of the high DOM concentrations.

- Stream biota will be much more susceptible to future changes in discharge and DOM concentration and chemistry due to climate change than to UVR exposure.


red = dominant biotic controls
black = important drivers demonstrated by this study
blue = remaining tasks
grey = relatively unimportant drivers
Warmer, drier climate
Wetland area and TYPE
Upland land use, ecosystem type, soils, slope, etc.
Hydrograph
DOM concentration, total flux, and chemical characteristics
Photodegradation and photoaggregation
UV-B and light penetration in water column
Microbial growth on and transformation of DOM
Aquatic foodwebs