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

U.S. Environmental Protection Agency's
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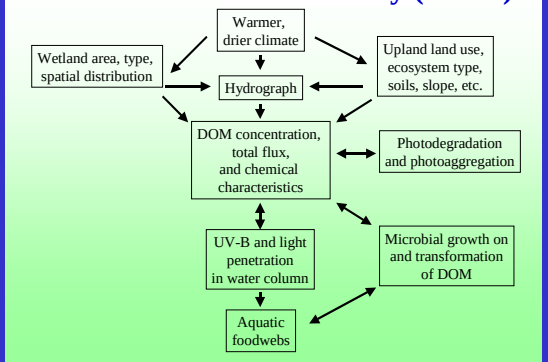
Overarching Goal

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

Stream UVR-DOM Study (SUDS)



Five Main Objectives

1. Relate DOM concentration and chemical characteristics to discharge, landscape characteristics, and stream geomorphology.
2. Determine how in-stream processing of DOM through biodegradation and photodegradation varies spatially within the watershed.
3. Determine how various climate change scenarios will affect discharge and, thus, DOM concentration at a variety of spatial scales.

Objectives, Cont.

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

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Objectives

1. Relate DOM concentration and chemical characteristics to discharge, landscape characteristics, and stream geomorphology.

Study Sites

Ontonagon watershed
-3600 km^2 watershed

-drains into Lake Superior

-streams 1st to 6th order

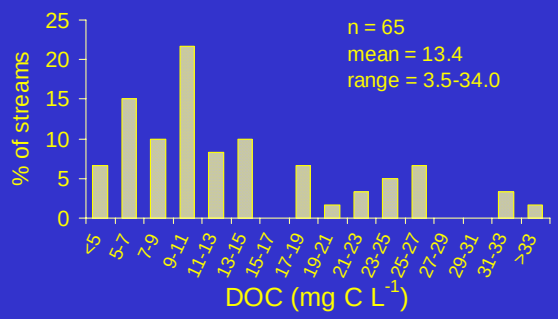
-60 sampling sites in Sept. 2002

-35 sites sampled ~ 2 months for 2 years

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

Sept. 2002 Sampling



Why the wide range in DOC among these streams?

landscape features	% lake % developed % evergreen % agriculture % wetland
stream geomorphology	log stream length log watershed area log watershed perimeter log drainage density log maximum slope log mean slope log standard deviation slope

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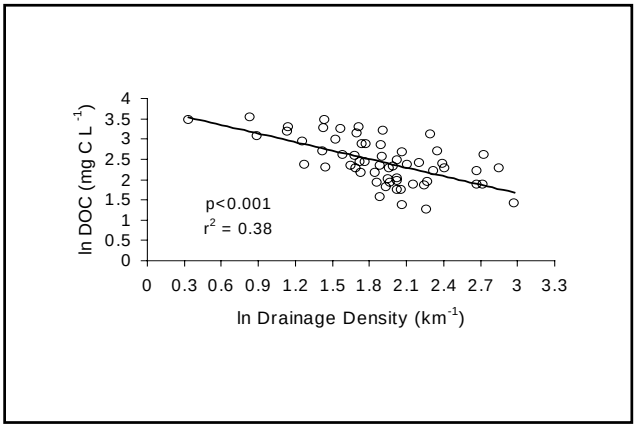
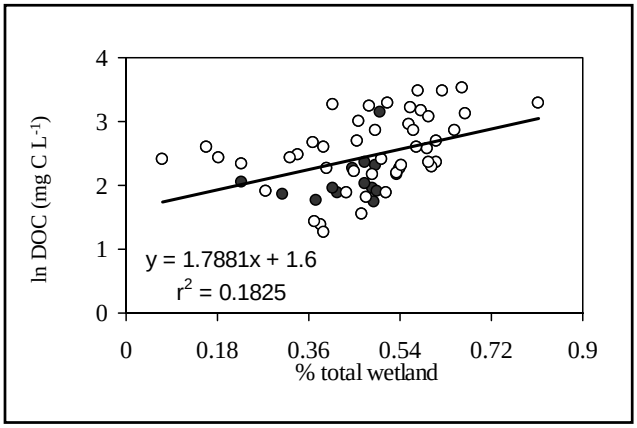




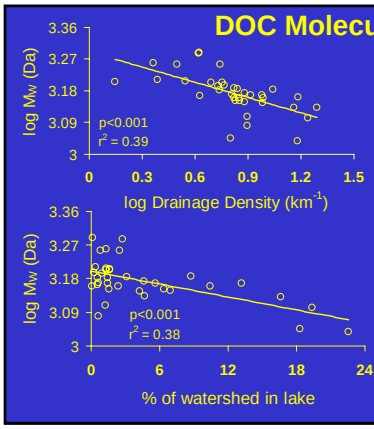
Multiple factor regression [DOC]

p< 0.0001
r^2 = 0.61

Predictor Variables

(5) % lake (-)
% developed
% evergreen
% agriculture
(4) % wetland (+)
log stream length
(2) log watershed area (-)
log watershed perimeter
(1) log drainage density (-)
log maximum slope
(3) log mean slope (-)
log standard deviation slope

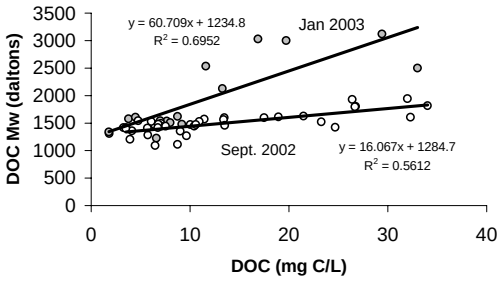
DOC Molecular Weight



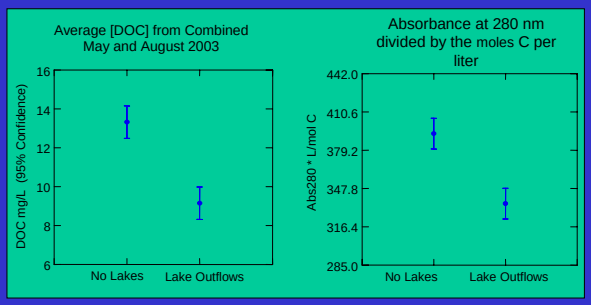
p< 0.0001, r^2 = 0.54

Predictor Variables

(2) % lake (-)
% developed
% evergreen
% agriculture
% wetland
log stream length
log watershed area
log watershed perimeter
(1) log drainage density *(-)*
log maximum slope
log mean slope
log standard deviation slope



May + August 2003 DOM Data



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Ongoing Landscape DOM Projects

- Expand GIS database by adding surficial geology, soil type, and soil C:N ratio. Compare different wetland databases and determine if wetland type is an important variable.
- Examine how landscape relationships with DOM concentration and chemistry vary with seasonally with ~ bimonthly sampling of stream survey.

Ongoing Landscape DOM Projects, Cont.

- Explore how DOM concentration and chemistry vary longitudinally in streams with and without lake outlets.

Objectives

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

Results to Date

- Biodegradation of high molecular-weight DOM is faster, and the low-molecular weight fraction is preferentially degraded.
- Biodegradation rates of DOM are dependent on microbial community structure.

Ongoing DOM Experiments

- Examine short- and long-term photodegradation and biodegradation rates of DOM from six different stream sources.
- With and without nutrient addition.
- How important is prior photodegradation in biodegradation?

Objectives

3. Determine how various climate change scenarios will affect discharge and, thus, DOM concentration at a variety of spatial scales.

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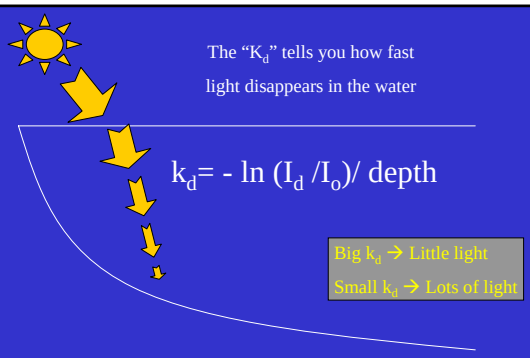
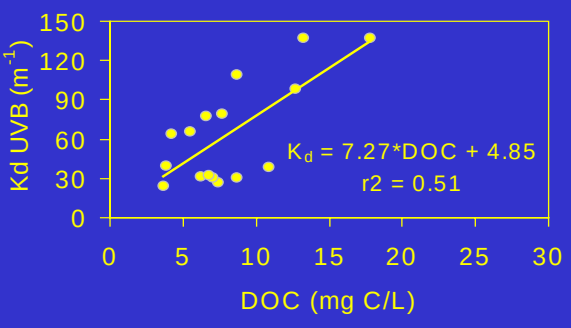
- Factor analysis has been used at the scale of the conterminous U.S., the Great Lakes region, and the Upper Great Lakes region to determine landscape and climatic correlates of annual and seasonal discharge in streams and rivers.

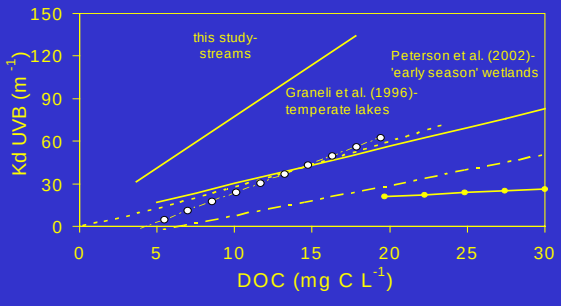
- We will gather as many [DOC] vs. discharge data as can be found for the Upper Great Lakes. Various climate change scenarios will be applied to these models to predict effects on DOM concentrations and UVR penetration into the water column.
- Mechanistic hydrological model for the Ontonagon Watershed?

Objectives

4. Determine interactions among UVR intensity and DOM concentration and chemistry.







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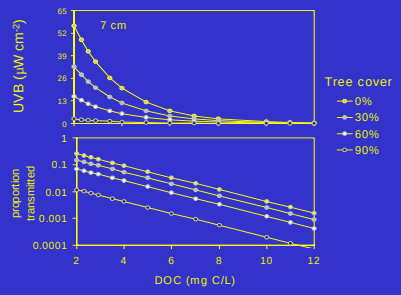
Stream UVB Model



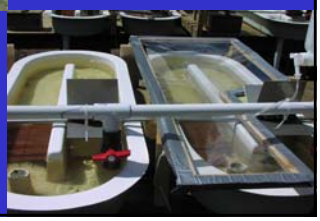
$irradiance_{benthos}$ = $irradiance_{top}$ x canopy attenuation x water attenuation

Ongoing UVR Landscape Research

- Mapping UVR penetration within the entire Ontonagon Watershed.
- Quantifying UVR dose spatially within a number of streams with 'dosimetry' strips.

Objectives

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

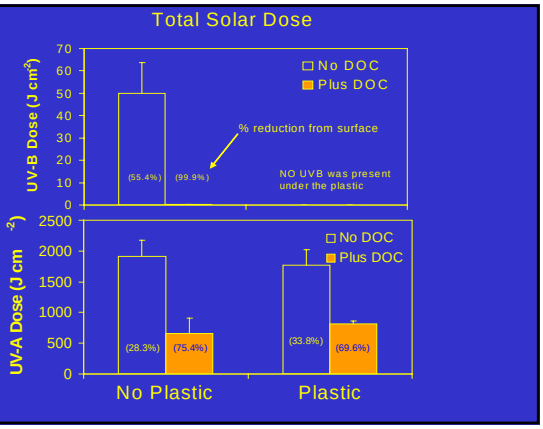


Controlled experiments to examine the interactive effects of UVR and DOM on stream food web structure

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



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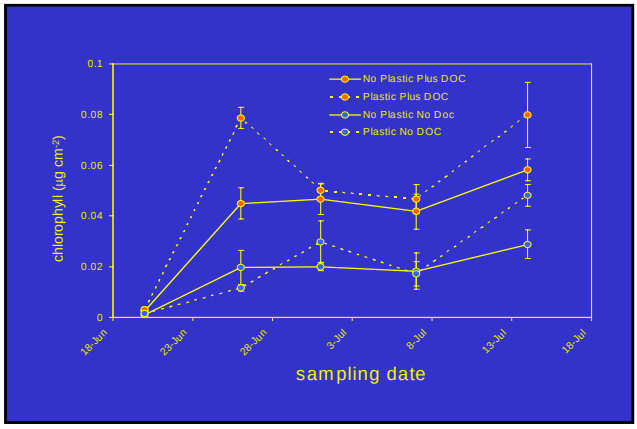

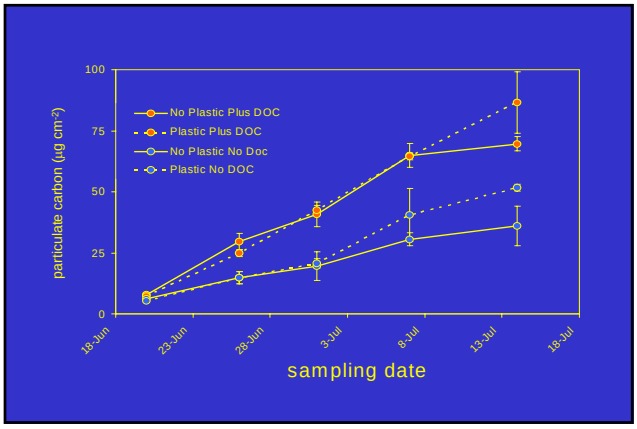

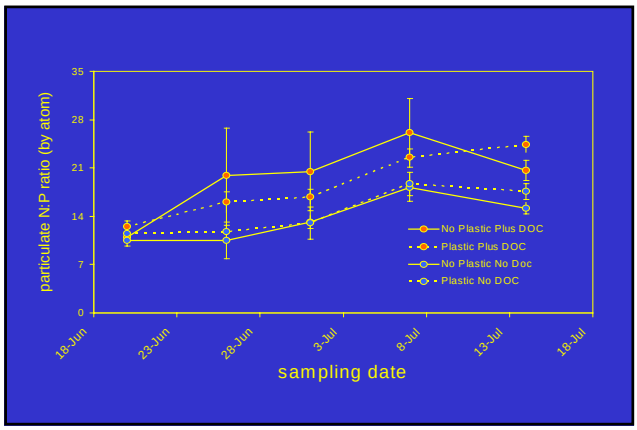

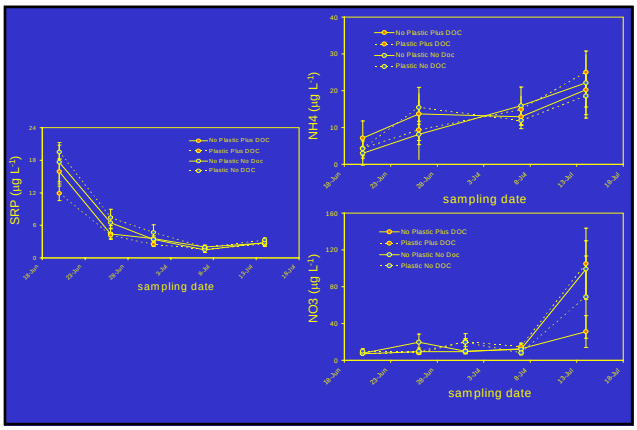

Ongoing Foodweb Experiments:

How does light intensity interact with UVR to affect periphyton growth?

	+ shading (-90%)	no shading
ambient		
- UVB		
-UVA + -UVB		

Ongoing Foodweb Experiments:

How do nutrients and DOM molecular weight interact to affect foodwebs?

	+ N, +P	- N, - P
no DOM (ground water)		
+ HMW DOM (~ 8 mg/L)		
+ LMW DOM (~ 8 mg/L)		

UVR excluded in all treatments

Periphyton; last week snails, mayflies, caddisflies, chironomids, amphipods