Critical Loads

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NPS-ARD
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(1) Critical Loads background
(2) Setting a CL (Rocky Mtn NP example)
(3) Critical Loads for surface waters- options
(3) Workshop Questions:

*How can we use our existing lake data to develop CLs?

*What changes are needed to our monitoring programs to support CL development?

Critical load/Target load

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- **Critical load**:

  "The quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge." (Nilsson and Grennfelt 1988)

- **Target load**:

  The level of exposure to one or more pollutants that results in an acceptable level of resource protection; may be based on political, economic, or temporal considerations.

Critical loads and target loads can be developed for any pollutants.

Development/Use of Critical Loads

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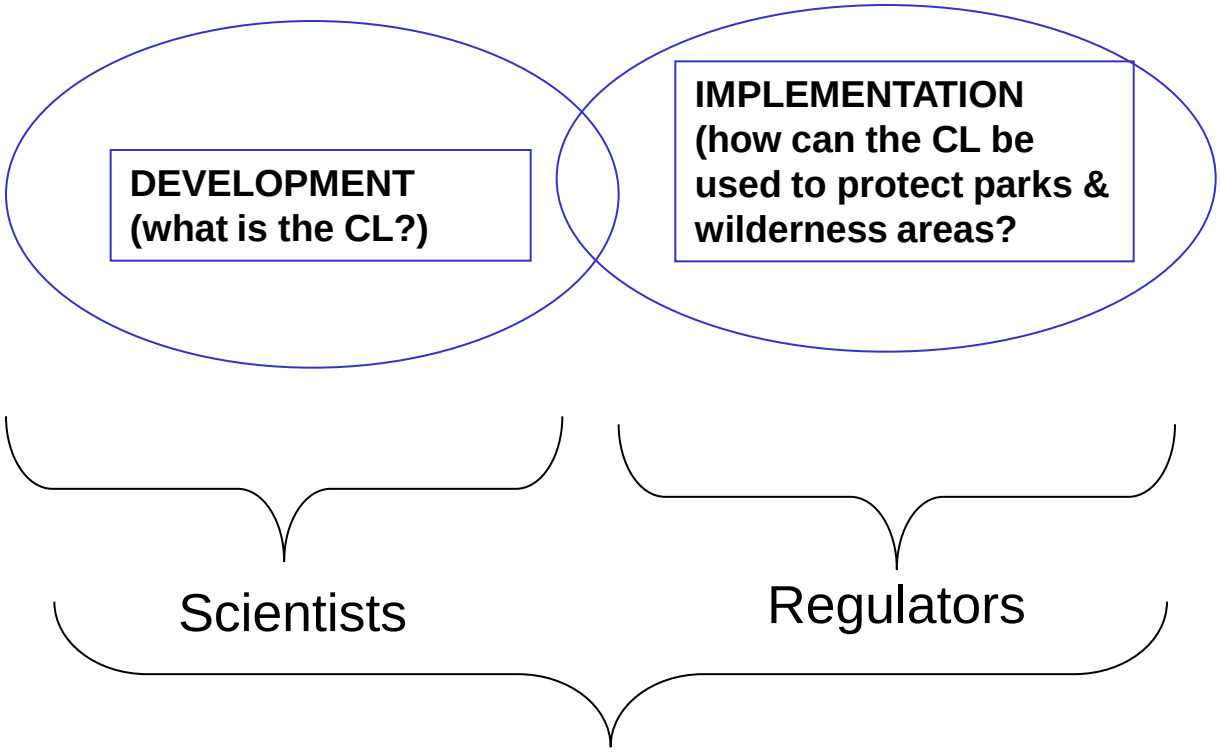

What are critical loads used for?

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- Land Managers- Assessing ecosystem health
- Land Management Planning (park, forest, wilderness)
- Air Regulators - Assess efficacy of emissions controls programs (e.g., Clean Air Interstate Rule, cap and trade, etc.)
- Air Regulators- Develop State and Regional Plans to improve air quality- Focus where it counts

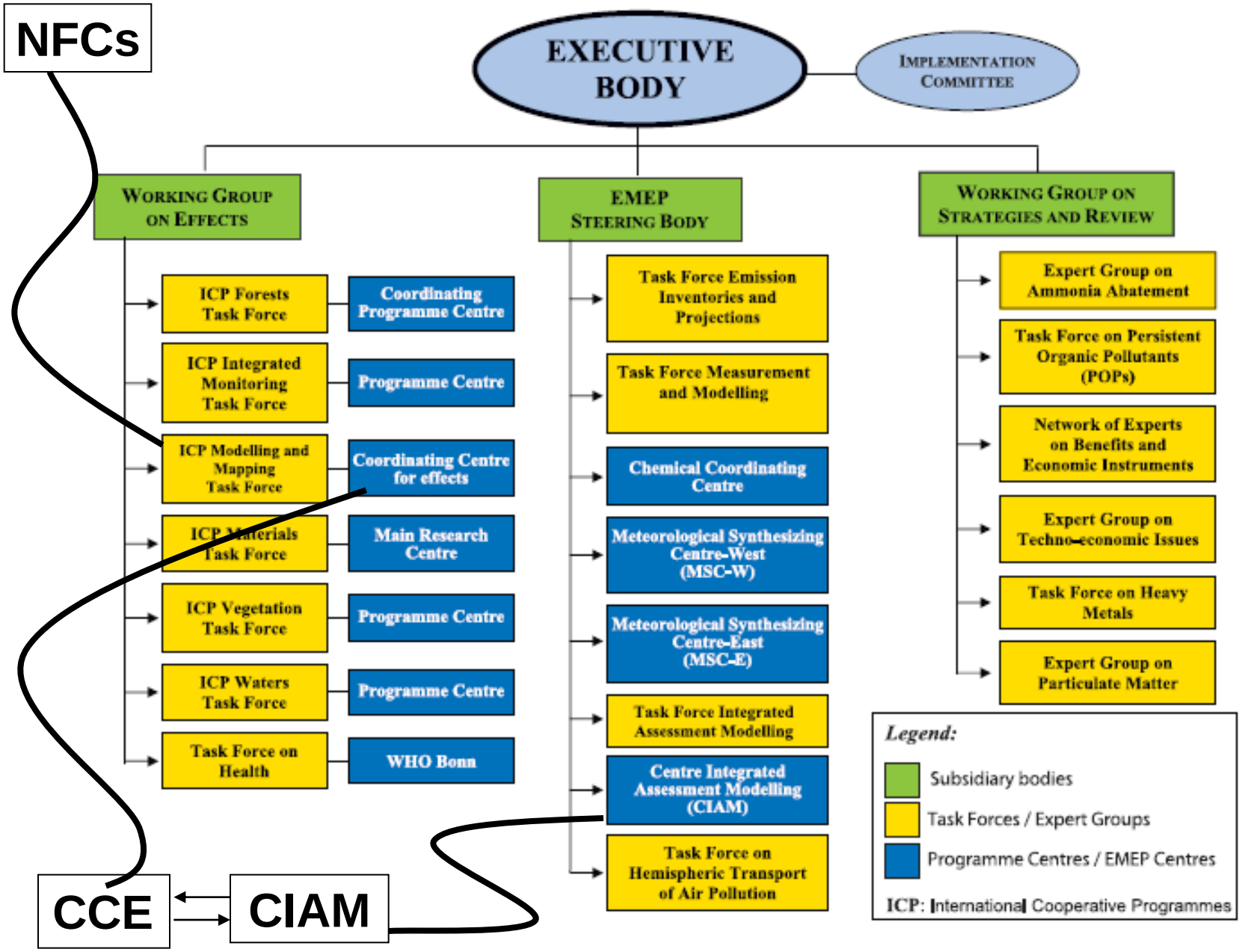
Multi- Agency Critical Loads Forum w/in NADP **(CLAD)-**

- Facilitate sharing of technical information on critical loads topics;
- Identify gaps in critical loads development in the US, and develop strategies to fill them;
- Provide consistency in development and use of critical loads in the US;
- Promote understanding of the critical loads approach through development of outreach and communications materials.

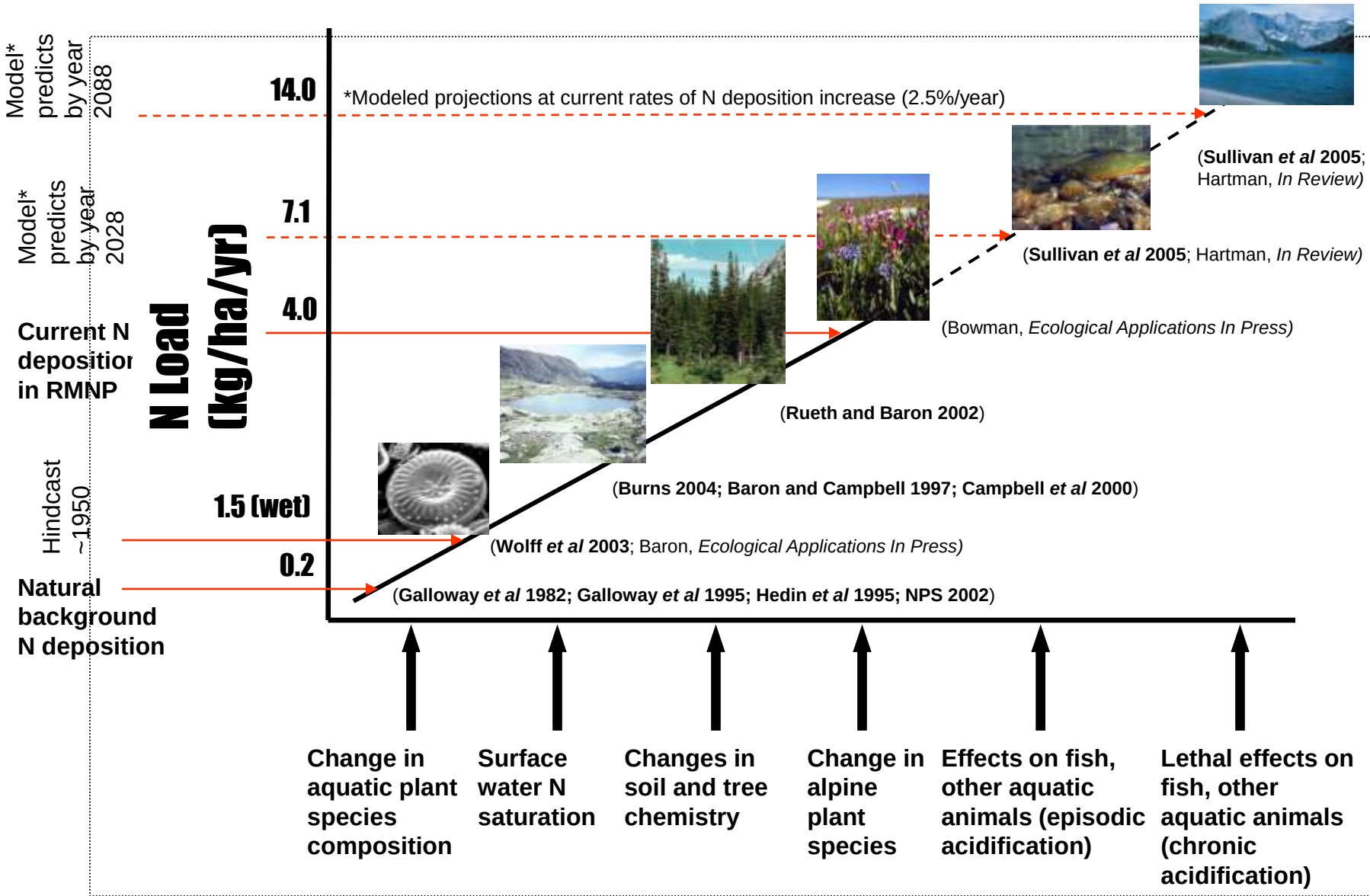
~150 participants in from multiple agencies and entities

CLAD meets 2x annually at NADP spring and fall meetings

LRTAP-Convention: intergovernmental Bodies, Expert Groups and Scientific Centres:



Rocky Mountain National Park: Continuum of Impacts to Ecological Health



Thresholds of unnatural ecosystem change are defined for specific indicators and endpoints

Diatoms are good indicators of environmental change

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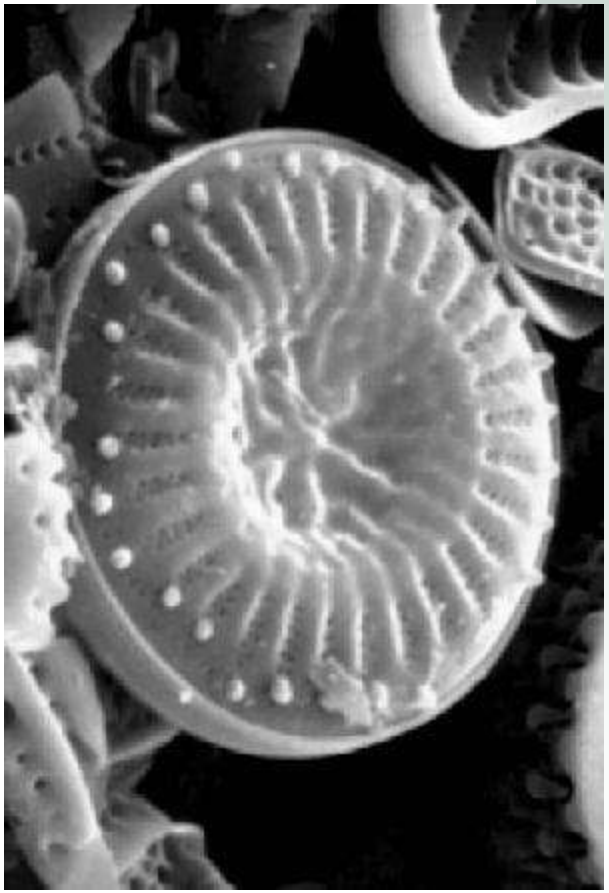
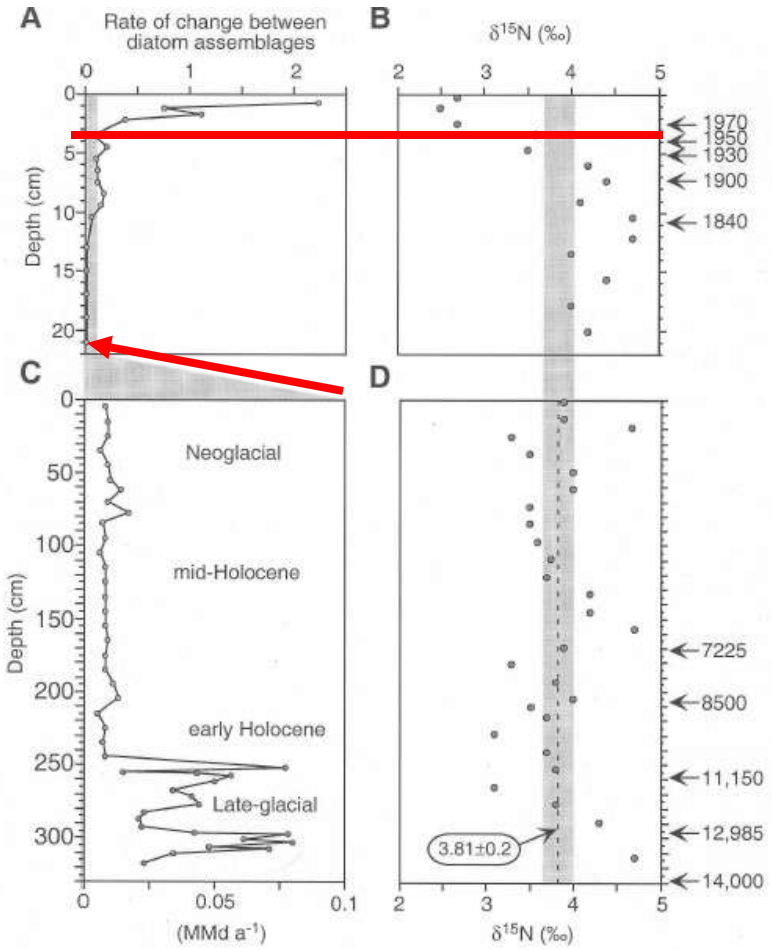
- Diatoms are algae: single-celled aquatic plants
- Species are very sensitive to water chemistry
- Glass (silica) cell walls do not decompose
- Each species has unique cell walls



Lakes Have Changed More Since 1950 than Previous 14,000 Yrs



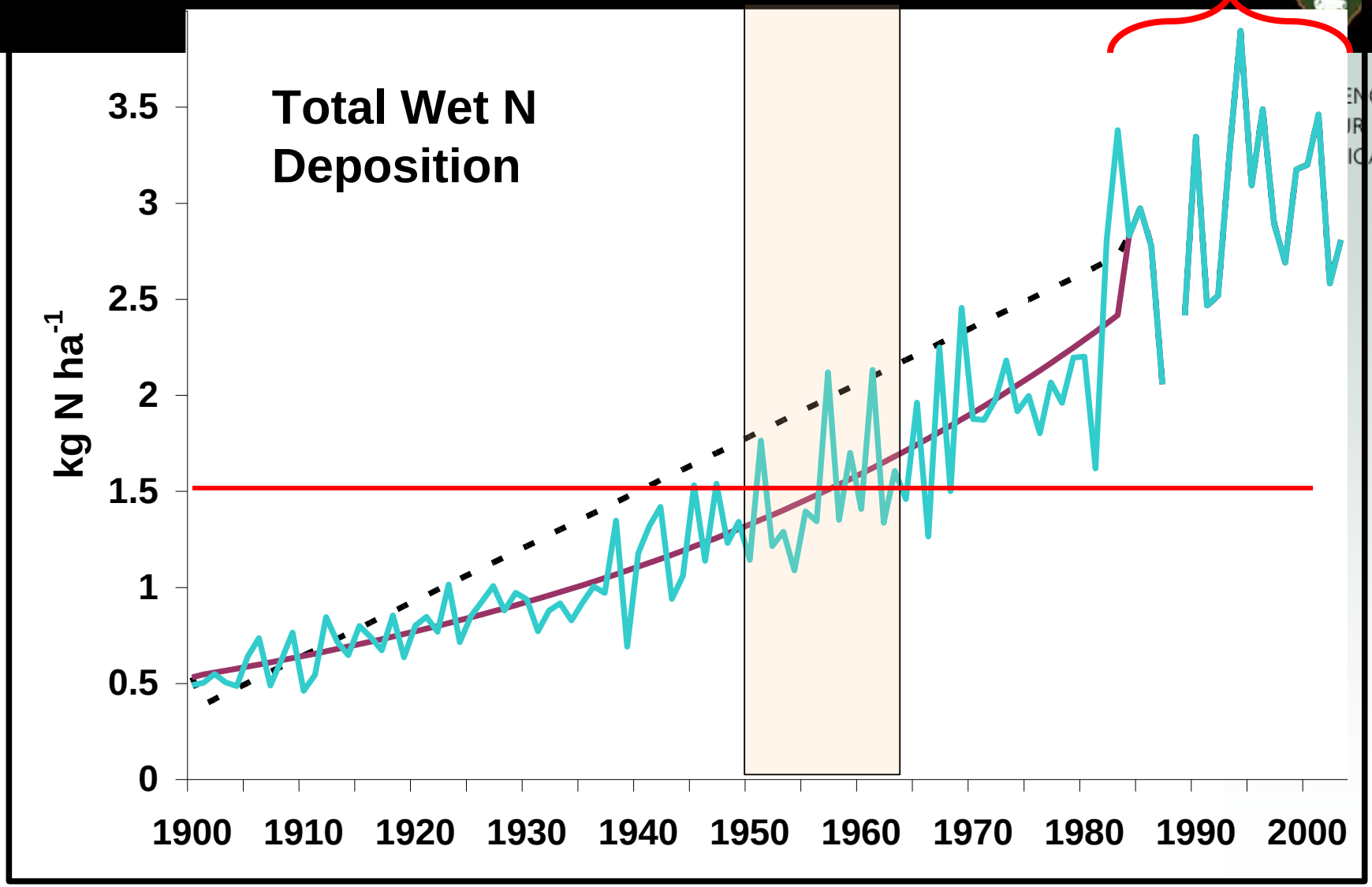
The <u>abundance</u> of diatoms is 8-25x greater post-1950.

Caused by dominance of 2 disturbance species: *Asterionella formosa* and *Fragilaria crotonensis.*
>40% of total diatoms since 1950

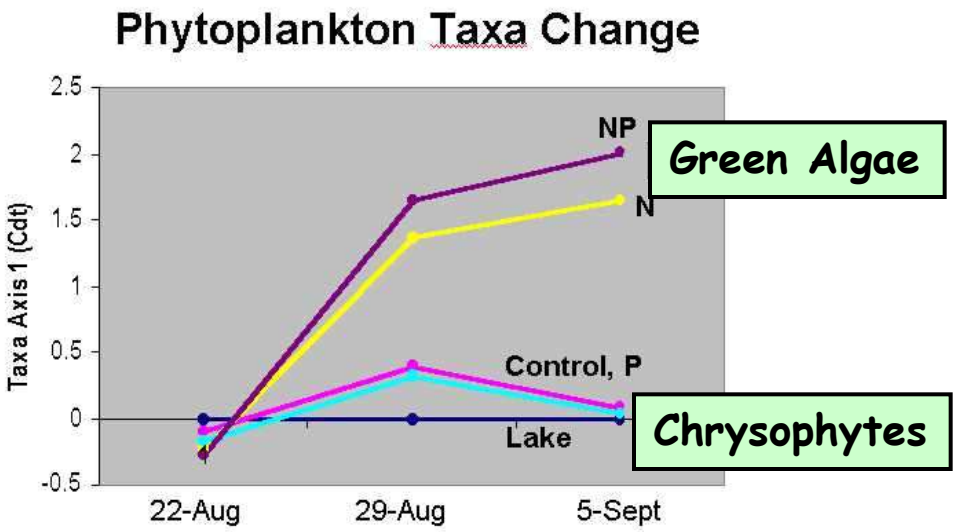
A. formosa and *F. crotonensis* are indicators of nutrient-rich waters

The <u>rate of change</u> in diatoms post-1950 is an order of magnitude greater than any change since Pleistocene.

Total Wet Nitrogen Hindcasts



Experiments:
Productivity increased with added N and N+P.
Communities changed to nutrient-loving algae.

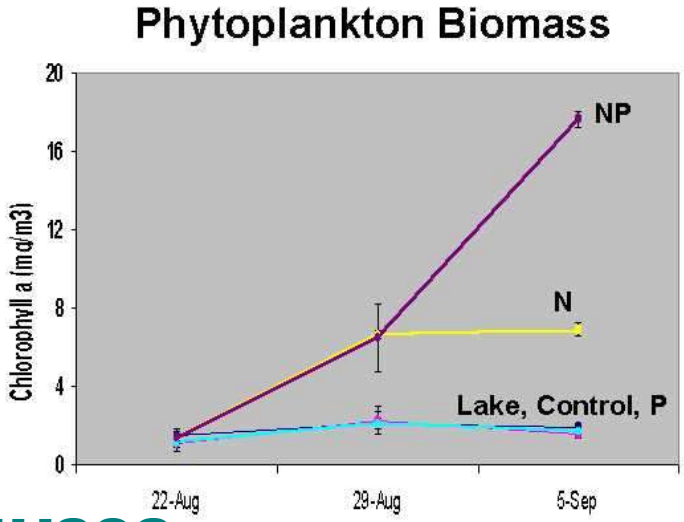


Green Algae

Chlamydomonas sp.

Chrysophytes

Dinobryon sp.



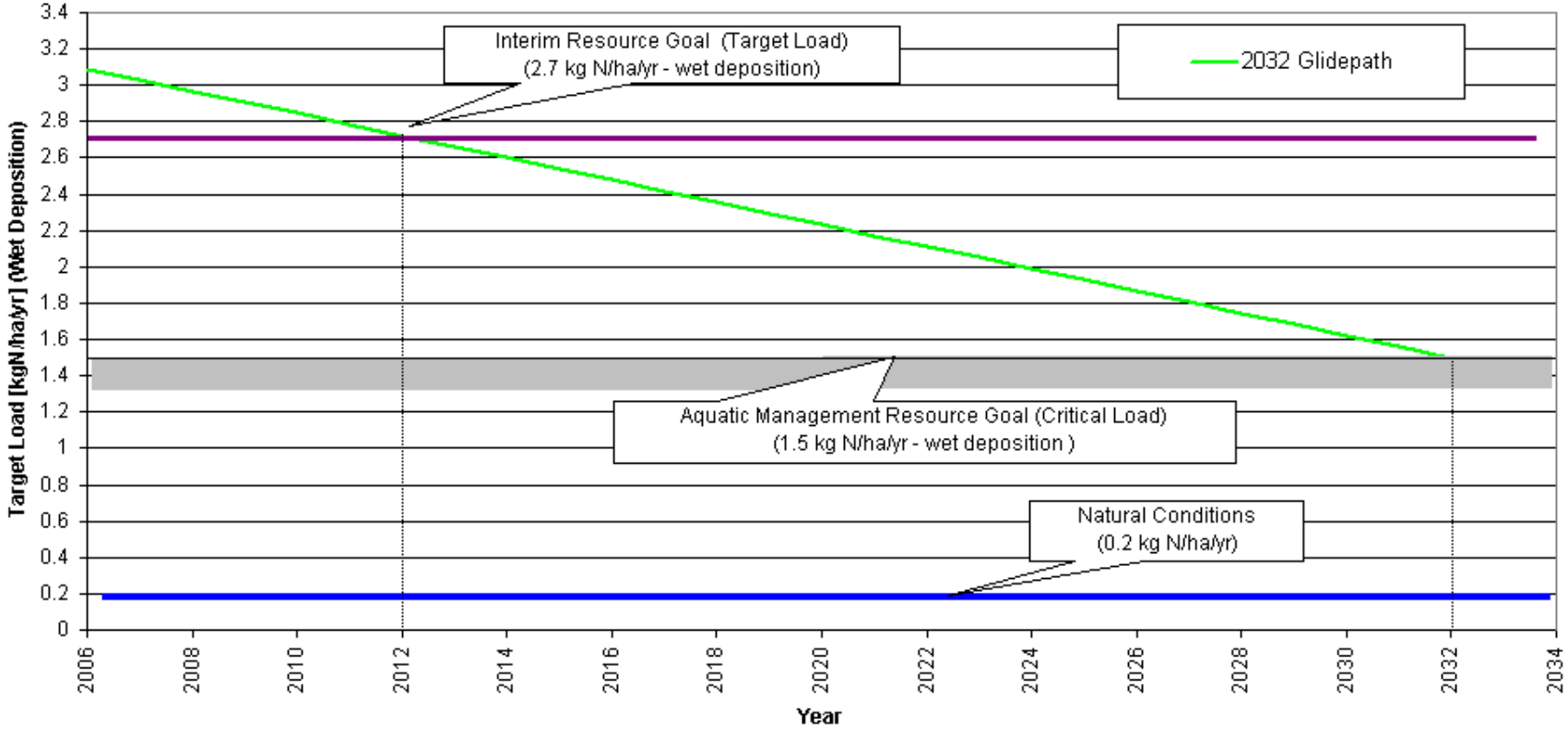
N Additions = Eutrophication

increased productivity
changed algal community

USGS

Rocky Mountain National Park

2032 Glidepath for Nitrogen Deposition Reduction



Options for aquatic ecosystem CL in western US

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Chemical indicators in western US aquatic ecosystems-
- NO_3 -indicator of N sat in soils
- NO_3 - indicator of aquatic biodiversity shifts
- Episodic ANC- indicator of impact to sensitive biota (e.g. fish or salamanders) (caveat- will be higher CL in western US because systems not close to acidification).

Biotic indicators-
diatom biodiversity & species shifts (as indicators of "aquatic ecosystem health"

Caveats-
- Diatoms responses to N may be confounded by P in P limited systems
- Should do experimental manipulations to ensure response is really linked to N
- Need to link biotic response to N deposition thresholds (deposition gradient, hindcasting, etc) to get critical loads

How do I connect N deposition to ecosystem response (indicators)?

1. Spatial N gradient: CMAQ or CAMX modeling; lots of throughfall measurements; (NADP + CASTNet) x PRISM;

2. Temporal N gradient:

NADP + CASTNet; Hindcasting;

CL Approaches - Need to understand ecosystem responses to N! Are you there yet????

1. Modeling for regional scale requires lots of deposition and water and soil chemistry data.

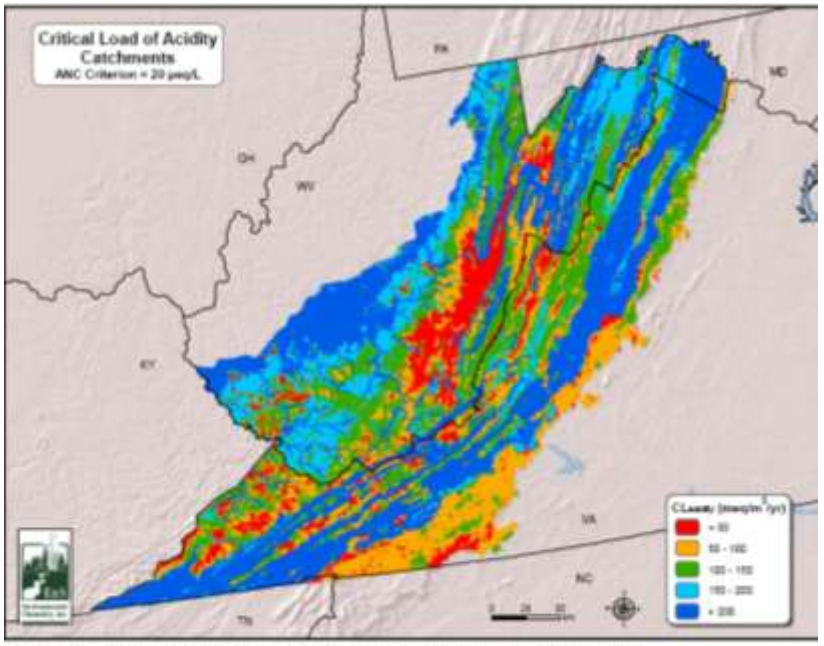
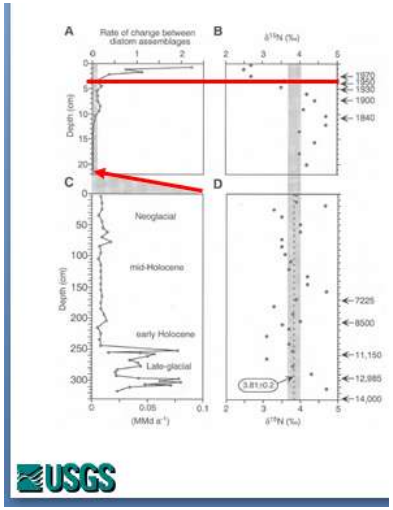


Figure 24. Final map of CL of acidity to protect stream ANC from falling below 20 µeq/L

2. Empirical CL is determined using site specific research eg (1) ecosystem changes (2) N addition expts (3) site dep estimates



CL's based on NO3 and other thresholds for aquatic systems (from Pardo CL monograph)

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Ecoregion	Forest Type	Critical Load	Level of Certainty	Ecosystem Response	Explanation	Reference
Temperate Sierras	and S/SW of	15	#	Elevated nitrate in stream and spring waters	Data are from *Pinus hartwegii* sites in the Desierto de los and Ajusco	Fenn et al. 1999, 2002a

Eastern Forests	Eastern Hardwood Forests	**8**	##	Increased surface water loading of NO_3^-		Aber 2003
Mediterranean California	San Bernardino mountains and southern range; mixed conifer forests	**17**	##	[NO3] > 14 µM	Based on regression of throughfall vs. peak streamwater NO_3 concentrations. Daycent simulations gave similar results.	Fenn et al. 2008

Aquatic	Rocky Mountain high elevation subalpine	2	##	Freshwater eutrophication		Baron et al. 1994

Tamara's Recommendations:

1. Start to fill in aquatic CL's for each ecoregion bit by bit

   Sierra Nevada: need some site specific data on N vs P, diatom response to NO3

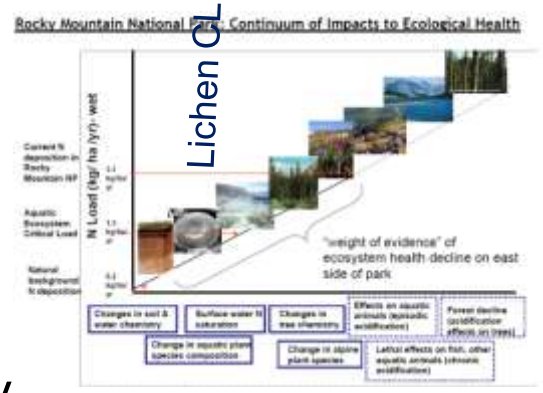
   PNW: need N vs P limitation, epi acid link to biota?

   Wind River Range: diatom analysis for Black Joe sed. core, explore macroinvert. links to "organic" impacts

   All: ground water influence to lakes determined, one sample (fall?) nationally consistent for hydroperiod (EPA CL)

2. Every Region's "continuum" or conceptual diagram may be different…ecosystems are different!

3. Look at FS -Limits of Acceptable Change -might use as basis for critical loads development in western aquatic systems



Discussion…