A NATIONAL APPLICATION OF CRITICAL LOADS BY THE US FOREST SERVICE TO ASSESS ATMOSPHERIC DEPOSITION EFFECTS ON WATERSHED CONDITION.

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Introduction

Achieving restoration of watersheds and forest health is a primary management objective of the Forest Service

--US Secretary of Agriculture Vilsack, 2010

Introduction: WCF

Watershed Condition Framework (WCF)

FS developed a national framework to:

- ***Assess and classify watershed condition*** for multiple environmental condition indicators
- ***Identify high priority watersheds*** and restoration activities
- ***Track and monitor*** accomplishments

Our challenge was to incorporate air pollution impacts into the WCA—the focus of this presentation

Introduction: Condition goals

Watershed Condition Assessment (WCA)

Properly functioning watersheds provide:

- ***Habitat*** for high biotic integrity
- ***Resilience*** from disturbance
- Lateral and vertical ***connectivity***
- Important ***ecosystem services***
- Long term ***soil productivity***

Air pollution affects most of these elements

Introduction: Watershed Classification

Watershed Condition Classification

- The process of describing watershed condition in discrete categories reflecting the level of watershed health or integrity
- Three classes of watershed condition
  - ***Good:*** functioning properly
  - ***Fair:*** functioning is at risk
  - ***Poor:*** impaired function

Introduction: Condition Indicators

Exceedance of CLs can characterize watershed condtion

The12 watershed condition indicators:

water quality	water quantity	aquatic biota
riparian vegetation	aquatic habitat	invasive species
roads & trails	range vegetation	fire regimes
forest health	forest cover	***soils***

We used CLs to asses air pollution effects on ***soils*** from acidity and nutrient N excesses.

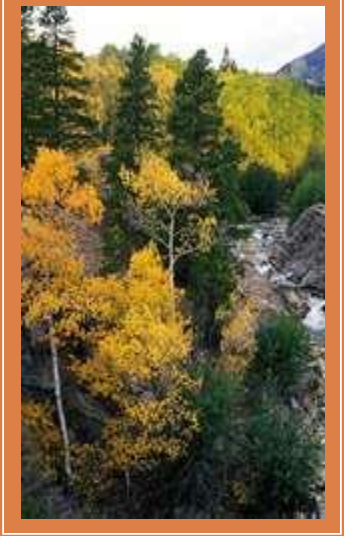
Introduction: CL Definition

Critical Loads background

- **Critical Loads Definition:** The ***deposition loading below which no harmful effects can be detected*** according to current knowledge.
- Science-based tool to help land managers understand existing resource conditions in relationship to our protection goals

Introduction: Objectives

Our project goals



- Goal: To ***use terrestrial CLs for acidity and nutrient N to assess air pollution effects to watershed condition*** throughout the national forest system
- To our knowledge, this is the ***first national scale application of CLs*** by a federal land management agency

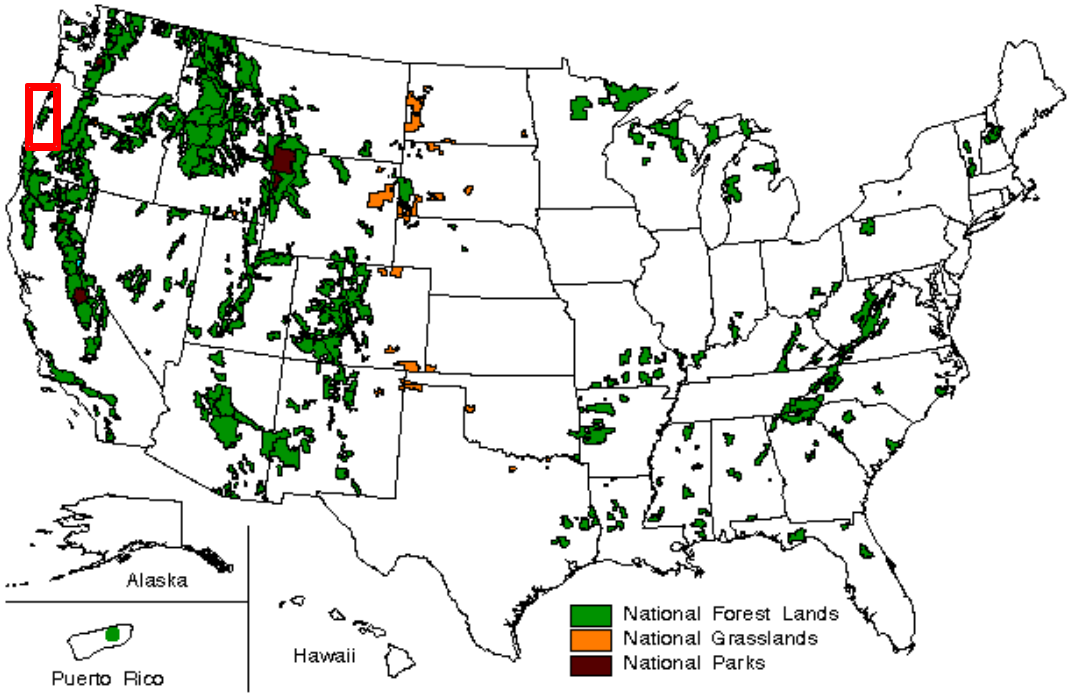
Methods

But there is only one surefire method of proper pattern recognition, and that is science.

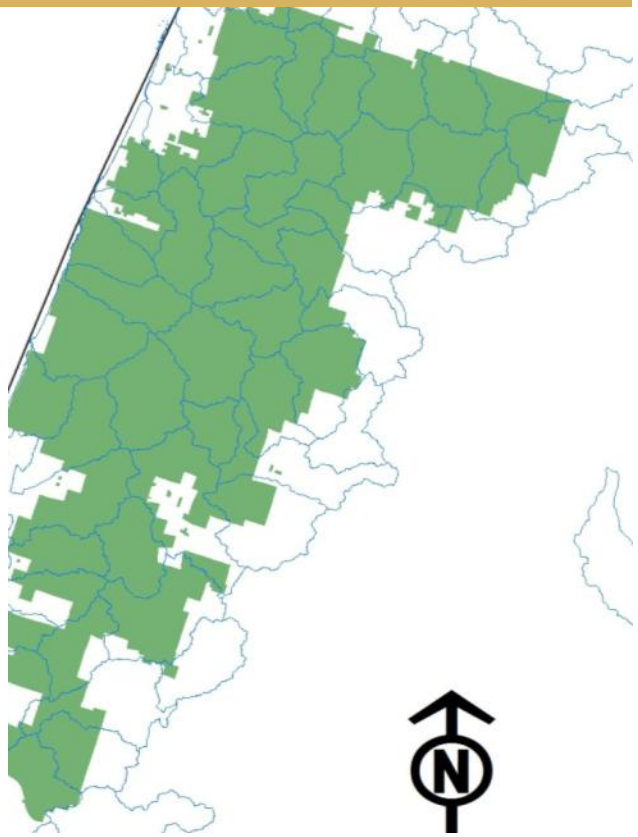
--Michael Shermer

Methods: Study Area

National Forest System map

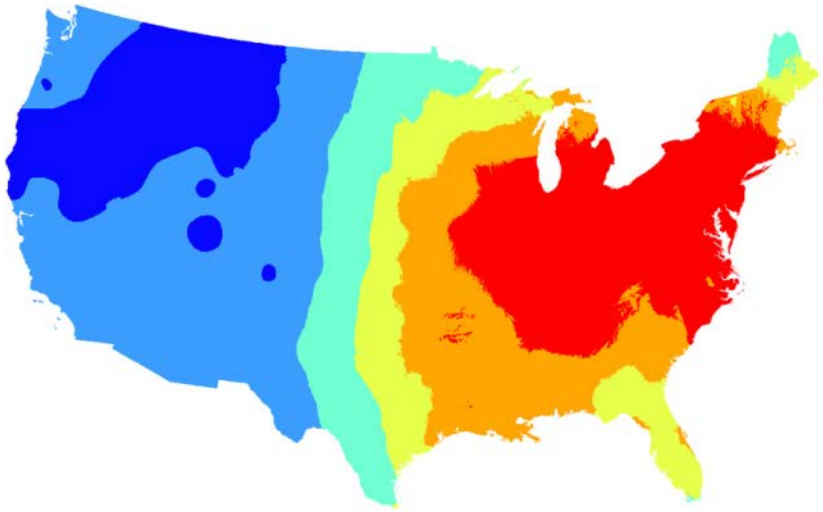


Map of 6th Level HUCs on the Siuslaw National Forest, OR



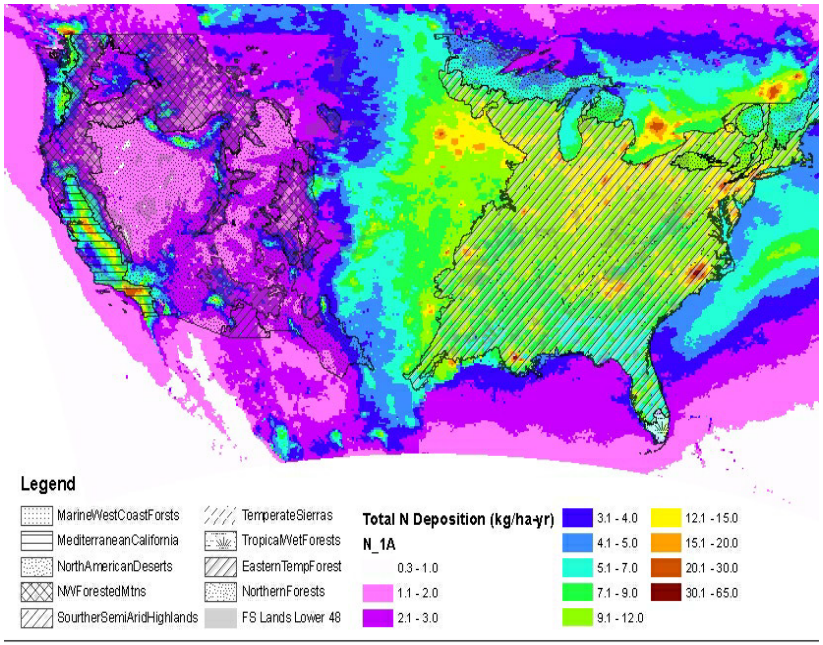
Methods: Current Deposition Data

CMAQ acidity deposition



Mean annual wet + dry N and S deposition (eq ha^{-1} yr^{-1}) for the conterminous US from 1994-2000 at a 1 km^2 spatial resolution. *Compiled by McNulty et al. 2007.*

CMAQ N deposition for 2006



2006 wet + dry N deposition based on EPA CMAQ model output, 12 km grid

Methods: CL models and datasets

Soil acidification CL dataset

Soil Acidification

- **Reference:** McNulty, Steven G; EC Cohen; JA Moore Myers; TJ Sullivan; H Li. 2007. **Estimates of critical acid loads and exceedances for forest soils across the conterminous US.** *Environmental Pollution* 149:281-292.
- **Summary:** Used a simple mass balance equation to estimate acidity CLs and exceedances from S + N deposition for forest soils at 1 km^2 resolution.

Methods: Calculating Exceedances

Soil Acidification

Acidity

- 1 km^2 spatial resolution for 48 states
- Reanalyzed for 6th level HUCs, yielding multiple 1 km^2 ratings for each HUC
- Used the 1 km^2 grid cell with maximum exceedance to classify the entire HUC

Methods: Watershed Classification

Soil Acidification

Acidity

- **Good:** Deposition is >10% *below* the CL
- **Fair:** Deposition is within 10% of the CL
- **Poor:** Deposition is > the CL

Methods: CL models and datasets

Data Sets:
Critical Loads

Nutrient N

References:

- Geiser, Jovan, Glavich, Porter. 2010. **Lichen-based critical loads for atmospheric nitrogen deposition in Western Oregon and Washington Forests, USA.** *Environmental Pollution* 158: 2412-2421.

- Pardo, Robin-Abbott, Driscoll (eds). 2011. **Assessment of N Deposition Effects and Empirical Critical Loads of N for Ecoregions of the US.** *USDA-FS Northern Research Station GTR NRS-80*

Methods: CL models and datasets

Data Sets:
Critical Loads

Nutrient N

Summary:

- Proportions of eutrophic lichens ↑ with ↑ N deposition, moderated by precipitation.
- Nutrient N CLs are the N deposition at the lichen response threshold, the point at which % eutrophs begins to increase.
- Can calculate CL ranges for major US ecoregions using ecoregional response thresholds, 800 m mean precip.

Methods: Calculating Exceedances

Terrestrial nutrient N

Nutrient N

- Calculated a CL for each HUC using PRISM precipitation (800 m grid) and ecoregion-specific lichen response thresholds in the PNW model.
- Compared the CL to CMAQ N deposition to determine if the CL was exceeded.

Methods: Classifying Watersheds

Terrestrial nutrient N

Nutrient N

- **Good:** if max N deposition < min CL in the HUC minus a 1 kg $ha^{-1}y^{-1}$ buffer
- **Fair:** if max N deposition is within 1 kg $ha^{-1}y^{-1}$ of the CL
- **Poor:** if max N deposition >max CL plus a 1 kg/ha/yr buffer

Final Products

"I think we're having fun. I think our customers really like our products. And we're always trying to do better."

-Steve Jobs

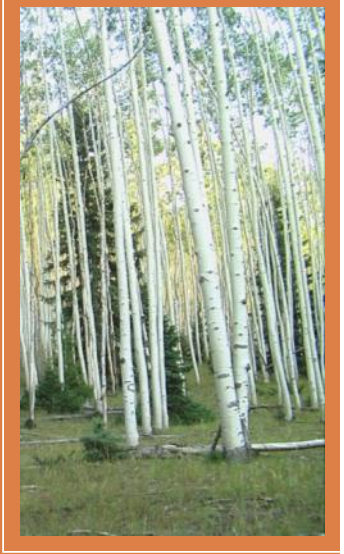
Final Products: Exceedance Table

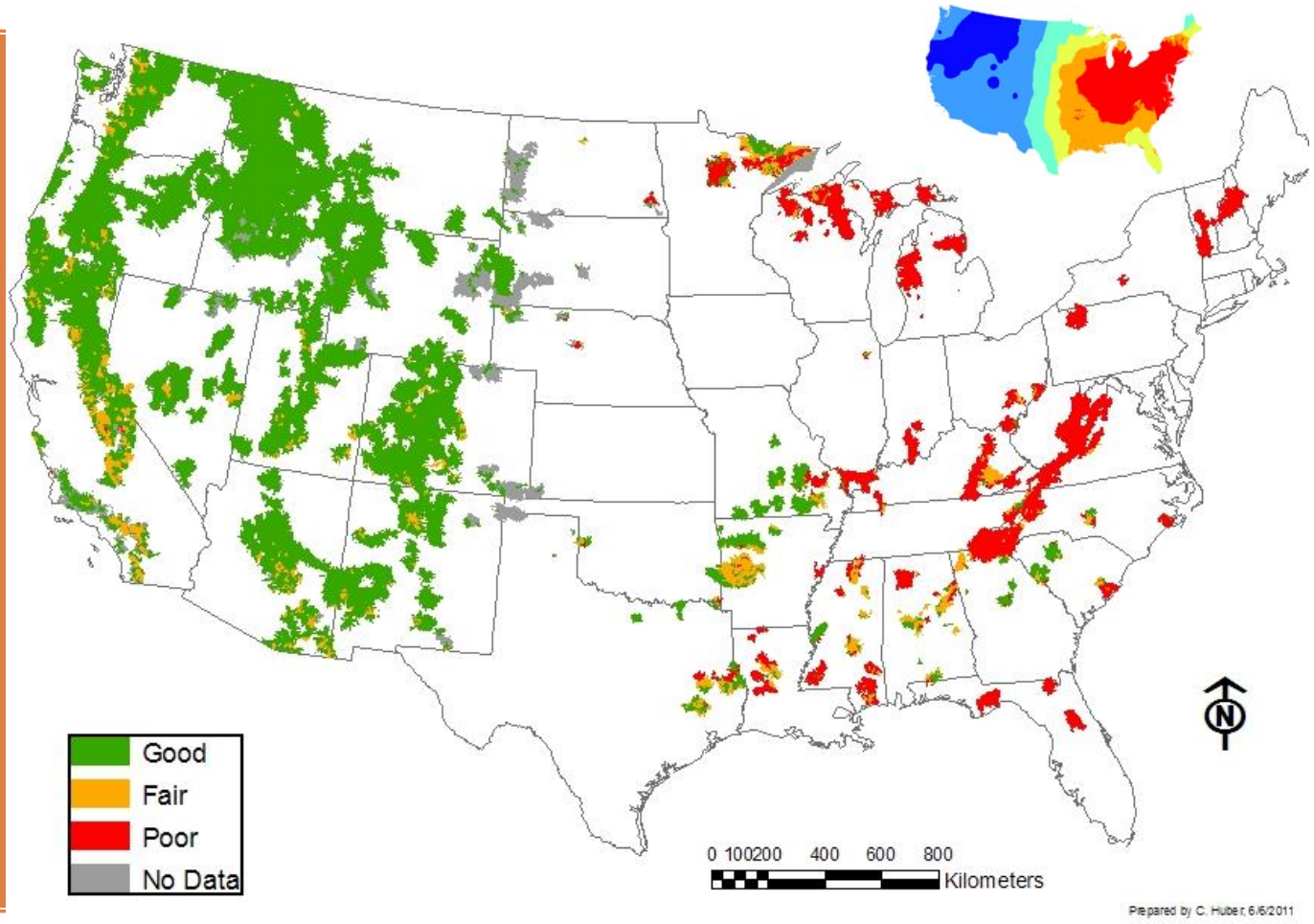
Spatial analysis: Sample table that Forest and District analysts used

States	HUC_12	HU_12_Name	Nutrient N Class	Acidity Class
ME,NH	010400010604	Chickwolnepy Stream-Androscoggin R	Poor	Poor
ME,NH	010400010605	Stearns Br	Poor	Poor
NH	010400010606	Horne Br-Androscoggin R	Poor	Poor
NH	010400010607	Dead R-Androscoggin R	Poor	Poor
NH	010400020101	Moose-Androscoggin R	Poor	Poor
NH	010400020102	Peabody R	Poor	Poor
ME,NH	010400020103	Lary Brook-Androscoggin R	Poor	Poor
ME,NH	010400020201	Wild R	Poor	Poor
ME	010400020202	Pleasant R	Poor	Poor

Final Product: Acidity Exceedance Map

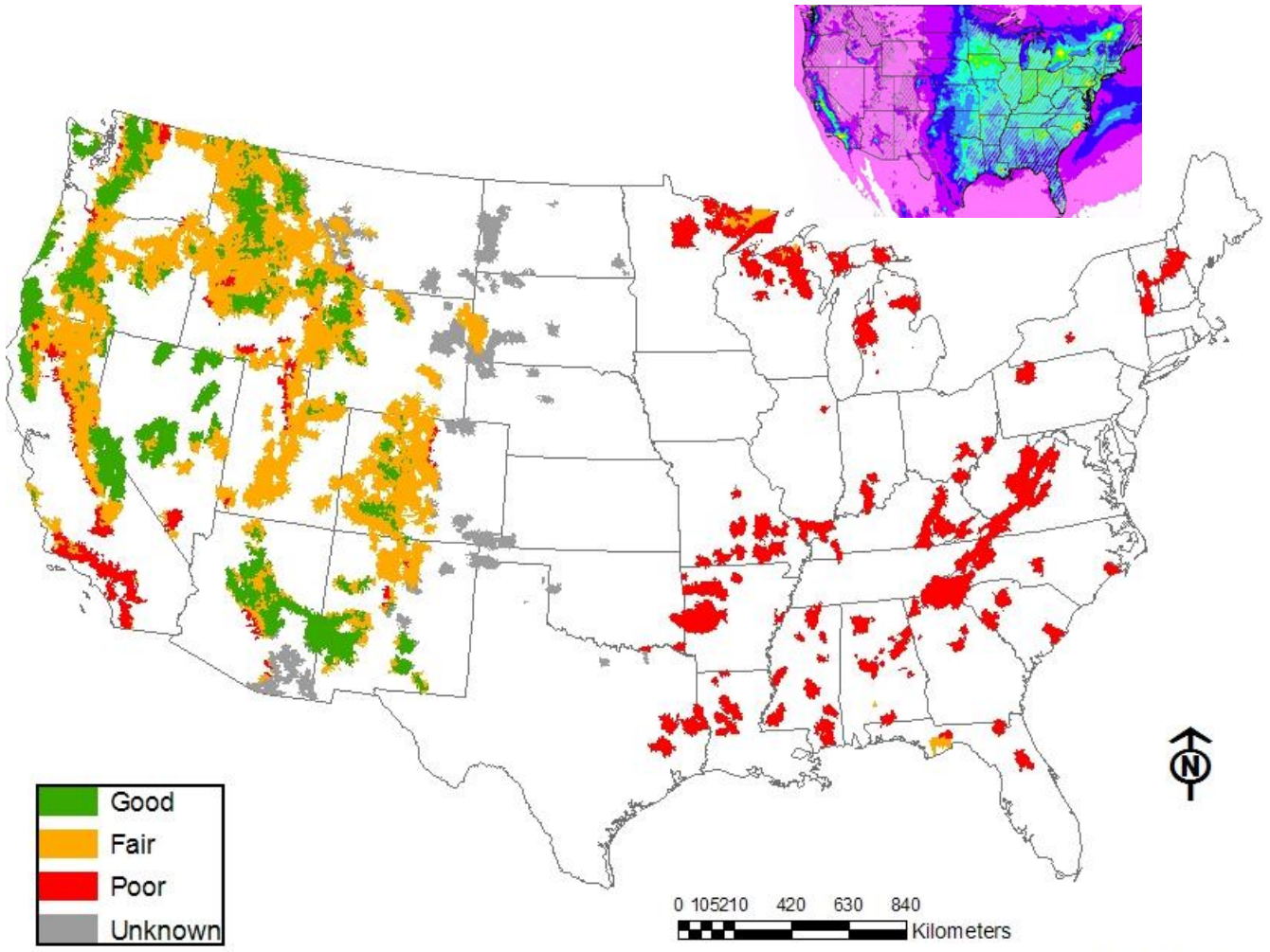
Spatial analysis: map of soil acidification exceedances





Final Product: Nutrient N Exceedance Map

Spatial analysis: Map of nutrient N exceedances



Users Responses and Conclusions

If you kick the person in the pants responsible for most of your trouble, you wouldn't sit for a month.

--Theodore Roosevelt

User Responses: Criticisms

Feed back from Forest Service users on the national forests and districts

- In the SE, some managers didn't think that their forests should be rated so poorly. Discussions between soil scientists, ecologists and air specialists increased understanding by all of soil acidification mechanisms.
- In the west, some suggested that nutrient N CLs really belonged within the Forest Health indicator. Next time N CLs will be assigned to the Terrestrial Condition Framework.

User Responses: Praise

Feed back from Forest Service users on the national forests and districts

- Many managers were happy that we conducted the analysis and gave them the watershed classifications because they would not have known how to do this on their own.
- Others appreciated the consistency of the approach across the landscape. They criticized other attributes in which different standards/criteria were applied by different forests in a region.

Conclusions

- CLs are useful in national scale land management.
- Selecting CLs requires evaluation of air resource management mandates and management goals.
- We identified the series of steps required to evaluate several different CLs on a watershed level.
- We applied one method to select a single classification from multiple values of exceedence for each watershed.
- We hope our experience can inform others.

Acknowledgements

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