Empirical critical loads for nitrogen for ecoregions of the US: current and future

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Outline

1. Background on critical loads
2. Empirical critical loads for lichens
3. A simple model for estimating lichens CLs
4. Refinement of empirical CL-other receptors
5. Next steps

Objectives

- synthesize current state of knowledge on effects of atmospheric N inputs on terrestrial and aquatic ecosystems in the U.S.→ Empirical CL
- Audience: land managers, policymakers, researchers

USFS General Technical Report

http://treesearch.fs.fed.us/pubs/38109

Ecological Applications Pre-print

http://www.esajournals.org/toc/ecap/0/0

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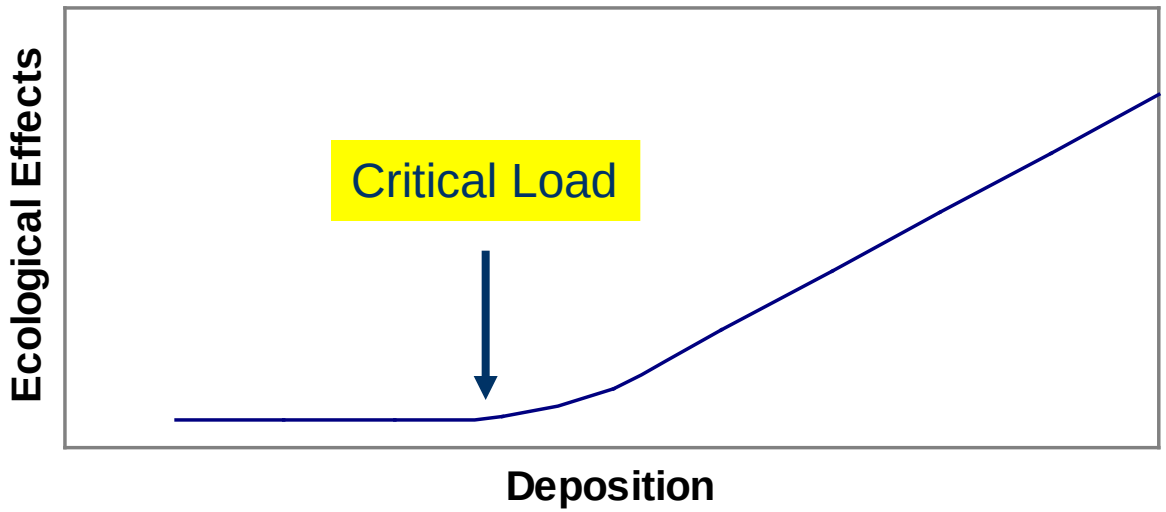
Critical Load

Critical load of nitrogen is the level of deposition below which no harmful ecological effects occur for an ecosystem



Empirical CL

- damage at observed N input
- N deposition set as CL
- extrapolated to similar ecosystems
- based on gradient studies, N additions, long-term observations

Exceedance of critical load

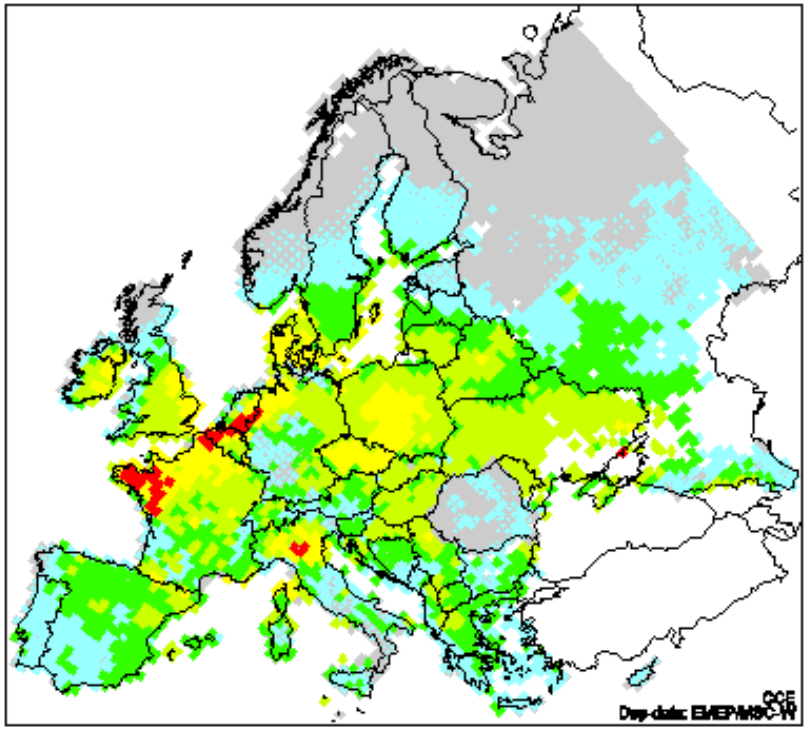
Exceedance =

Actual N deposition – Critical load

Communicates extent of risk to ecosystems

Critical load use in Europe

Models forecast widespread negative effects of nitrogen on ecosystems



Exceedance of nutrient critical loads in 2010
with current legislation emission scenario

- No exceedance
- < 200
- 200 - 400
- 400 - 700
- 700 - 1200
- > 1200

} eq.ha^{-1}.yr^{-1}

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ECOLOGICAL REGIONS OF NORTH AMERICA

Toward a Common Perspective

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Biodiversity/changes in species composition

- Mycorrhizal fungi
- Lichens and bryophytes
- Vascular plants
  - Understory (herbs)
  - Overstory (trees)
- Aquatic micro-fauna & flora

Methods

- Data Sources:
- Literature review, reports, unpublished data

RESULTS:
Ranking of CL by receptor

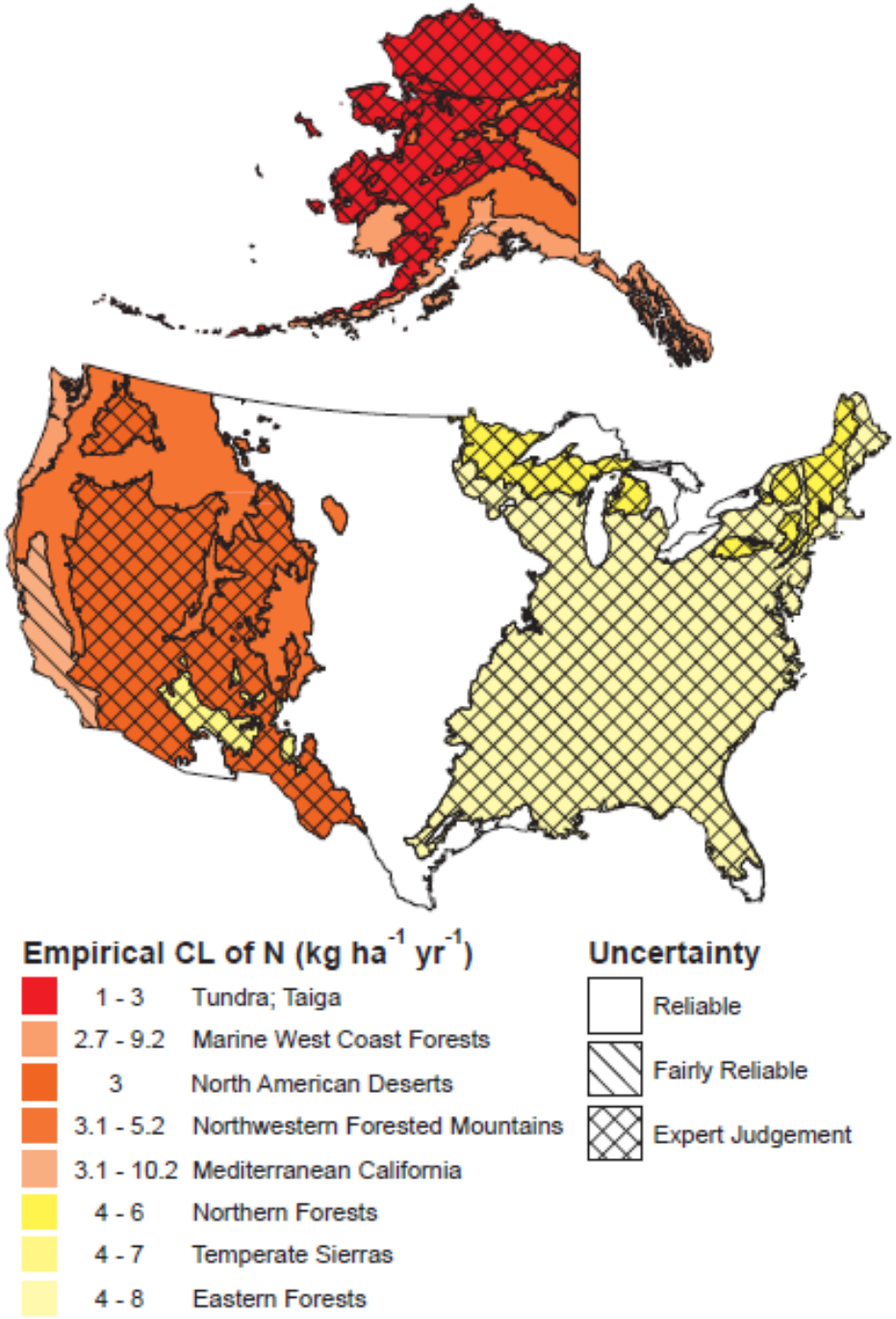
- algae (diatoms) <lichens<mycorrhizal fungi<herbs + shrubs < trees/forests

Responses: Epiphytic lichen

- Increased in tissue N concentration
- Altered community composition:
  shifts away from oligotrophs to eutrophs

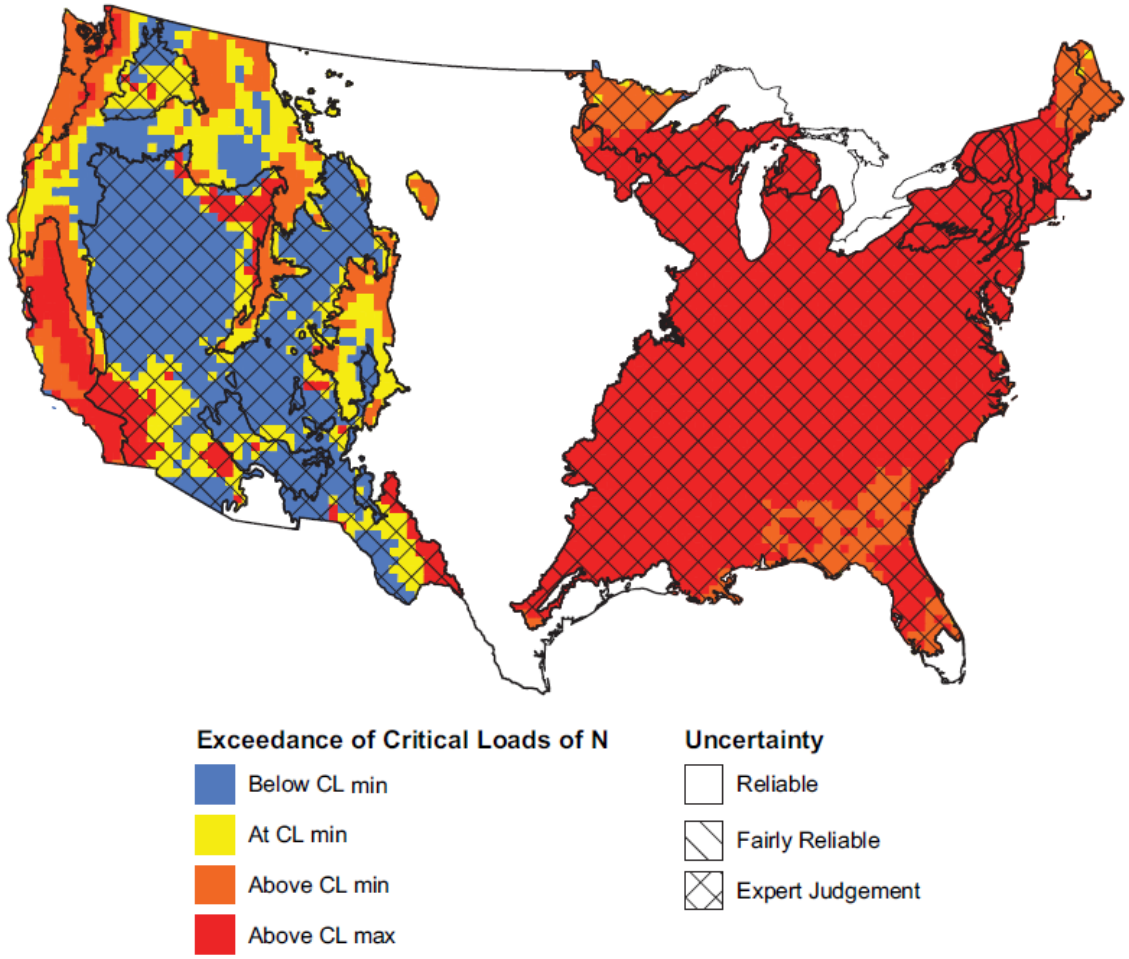
Most sensitive bioindicators in terrestrial ecosystems

Lichens CL


Empirical CL of N (kg ha-1 yr-1)
1 - 3 Tundra; Taiga
2.7 - 9.2 Marine West Coast Forests
3 North American Deserts
3.1 - 5.2 Northwestern Forested Mountains
3.1 - 10.2 Mediterranean California
4 - 6 Northern Forests
4 - 7 Temperate Sierras
4 - 8 Eastern Forests
Uncertainty
Reliable
Fairly Reliable
Expert Judgement

Exceedance= Deposition-CL

Lichens



Relating Lichen condition to N deposition

- Based on shifts in community composition
- Simple model
  - N deposition
  - Precipitation volume
  - Air score

From: Geiser et al. *2010.* Lichen-based critical loads for N deposition in W. Oregon and Washington
Env Poll **158**:2412-2421

Relating Lichen condition to N deposition

- Regressions:
  - Air score to total N dep +precip

  Best Fit

Air score =

-0.0918 + -0.0024 * Precip (cm) + 0.1493 * Total N (kg ha-1 y-1)

N deposition based on CMAQ Model

From: Geiser et al. *2010.* Lichen-based critical loads for N deposition in W. Oregon and Washington *Env Poll* **158**:2412-2421

Air Score by Ecoregion Geiser et al. 2010

Ecoregion	Mean Annual Precip. (cm)		Air Score
	Min	Max	
Taiga*	20	80	0.02-0.21
Northern Forests*	100	240	0.21
NW Forested Mtns.	30	203	0.21-0.49
Marine W. Coast	44	451	0.21
East. Temperate Forests*	71	305	0.33
Mediterran. CA	41	127	0.33-0.49
Temperate Sierras*	30	178	0.49

*Extrapolated values

Next steps of empirical CL for lichens

- Improve extrapolated air scores
  - Northern and Eastern Forests, Temp. Sierras
  - Using existing FIA data
- Calculate CL at finer grid (finer precipitation data: 4km → 800m)

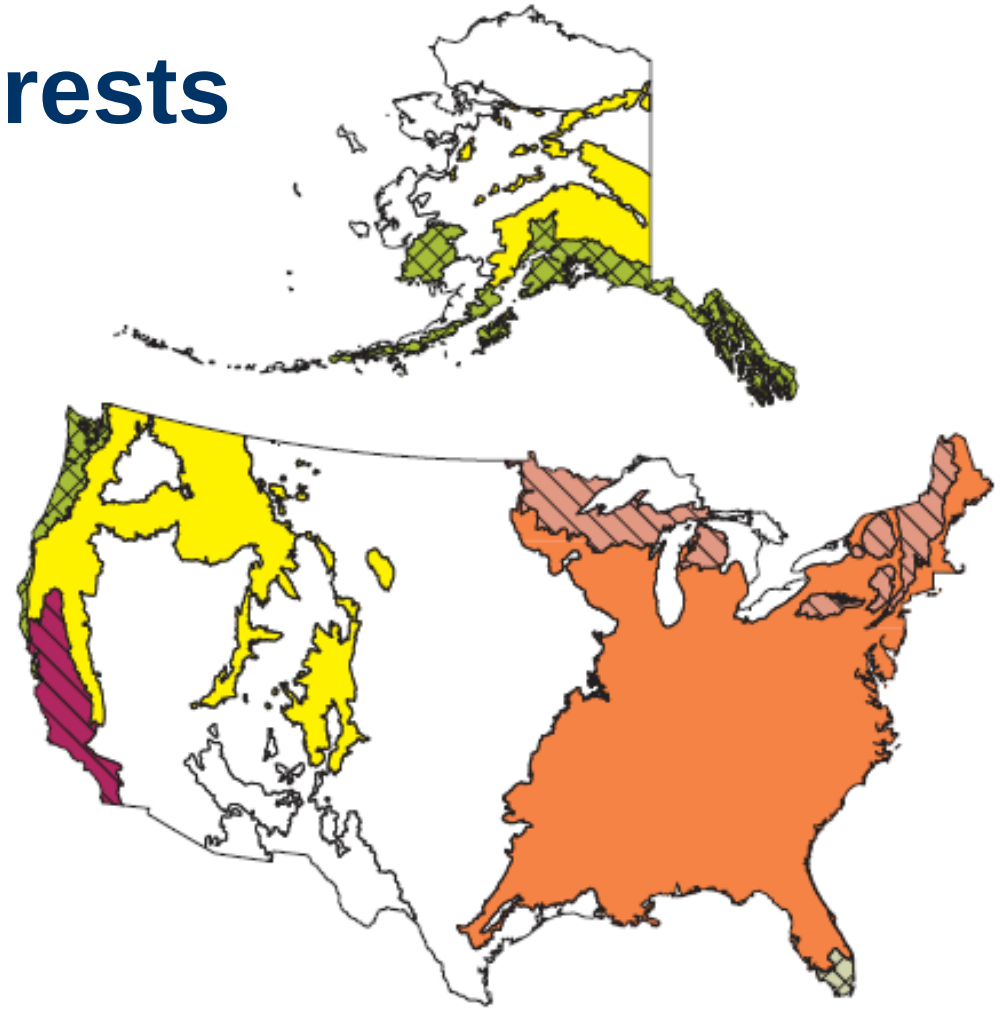
Importance of empirical models as a basis for dynamic modelling

- Factors that affect CL/response
  - Biotic
  - Abiotic
- Need to expand dataset
- Develop and improve dynamic N cycling models (including biodiversity)

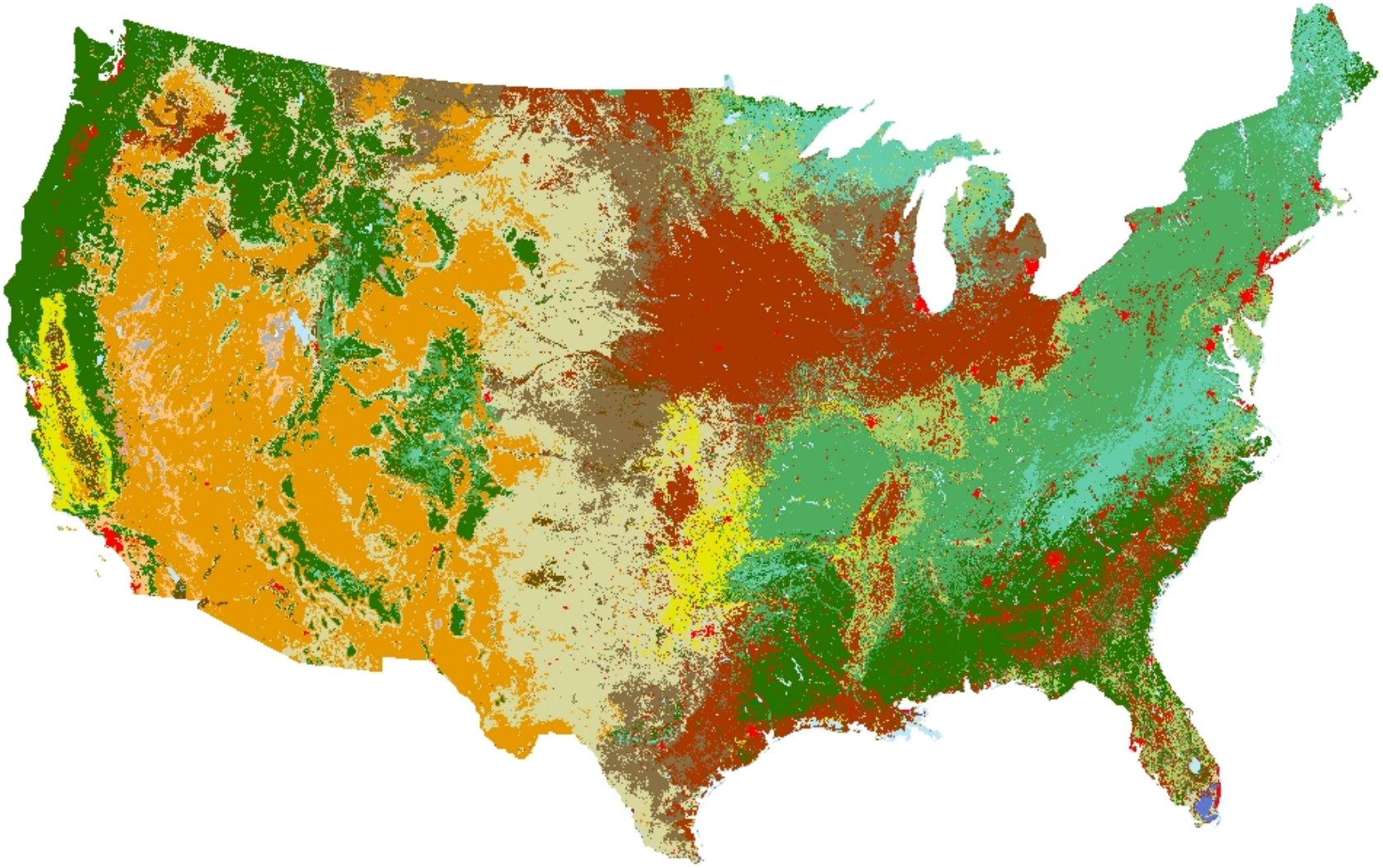
Refinement of CLs

1. Fine-scale land-cover map

Forests


Empirical CL of N (kg ha-1 yr-1)
>3 - 8 Eastern Forests
>3 to <26 Northern Forests
4 Northwestern Forested Mountains
5 Marine West Coast Forests
<5 - 10 Tropical and Subtropical Humid Forests
17 - 39 Mediterranean California
Uncertainty
Reliable
Fairly Reliable
Expert Judgement

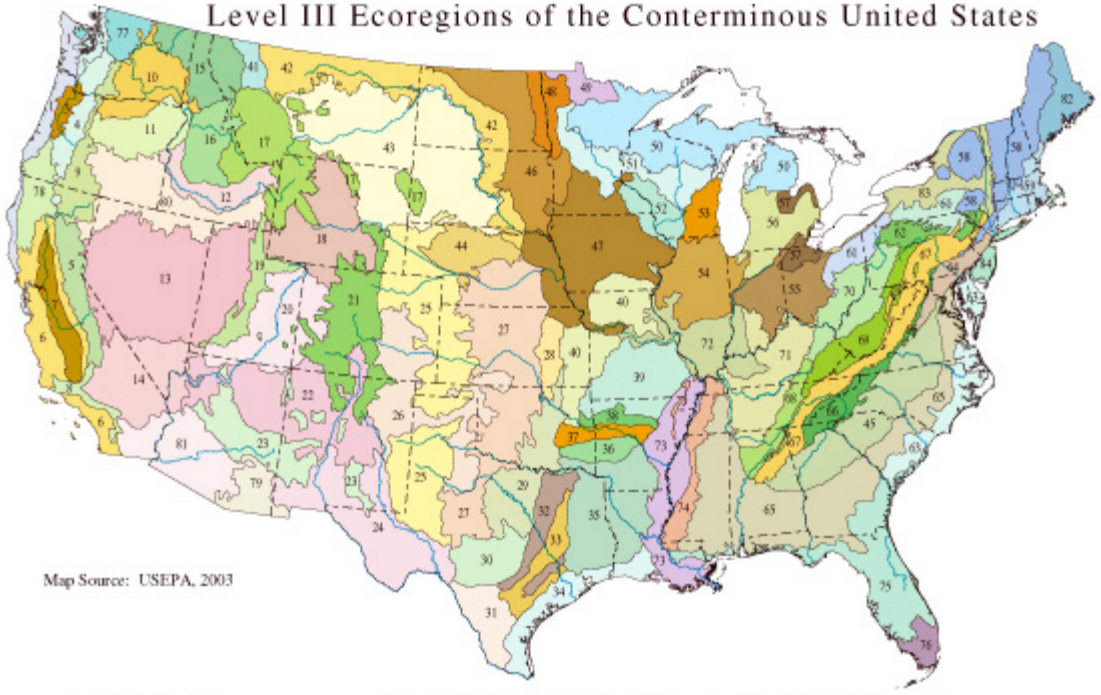
Landcover 1km



Legend

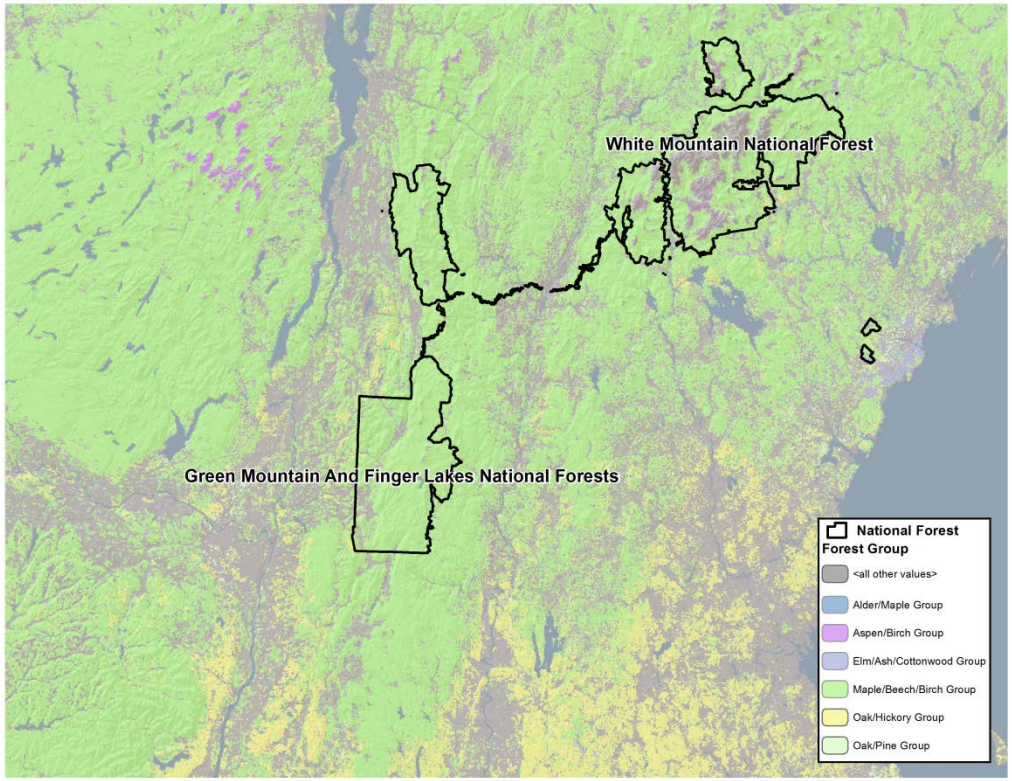
- Urban and Built-Up Land
- Dryland Cropland and Pasture
- Irrigated Cropland and Pasture
- Cropland/Grassland Mosaic
- Grassland
- Shrubland
- Mixed Shrubland/Grassland
- Savannah
- Deciduous Needleleaf Forest
- Evergreen Broadleaf Forest
- Mixed Forest
- Water Bodies
- Barren or Sparsely Vegetated
- Wooded Tundra
- Mixed Tundra

Level III Ecoregions of the Conterminous United States



Map Source: USEPA, 2003

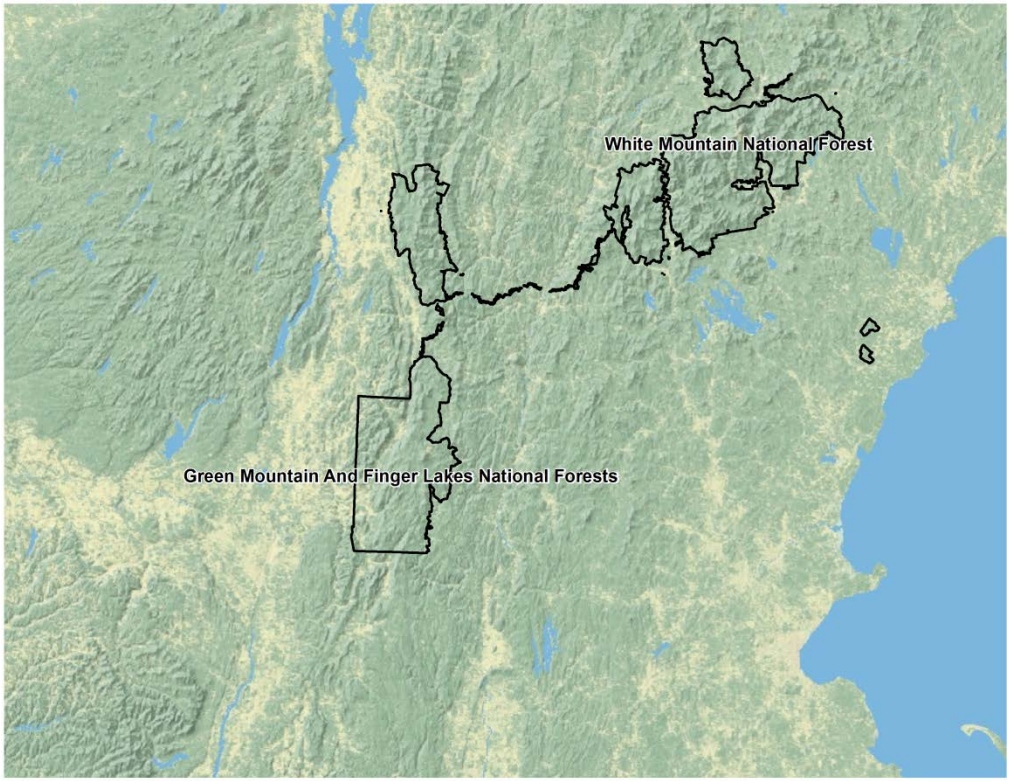
1 Coast Range
2 Puget Lowland
3 Willamette Valley
4 Cascades
5 Sierra Nevada
6 Southern and Central California Chaparral and Oak Woodlands
7 Central California Valley
8 Southern California Mountains
9 Eastern Cascades Slopes and Foothills
10 Columbia Plateau
11 Blue Mountains
12 Snake River Plain
13 Central Basin and Range
14 Mojave Basin and Range
15 Northern Rockies
16 Idaho Batholith
17 Middle Rockies
18 Wyoming Basin
19 Wasatch and Uinta Mountains
20 Colorado Plateaus
21 Southern Rockies
22 Arizona/New Mexico Plateau
23 Arizona/New Mexico Mountains
24 Chihuahuan Deserts
25 Western High Plains
26 Southwestern Tablelands
27 Central Great Plains
28 Flint Hills
29 Central Oklahoma/Texas Plains
30 Edwards Plateau
31 Southern Texas Plains
32 Texas Blackland Prairies
33 East Central Texas Plains
34 Western Gulf Coastal Plain
35 South Central Plains
36 Ouachita Mountains
37 Arkansas Valley
38 Boston Mountains
39 Ozark Highlands
40 Central Irregular Plains
41 Canadian Rockies
42 Northwestern Glaciated Plains
43 Northwestern Great Plains
44 Nebraska Sand Hills
45 Piedmont
46 Northern Glaciated Plains
47 Western Corn Belt Plains
48 Lake Agassiz Plain
49 Northern Minnesota Wetlands
50 Northern Lakes and Forests
51 North Central Hardwood Forests
52 Driftless Area
53 Southeastern Wisconsin Till Plains
54 Central Corn Belt Plains
55 Eastern Corn Belt Plains
56 Southern Michigan/Northern Indiana Drift Plains
57 Huron/Erie Lake Plains
58 Northeastern Highlands
59 Northeastern Coastal Zone
60 Northern Appalachian Plateau and Uplands
61 Erie Drift Plain
62 North Central Appalachians
63 Middle Atlantic Coastal Plain
64 Northern Piedmont
65 Southeastern Plains
66 Blue Ridge
67 Ridge and Valley
68 Southwestern Appalachians
69 Central Appalachians
70 Western Allegheny Plateau
71 Interior Plateau
72 Interior River Valleys and Hills
73 Mississippi Alluvial Plain
74 Mississippi Valley Loess Plains
75 Southern Coastal Plain
76 Southern Florida Coastal Plain
77 North Cascades
78 Klamath Mountains
79 Madrean Archipelago
80 Northern Basin and Range
81 Sonoran Basin and Range
82 Laurentian Plains and Hills
83 Eastern Great Lakes and Hudson Lowlands
84 Atlantic Coastal Pine Barrens


White Mountain National Forest
Green Mountain And Finger Lakes National Forests
National Forest
Forest Group
<all other values>
Alder/Maple Group
Aspen/Birch Group
Elm/Ash/Cottonwood Group
Maple/Beech/Birch Group
Oak/Hickory Group
Oak/Pine Group

Refinement of CLs

1. Fine-scale land-cover map

2. Constrain range of CL
biotic and abiotic factors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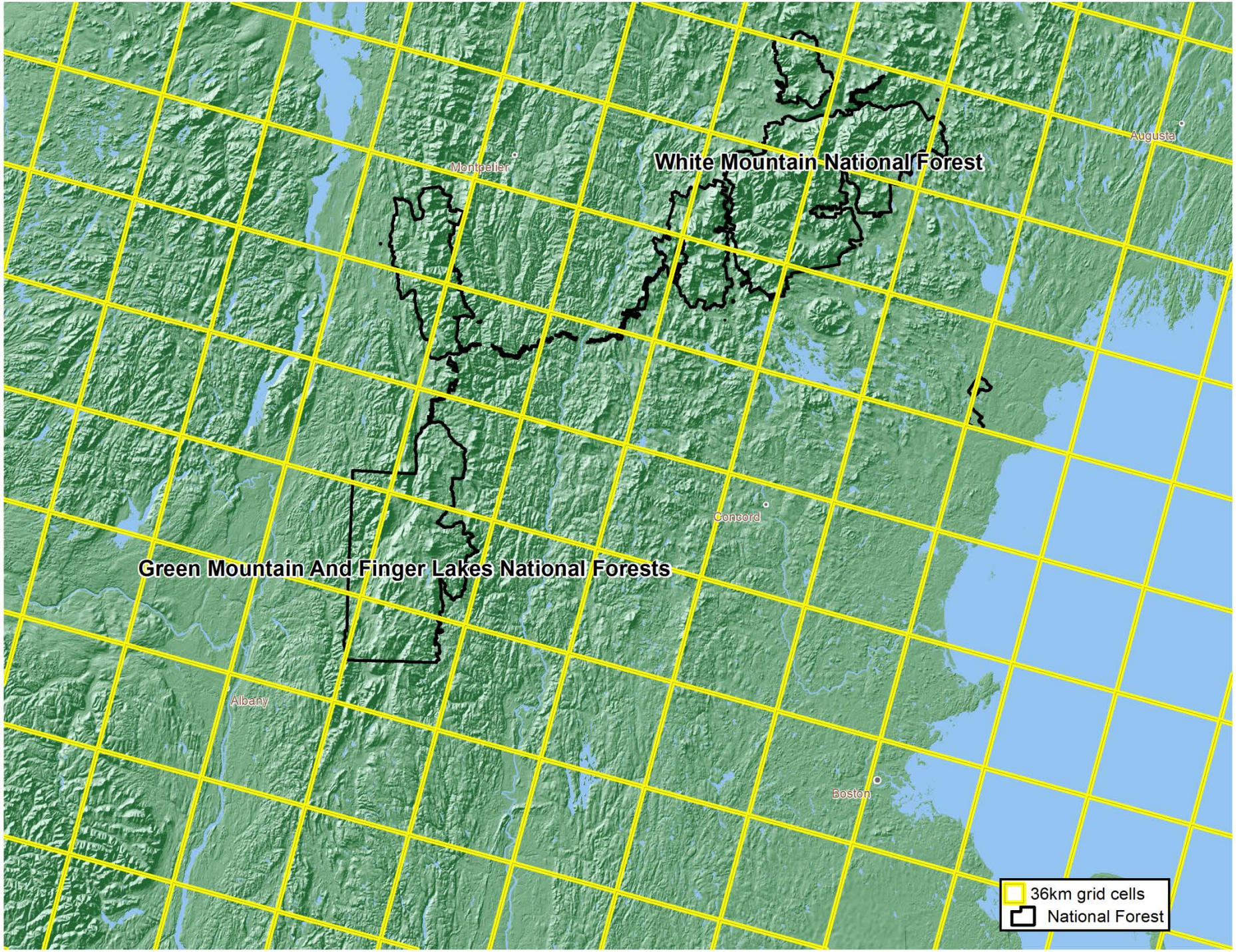
Green Mountain And Finger Lakes National Forests


White Mountain National Forest
Green Mountain And Finger Lakes National Forests
Montpelier
Augusta
Concord
Albany
Boston
36km grid cells
National Forest

Refinement of CLs

1. Fine-scale land-cover map

2. Constrain range of CL
biotic and abiotic factors

3. Input from resource managers on receptor and responses of concern

Responses: Ectomycorrhizal fungi

- Altered community structure and composition
- Decrease species richness

Responses: Herbaceous plants

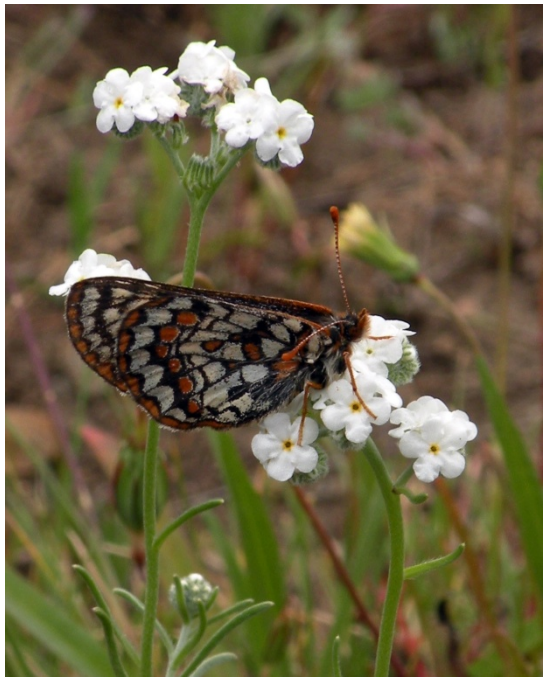
- Altered community composition:
- Increases in nitrophilic species
- Increased invasives
- Decreased species richness (native species)
- Increased fire

Responses: Forests

- Increased nitrate leaching
- Increased foliar N concentration
- Increased SOM N, nitrification
- Decreased growth, root biomass, survivorship, health

Responses of concern

- Fire frequency: Joshua Tree
- Checkerspot butterfly (Weiss)
- Pitcher plant



Next steps

- Refine empirical CL model for lichens
- Refine empirical CL estimates to finer than ecoregion scale
- Provide input for potential dynamic modelling