EPA
United States
Environmental Protection
Agency

Performance Indicators

Lessons Learned From Environmental Monitoring

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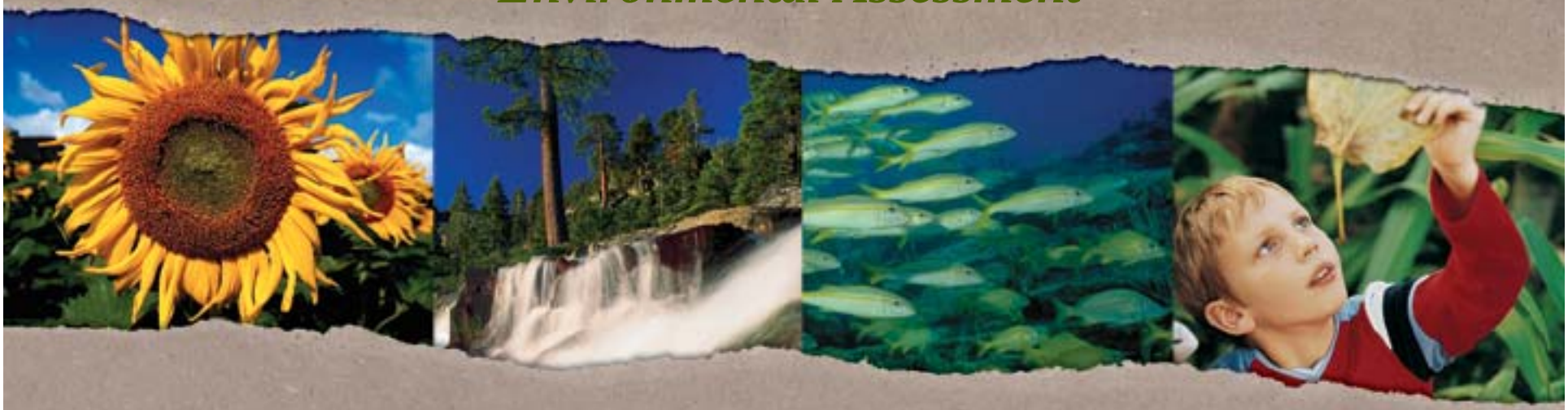
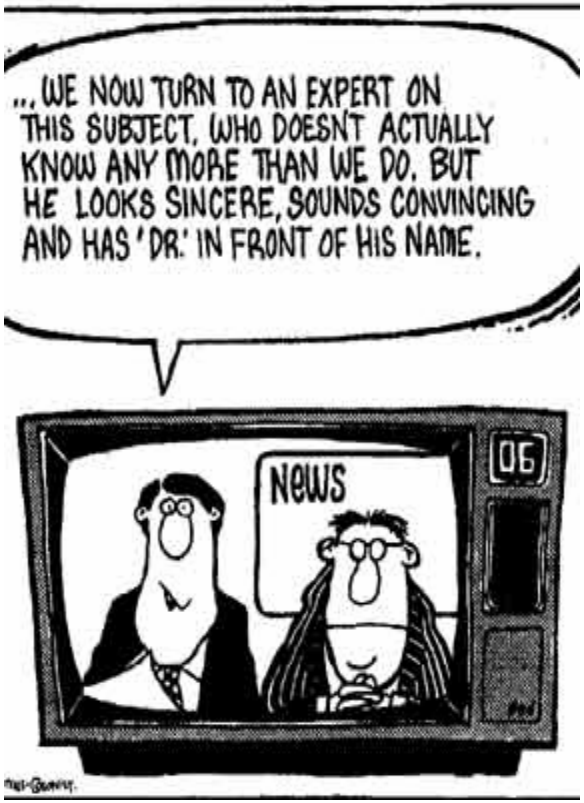


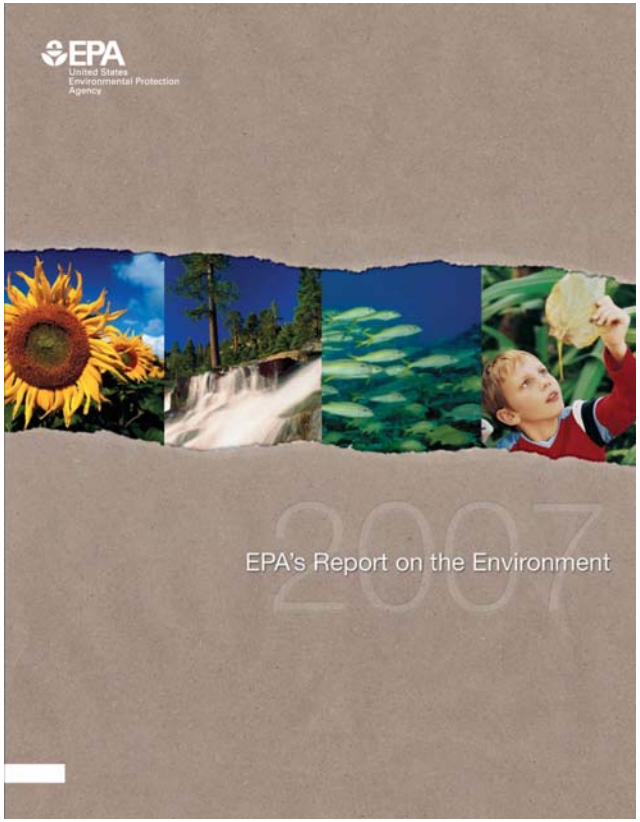
Office of Research and Development
National Center for Environmental Assessment

February 12, 2008

So what is an environmental engineer doing here?



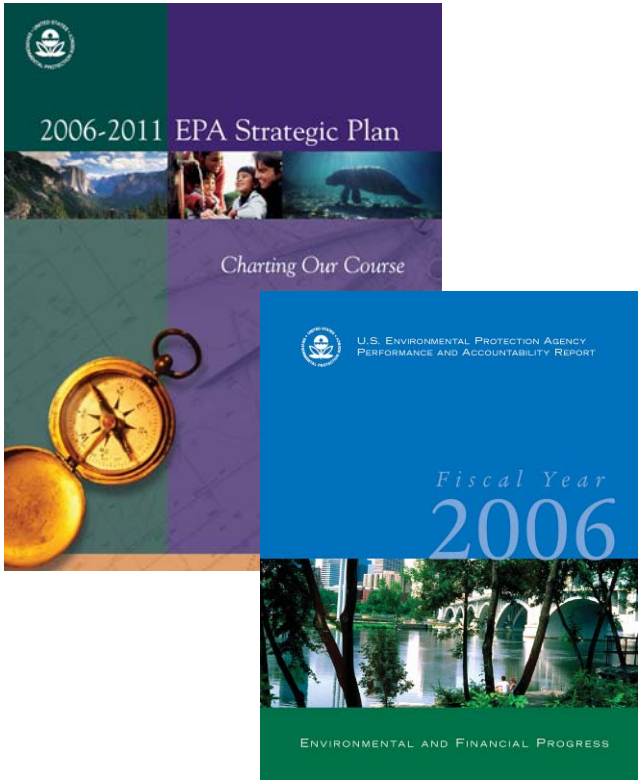
Broad Accountability
EPA's Report on the Environment



- Focuses on long-term, big picture trends in air, water, land, health, and eco.
- Indicators are not tied to specific programs or short-term management objectives

Focused Accountability

EPA's Strategic Plan & Performance Reports

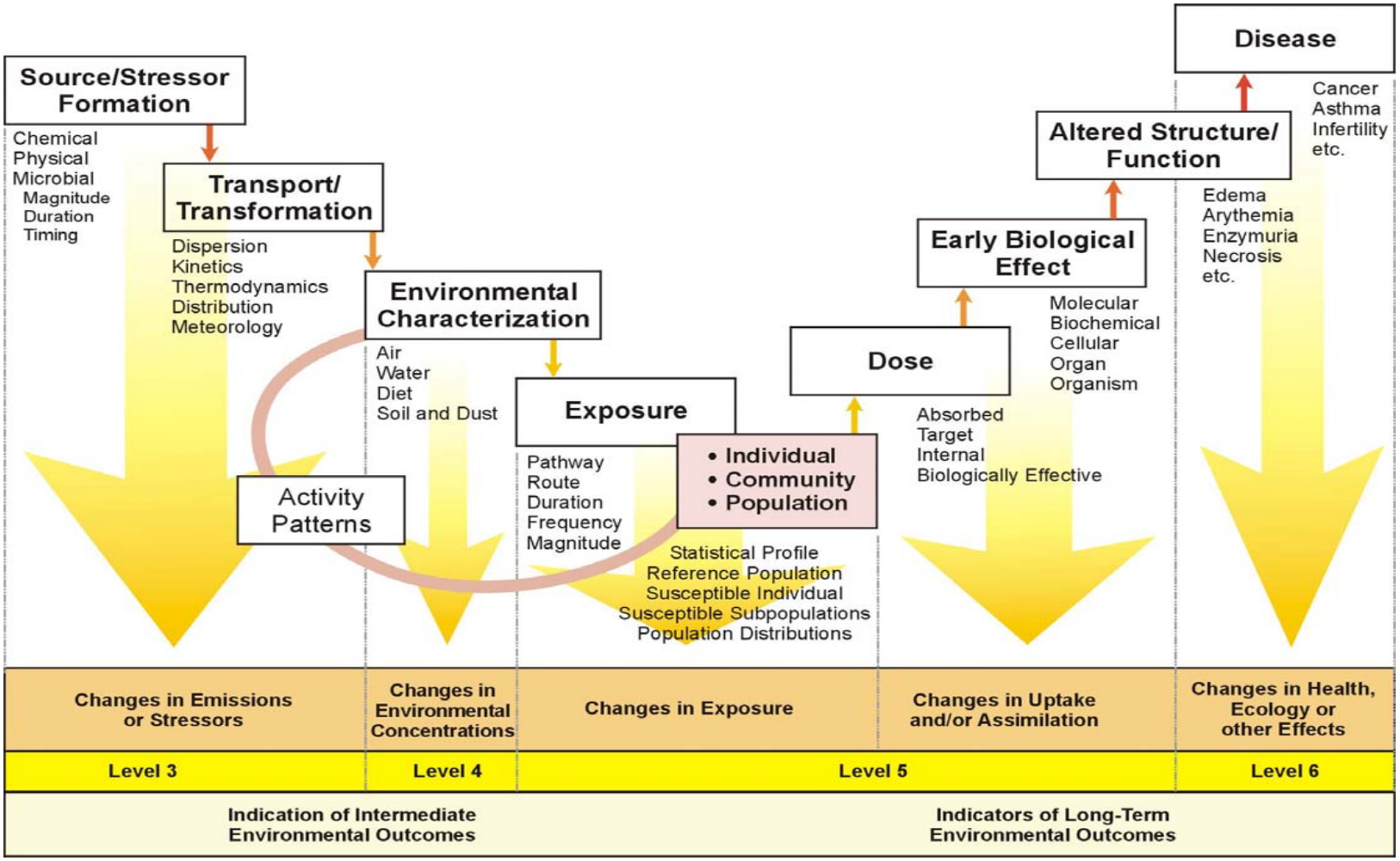


- EPA Strategic Plan
  - Sets EPA's goals and 5-year performance objectives.
- EPA Annual Performance Reports
  - Reports on achievement of performance objectives.

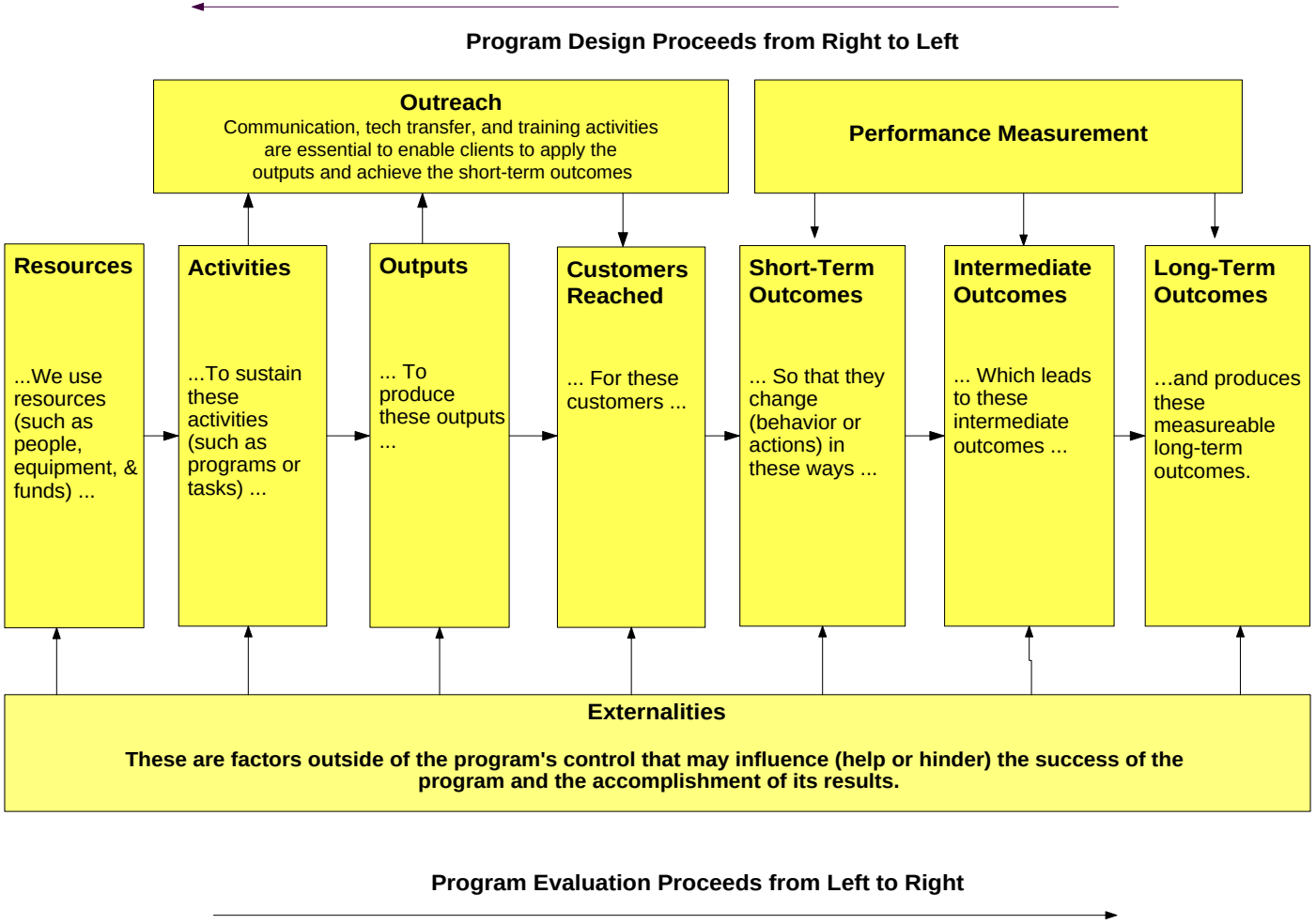
Government Performance and Results Act (GPRA)

- Establish performance goals to define the level of performance to be achieved by a program activity
- Express goals in an objective, quantifiable, and measurable form
- Establish performance indicators to measure the relevant outputs, service levels, and outcomes of each activity
- Provide a basis for comparing actual program results with the established performance goals
- Describe the means used to verify and validate the measured values

The Risk Model….



.. is not the same as the Logic Model



Will any old performance indicator do?

What makes a good performance indicator?

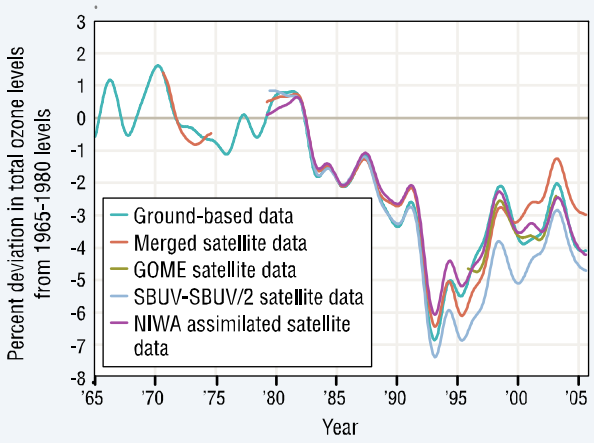
- Important
- Specific to action
- Sensitive
- Representative
- Acceptable measurement uncertainty
- Timely results
- Appropriate scale
- Careful around elephants

An important example

Stratospheric Ozone

Shorter term outcome anticipates longer term outcome

Exhibit 2-46. Total ozone levels over North America, 1965-2005[a,b]

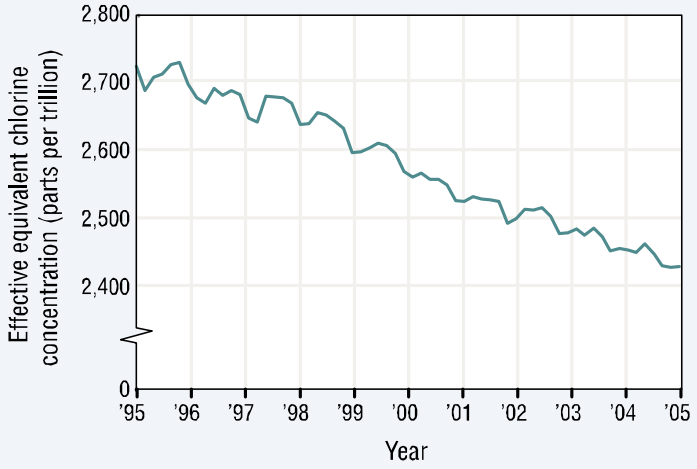


[a]Total ozone refers to the total ozone concentration in a column of air between the Earth's surface and the top of the atmosphere.

[b]Trend data are representative of latitudes ranging from 35 degrees North to 60 degrees North.

Data source: *1965-2003 data from WMO et al., 2003, and 2004-2005 data from unpublished results provided by WMO*

Exhibit 2-44. Global effective equivalent chlorine concentrations, 1995-2005[a]



[a]Effective equivalent chlorine (EECl) is typically used to represent atmospheric concentrations of ozone-depleting substances. The EECl reflects contributions from multiple ozone-depleting substances, weighted by their potential to catalyze the destruction of stratospheric ozone.

Data source: *NOAA/ESRL/GMD, 2006*

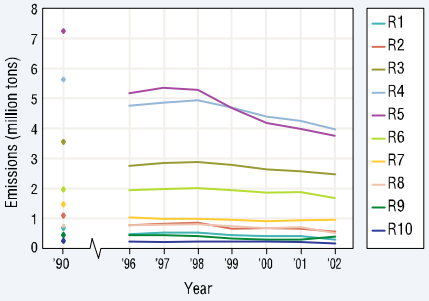
Another important example

Acid rain

- How many lakes and streams in the U.S. were acidic because of acid deposition?
  - National Surface Water Survey (probability sample in geologically sensitive areas)
- How many would be expected to recover or get worse under different SOX and NOX emission scenarios?
  - Direct-Delayed response model
- How many actually did recover or get worse after controls were put into place?
  - TIME/LTM program

Shorter term outcomes anticipate longer-term outcomes

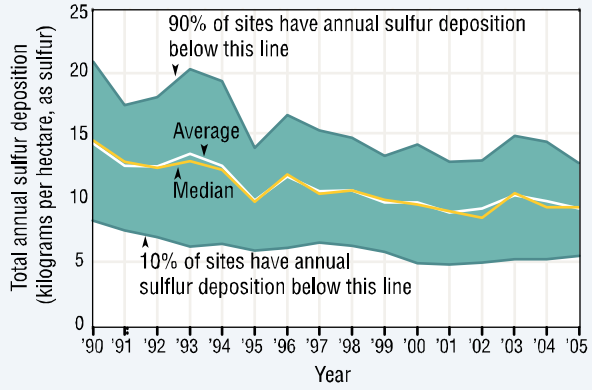
Exhibit 2-28. SO_2 emissions in the U.S. by EPA Region, 1990 and 1996-2002[a]



[a]Data are presented for 1990 and 1996-2002, as datasets from these inventory years are fully up-to-date. Data are available for inventory years 1991-1995, but these data have not been updated to allow comparison with data from 1990 and 1996-2002.

Data source: *U.S. EPA, 2007b*

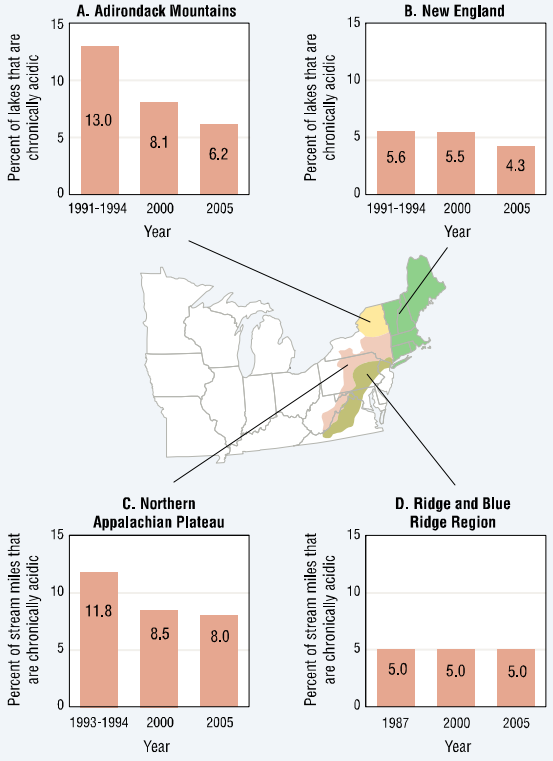
Exhibit 2-33. Total sulfur deposition in the eastern United States, 1990-2005[a]



[a]**Coverage:** 34 monitoring sites in the eastern United States.

Data source: *MACTEC Engineering and Consulting, Inc., 2006*

Exhibit 2-36. Lake and stream acidity in selected acid-sensitive regions in the U.S., 1987-2005



Data source: *U.S. EPA, 1988, 2003, 2007*

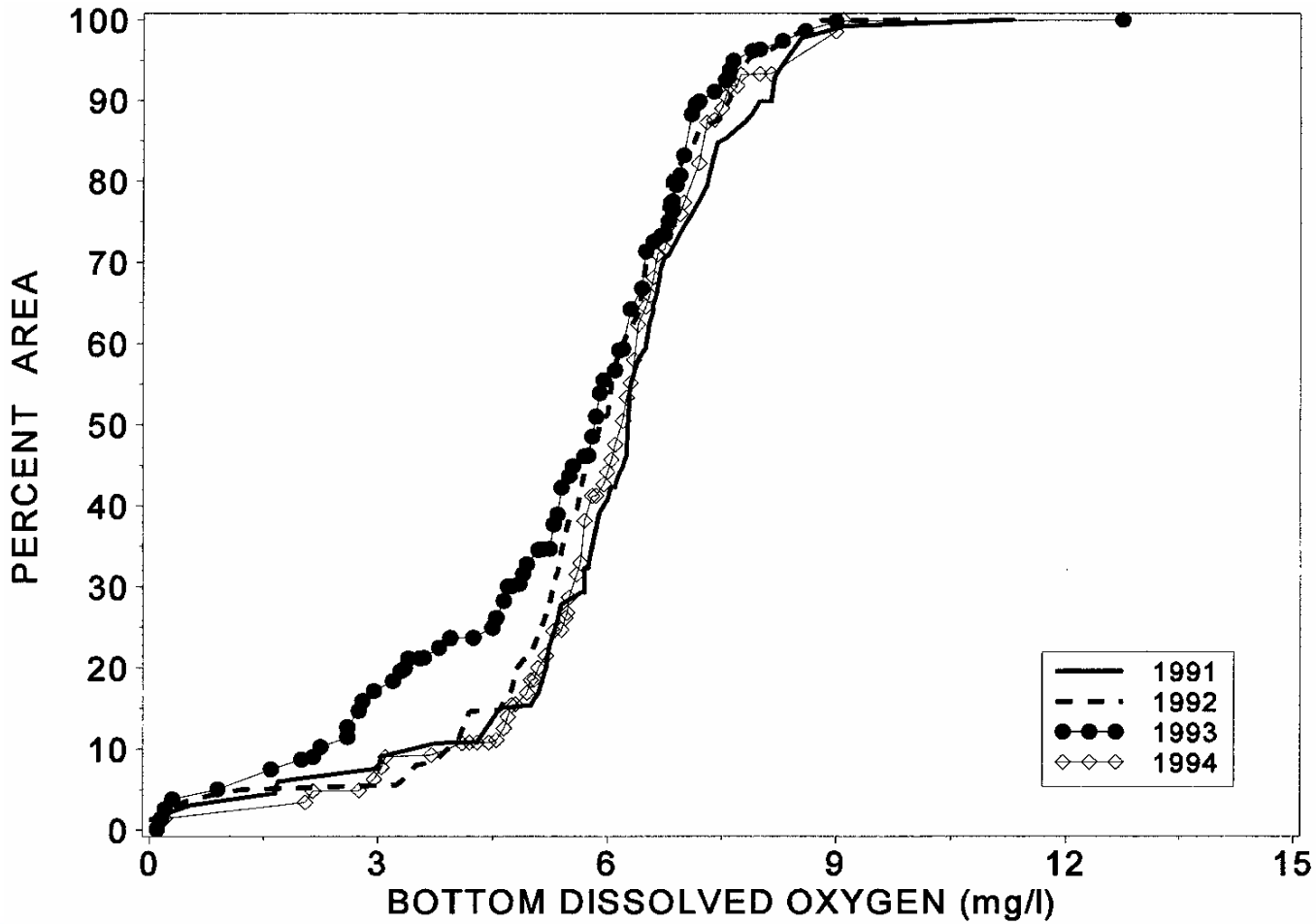
Another important example
– Surface Waters

- How many acres/miles of surface waters are in good condition, and what are the trends over time?
  - National Coastal Condition Assessment
  - Wadeable Streams Assessment
  - More to come (large rivers, lakes, wetland condition)
- Probability sampling to insure representative results
- Emphasis not just on chemistry but also biological community structure

Probability sampling

Dissolved Oxygen in Gulf Coast Estuaries 1991-1994

Despite diurnal oxygen fluctuations, annual frequency distributions are similar



Representative sample
Wadeable stream indicators

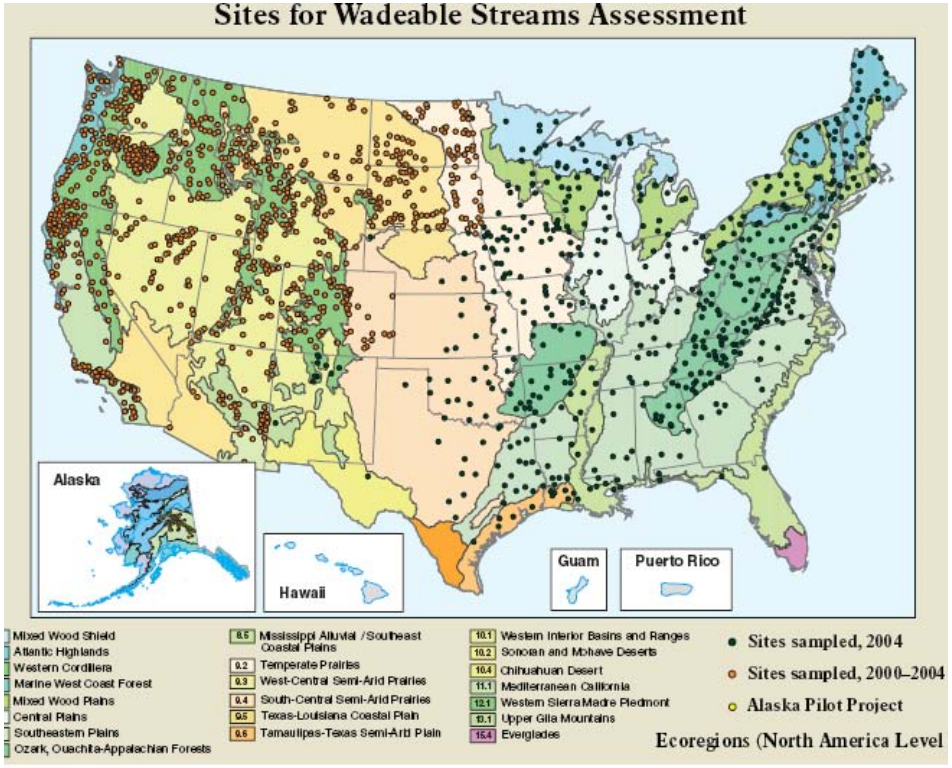
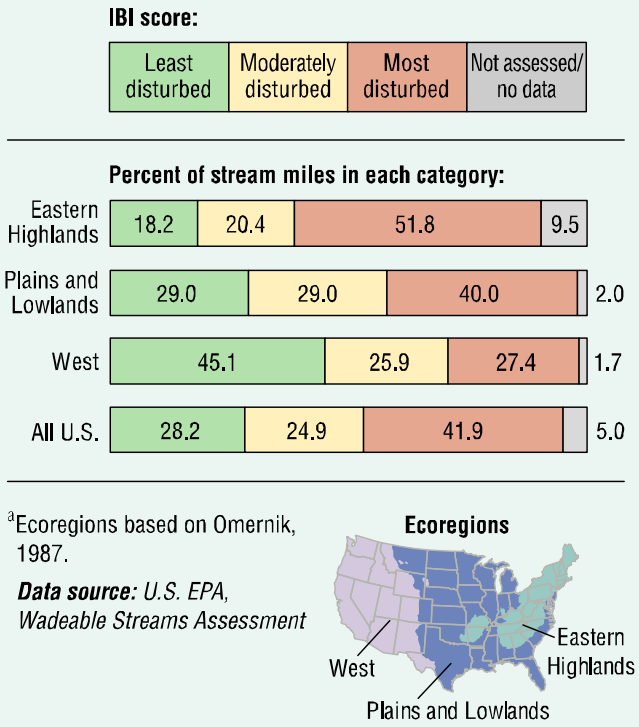


Exhibit 3-12. Index of Biological Integrity (IBI) for benthic macroinvertebrates in wadeable streams of the contiguous U.S., by ecoregion, 2000-2004[a]

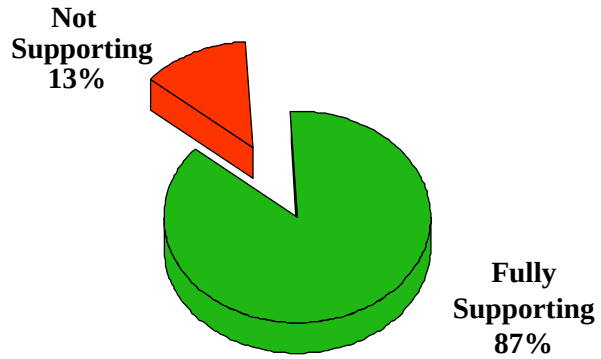


[a]Ecoregions based on Omernik, 1987.

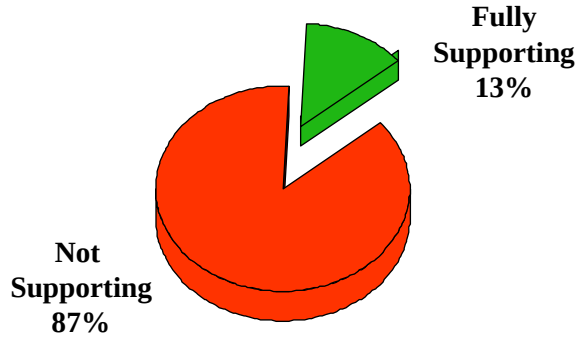
Data source: *U.S. EPA, Wadeable Streams Assessment*

Comparisons with stream non-representative 305(b) reports

Delaware

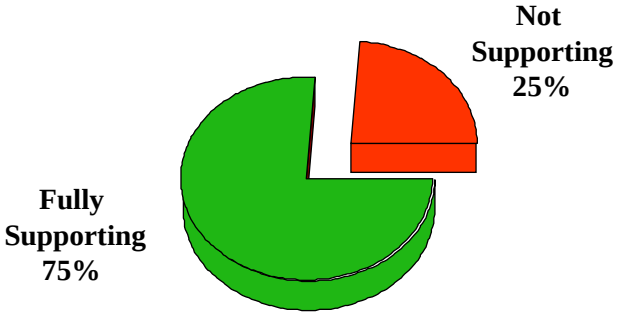


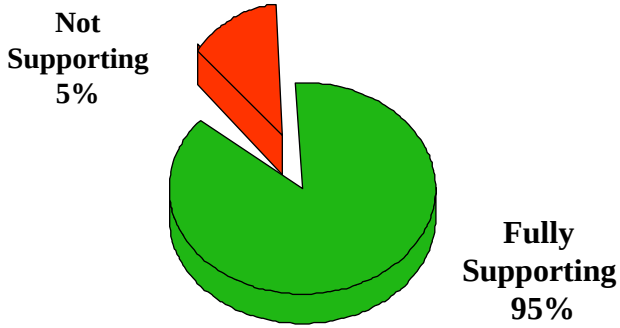
Traditional Targeted Monitoring



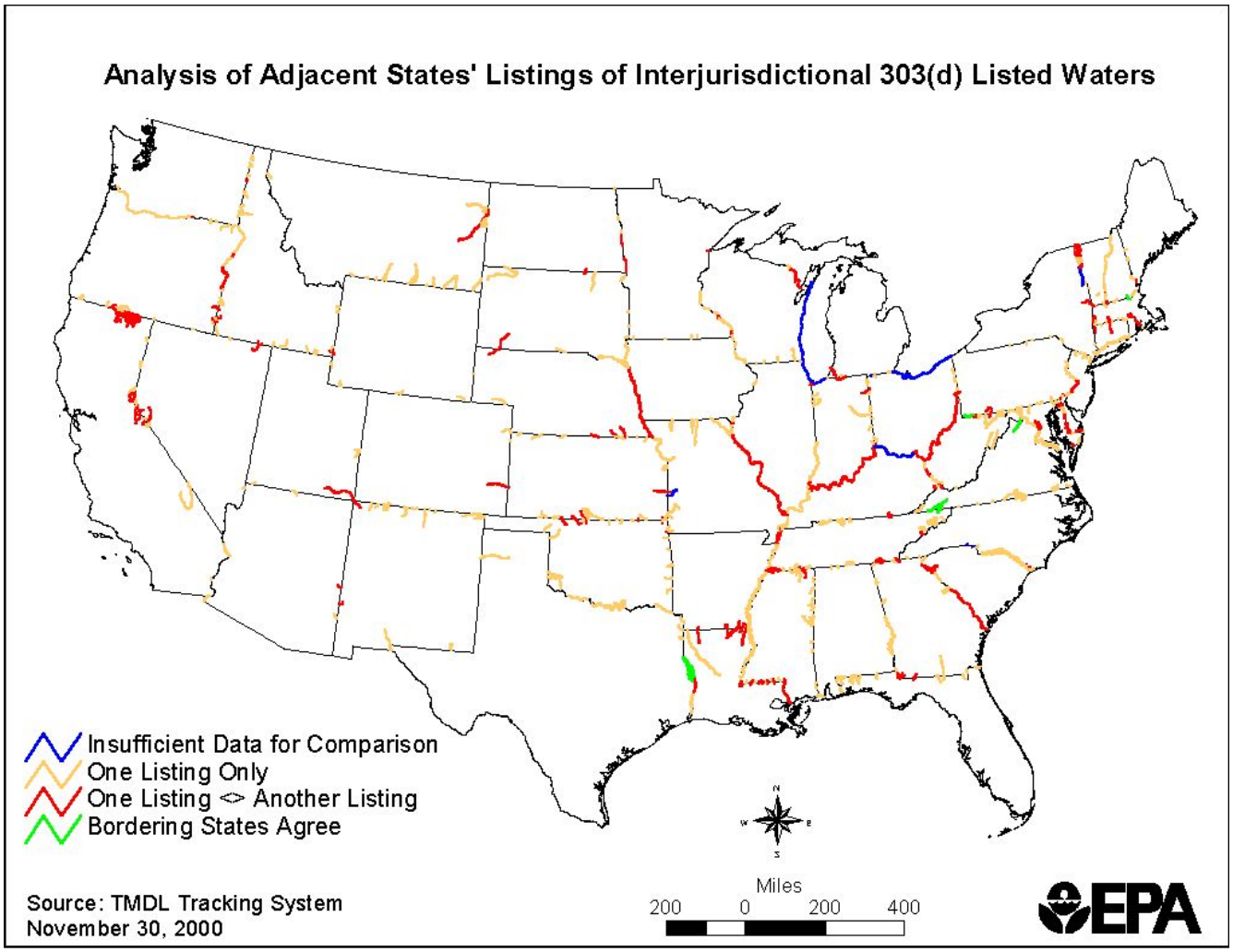
Probability Survey

Nebraska





Example of lack of comparability in state water quality data

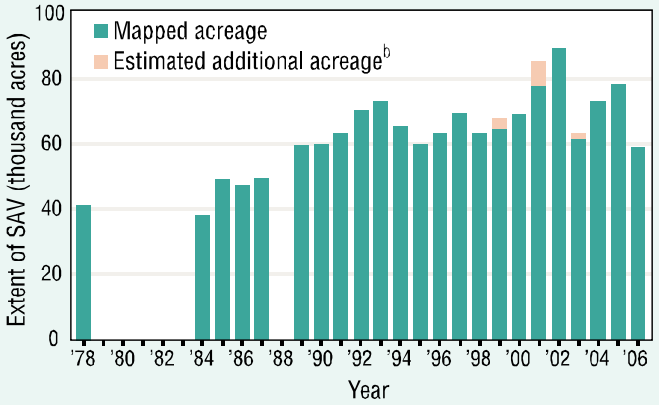


Sensitivity

SAV in Chesapeake Bay

By 2008, SAV will increase to 120,000 acres

Exhibit 3-30. Extent of submerged aquatic vegetation (SAV) in the Chesapeake Bay, 1978-2006[a]



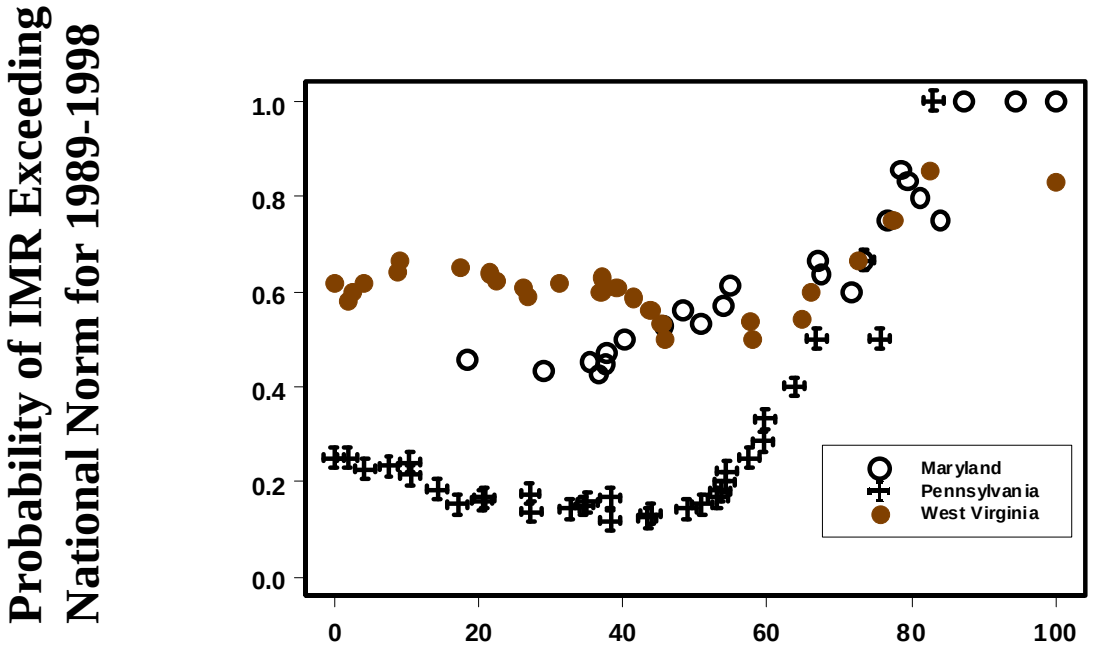
[a]There were no Bay-wide surveys from 1979 to 1983, or in 1988.

[b]For years with incomplete photographic coverage, SAV acreage in the non-surveyed areas was estimated based on prior years' surveys.

Data source: *Chesapeake Bay Program, 2007*

Specific to management action?

Relationships between infant mortality rate and stream degradation

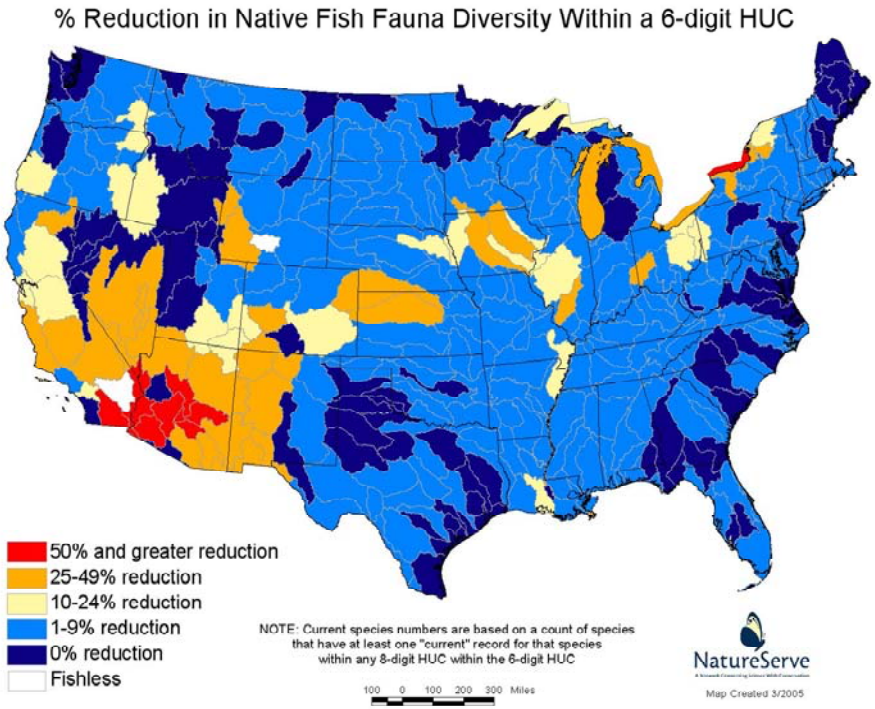


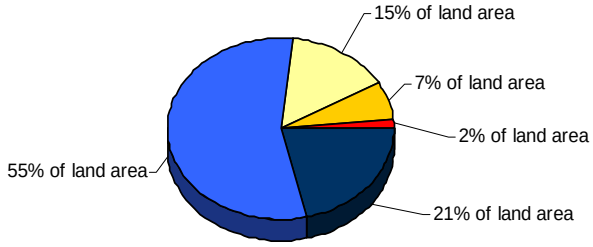
Let's also take a look at some more examples of regional variability

Regional differences in impact

Loss of native fish species

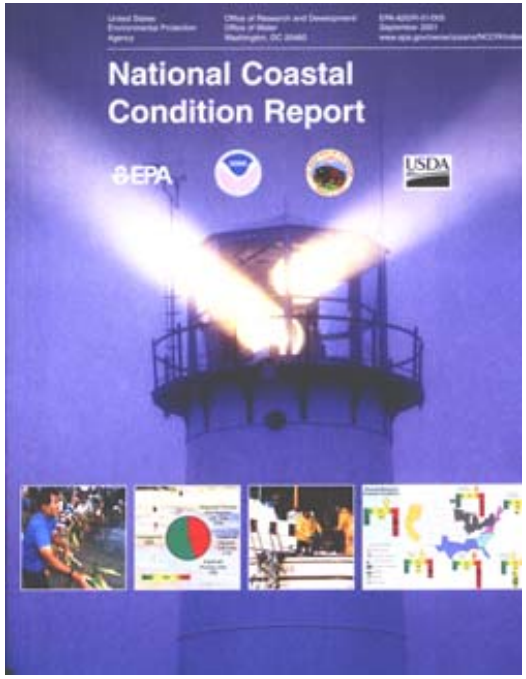
Figure 128-1.

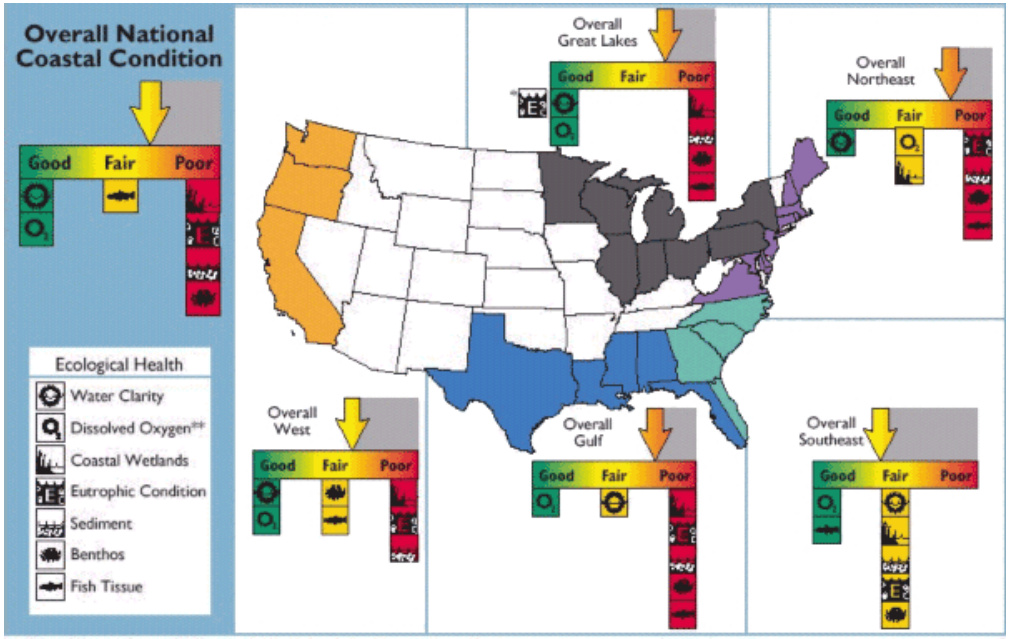




Regional differences and accountability targets

Coastal condition indicators

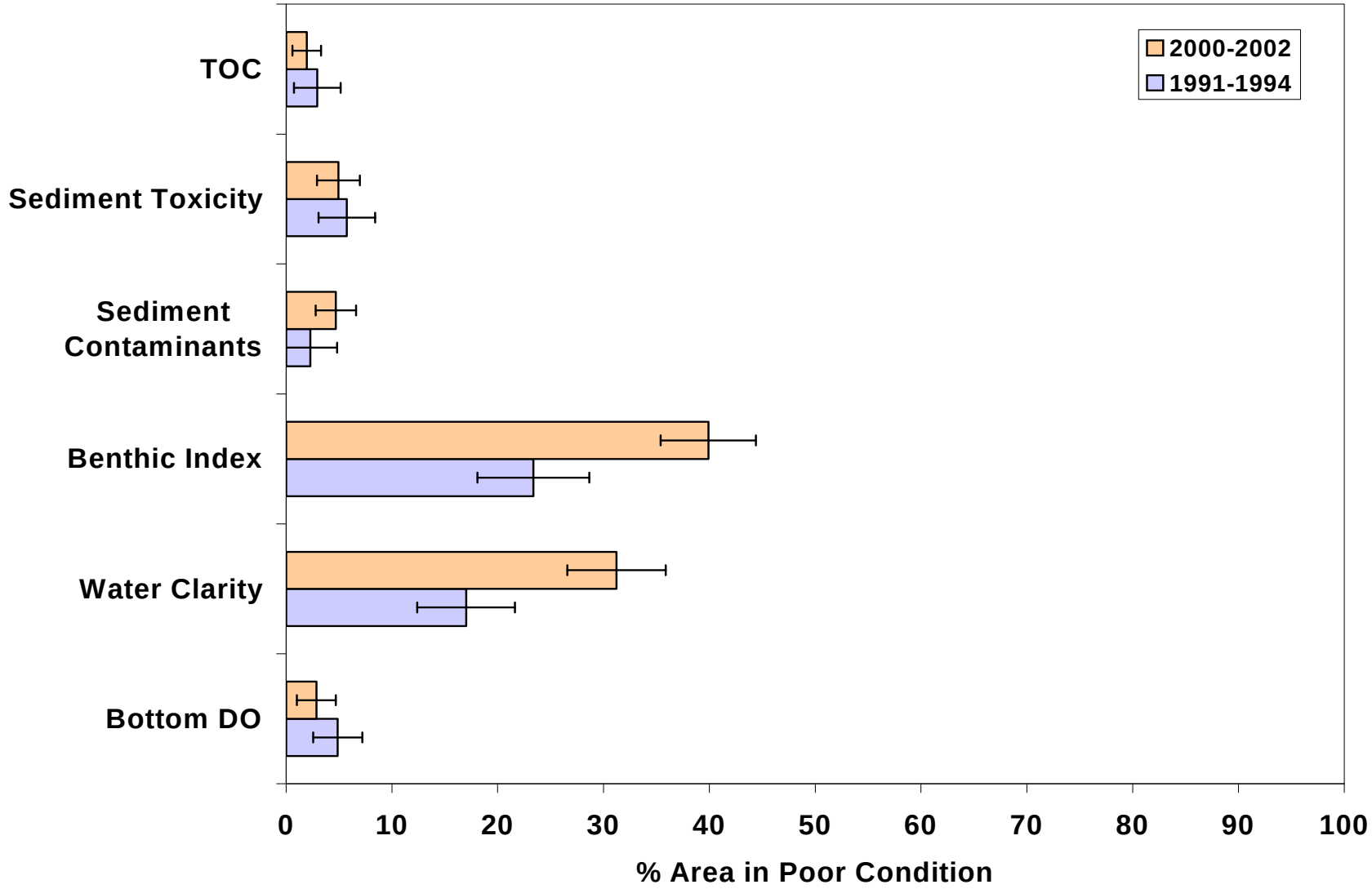




By 2008, increase all indices by 2%

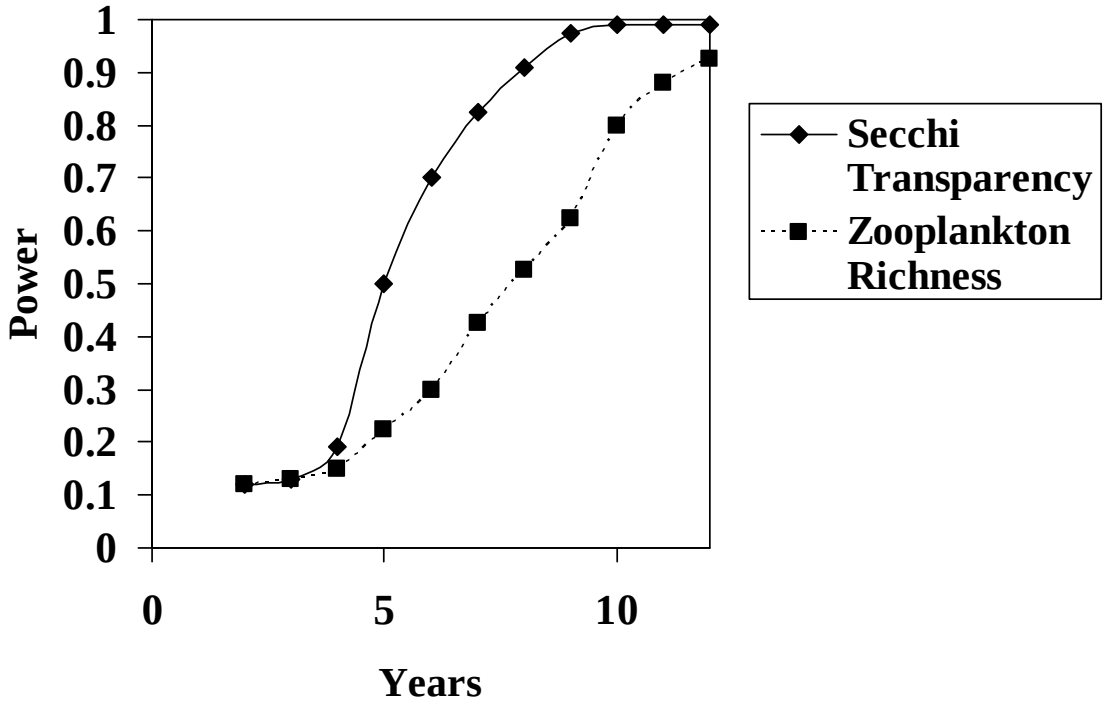
Measurement uncertainty

Gulf of Mexico Coastal Indicators



Measurement uncertainty

Power to detect a trend or achieve a target in two lake indicators

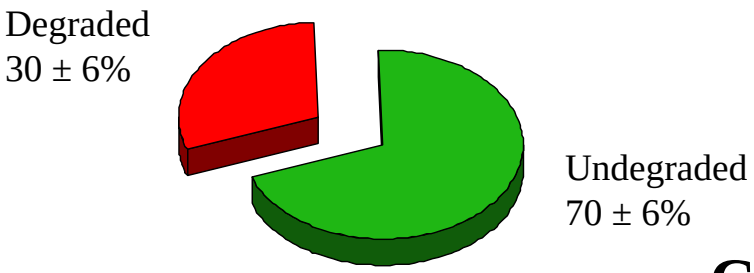


The power to detect a 2% peryear trend in Secchi transparency and zooplankton species richness with a sample size of 50 lakes per year. Data were generated from the 1991-1994 EMAP lakes study in New England.

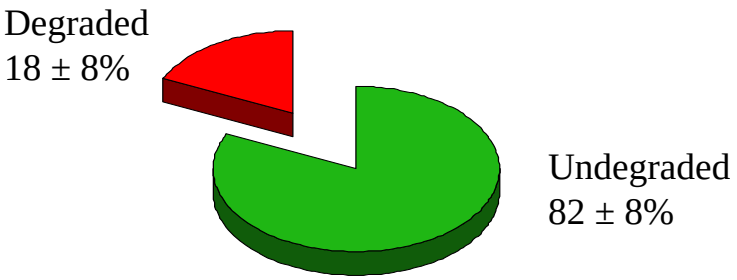
Regional differences in stressors

Estuarine Benthic Invertebrate IBI

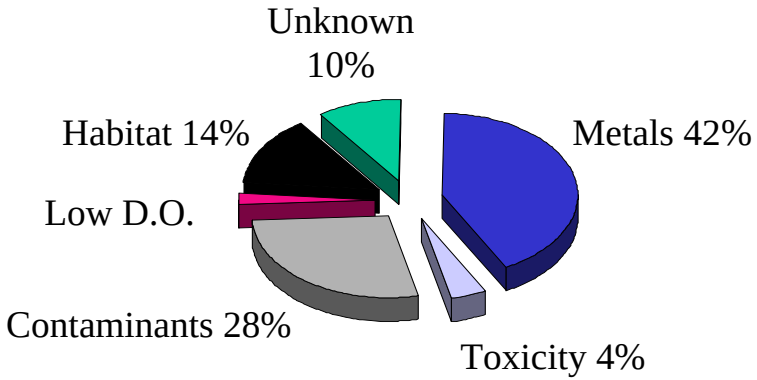
Louisianian Province

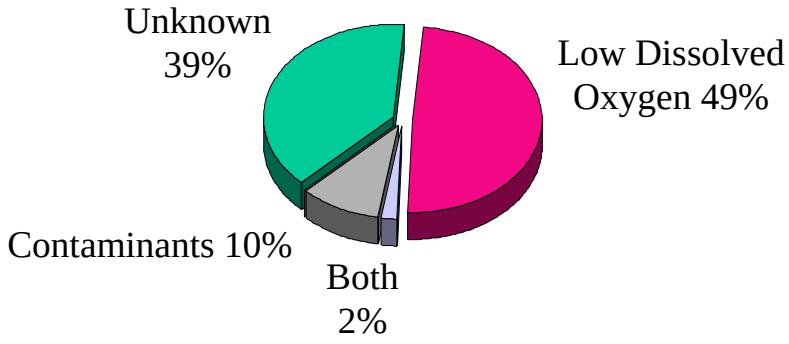


Virginian Province



Condition



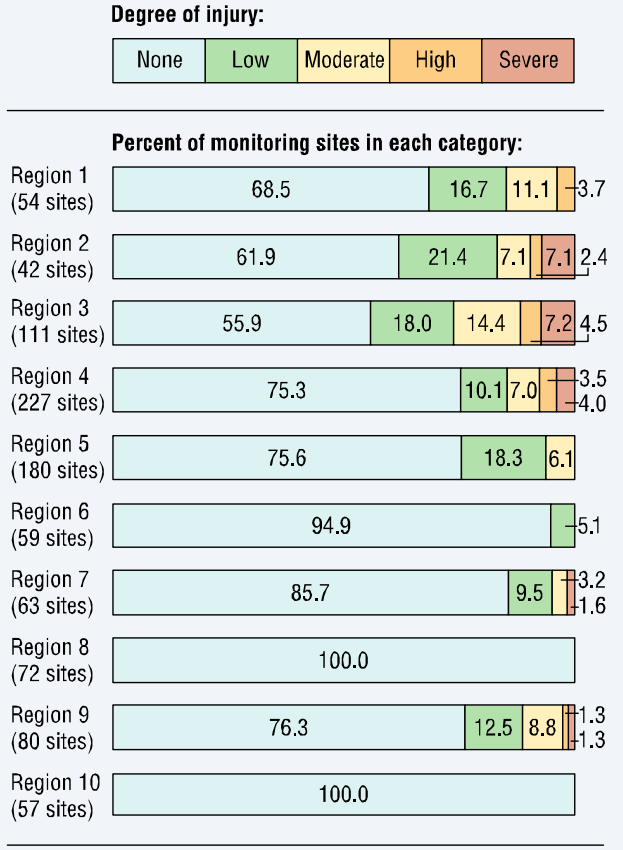


Stressors Associated with Degraded Condition

Regional differences in a pollutant-specific response indicator

Ozone injury to forest plants

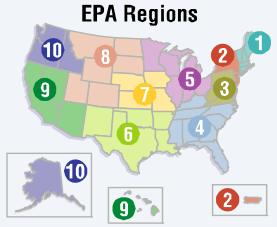
Exhibit 2-15. Ozone injury to forest plants in the U.S. by EPA Region, 2002[a,b]



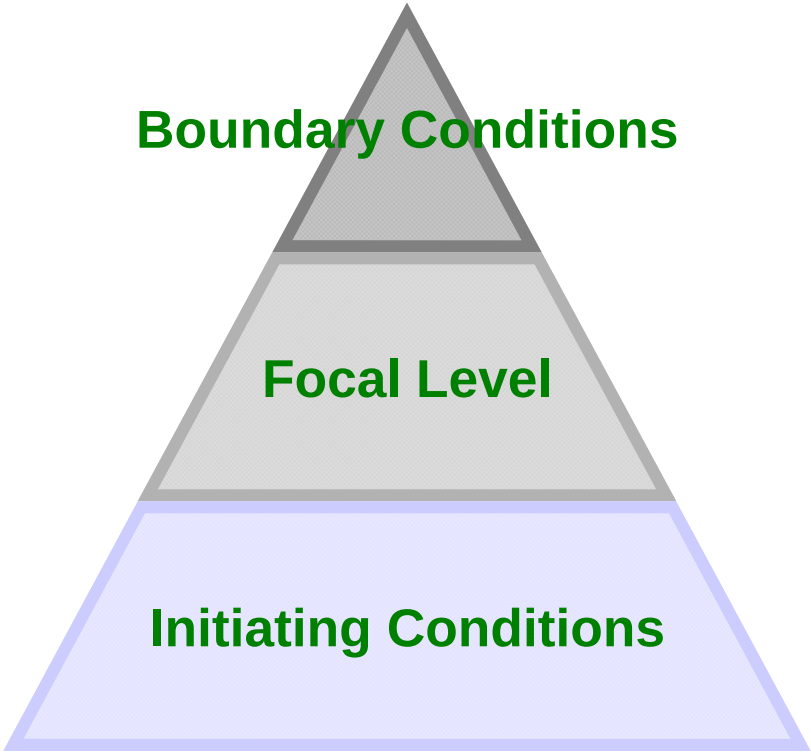
[a]**Coverage:** 945 monitoring sites, located in 41 states.

[b]Totals may not add to 100% due to rounding.

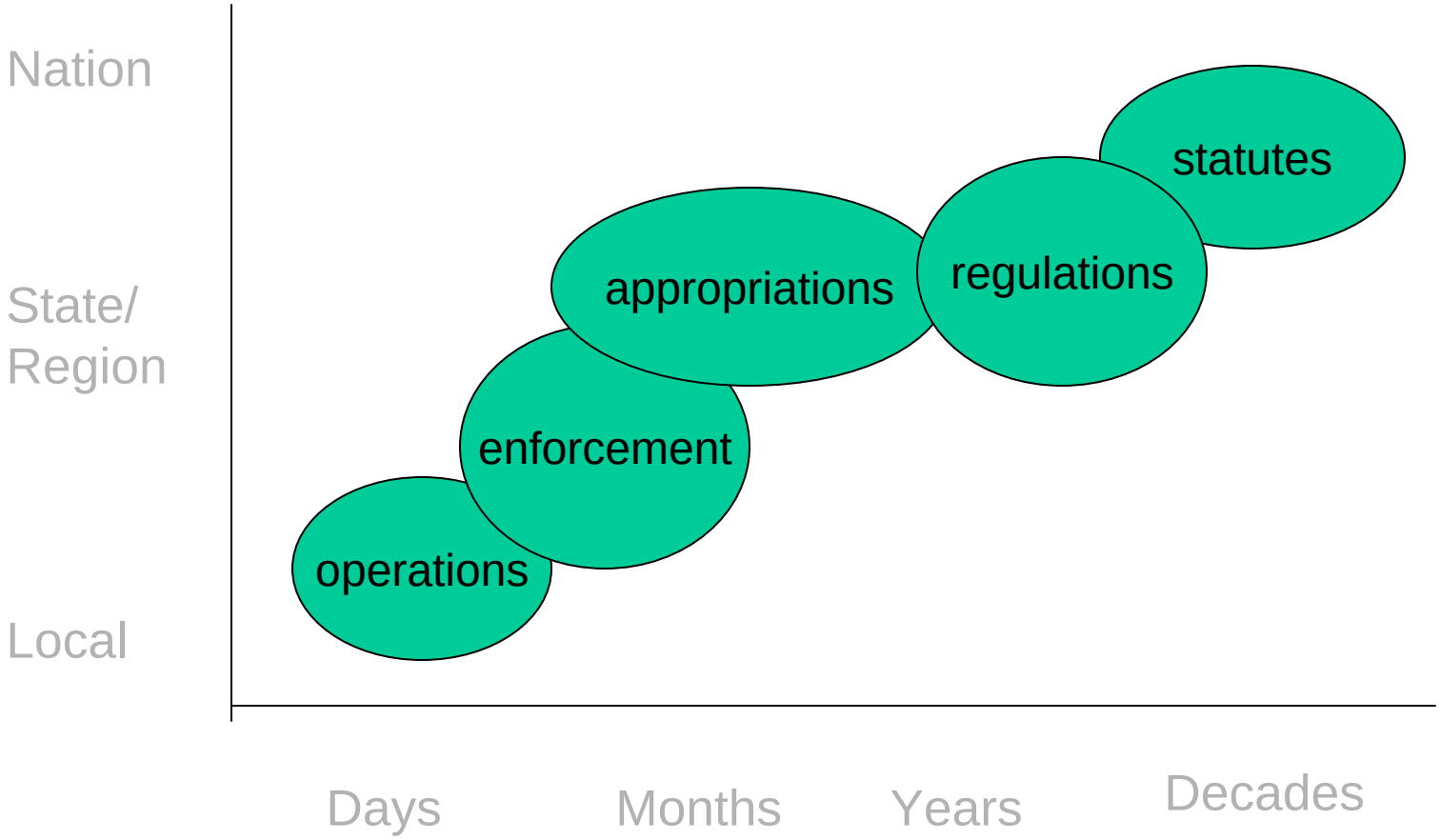
Data source: *USDA Forest Service, 2006*



Do indicators scale by hierarchy?



Hierarchy and Scale



Importance of indicator scale

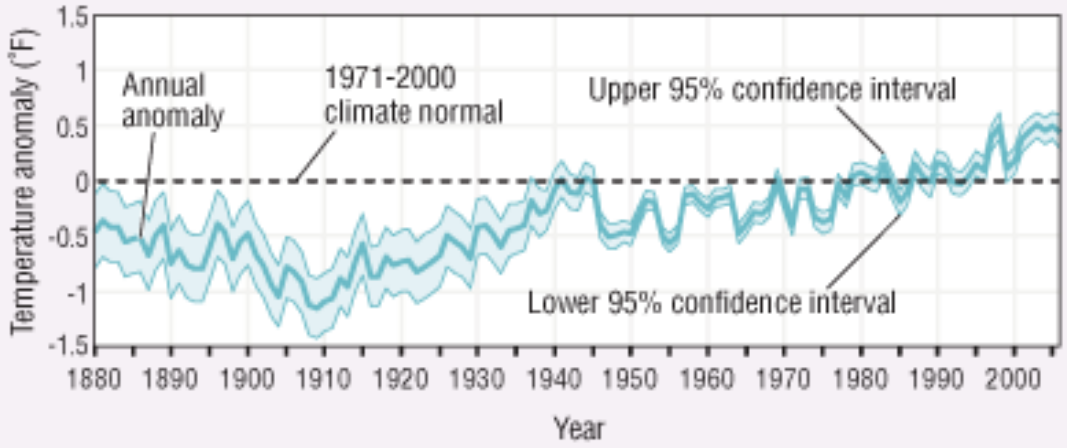
- National trends may mask important regional, state, and local variation
- Are we concerned about
  - a family?
  - a community?
  - a state or region?
  - A nation?
  - the globe?

Each concern may require an indicator or performance measure with a time and space scale that is “just right.”

Scale of outcomes

Global sea surface temperature

Exhibit 6-19. Annual global sea surface temperature anomaly, 1880-2006[a]



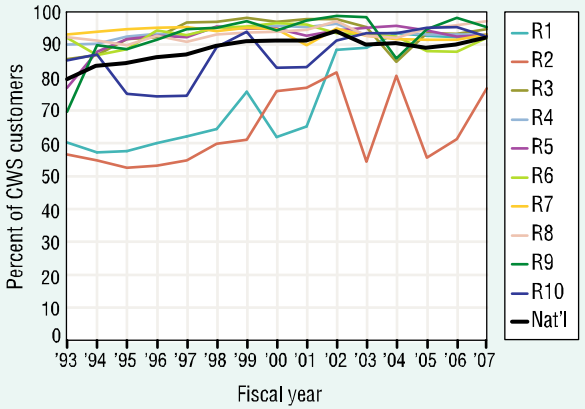
[a] **Coverage:** Anomaly with respect to the 1971-2000 climate normal, which is plotted as zero.

Data source: *NOAA, 2007b*

Scale of accountability targets

Regional safety of public water supplies

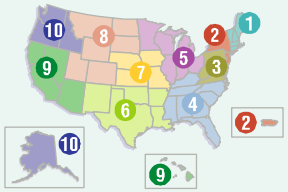
Exhibit 3-36. U.S. population served by Community Water Systems with no reported violations of EPA health-based standards, by EPA Region, fiscal years 1993-2007[a,b]



[a] **Coverage:** U.S. residents served by Community Water Systems (CWS) (approximately 95% of the total U.S. population).

[b] Based on reported violations of the standards in effect in any given year.

Data source: *U.S. EPA, 2007*



EPA Regions

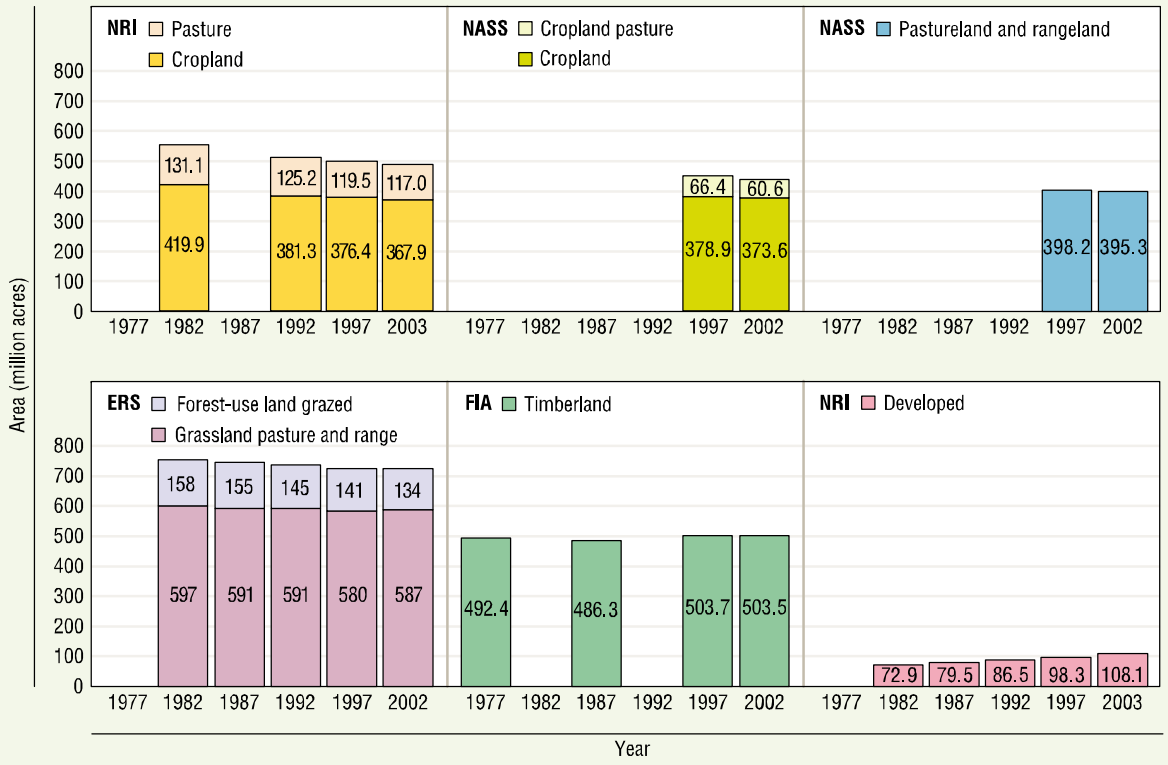
Scale of restoration targets

Local - Brasstown Creek, NC
Stream restoration

Year	EPT	BI	State bioclassification
1994	18	--	Fair
1999	44	4.6	Good
2004	53	4.8	Excellent

Scale – national urbanization

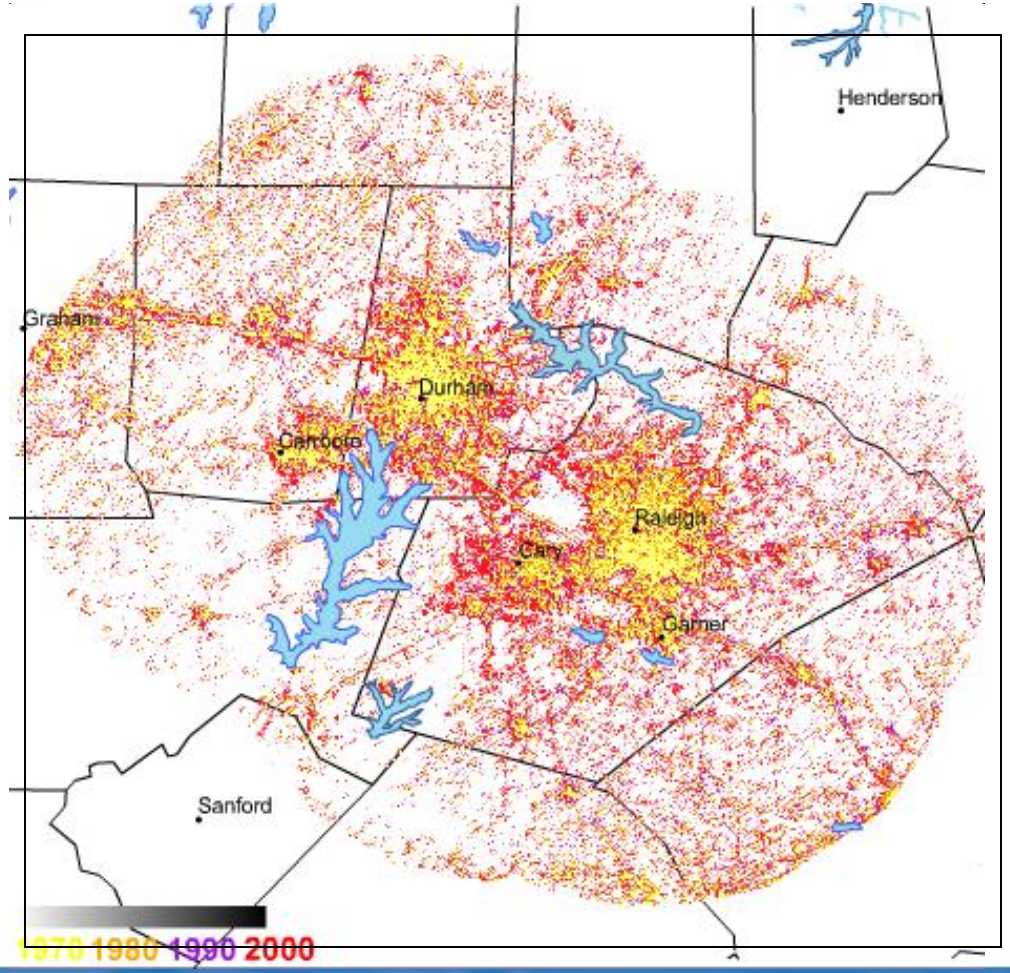
Exhibit 4-5. Land use trends in the U.S., 1977-2003[a]

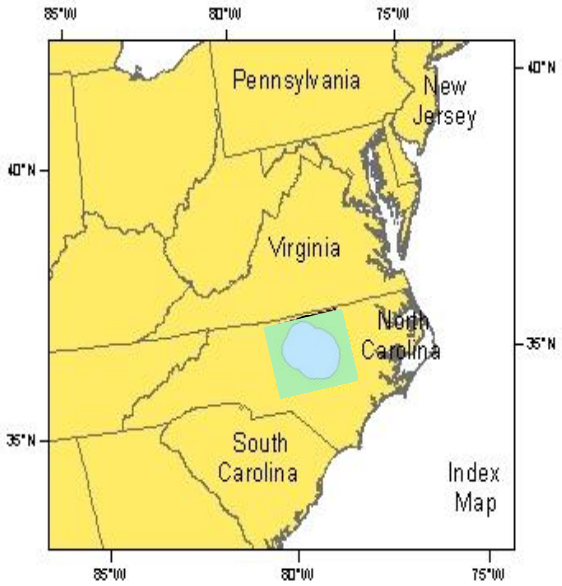


[a]See box in text for definitions of land use categories.

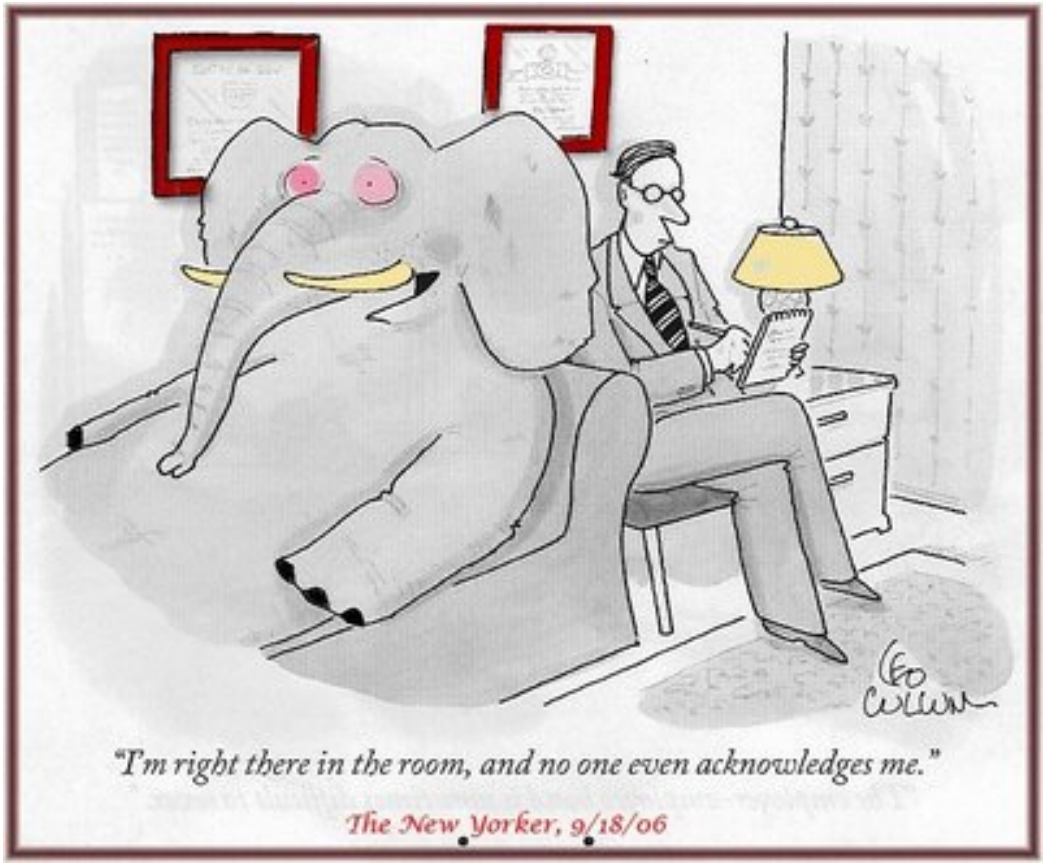
Data source: *Lubowski, et al., 2006; Smith et al., 2004; USDA NASS, 2004; USDA NRCS, 2007*

Scale – local urbanization



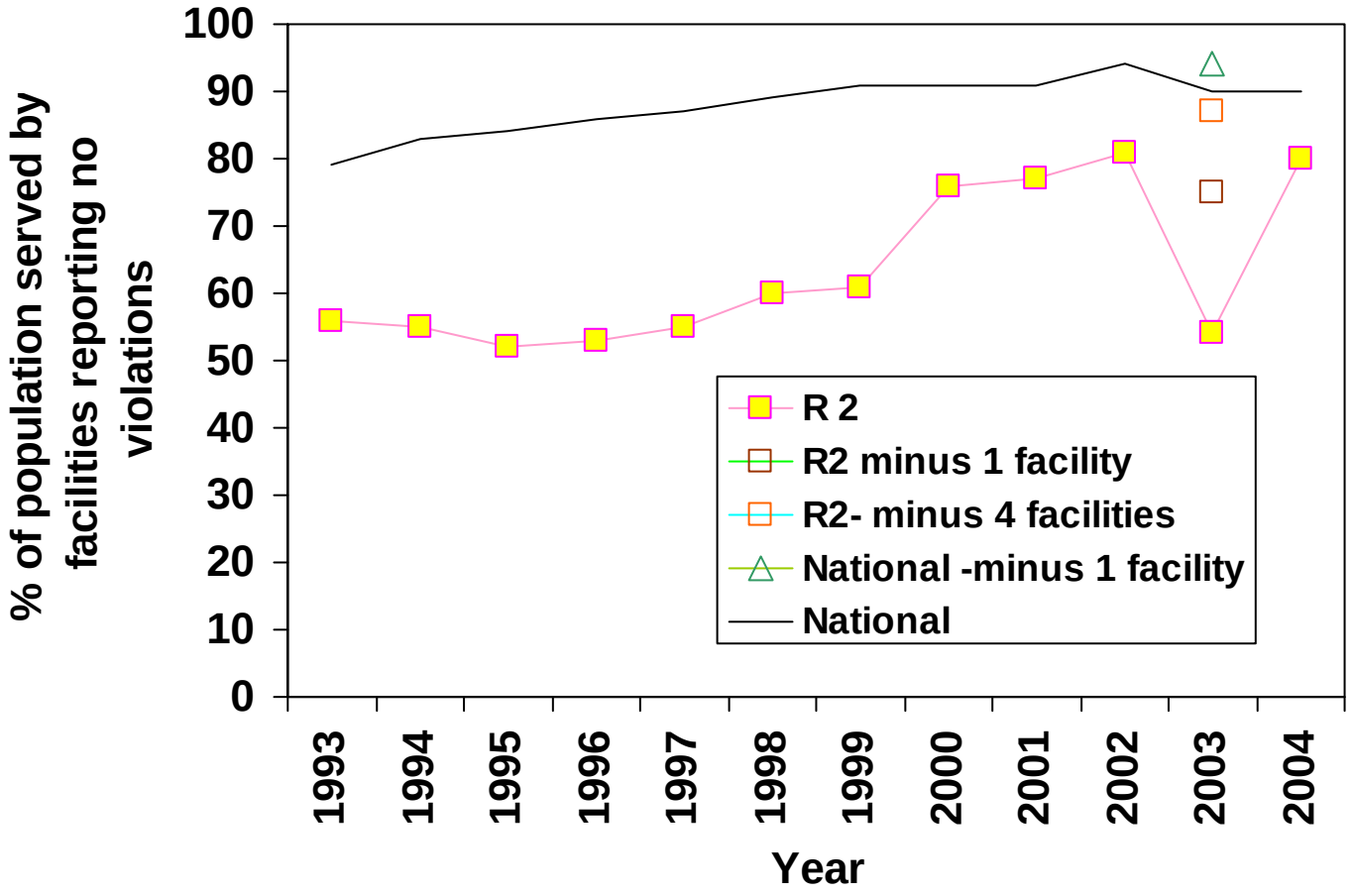


Importance of elephants (large facilities)



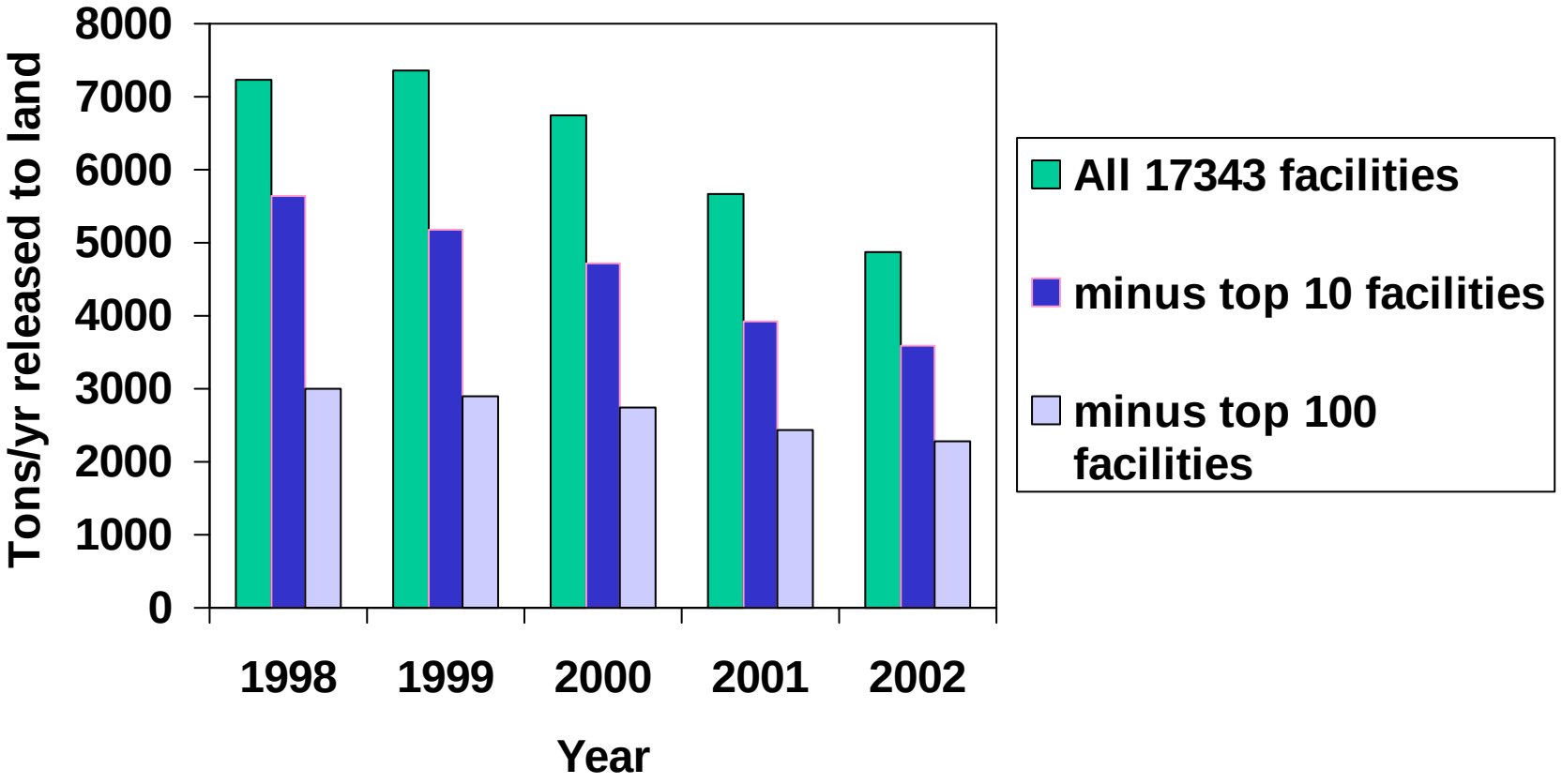
Importance of large facilities

Trends in Health-Based Violations at Community Water Systems



Importance of large facilities

Trends in TRI Releases to Land
(1988 core chemicals)



Take Home Messages

- When constructing performance indicators -
  - Consider their importance, sensitivity, measurement uncertainty, timeliness, and representativeness
  - Consider the potential importance of scale and hierarchy
  - Watch out for the elephants!

Or else ….