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From EMAP to NARS: How Monitoring Objectives and Institutions Influence Survey Design Research and Implementation

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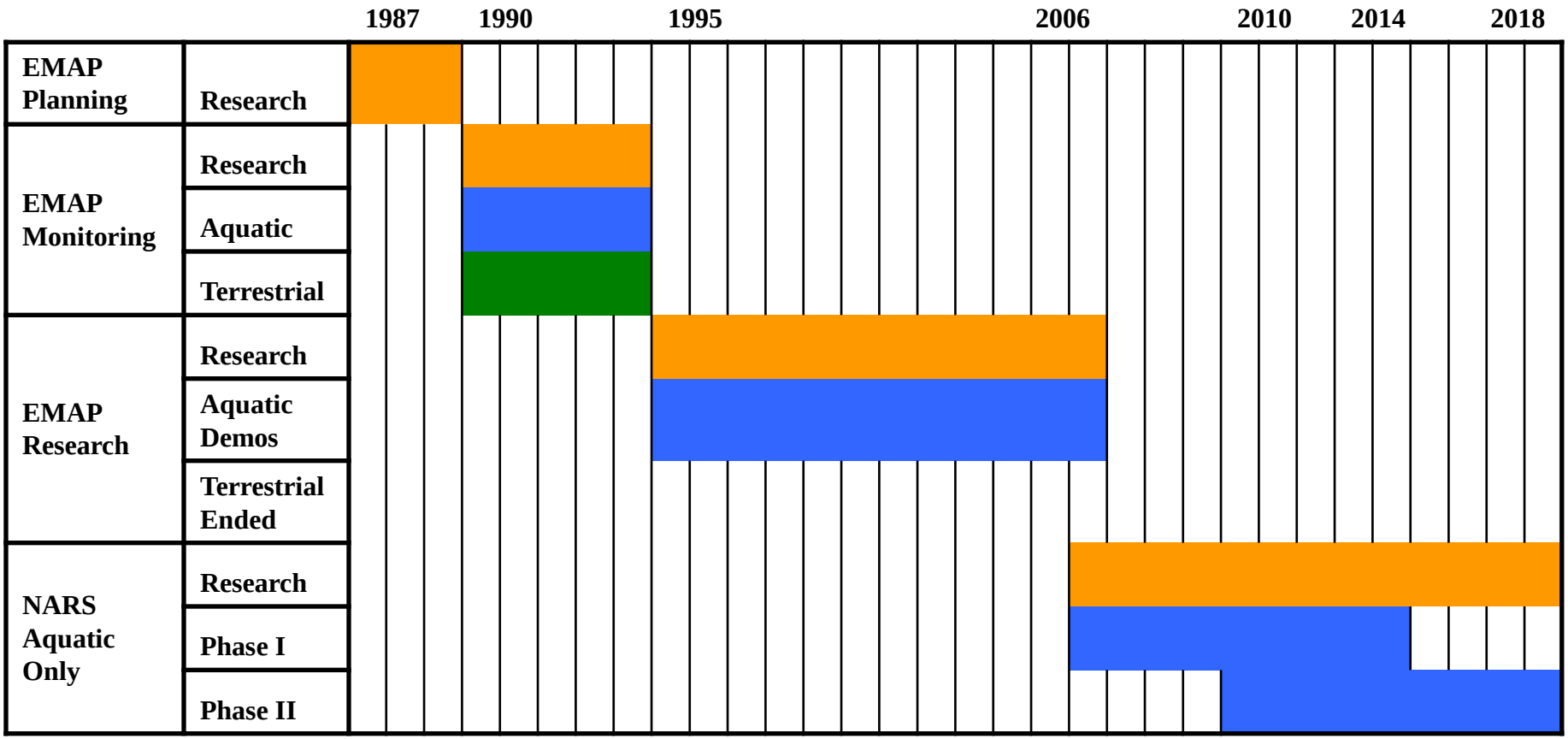
EMAP to NARS

- **EMAP: Environmental Monitoring and Assessment Program**
  - A national EPA program for monitoring ecological status and trends of all ecosystems
  - Led by USEPA Office of R&D with other federal and state agency partners
- **NARS: National Aquatic Resource Surveys**
  - An EPA program for monitoring status and trends of all aquatic ecosystems
  - Led by USEPA Office of Water with technical support by ORD and implemented with state partners

EMAP to NARS Time Line



EMAP Goals (Objectives)

- **To estimate current status, extent, changes, and trends in indicators of the Nation's ecological resources on a regional basis with known confidence**
- **To monitor indicators of pollutant exposure and habitat condition, and to seek correlative relationships between human-induced stresses and ecological condition that identify possible causes of adverse effects;**
- **To provide periodic statistical summaries and interpretive reports on ecological status and trends to the EPA Administrator and the public.**

Messer et al (1991) "An EPA program for monitoring ecological status and trends" Environmental Monitoring and Assessment 17:67-78

Environmental Monitoring and Assessment Program

RESOURCE MONITORING

- Landscape Ecology
  - Agroecosystems
  - Arid Ecosystems
  - Estuaries
  - Forests
  - Great Lakes
  - Lakes and Streams
  - Wetlands

INTEGRATION AND COORDINATION ACTIVITIES

- Statistics and Design
- Indicators
- Logistics
- Total Quality Management
- Air and Climate
- Landscape Characterization
- Information Management
- Integration and Assessment

DEVELOPMENTAL RESEARCH

- Biological/Ecological Indicators
  - Existing Indicators
  - New Indicators
  - Spatial and Temporal Changes in Indicators
- Assessment Methodologies
- Environmental Statistics

Federal/State Partners

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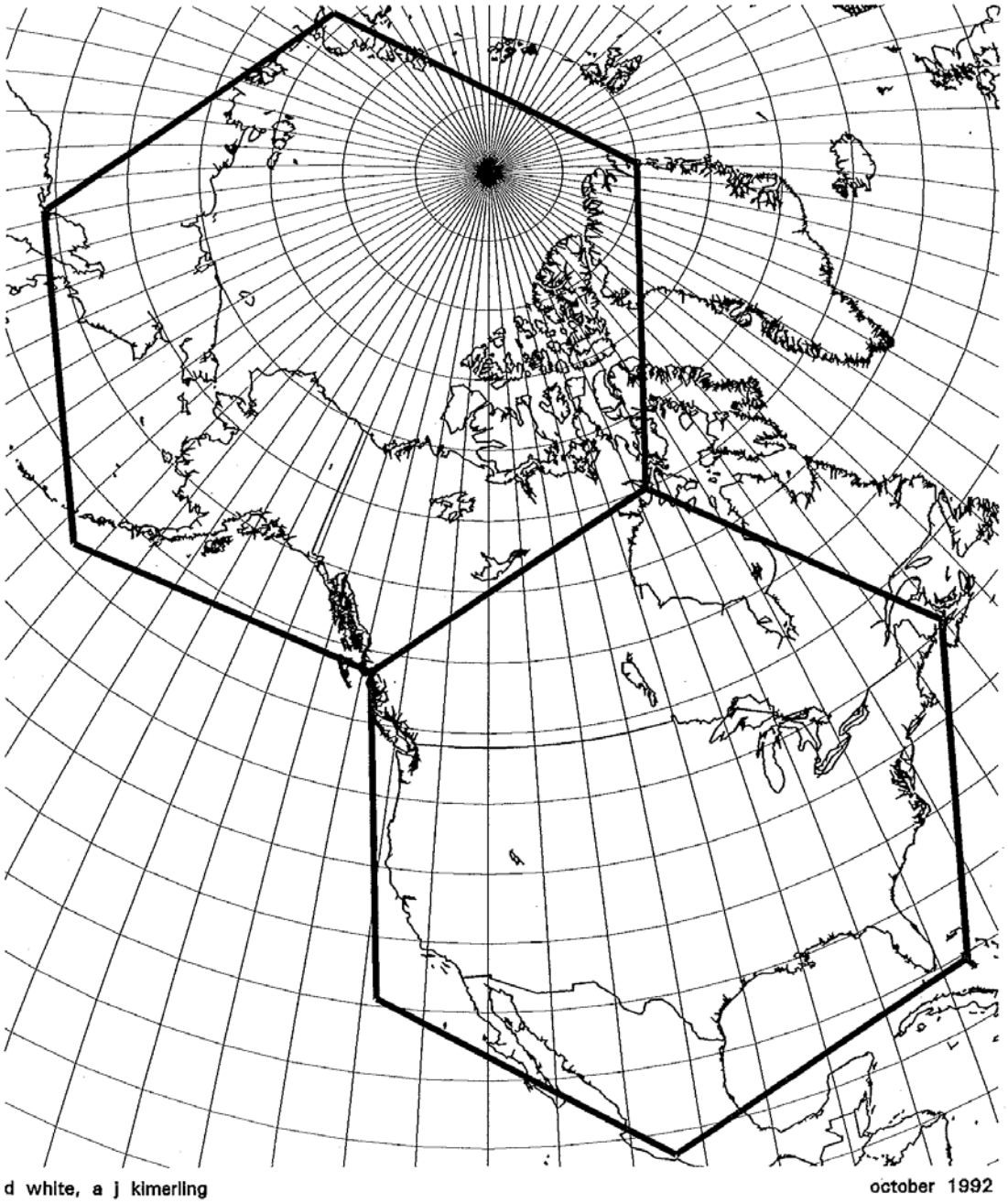
Is it possible to design a monitoring program with an integrated design for all ecological resources?

Extensive discussion of alternatives 1987-1990

EMAP hexagon origin: ecologists, statisticians, geographers



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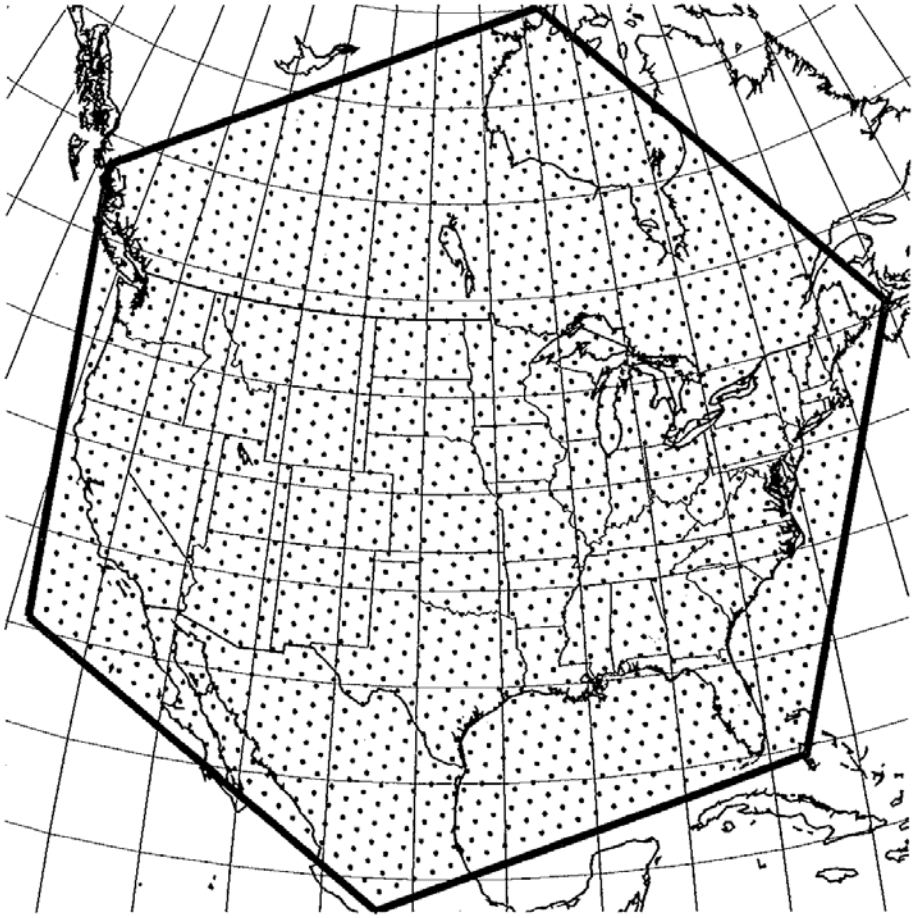
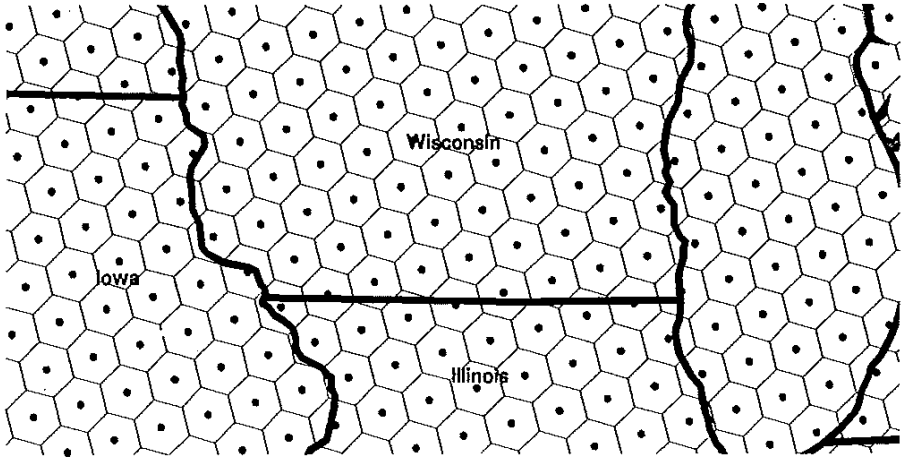
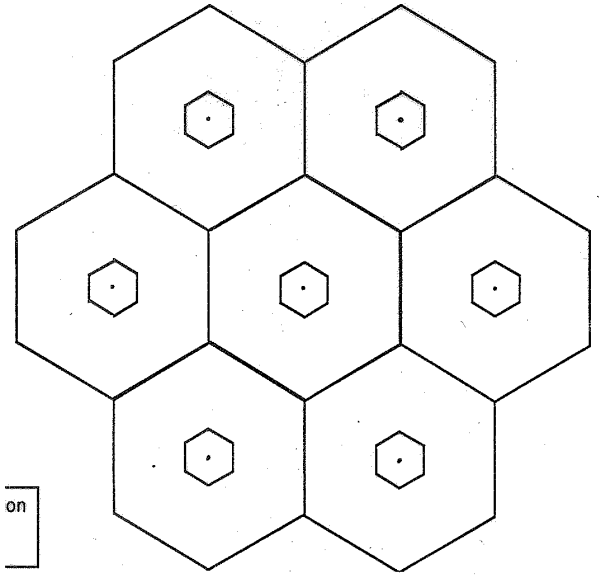
EMAP Sampling Grid Implementation



Point grid over the hexagon shown in reduced density



27 km point spacing; 635 sq km tessellation hexagons



EMAP Reduced Sampling Grid for Alaska

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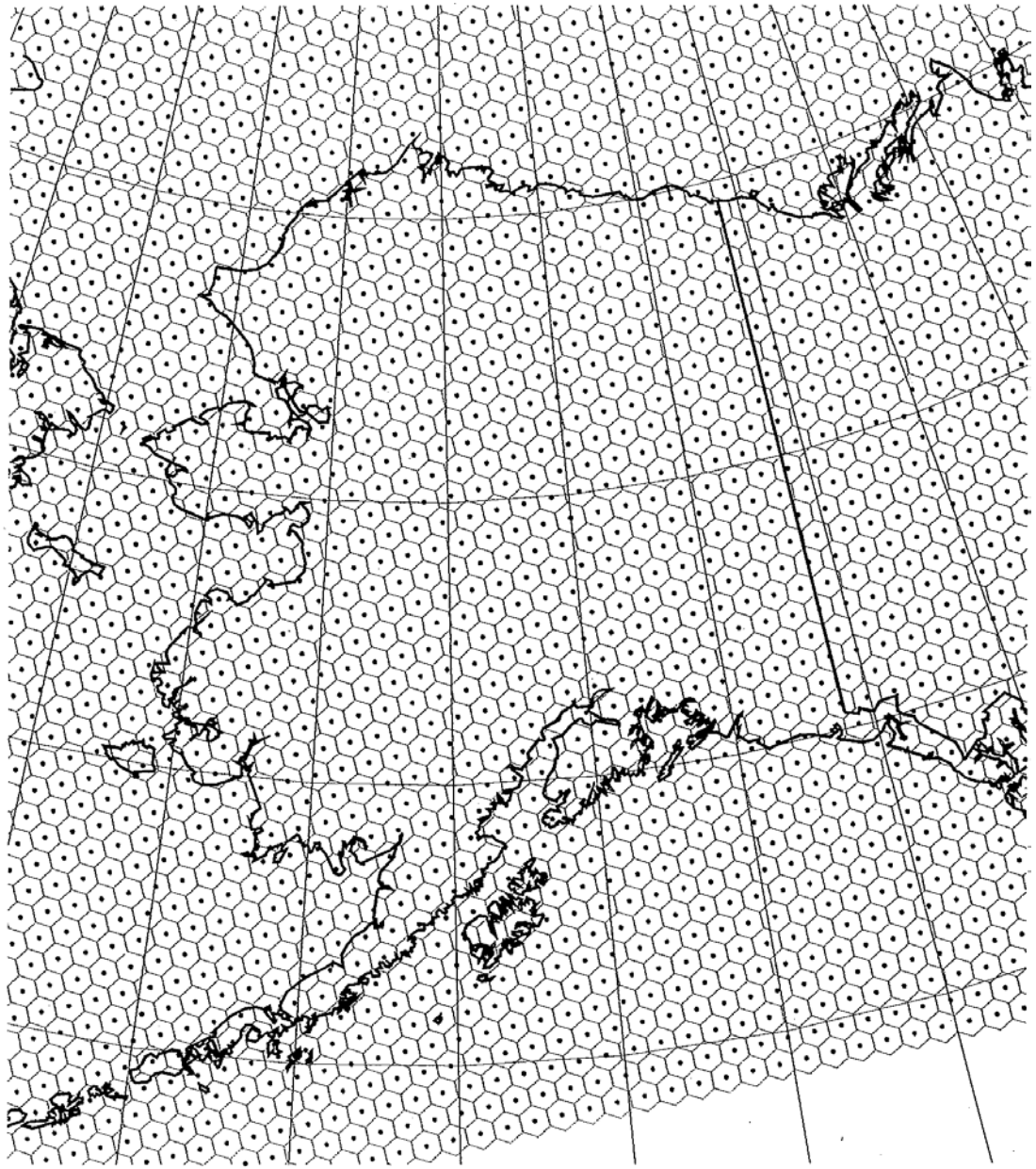
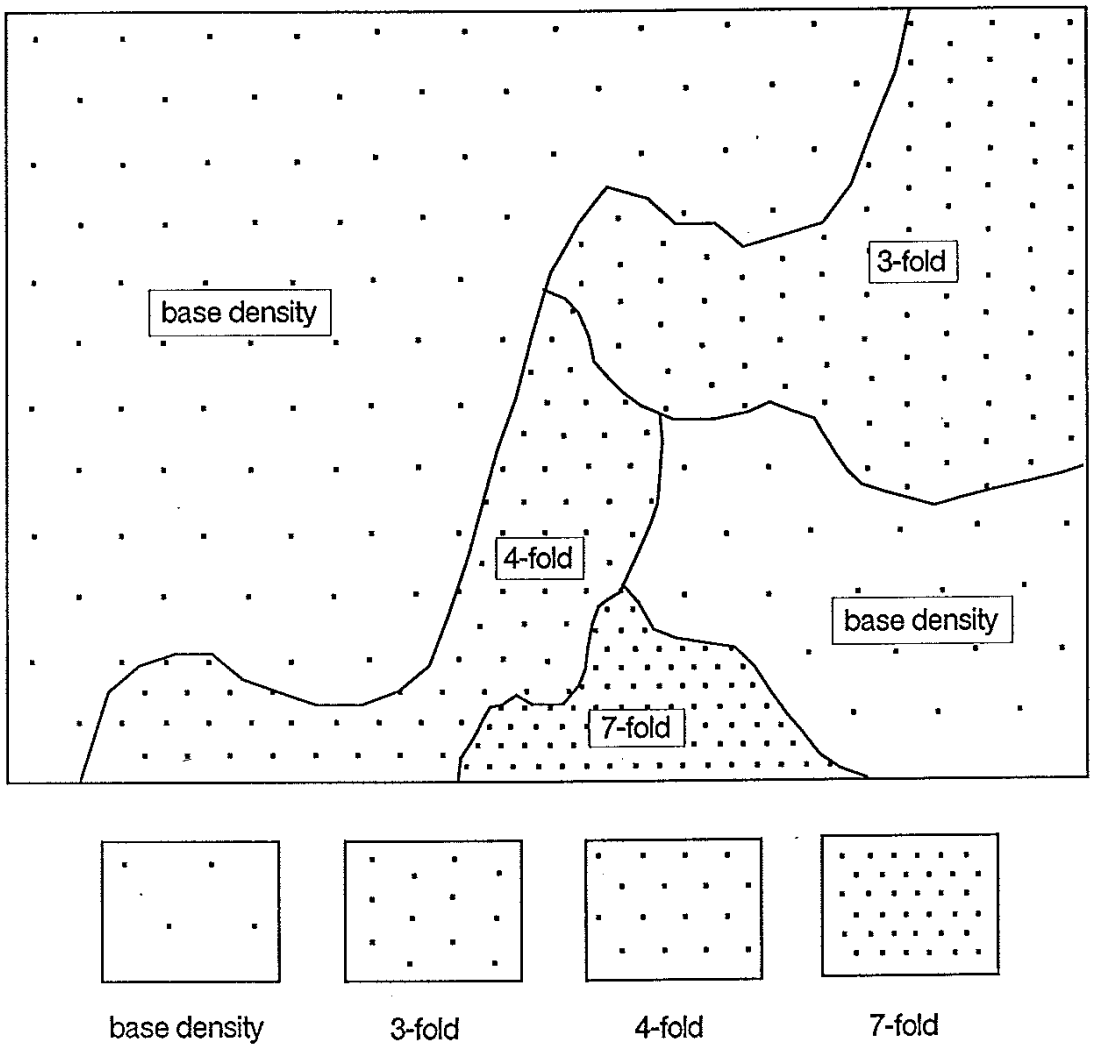


4-fold reduction, 54 km point spacing, 2500 sq km tessellation hexagons

d white, a j kimerling

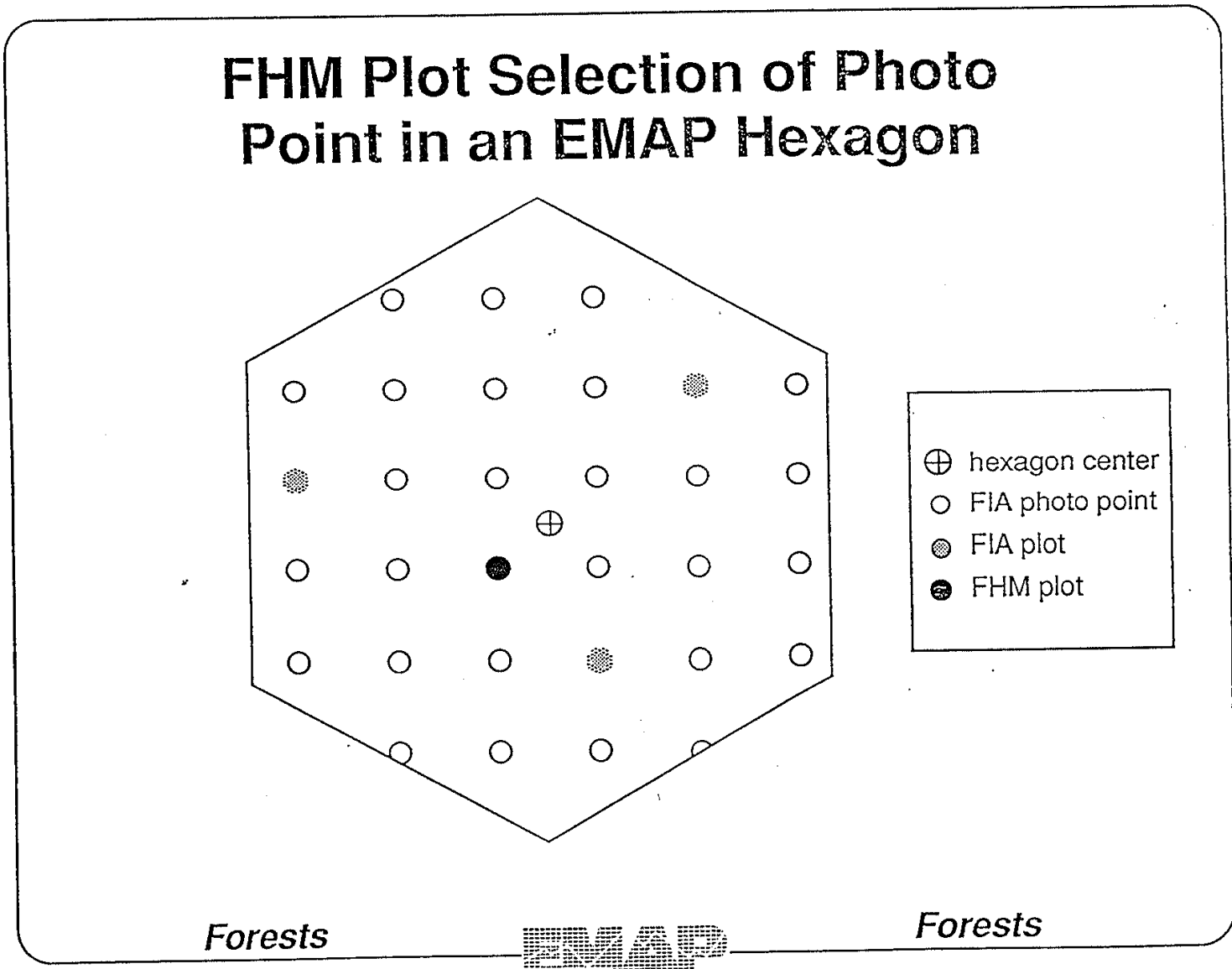
october 1992

Grid Density Enhancement



Enhancement factors for increasing the base grid density.

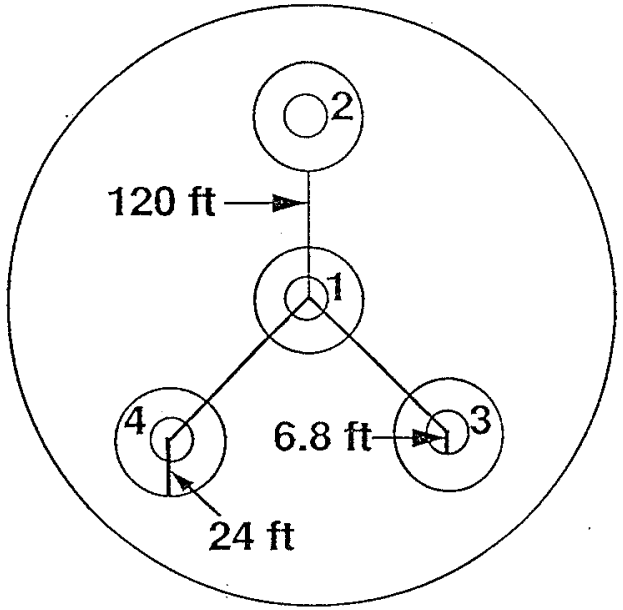
Example: Integrating existing program (FIA) with EMAP FHM (joint with USFS)



Indicator Response Designs

FHM Plot Design

1/24-Acre Each
1/6 - Acre Total



Azimuth 1-2 = 360
Azimuth 1-3 = 120
Azimuth 1-4 = 240

Area = 1 Hectare

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Emphasized:

precise, quantitative statement of objectives

and

specification of data quality objectives

Status Target DQO

- For each indicator of condition and resource class, on a regional scale, estimate the proportion of the resource in degraded condition within 10% (absolute) with 90% confidence based on four years of sampling.
- Example: If the estimated percent degraded is 15%, then the 90% confidence interval is from 5% to 25%.

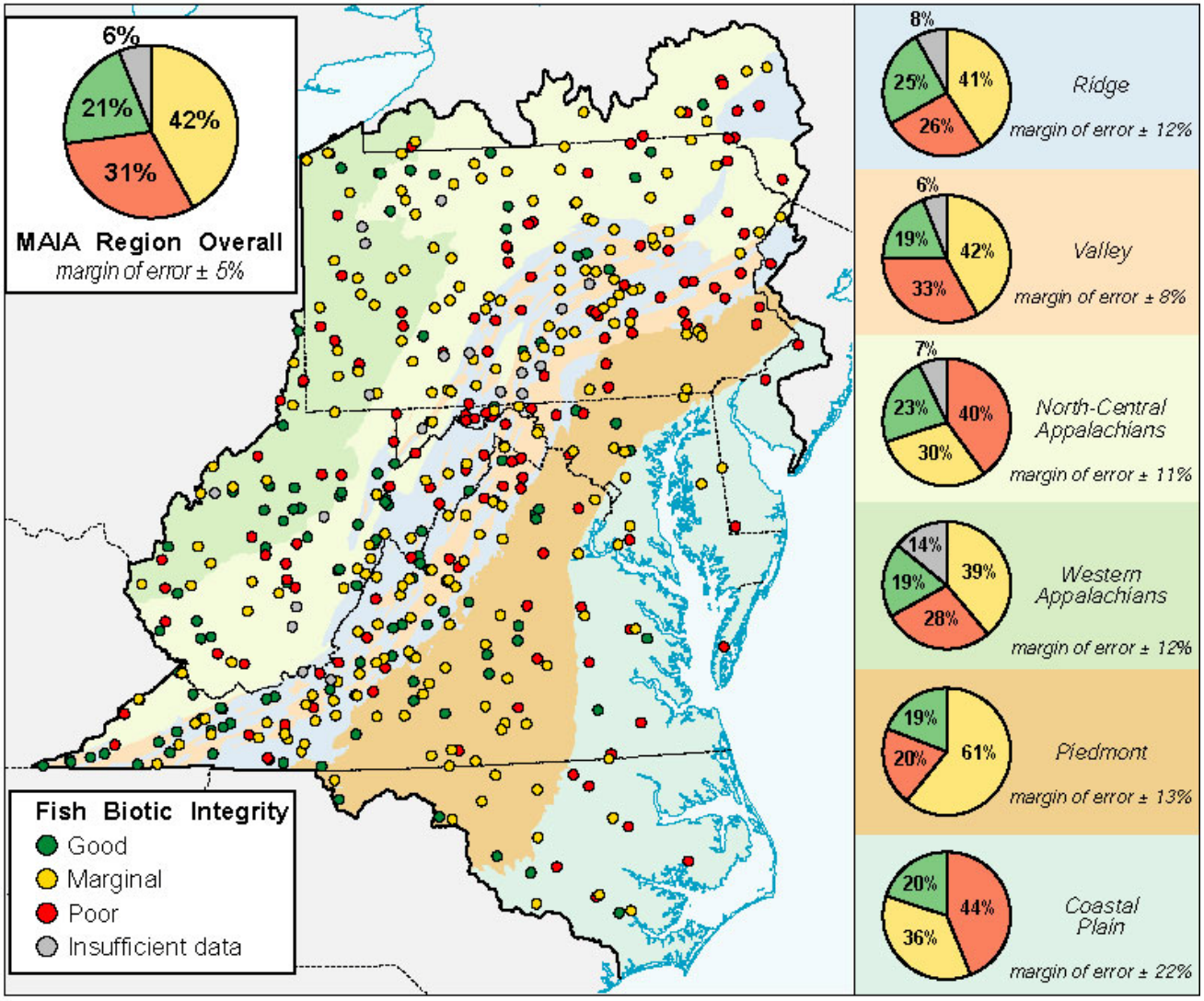
Trend Target DQO

Over a decade, for each indicator of condition and resource class, on a regional scale, detect a linear trend of 2%(absolute) per year, i.e. 20% change for a decade, in the percent of the resource class in degraded condition. The test for trend will have a maximum significant level of $\alpha = 0.2$ and a minimum power of 0.7 ($\beta = 0.3$).

EMAP Organization Operation

- Focus on biological/ecological condition indicators with physical habitat and stressor indicators included to look at associations
- Cost per site ranged from $4,000 to $8,000. Includes all field operation and associated laboratory analyses.
- Constraint: crew of 2-4 take one day per site
- Central core staff designed study, led implementation, did data management, completed analyses and wrote reports and journal articles
- Field operations combination of state staff, federal staff or contract staff depending on study.

Example Assessment: Streams



EMAP Monitoring Ends

NARS begins based on EMAP

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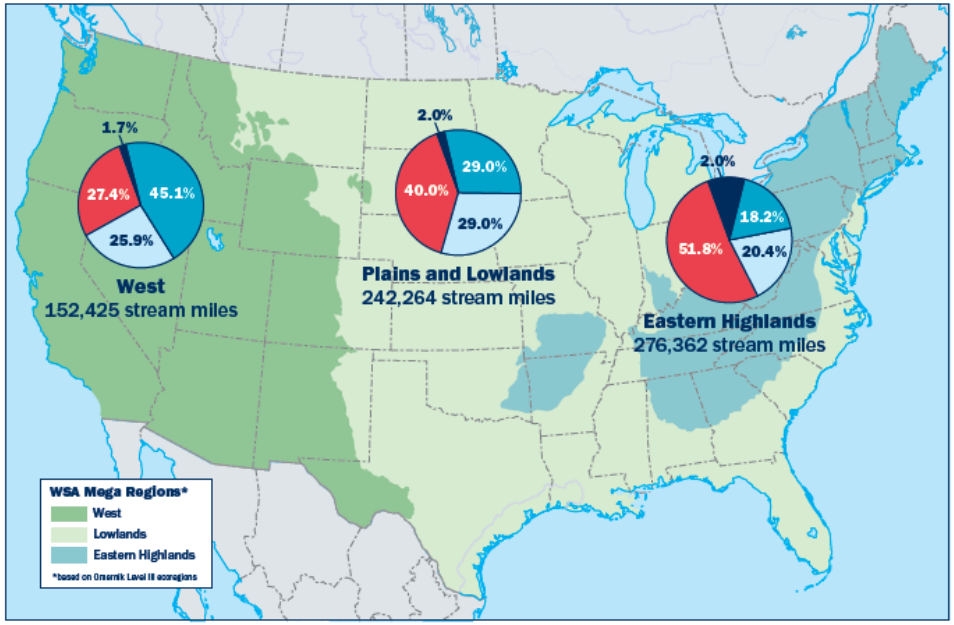
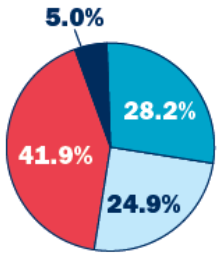
National Aquatic Resource Surveys

- **Purpose**
  - Report on the condition of the nation's waters
  - Help build state capacity for monitoring and assessment
  - Promote collaboration across jurisdictional boundaries in the assessment of water quality
- **Answer key questions**
  - What's the extent of waters that support healthy ecosystems, recreation, and fish consumption?
  - How widespread are the most significant water quality problems?
  - Is water quality improving?
  - Are we investing in restoration and protection wisely?

Wadeable Stream Assessment Results

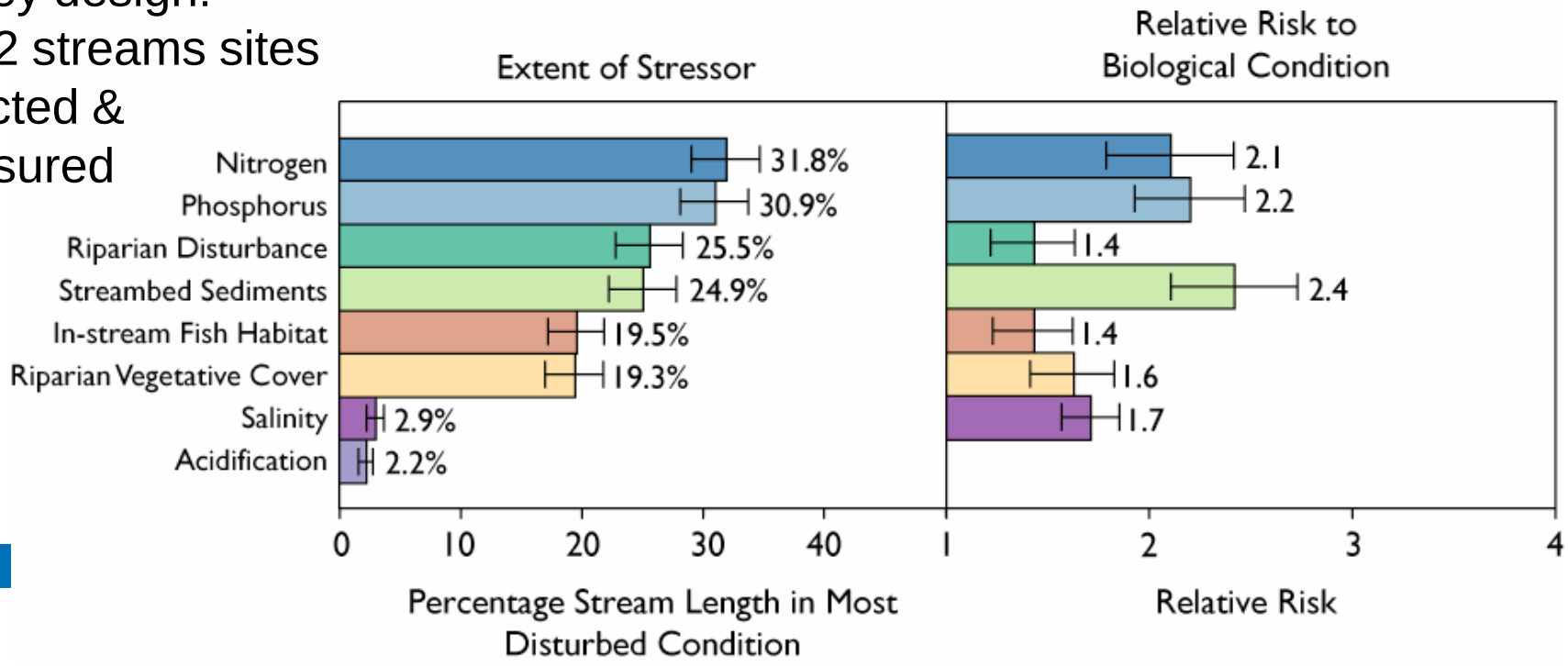
Spatially balanced survey design:
1,392 streams sites selected & measured





National Biological Quality

Good
Fair
Poor
Not Assessed



National Aquatic Resource Surveys

	2006	2007	2008	2009	2010	2011	2012
Lakes	Design Research	Field Research	Lab, data Research	Report Research	Evaluate & Design	Operational Preparation Research	Field Research
Rivers Streams	WSA Report Research	Design Research	Field: Lab/Data Research	Field: Lab/data Research	Lab, data Research	Report Research	Evaluate & Design
Coastal	Lab, data Research	NEP Coastal Report Research	Evaluate & Design NCA III Rpt	Operational Preparation Research	Field Research	Lab, data Research	Report Research
Wetlands	Research	Research	Planning Research	Evaluate & Design Research	Operational Preparation Research	Field Research	Lab, data Research

NARS Organization & Operation: Joint federal-state-tribal partnership

- EPA Office of Water leads
- EPA Office of Research & Development (former EMAP staff) technical support/research
- Working groups define target population, subpopulations, indicators, field protocols
- Core staff: funding, survey design, field manuals, training, field implementation coordination, information management, data analysis and report preparation
- States and Tribal Nations: field implementation with option to use contract staff

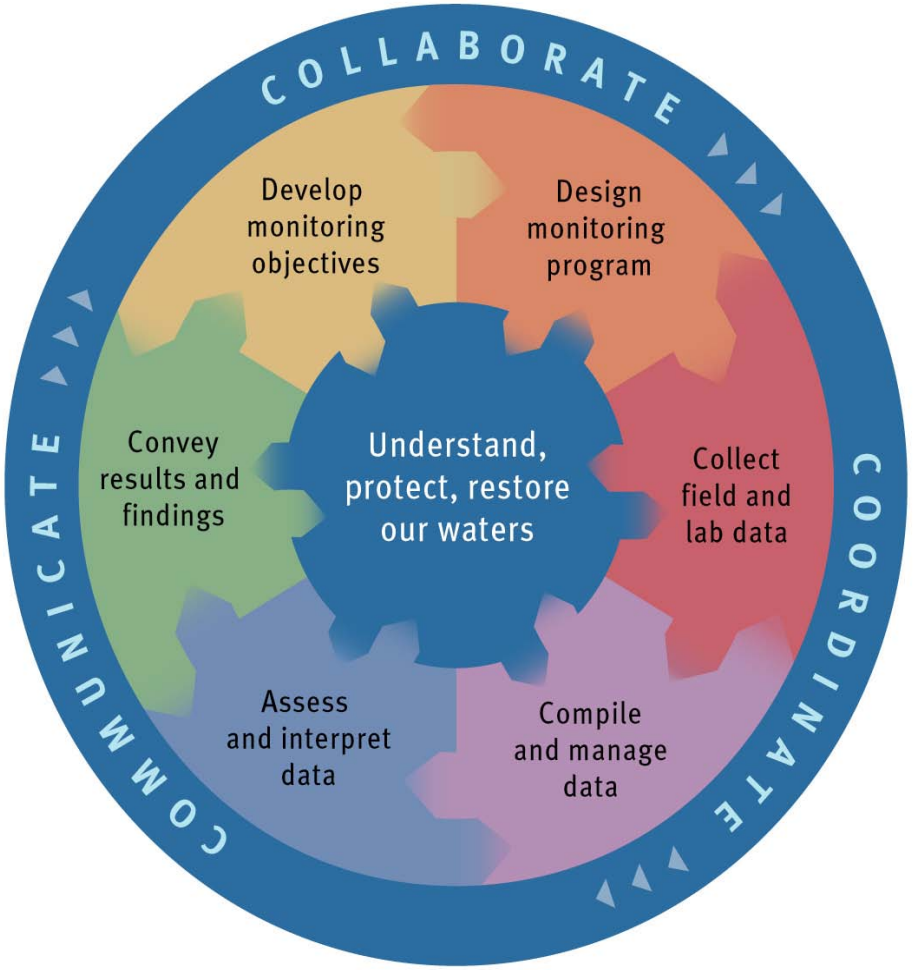
NARS Implementation

- Survey design
  - Spatial design: spatially-balanced, stratified, unequal probability
  - Temporal design: Repeat aquatic resource every 5 years, 50% sites revisits from prior survey
  - Response design: depends on indicator and aquatic resource
- Sites, costs, laboratory analyses, protocols
  - 1000 site-visits per aquatic resource (lakes, streams, rivers, coastal waters, wetland): 900 unique sites; 100 revisits
  - Field and laboratory costs per site: $8,000
  - Laboratory analyses: central lab preferred
  - Field measurement protocol same nationally
- States have option of monitoring additional sites to make state-level estimates

Indicators & Special Studies

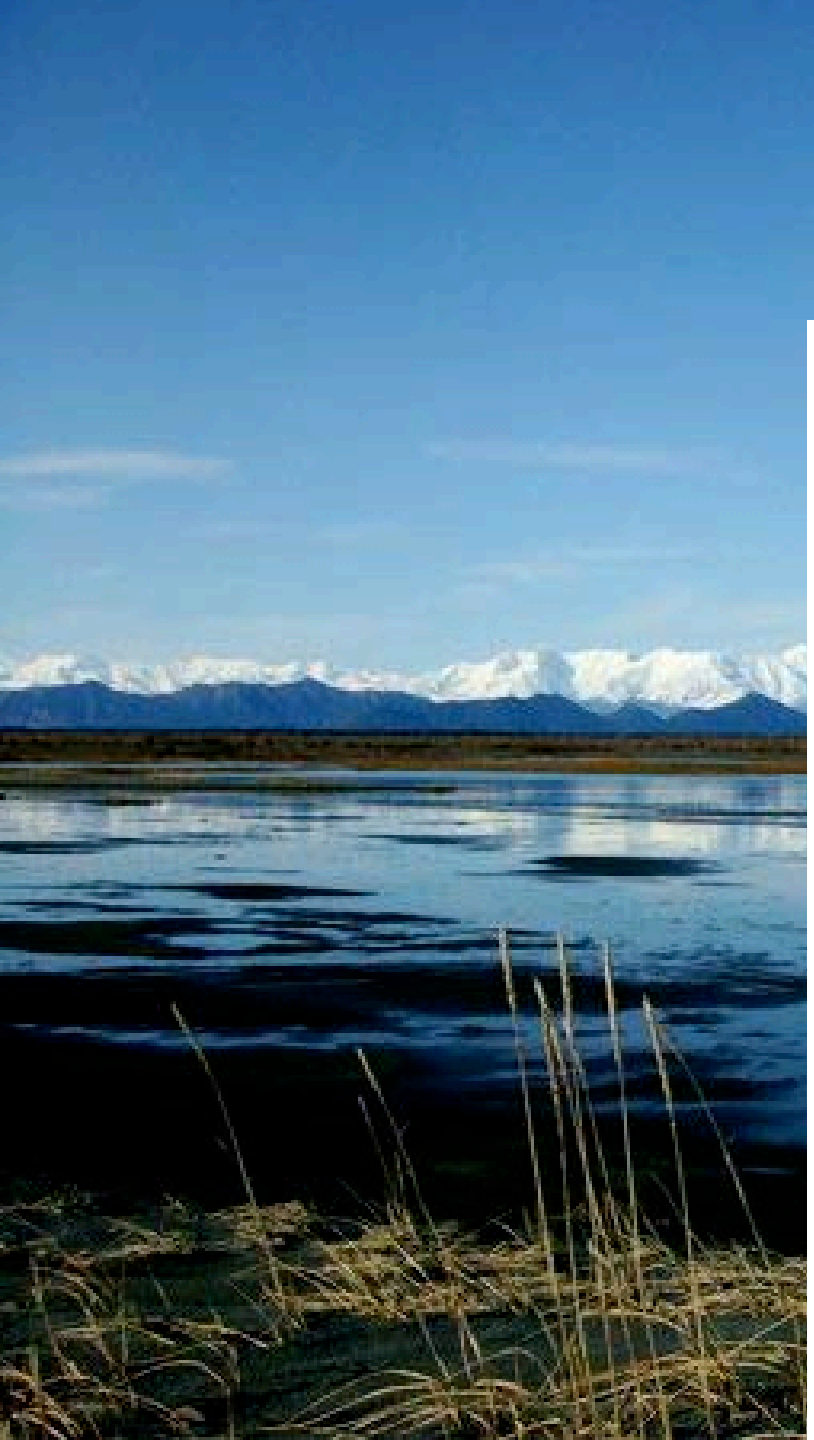
- Core indicators
  - Included in monitoring program for long term
  - Changes in protocols only made when weaknesses identified
- Supplemental Studies
  - Short-term study to meet special need
    - Requires supplemental funding to cover additional laboratory cost or additional sites
    - Reduces cost by leveraging NARS core surveys
  - Research indicator studies
    - New indicators requiring demonstration before being considered as core indicator
    - May not be measured at all sites

National Water Quality Monitoring Council: Monitoring Framework

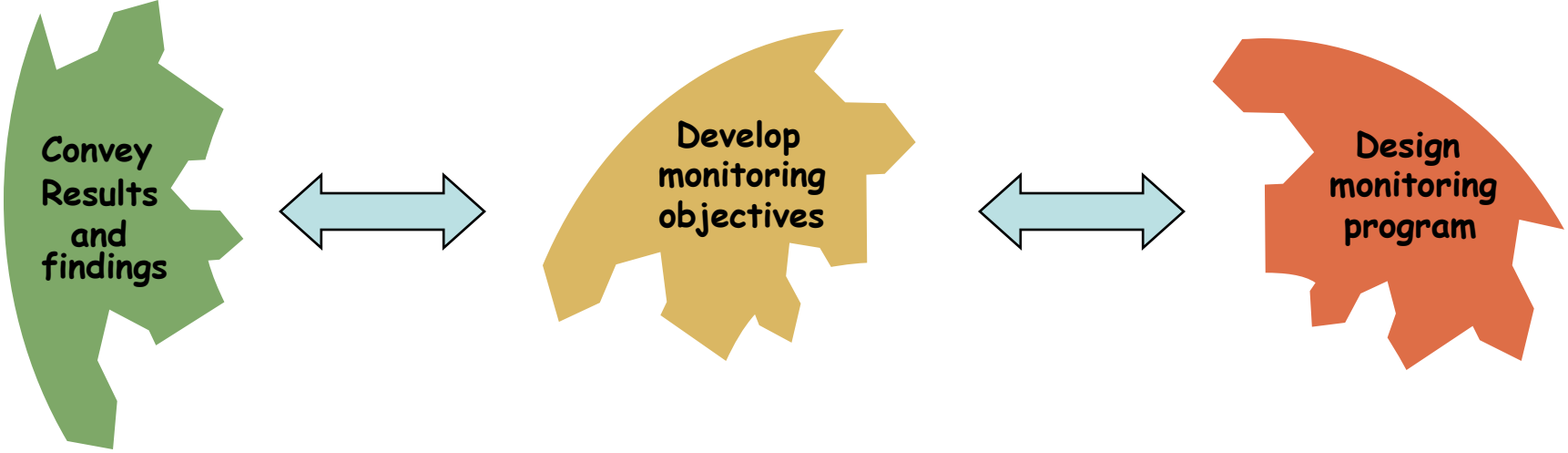


- View as information system
- Monitoring pieces must be designed and implemented to fit together
- Comprehensive monitoring strategy can become central organizing approach
- Assessment monitoring requires consistent framework by federal, state, and tribal nation partners

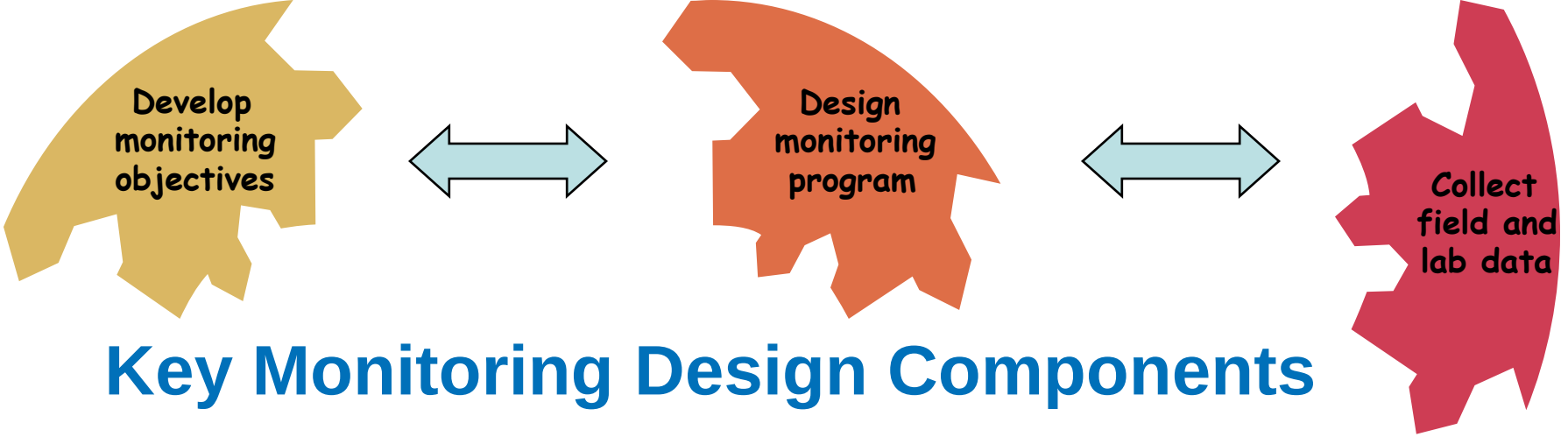
- Reference: Water Resources IMPACT, September 2003 issue




COLLABORATE
COORDINATE
COMMUNICATE
Develop monitoring objectives
Design monitoring program
Collect field and lab data
Compile and manage data
Assess and interpret data
Convey results and findings
Alaska Ecoregional Monitoring Partnership



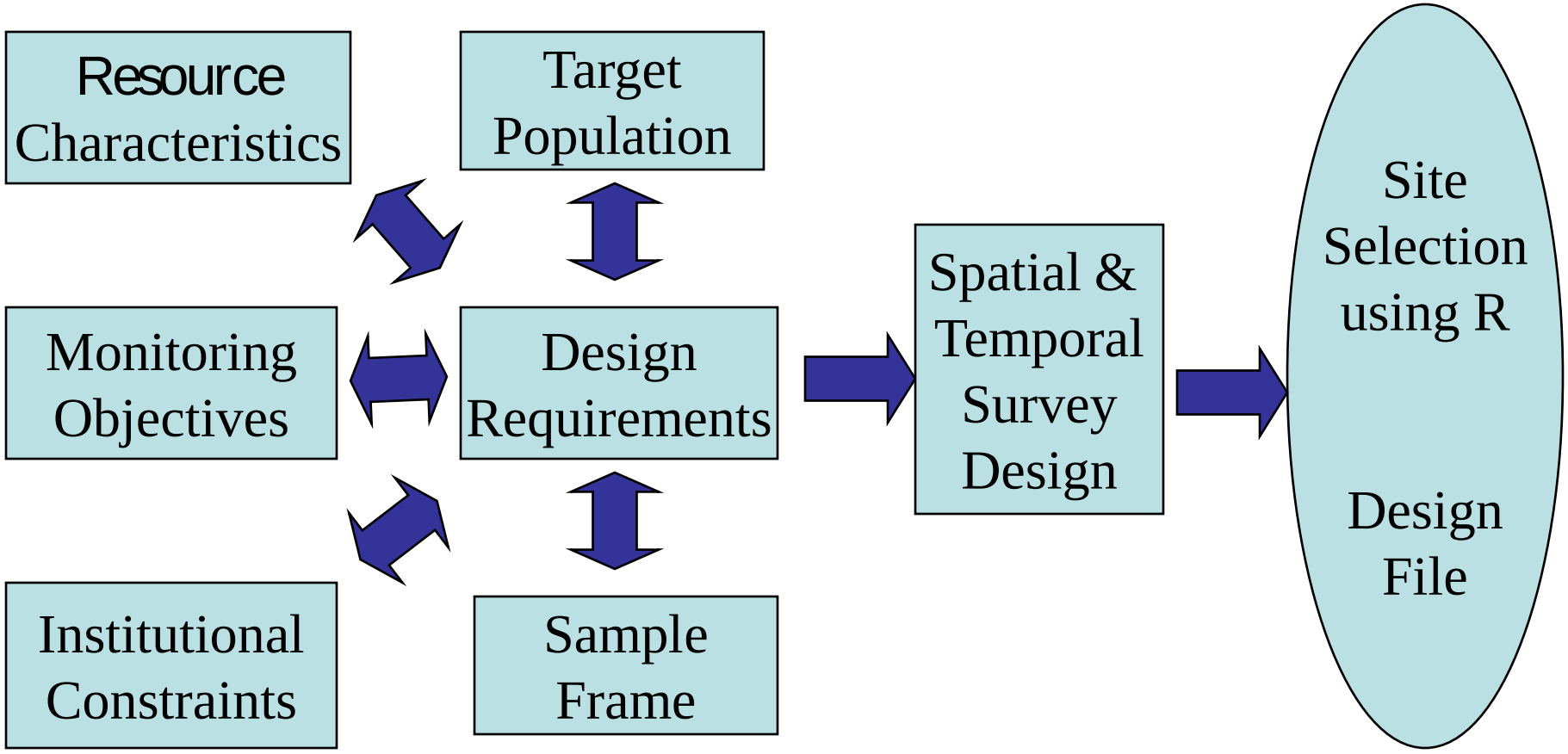
- Initially objectives are stated in common sense statements
  - challenge is to transform them into quantitative questions that can be used to specify the design
  - Useful to define tables and graphics that will appear in final report
- Kish (1965): “The survey objectives should determine the sample design; but the determination is actually a two-way process…”



Key Monitoring Design Components

- **Ecological resource to be monitored**
  - Target population: precise definition required
  - Sub-populations: Are estimates required for specific subsets?
  - Report Times: When are results required to be reported?
- **Ecological indicators to be reported**
  - What will be measured?
  - How will they be measured?
  - How will they be summarized to create metrics and indices?
- **Monitoring survey design**
  - Spatial design (Site selection): Where will the measurements be taken?
  - Temporal design: When will sites be revisited and which ones?
  - Response design: What is the field plot design and calculation methods to obtain indicator value for a site?

Spatial & Temporal Survey Design Process



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Is it conceptually feasible to visit and make measurements at all or nearly all potential sites in the study region?

- If yes, then options to select sites are
  - Census
  - Survey design
  - Model-based design (geostatistical, process, empirical)
- If no and can not construct list of feasible sites, then observational (judgment) site selection
- If no and can construct list of feasible sites, then options
  - Survey design
  - Model-based design

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Selecting a monitoring design

- Observational, model-based, survey design
- Single stage, multiple stage, multiple phase
- Auxiliary information available to focus design: Equal, Stratified, Unequal, Stratified Unequal
- Spatial balance over study region: IRS, GRTS, SYS
- Decision to continue sampling based on observed results at site: adaptive sampling, no adaptive sampling