

*NPS WRD Annual Meeting and I&M Wetland Meeting,  
February 12-15 2008, Fort Collins*

# Rocky Mountain I&M Network Wetland Ecological Integrity Long-term Monitoring Protocol



## *Summary of Pilot Project and Overall Strategy*

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# I&M Wetland Monitoring

## 'Follow Up' Meeting

- This talk is a general and topical summary
  - 20 minutes!
- Details and more content in follow up I&M Wetland Meeting this Thursday afternoon and Friday morning, here in the Hilton
- Any and all welcome
- Please talk to Brian Mitchell or me

# Talk Contents

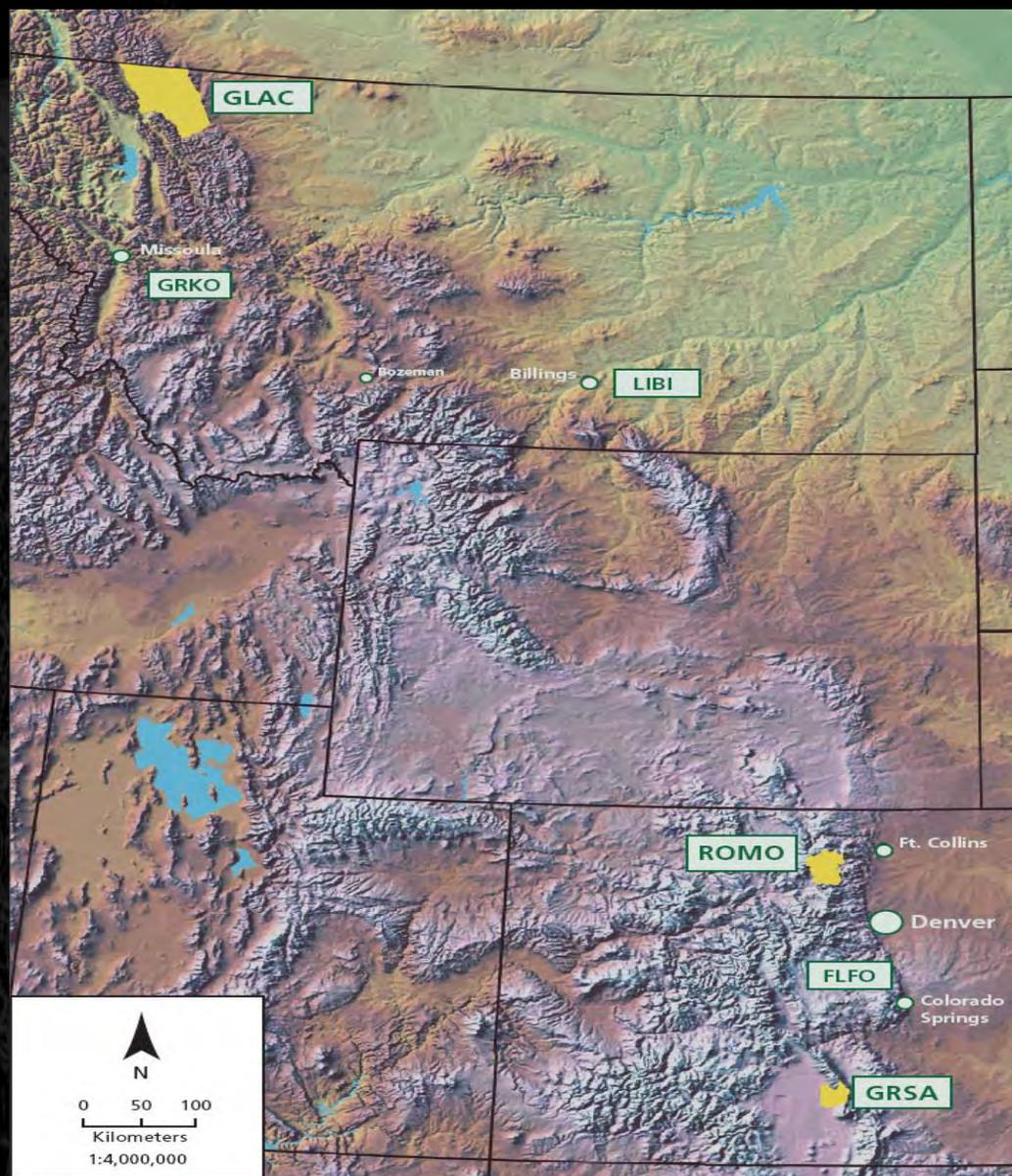
- ROMN Network and Vital Signs
- Wetland Protocol Objectives and Pilot
- Sample Design
- Response Design and Measures
- Preliminary Results and Analyses in Progress

# ROMN Vital Signs Network

- Six parks

1. Glacier NP
2. Grant-Kohrs Ranch NHS
3. Little Bighorn Battlefield NHS
4. Rocky Mountain NP
5. Florissant Fossil Beds NM
6. Great Sand Dunes NP

- Phase 4 complete
  - Several protocols in production



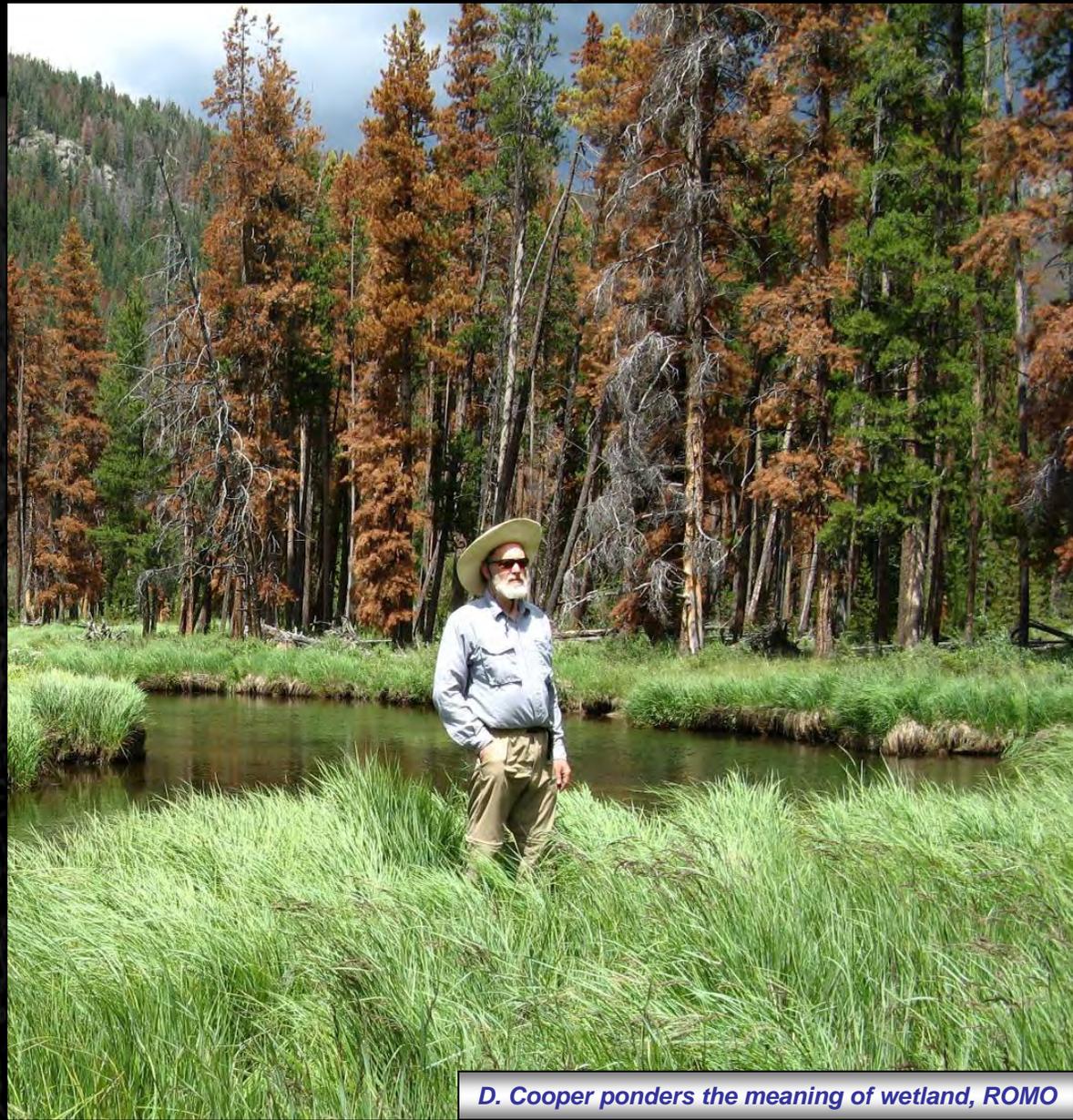
# Vital Signs of the ROMN

- \*Landscape dynamics
- \*Weather and climate
- Wet and dry deposition
  - \*Snow chemistry
- \*Vegetation and soil
  - Shrub-grasslands
  - Alpine: GLORIA
- Focal species
  - Grizzly bear, elk, beaver, endemic sand dune insects
- Invasive exotic plants
- Invasive aquatic biota
- Alpine Lake Ecological Integrity
- \*Wetland Ecological Integrity (WEI)
  - [Focus of this talk]
- \*Stream Ecological Integrity
  - Similar approach as used with wetlands
  - Integrated survey, sentinel and gradient designs
  - Benthos and periphyton
    - Bioassessment: MMI and O:E
  - Q and physical habitat
  - Water chemistry
  - Field methods derived from EMAP and USGS
  - Currently in 2<sup>nd</sup> year of pilot in Glacier

*List is in not in priority order*

*\*Indicates active current development by ROMN or a partner*

# Wetland Objectives and Pilot



# Wetland Protocol Highlights

- Integrated, long term monitoring of wetland ecological condition
- Multiple monitoring objectives and goals... all essentially distill to quantifying 'status and trend in wetland condition'
- Emphasis on
  - Bioassessment using wetland vegetation
    - MMI and O:E models
  - Ground water hydrology
    - IHA, RHeSSYS and other models
- Explicit reference conditions for assessment of wetland biological response
- Park and site specific spatial scales
  - Valid inference of status at park scale
- Annual trend at select sites
  - Power for park-scale trend will accrue more slowly

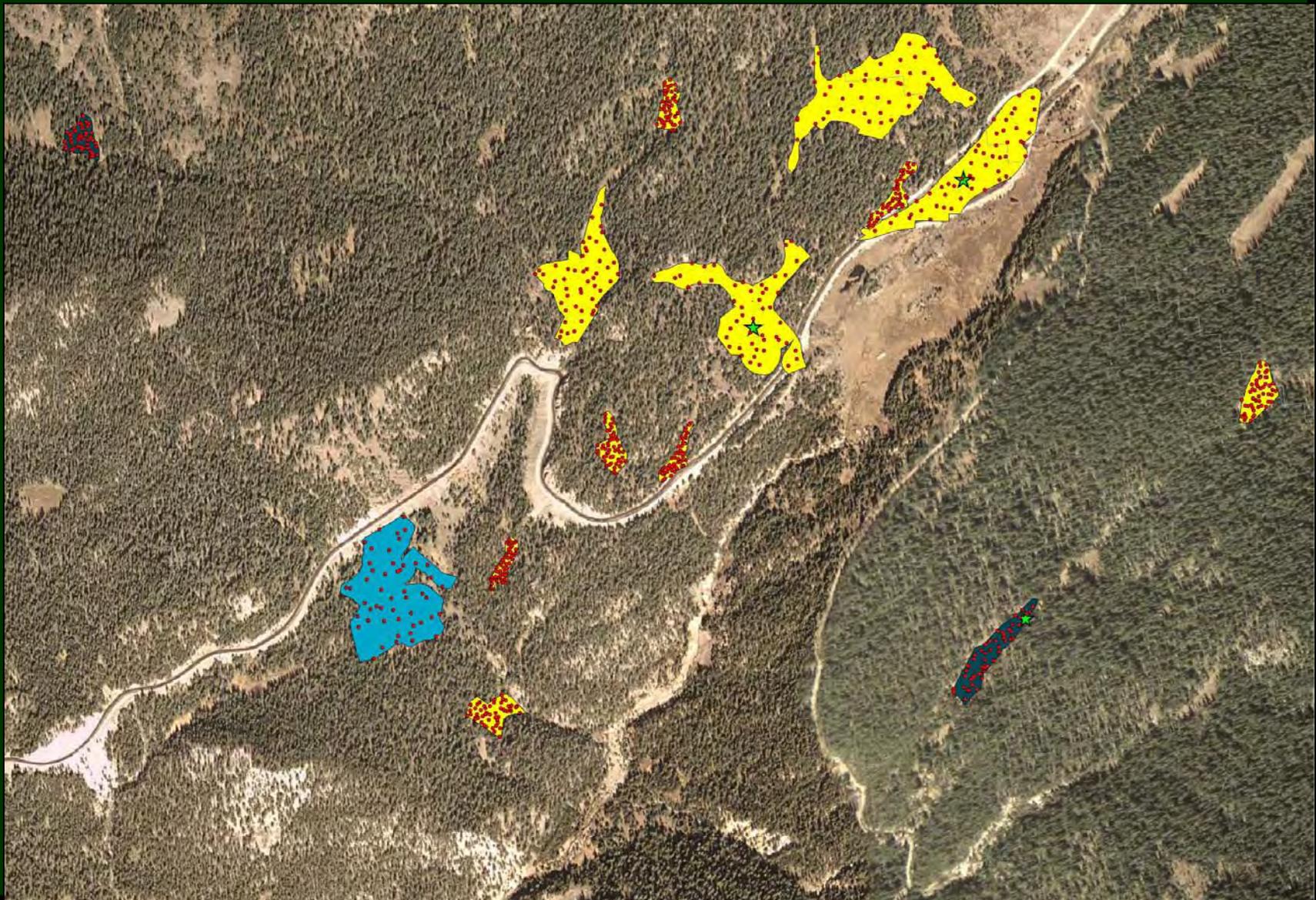
# Pilot

## Rocky Mountain National Park

- 3+ year study
  - Colorado State University co-PIs
  - Close collaboration with the park and CNHP
  - EPA National Wetland Survey
  - Working with other Networks (esp. SIEN that has a nearly identical effort)
- Why ROMO?
  - Wetland issues... elk-beaver-willow; direct hydrologic modification and indirect via climate change, nutrient deposition, invasive taxa, etc.
  - Lots of existing D. Cooper and CNHP work
- Pilot objectives
  - Develop field methods and costs
  - Specify sample sizes and frequency
    - The ideal or the consequences of the affordable
  - Create baseline reference conditions
  - Interpret and recalibrate existing MMI models
  - Begin to create novel O:E models
  - Publish as peer reviewed protocol



# Sample Design

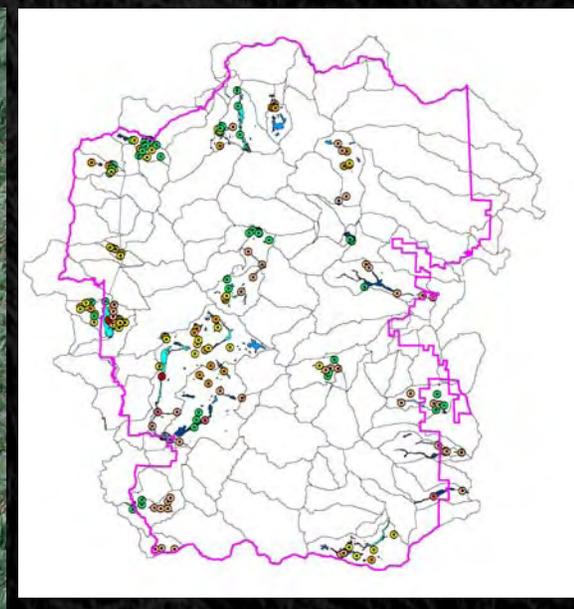
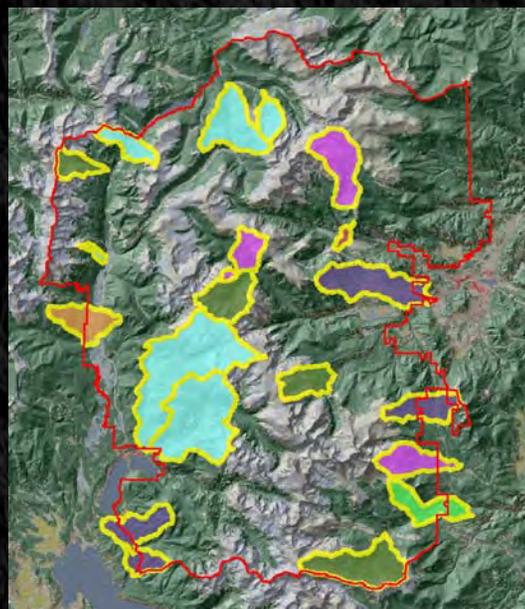
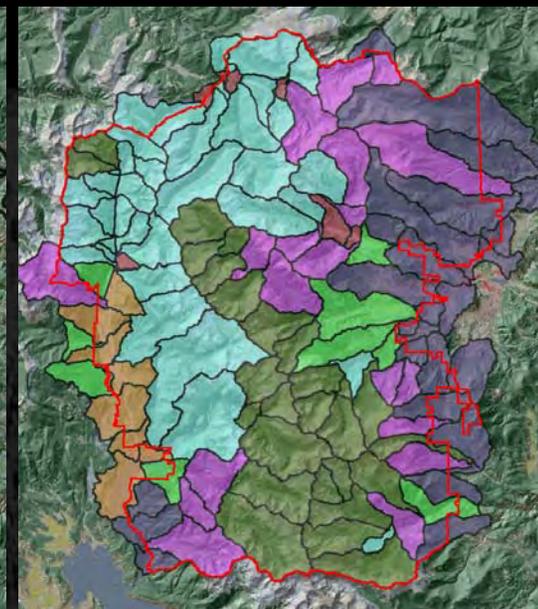


# Sample Design Types

- Four design forms within the WEI protocol:
    - All have spatial and temporal components
    - All **integrated** with one another via varying degrees of shared field methods, QA/QC and analysis:
1. Probabilistic **survey** design
  2. Hand-picked or targeted **sentinel** design
  3. Model-based **gradient** design
  4. Large-scale harvesting of data from existing designs
    - Research component of pilot

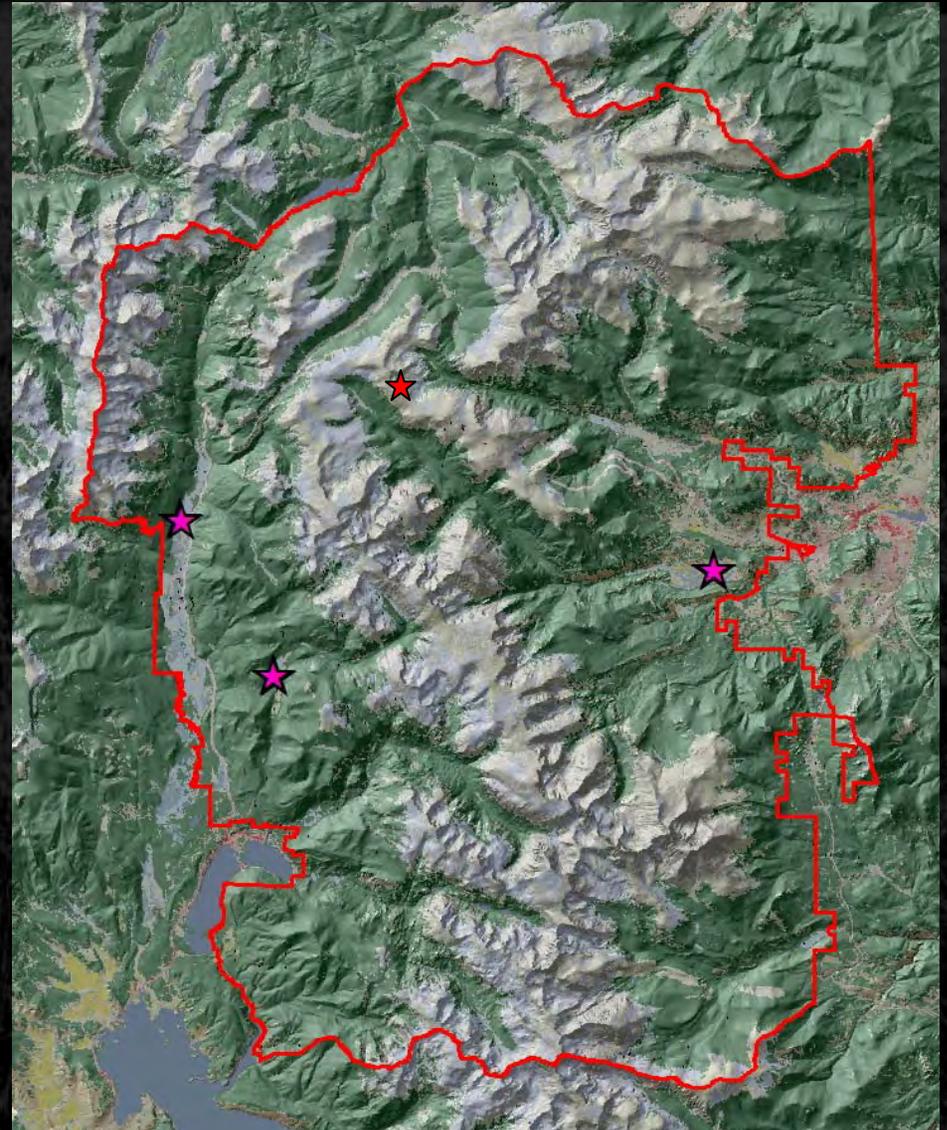
# Survey

- Three stage GRTS (probability survey)
  - 1<sup>st</sup> stage: Watersheds
    - Basin type strata from cluster analysis of drivers
  - 2<sup>nd</sup> stage: Wetland complexes
    - Three wetland types (fen, wet meadow and riparian) from VegMap-topography-expert review frame
    - Underlain by a cost surface
    - Design uses unequal weighting across wetland type-cost subpopulations
    - 30-35 per type, basis in CI for proportions, but will be adjusted pending other power analyses
    - Sampled episodically (5 to 10 years)
  - 3<sup>rd</sup> stage (part of response design): Actual candidate sample locations within a complex
    - Dense array of points per complex
    - Points evaluated in design order within a complex until best (based on explicit criteria) site found
  - Why?
    - Statistically valid, unbiased park-scale inference of status
    - Complexity required given nature of wetland (sample frame, etc.) (but design is probably over specified)
    - Will fit with National Wetland Survey



# Sentinel

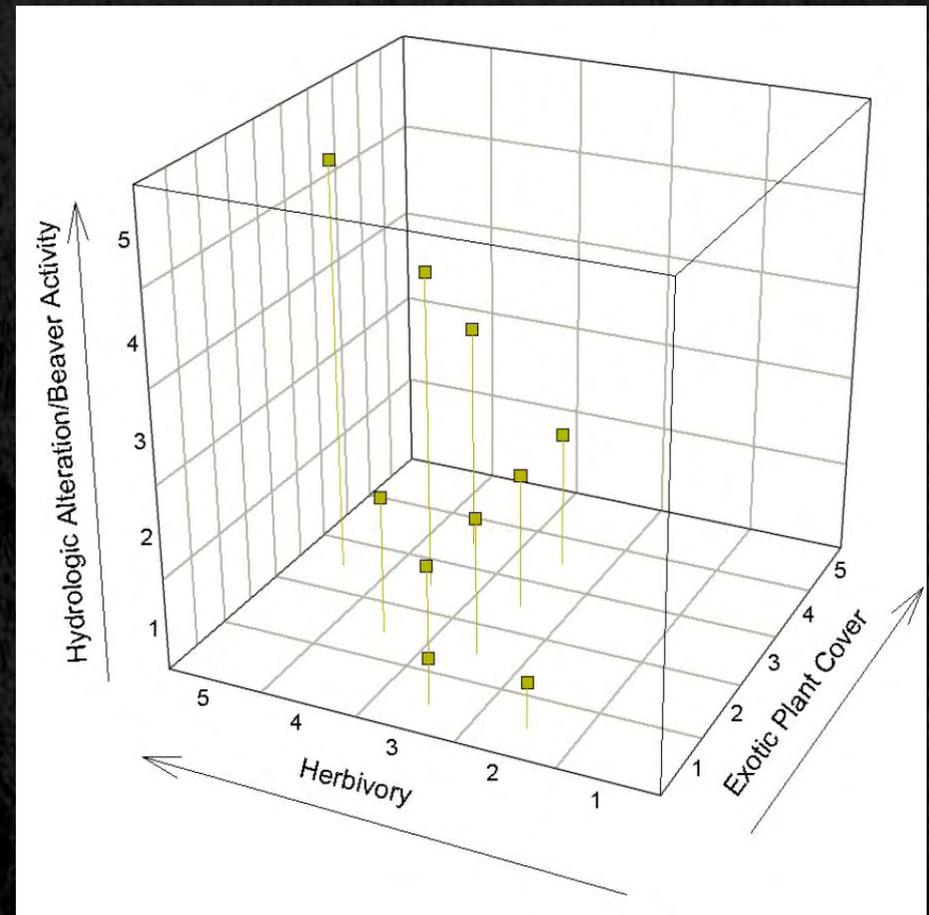
- Hand picked or targeted
- Existing monitoring, known wetland of interest, etc.
  - Currently 3 in ROMO, Kawuneechee, Big Meadows and Moraine Park
  - Adding 4<sup>th</sup> high elevation site probably off Trail Ridge
  - Sampled seasonally or on the hydrograph
- Why?
  - Site-specific status
  - Trend seasonally and/or on the hydrograph
  - Connect to existing work
  - Monitor known problem or opportunity wetlands
  - More detailed response
  - Key limitation is inferential capacity: response applies to site only (in lieu of modeling)



# Gradient

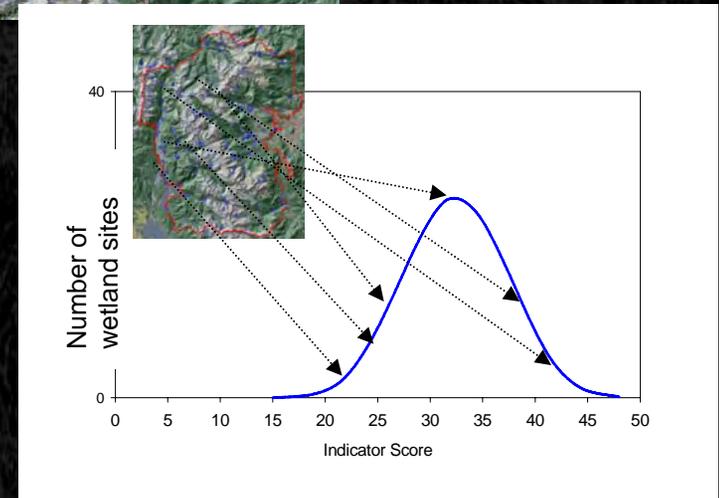
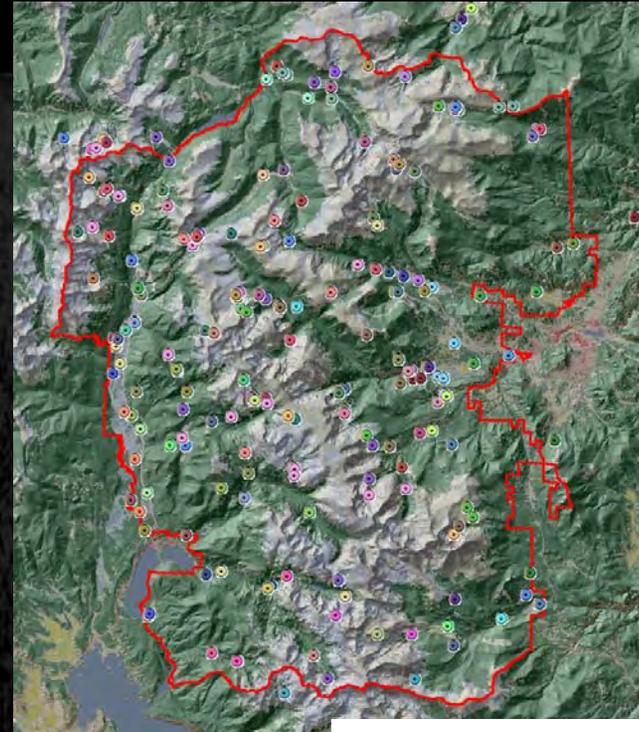
- **Model-based (and/or hand picked)**
- Currently: sites placed along three qualitative disturbance gradients
  - Herbivory
  - Hydrologic alteration
  - Invasive plant presence
- Future: augment or reanalyze with landscape disturbance model (next slide)
- Expect **30** (10 per type), with most likely biased to disturbed sites (expected to be rarer in park)
  - Sampled with surveys
- **Why?**
  - 'Fill out' expected condition gradient in park
  - Generation or calibration of MMI and O:E models

Wet Meadow Disturbance Matrix



# Existing

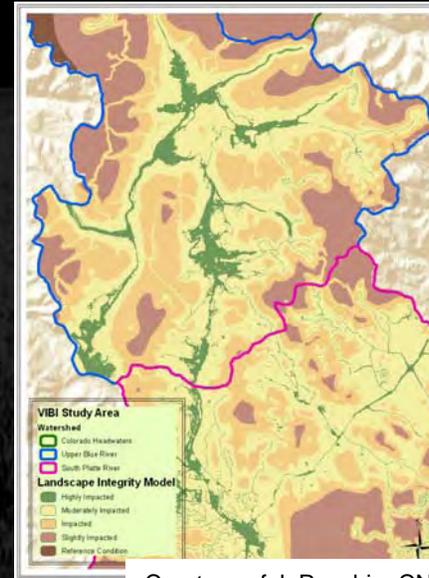
- Existing datasets/projects in and around park
  - For example, recent VegMap
- Why?
  - Possible solution to challenge of developing a reference condition for wetland biological condition in ROMO
    - Complex and critical subject... beyond my 20 minutes!
      - See Stoddard et al 2006
      - C. Hawkins plenary talk (and several pubs)
- 200+ wetland sites with complete vegetation characterization (600 full plots in all habitat types, 1200 AA points)
  - Sites by definition placed in 'natural' vegetation types (may meet relevant reference criteria)
- Use sites as is to build a baseline reference distribution... or....



# Landscape Disturbance Model

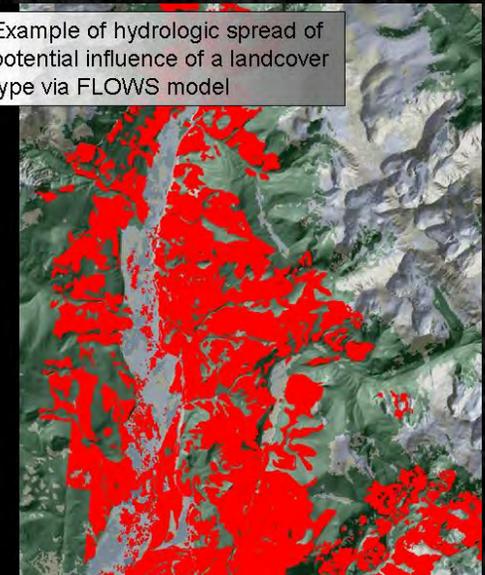
## Evaluating Existing Datasets

- Classify their expected condition based on a landscape disturbance model under development
- Geospatial model of landscape condition
  - Expands on a similar CNHP effort
- Model weights landuse/cover classes with emergy coefficients (Brown and Vivas 2005)
  - We expand CNHP model to include landuse features at finer scale (existing and historic dams, drainage tiles and ditches, culverts, etc.)
    - Some data not public
- Integrated with a beaver habitat suitability model under development with B. Noon and D. Theobald
  - Exploring similar elk habitat suitability model
    - Outcome of the current Elk/Vegetation EIS in ROMO
- Allocates the cumulative load of all these factors across landscape and within stream network using FLOWS tool (D. Theobald)
  - Sophisticated 'hydrologic spread'
- Part of the ROMO Watershed Condition Assessment project



Courtesy of J. Rocchio, CNHP

Example of hydrologic spread of potential influence of a landcover type via FLOWS model



# Response Design and Measures



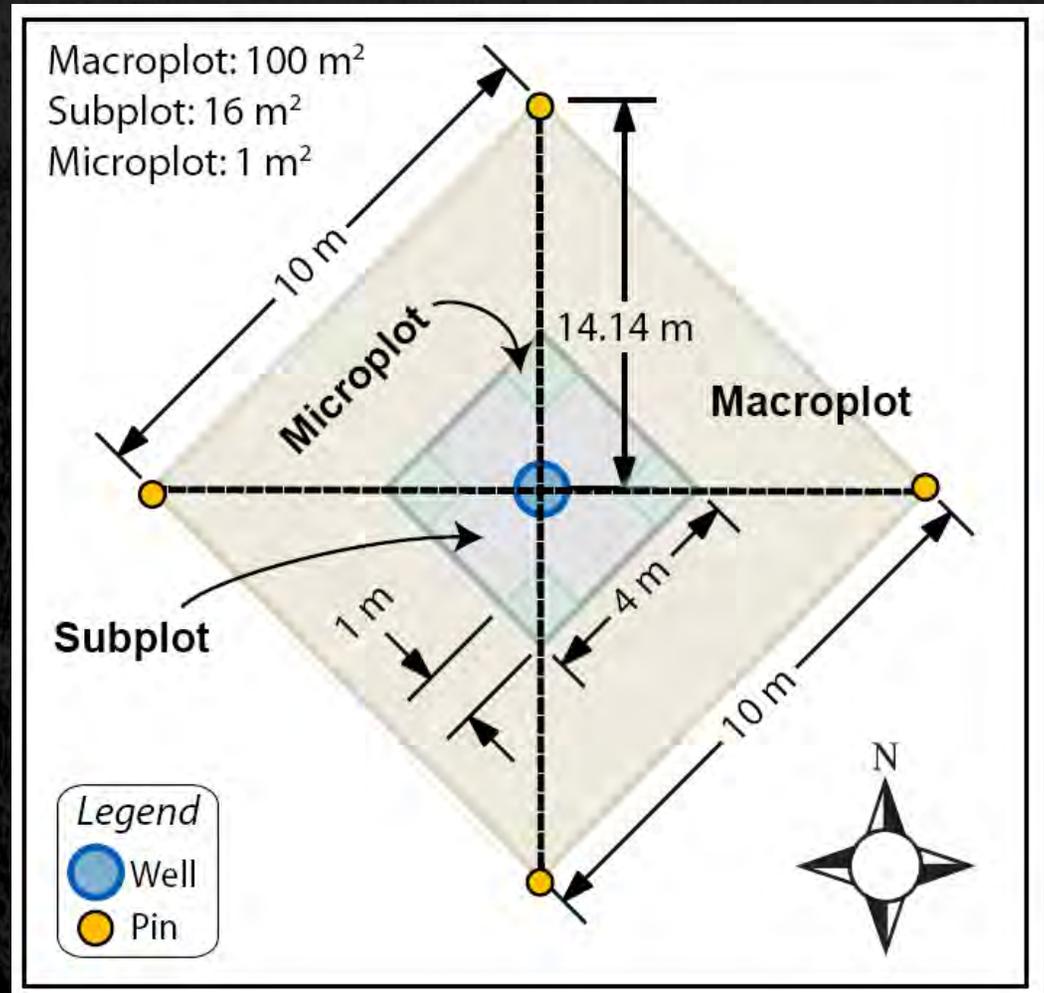
# Response Measures

## Summary

- Extent and type of wetland
  - Statistically via 3rd stage sample design point evaluation
- Vegetation community composition
  - Vascular cover by species
  - Bryophyte cover by species
- Ground water depth
  - Wells at all sites
- Ground water dynamics
  - Logging of continuous water table depth at subset of site
- Woody species size structure
  - Sapling, seedling and mature woody stem counts
- Woody species herbivory
  - Three semi-quantitative browse indices
- Soil stratigraphy and organic content
  - Munsell characterization and % organic matter
- General habitat
  - Litter, bare ground, etc.
  - ‘Rapid assessment’ methods
- Elk and beaver habitat use
  - ‘Rapid assessment’ methods
- Hydrologic characterization
  - Type, control
  - ‘Rapid assessment’ methods
- Context and disturbance
  - Site and mesoscale categorical measures
  - ‘Rapid assessment’ methods
- Landscape geoclimatic-spatial context and disturbance regime
  - Landscape disturbance model
  - Other geospatial and climatological data used to describe each sites catchment

# Response Design

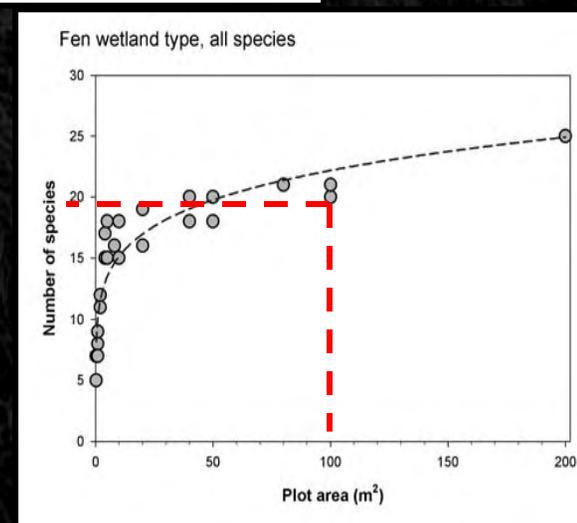
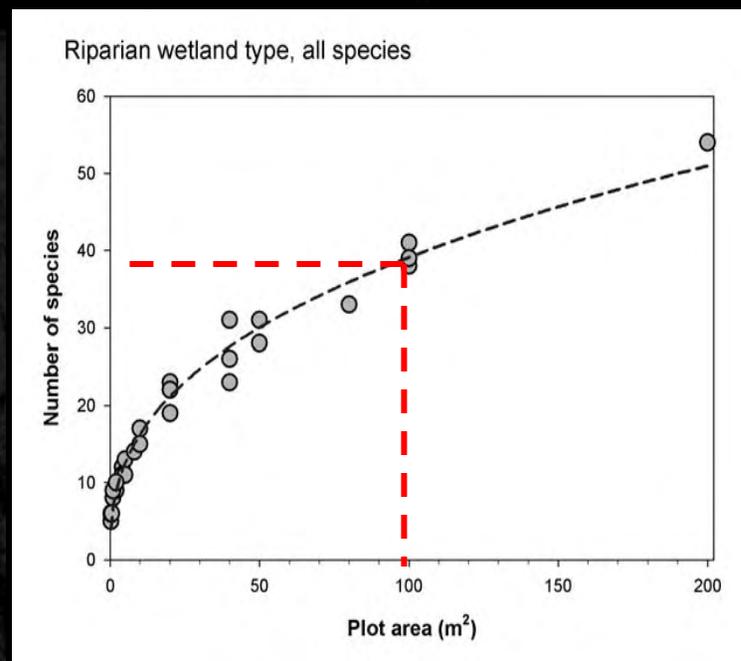
- Derived from CNHP plot structure
  - Peet et al 1998, Mack 2004
- Nested plot design
  - 10 x 10 Macroplot (100 m<sup>2</sup>)
  - 4 x 4 Subplot (16 m<sup>2</sup>)
  - 1 x 1 Microplot (1 m<sup>2</sup>)
- Centered on groundwater monitoring well
- Same plot form for each wetland type and sample design
  - Rectangular version available for long, thin polygons



# Field Plot

## Choosing a Plot Size

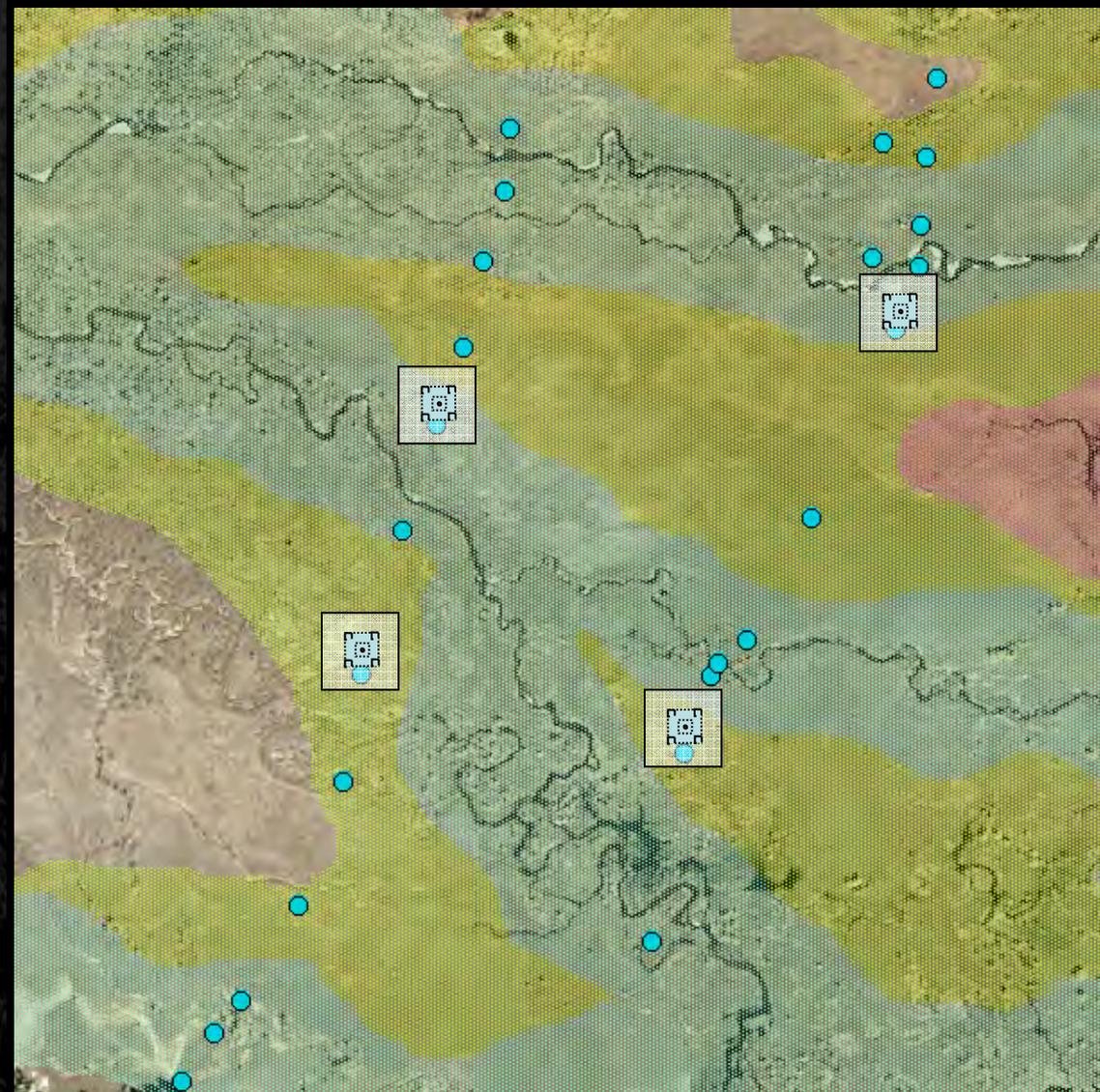
- Sample effort curves
  - Small samples in 2006...anecdotal
  - Large literature and data set for ROMO that we can also use...
- Some variation across wetland type, but in general curves tend to plateau around a search area of 100m<sup>2</sup>
- Developing species accumulation curves with 2007 pilot data
  - Nested subplots
- Real trade-off in survey sample size vs. effort at a site
  - Feel we have balance with plots around 100m<sup>2</sup>
- Most importantly, survey target population is all wetland in park, not a specific wetland complex, and our sample must be optimized for this scale



# Sentinel Site Response Design

## Within Site Replication

- Same basic plot shape and size
- However, scale is the site and plots can or should be replicated
  - Also analogous to CNHP methods
- 2008 includes focus on developing appropriate within sentinel site N

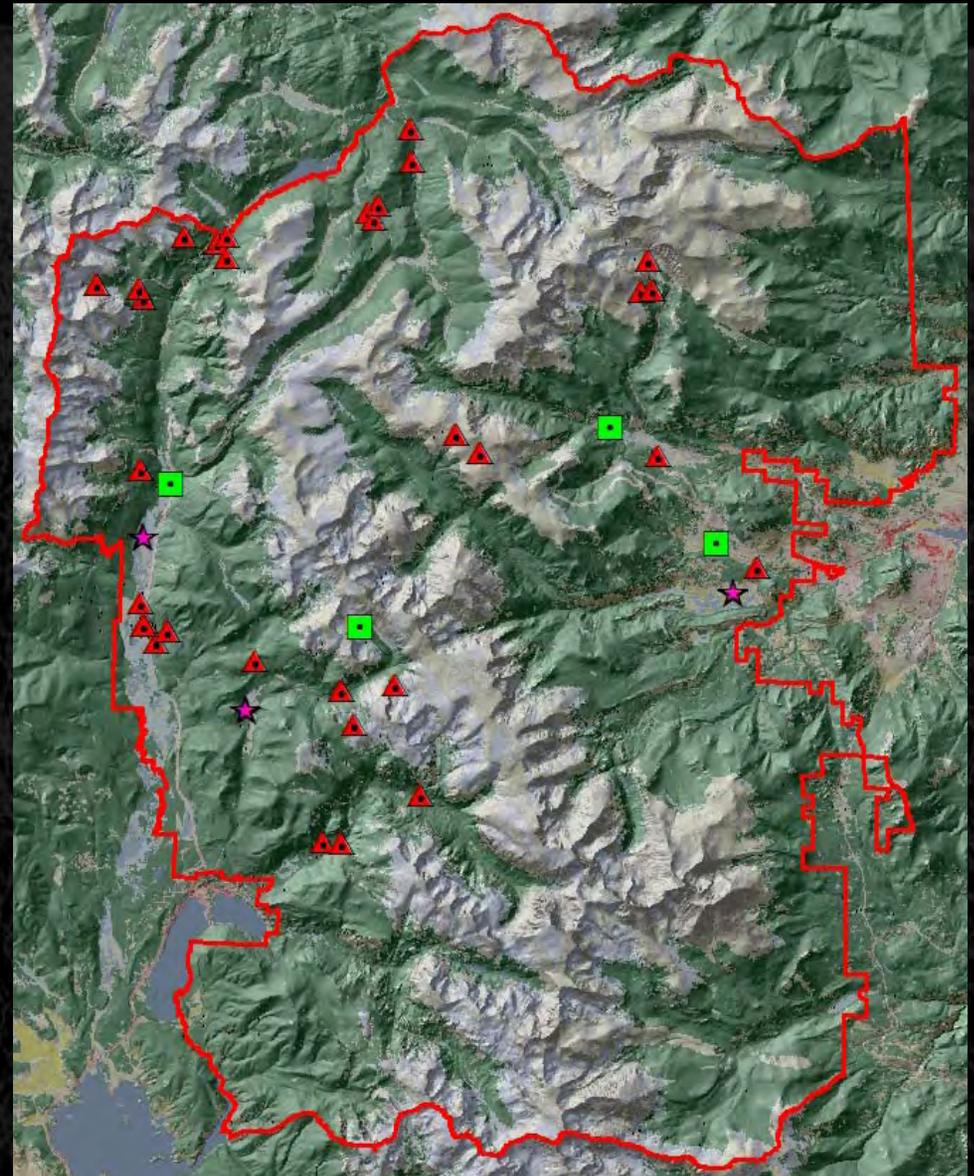


# Preliminary Results and Analyses in Progress



# 2007 Sample Events

- 53 total sample events
  - 7 of which were revisits
- Survey
  - 16 Fens, 19 Meadows, 8 Riparian
  - Survey design is working...
    - Unbiased park-scale yet more or less accessible
- Gradient:
  - 3 Fens, 1 Meadow
  - Will be modifying based on the LDM
- Sentinel:
  - 6 sample events across all types
  - Adding high elevation site



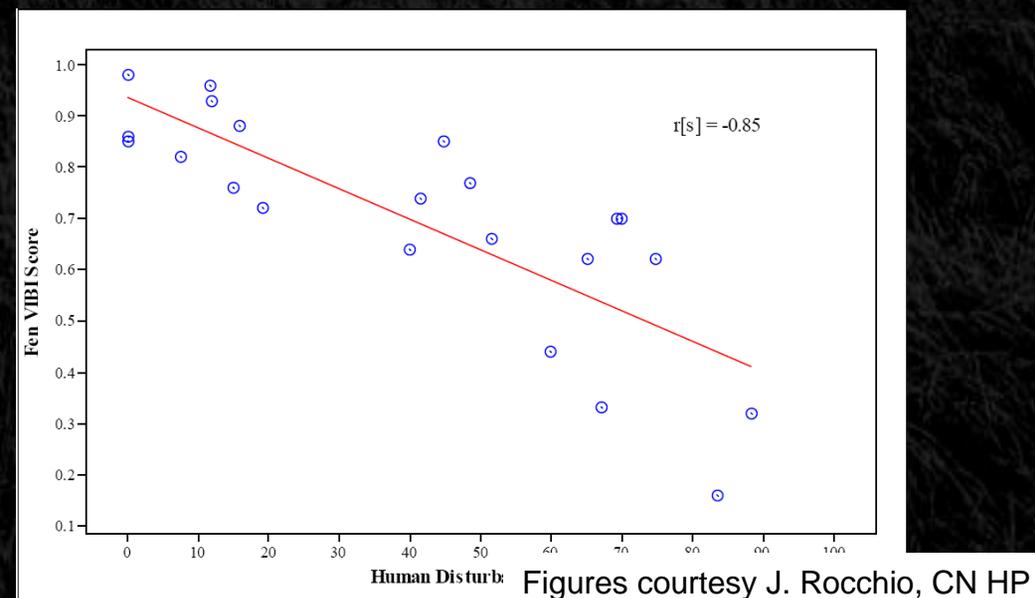
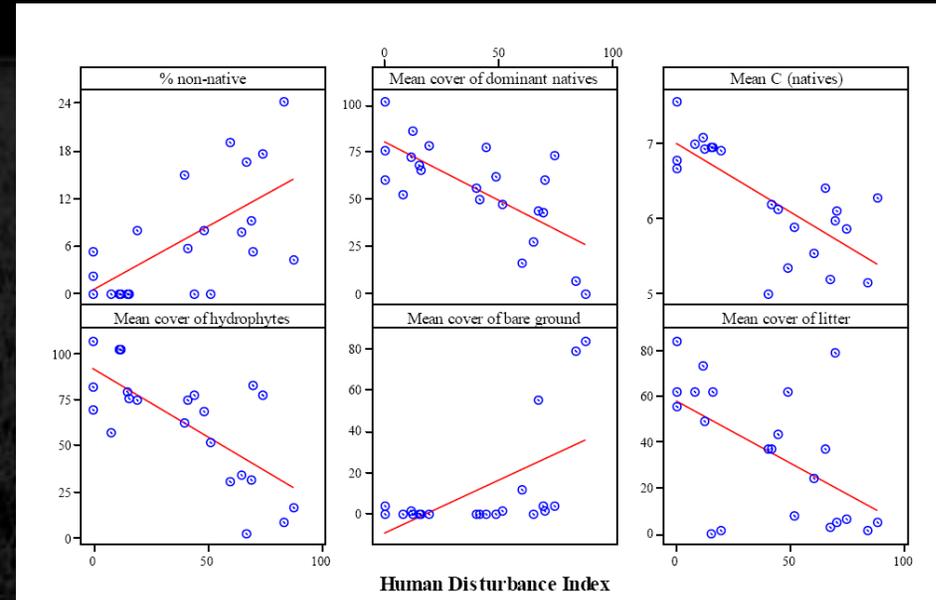
# Vegetation Based Bioassessment Tools

- Recall we are developing two models to assess wetland vegetation: O:E and MMI
- No time to cover O:E basis;
  - C. Hawkins good summary in plenary
- ROMO O:E model would be first application to wetland vegetation... cool!
  - Intuitive management application
  - Using ROMO VegMap as reference data set
  - Will need to resolve issues with predictors in model... ground water dynamics and (for riparian) date since disturbance key

# Vegetation MMI

## In a Nutshell

- Independently generate gradient of expected condition across wetland sites (*within a priori* classification of wetland type)
  - LDM analysis of ROMO VegMap and our gradient sites
- Generate broad suite of metrics for vegetation assemblage at these sites
- Evaluate metrics along this gradient (reference to degraded) to determine responsiveness to stressors, statistical qualities, etc
  - Example metrics include life history classes (%annual), nativity (%invasive), resilience (%tolerant), wetland indicators (%obligate), C-scores, etc.
- Combine best metrics (separation, statistical qualities) into multimetric index
- Measure of the overall response of the community to environmental alteration and stressor conditions = "integrity"

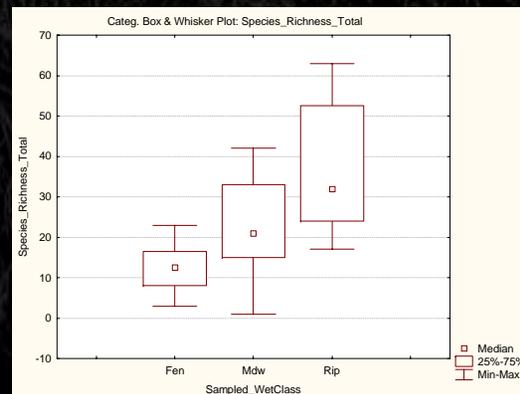
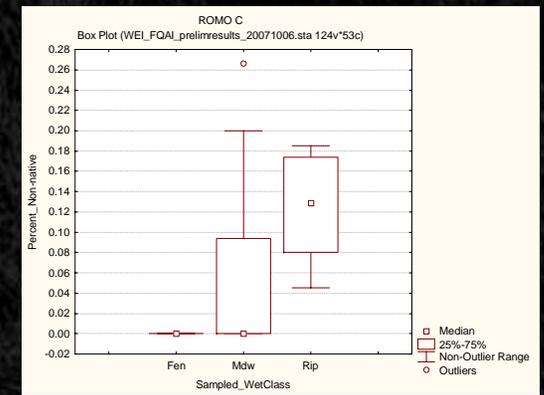
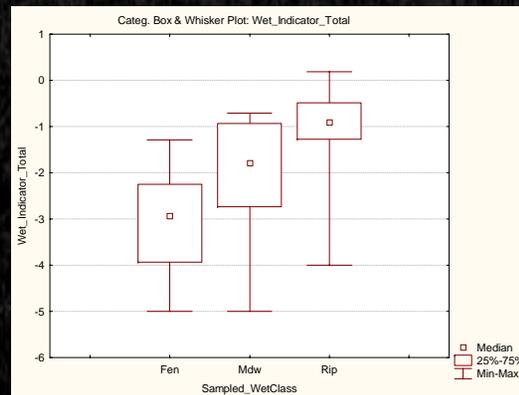
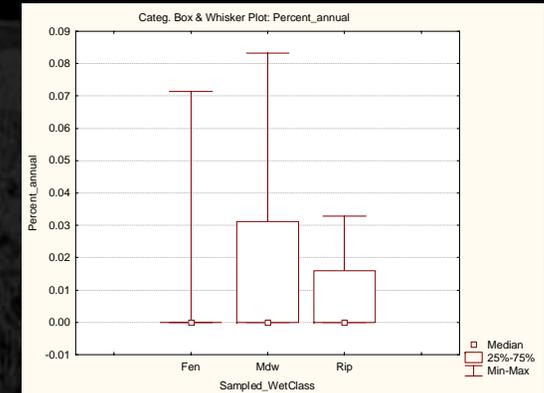
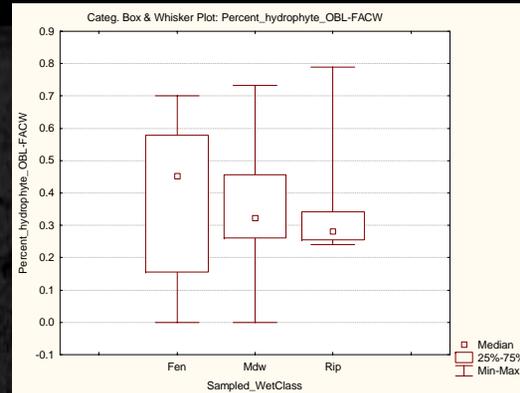


Figures courtesy J. Rocchio, CN HP

# Vegetation

## Basic Metrics

- Species richness
  - OBL or FACW = must be in an aquatic environment
- Proportion hydrophyte
  - OBL or FACW = must be in an aquatic environment
- Proportion non-native
  - Very few, riparian highest
- Mean wetland indicator score
  - From NWI
  - Range: -5 (OBL) to 5 (UPL) (lower is more wet)
- Proportion annual
  - Very few

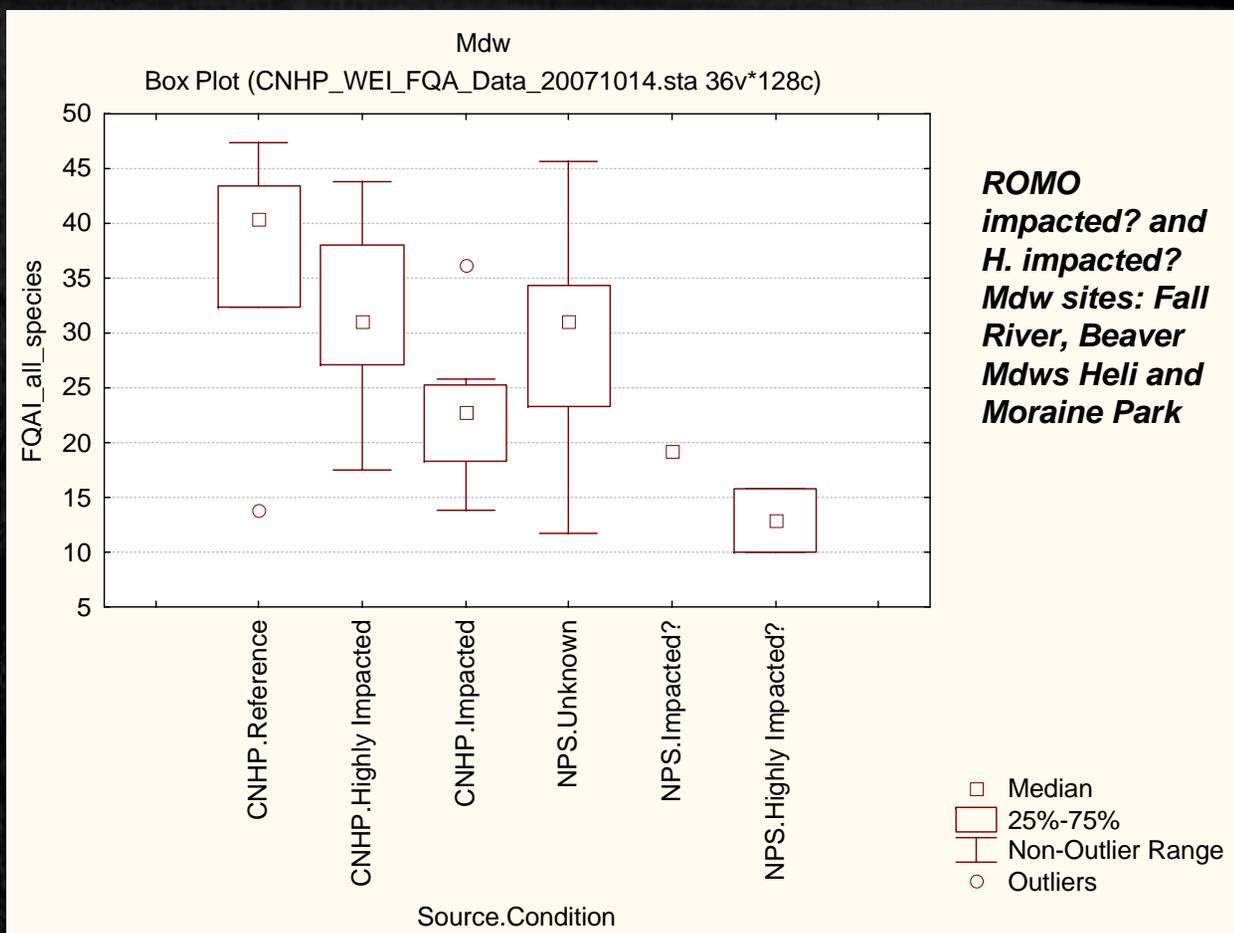


*Note that the meaningful comparisons are across disturbance gradients within a wetland type, so no comparative stats have been done with these data*

# Vegetation

## W. Meadows - Comparing ROMO to S. Rockies

- “Coefficients of Conservatism” (C) expert opinion based tendency of a taxa to occur in pristine (or not) habitats
- Floristic Quality Index
  - Good separation for both CNHP and ROMO sites
  - ROMO sites fall in range of impacted CNHP sites
    - Classification issues?



*Note that sample sizes and issues with classification across ROMO and CNHP studies (and my available time!) prevented any statistical comparisons here*

# New in 2008

- Continue O:E modeling
- Refinement of gradient sample locations
- Improved sentinel site response design
- Select Water Chemistry (SC, pH, Temp)
  - Will all have the full NCPN QA/QC!
- QA/QC
  - Continue rigorous training and protocol adherence
  - Continue with within and across year revisits
    - S:N and  $p(\text{trend})$  and  $SE(\text{status})$  via linear modeling
  - Add within sample event methods
    - Replication
    - Blind double vegetation characterization from different botanists



# Conclusion

- *The Scary Figure...*
- This is where we need to be (and are) going with several ROMN protocols...
- But we feel that this will only be as good as what we put into it and it will take a long term monitoring protocol with all the elements just summarized (but especially: survey designs, bioassessment and explicit reference conditions) to get here with any real confidence...

	Air	Water	Geology & Soils	Biological Integrity	Landscapes
ROMO					
GLAC					
GRKO					
FLFO					
LIBI					
GRSA					