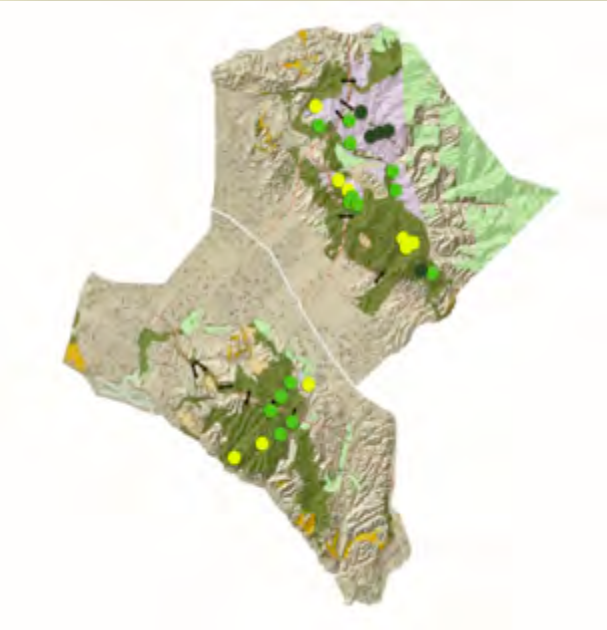
Ecological Research and Restoration in Orange County
Jan 27, 2012

Vegetation Monitoring in Orange County

Douglas Deutschman

Professor of Biology and
Institute for Ecological Monitoring and Management
San Diego State University

Outline



- Monitoring in an Adaptive Management Framework
- Vegetation Monitoring in Orange County
  - Baseline Phase: Objectives, Pilot Testing
  - Results from Monitoring: CSS, Chaparral and Grasslands: Structure, Composition, and Dynamics
  - Analysis and Adaptation: Variance Components and Power Calculations
- Questions/Discussion

Monitoring in an Adaptive Management Framework

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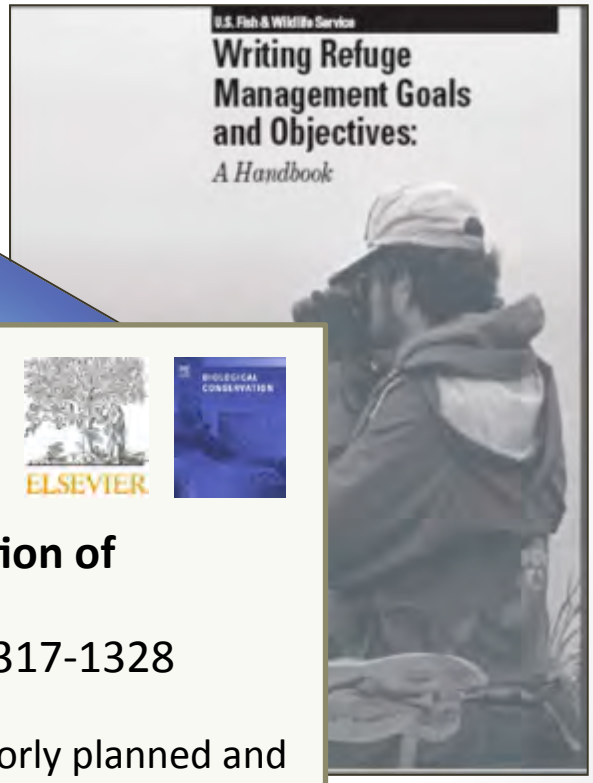
Lindenmayer and Likens.
2010.

The science and application of ecological Monitoring.
Biol. Conservation 143:1317-1328

There is a long history of poorly planned and unfocused monitoring programs that are either ineffective or fail completely.



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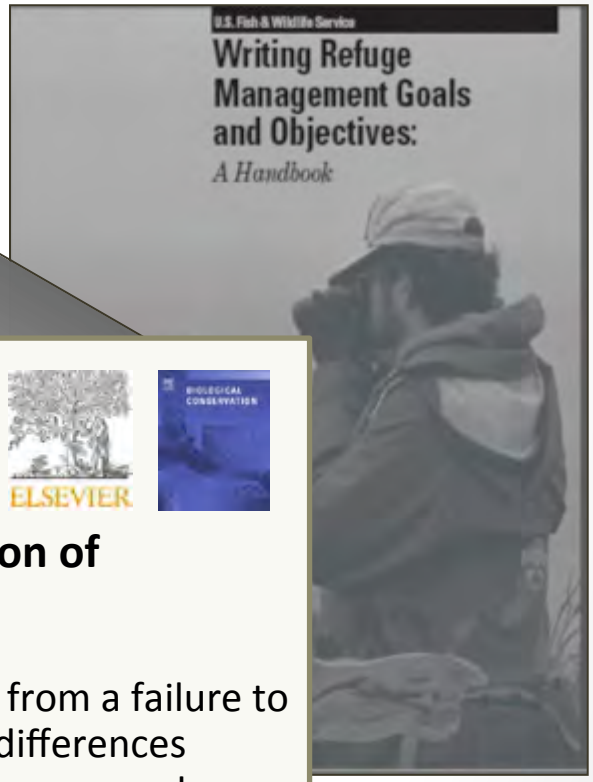
The science and application of ecological Monitoring.

Ineffective monitoring stems from a failure to recognize the values of, and differences between large mandated programs and smaller question-driven programs. We must coordinate these to produce integrated assessments useful to decision-makers.



Monitoring in an Adaptive Management Framework

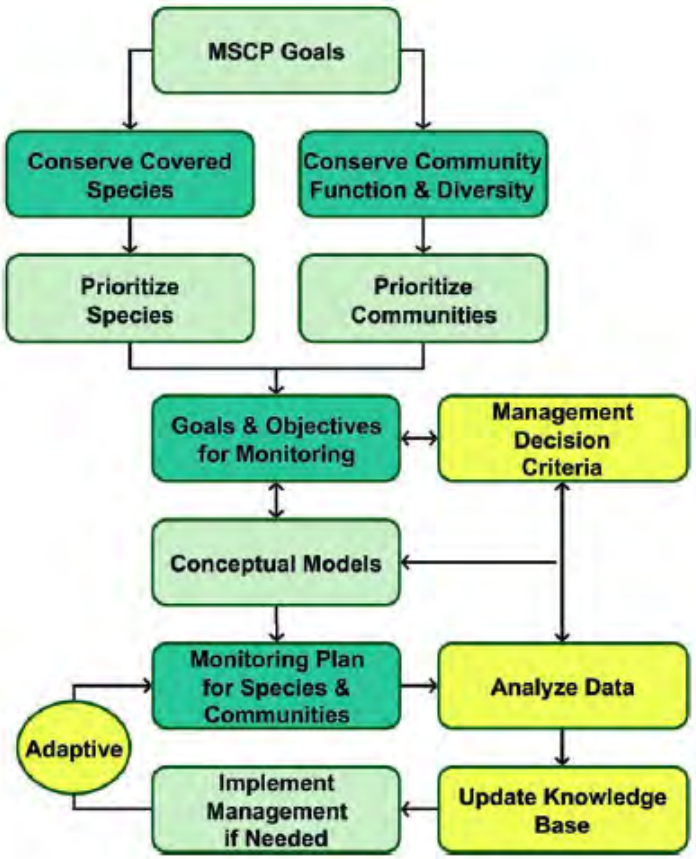
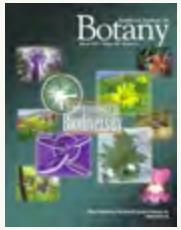


Fig. 3. Flow diagram of steps involved in designing a monitoring program for a multiple-species habitat conservation plan. MSCP: Multiple Species Conservation Program

Franklin et al. 2011.



Planning, implementation and monitoring of multiple-species habitat conservation plans Am. J. Bot. 98:559-571

Monitoring objectives should be derived from, and support, the goals of the conservation plan. Having goals at multiple levels require that an integrated monitoring program must use protocols for species, natural vegetation communities, and ecosystem-level elements.

Monitoring in an Adaptive Management Framework

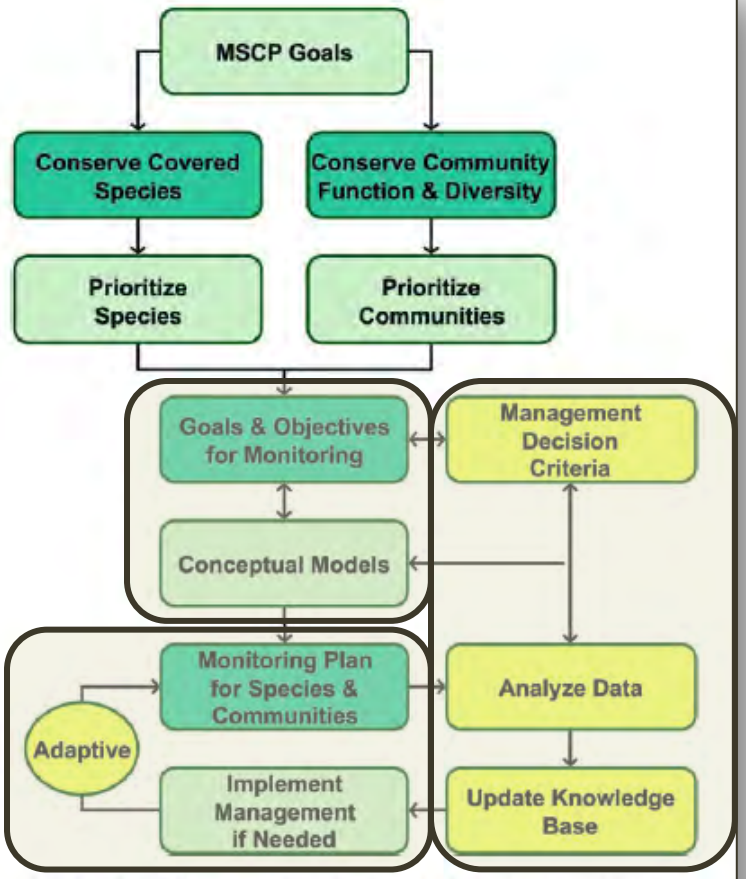
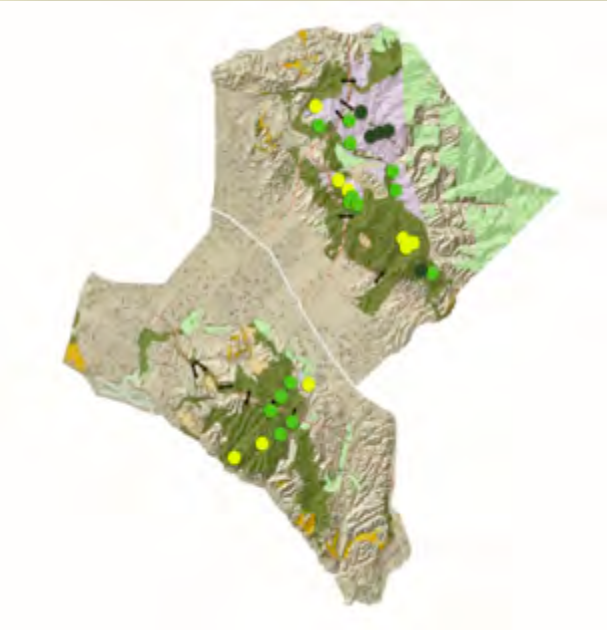


Fig. 3. Flow diagram of steps involved in designing a monitoring program for a multiple-species habitat conservation plan. MSCP: Multiple Species Conservation Program

Step	Scientific Literature
Goal and hypothesis formulation	Yoccoz et al 2001, Atkinson et al 2004, , Legg and Nagy 2006, Nicolas and Williams 2006, Lindenmayer and Likens 2009, Ferretti 2009, Lindenmayer and Likens 2010
Conceptual Models	Atkinson et al 2004, Regan et al 2008, Lindenmayer and Likens 2009, Lidenmayer and Likens 2010
Statistically Sound Design	Fuller 1999, Urquhart and Kincaid 1999, Yoccoz et al 2001, McDonald 2003, Legg and Nagy 2006, Lindenmayer and Likens 2009, Ferretti 2009, Lindenmayer and Likens 2010
Variance Partitioning	Larsen et al 2001, Yoccoz et al 2001, Kincaid et al 2004, Simms et al 2006
Power Analysis	Legg and Nagy 2006, Nielsen et al 2009, Mattfeldt et al 2009*, Quinn & Keough 2002, DiStefano 2003
Adaptive Management	Atkinson et al 2004, Nicolas and Williams 2006, Lidenmayer and Likens 2009, McDonald-Madden et al 2010, Lidenmayer and Likens 2010

Outline



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Goals and Objectives

Primary Goal: An adaptive management approach with the primary goal of maintaining long-term net habitat value within the subregion.

- Support ***a broad range of 'CSS species' over the long term***
- Maintain a ***viable ecosystem which minimizes the need for active intervention to support viable populations of the 'Target Species'***
- Implement a ***sampling program will focus on the coastal California gnatcatcher, coastal cactus wren, orange-throated whiptail, and the CSS vegetation community***

County of Orange (Environmental Management Agency), US Fish and Wildlife Service, CA Department of Fish and Game**. 1996.** NCCP/HCP Plan: Central and coastal subregion Natural Community Conservation Plan/Habitat Conservation Plan.

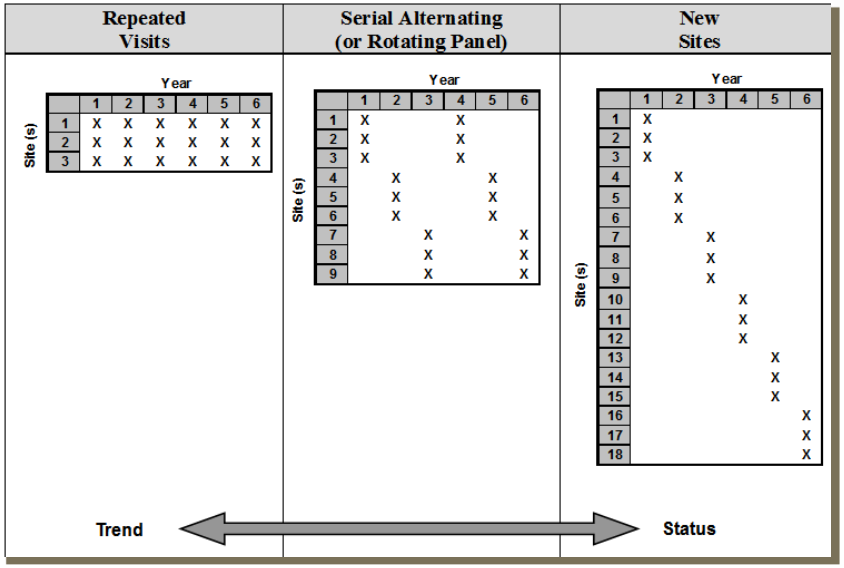
Goals and Objectives

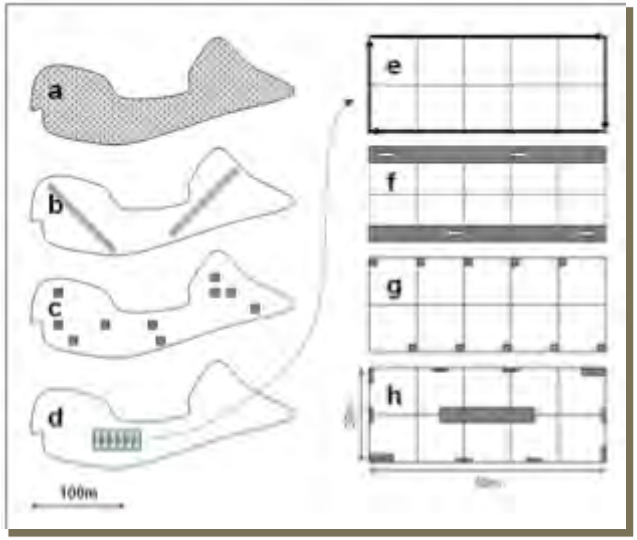
Systematic vegetation monitoring provides multiple benefits to an integrated, large-scale program:

- Vegetation composition at multiple scales
- Dynamic picture of structure and function
- Habitat correlates for many covered species

Critical Habitat Component	Species or Taxa
Cover of a specific woody species	• Gnatcatcher • Cactus Wren • Hermes copper • Thorne's hairstreak
Cover of a specific herb	• Quino Checkerspot
Bare ground/ mineral substrate	• Arroyo toad • Burrowing Owl • Reptiles • Burrowing animals
Fuels	• Oaks • Tecate Cypress
Non-native grass/ forb cover	• Stephen's Kangaroo Rat • Other small mammals

Sampling and Response Design

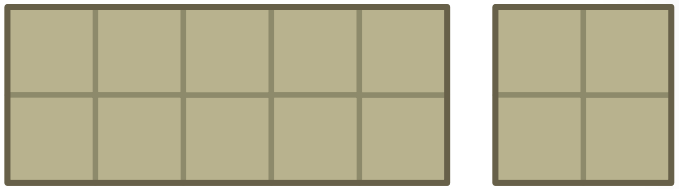


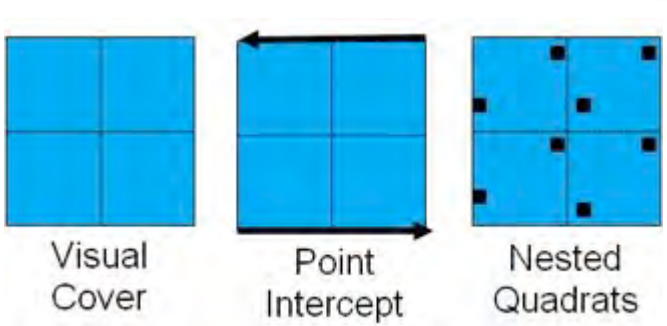


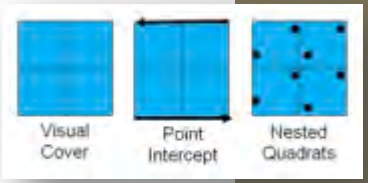
Protocol Development and Testing

Initial effort focused on refining methods and reducing inter-observer variability.

Included an evaluation of cost for each method as well as the number of replicates

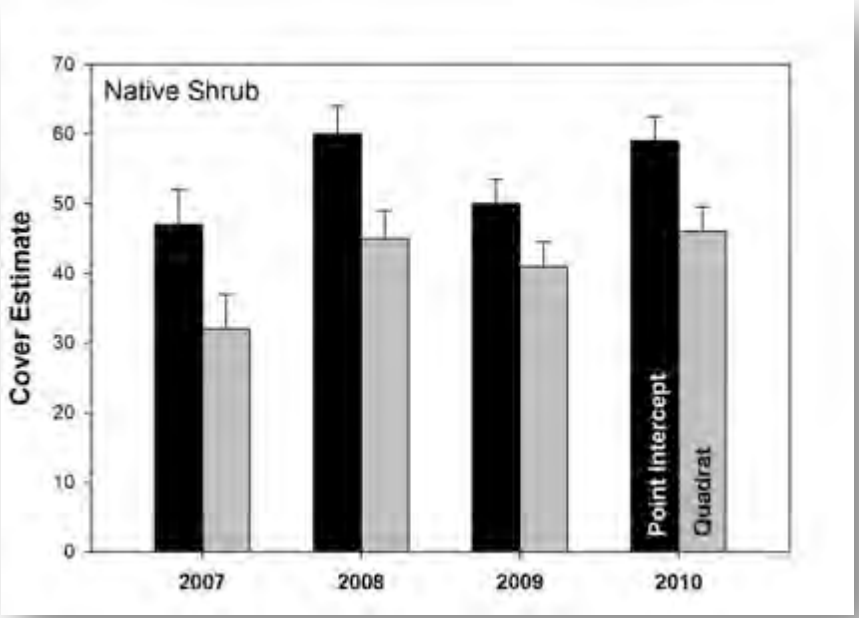


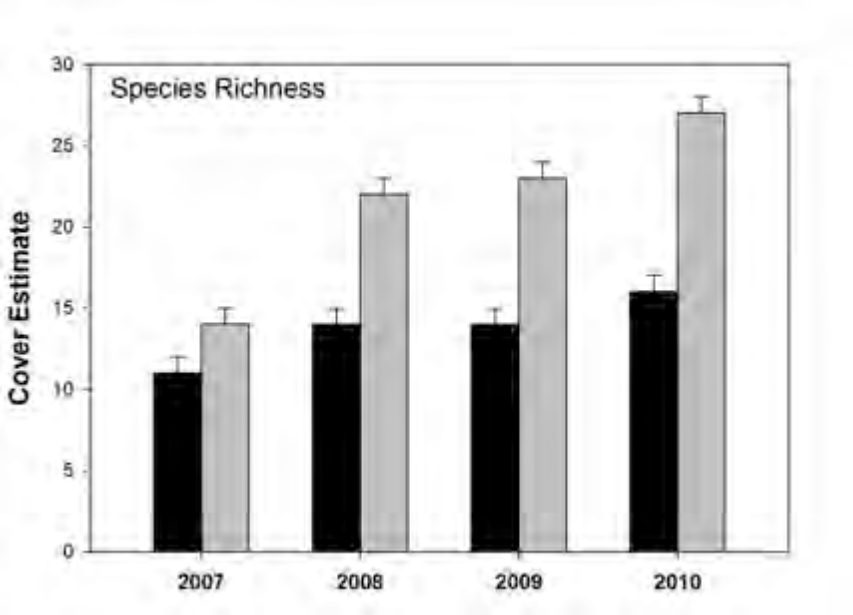




Protocol Testing

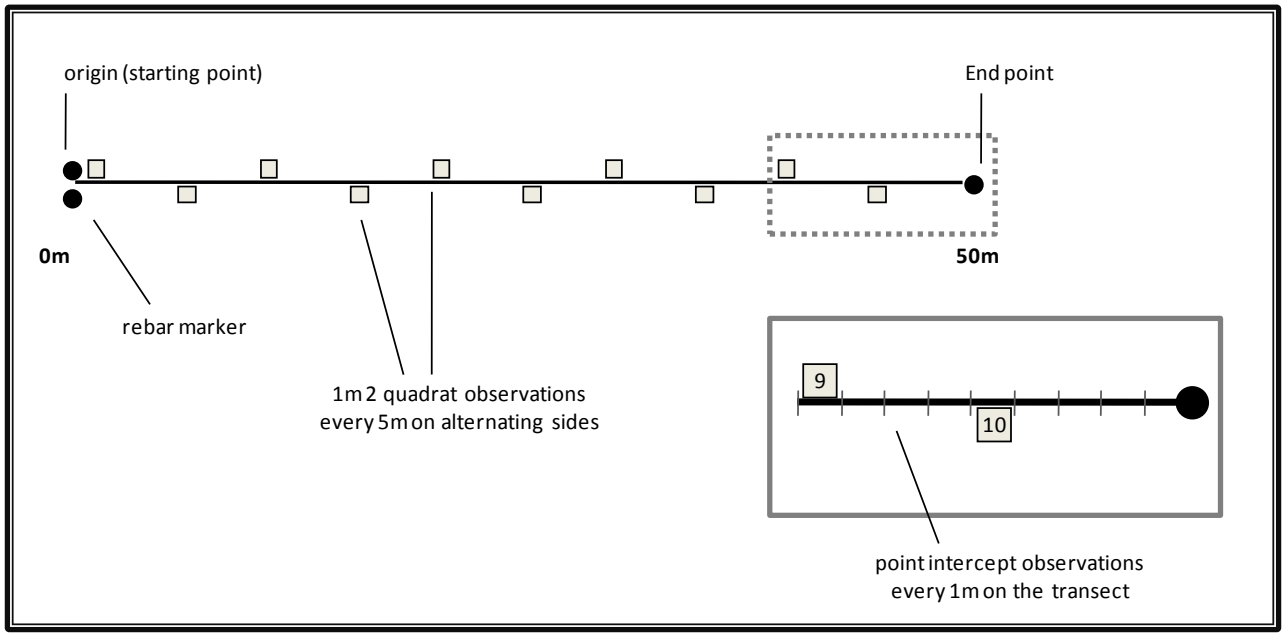
- The largest component of methodological variance was attributed to method (Point Intercept vs Quadrat).



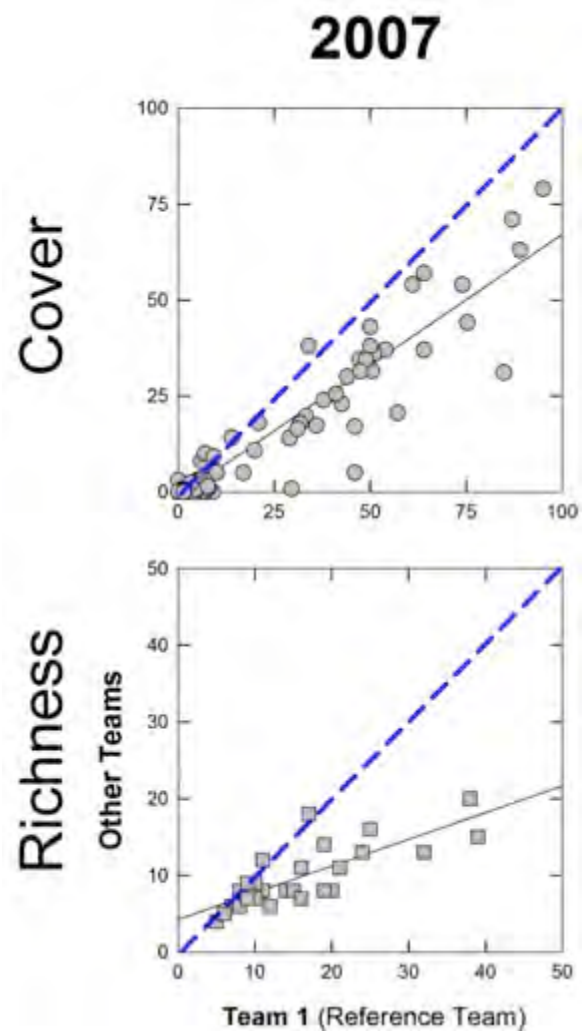


Final Protocol

Developed a cost-effective and repeatable protocol using both point intercept and quadrat methods.



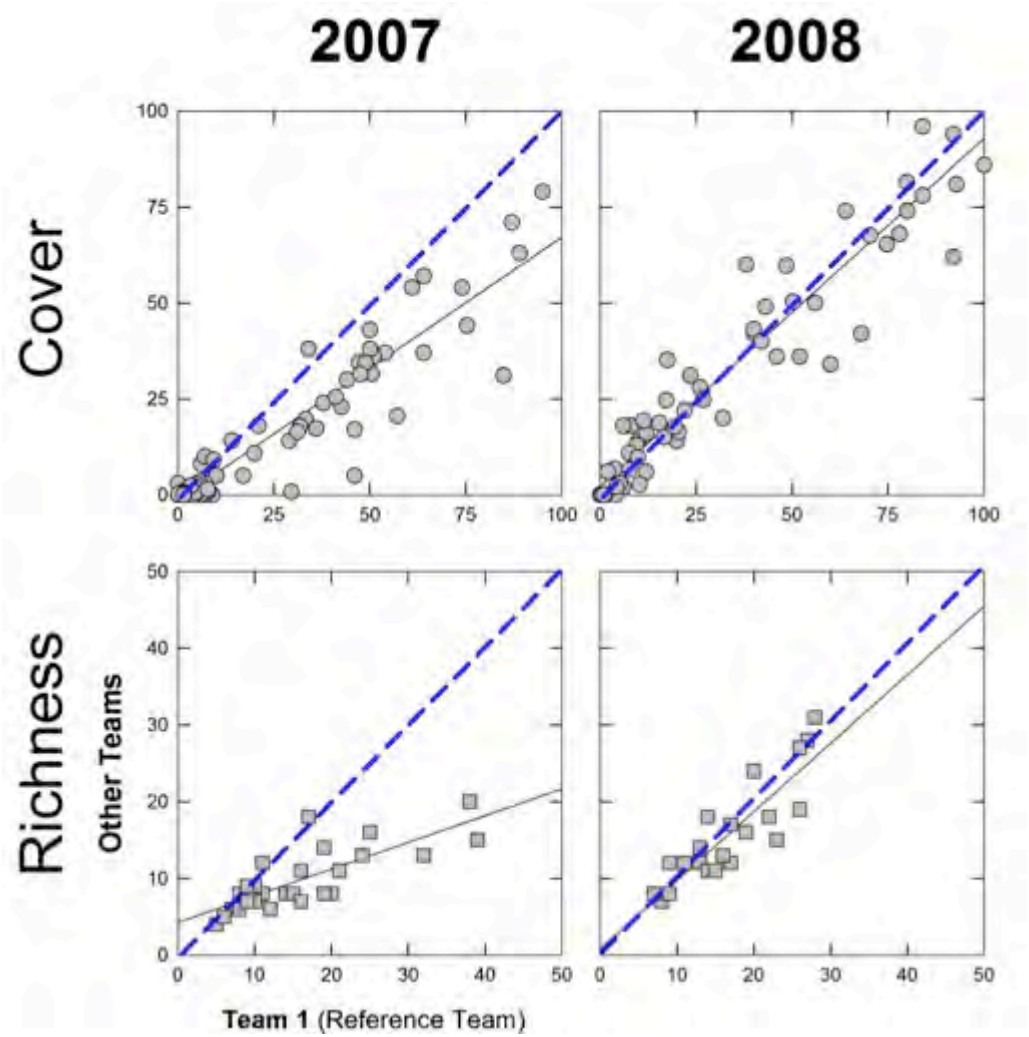
Minimizing Inter-observer Variability



Cover tended to be lower for less experienced teams

Richness was even worse.

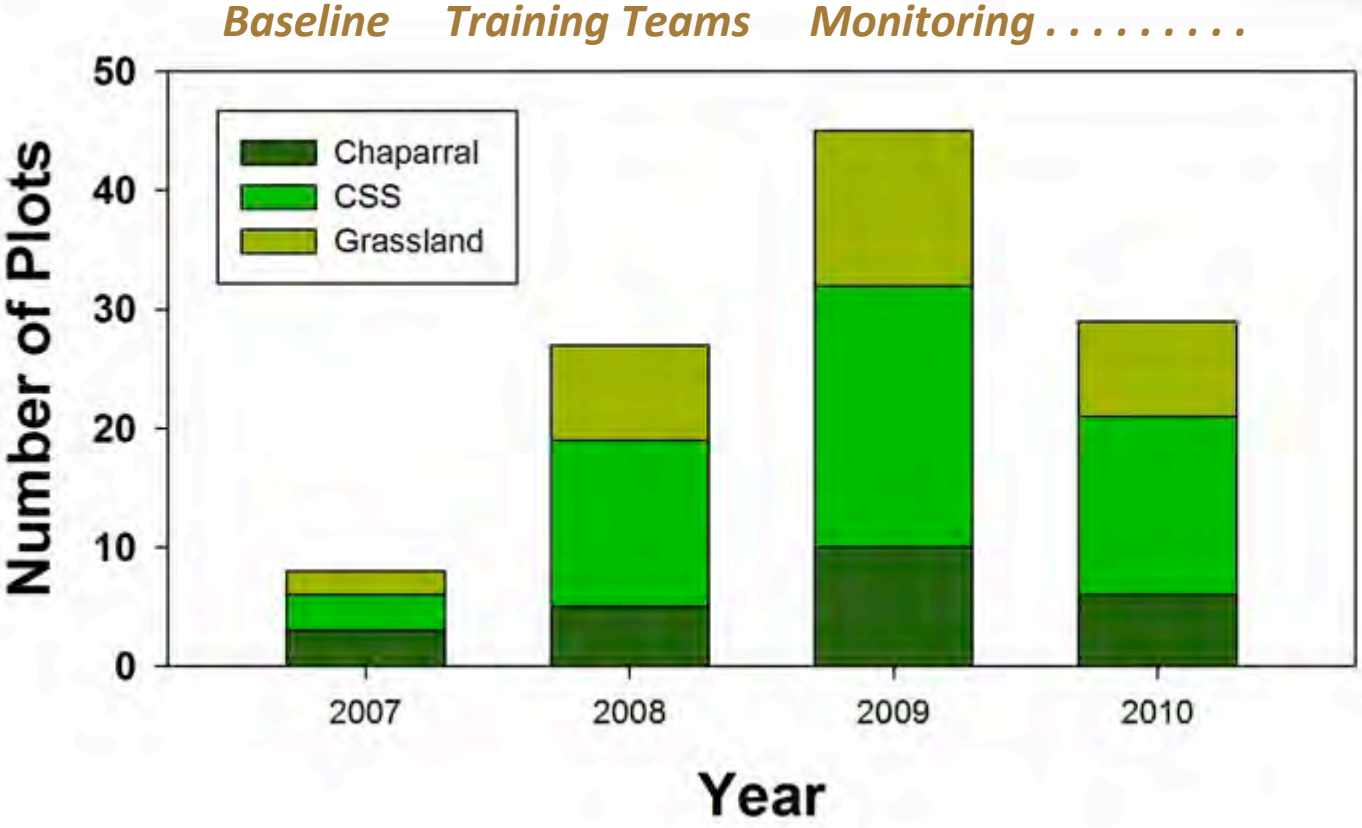
Minimizing Inter-observer Variability



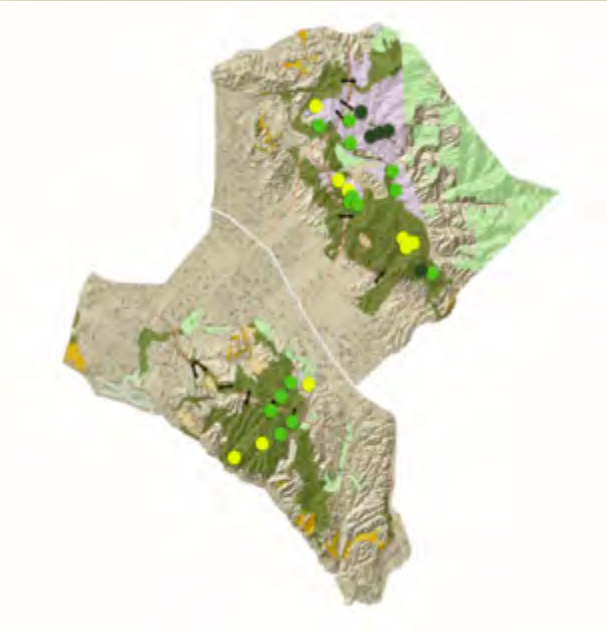
Cover was unbiased among teams.

Richness was about the same.

Increased Effort



Outline



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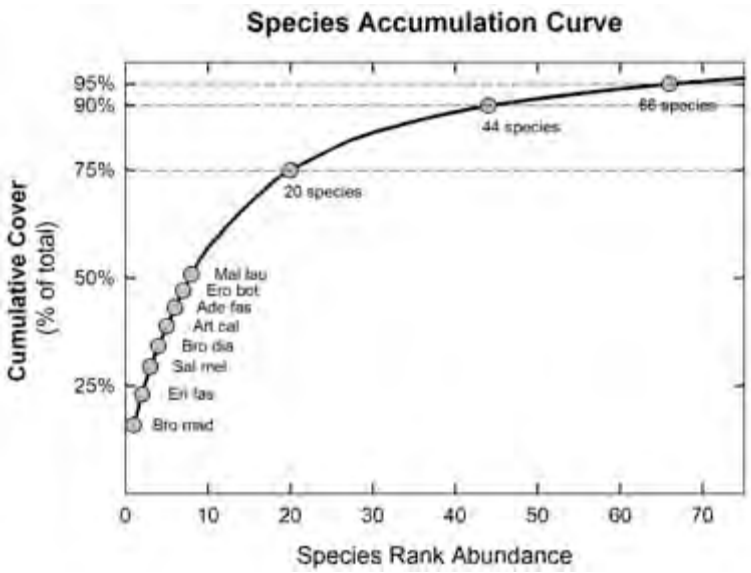
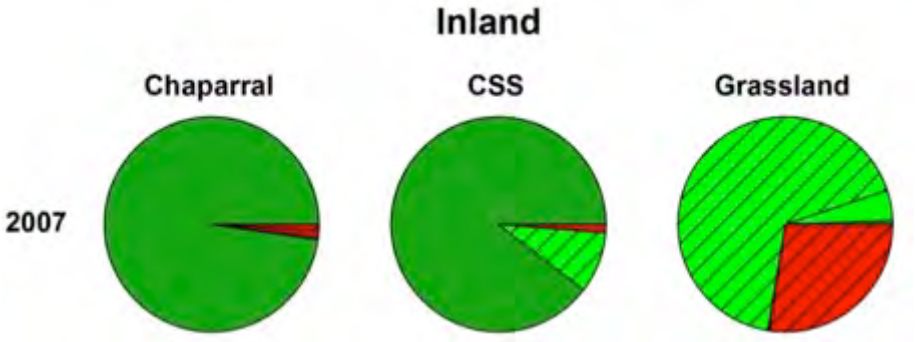
Species Richness

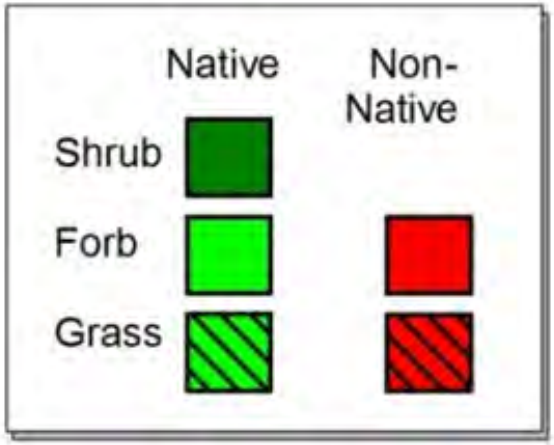
- Diverse Flora:
  206 species identified
- Most of the species richness was attributable to native forbs



	All Plots			Chaparral			CSS			Grassland		
Species	Rank	Avg Cover	Rel Fraction	Chap Rank	Avg Cover	Rel Fraction	CSS Rank	Avg Cover	Rel Fraction	GL Rank	Avg Cover	Rel Fraction
Bromus madritensis	1	20.7	15.9%	2	15.6	15.0%	1	22.6	17.0%	2	21.8	14.3%
Eriogonum fasciculatum	2	9.3	7.1%	9	2.8	2.7%	2	15.5	11.6%	18	1.9	1.3%
Salvia mellifera	3	8.3	6.4%	3	9.8	9.4%	3	11.1	8.3%	102	0.0	0.0%
Bromus diandrus	4	6.2	4.7%	46	0.2	0.2%	19	1.4	1.1%	1	24.5	16.0%
Artemisia californica	5	6.1	4.7%	12	1.6	1.5%	4	10.1	7.5%	19	1.6	1.1%
Adenostoma fasciculatum	6	5.7	4.4%	1	22.6	21.6%	171	0.0	0.0%	103	0.0	0.0%
Erodium botrys	7	5.1	3.9%	120	0.0	0.0%	7	3.9	2.9%	4	13.6	8.9%
Malosma laurina	8	4.9	3.8%	5	6.6	6.3%	5	6.1	4.6%	104	0.0	0.0%
Nassella pulchra	9	4.5	3.5%	53	0.1	0.1%	15	2.0	1.5%	3	15.7	10.3%
Vulpia myuros	10	3.4	2.6%	13	1.6	1.5%	6	5.2	3.9%	21	1.4	0.9%
Erodium cicutarium	11	2.9	2.2%	27	0.6	0.6%	9	3.7	2.7%	9	3.8	2.5%
Hirschfeldia incana	12	2.8	2.2%	6	4.8	4.6%	12	2.9	2.2%	34	0.4	0.3%
Bromus hordeaceus	13	2.7	2.1%	40	0.2	0.2%	11	3.0	2.2%	7	4.9	3.2%
Avena barbata	14	2.6	2.0%	76	0.0	0.0%	37	0.5	0.4%	6	10.6	6.9%
Lolium multiflorum	15	2.4	1.8%	51	0.1	0.1%	103	0.0	0.0%	5	10.6	7.0%
Lotus scoparius	16	2.3	1.8%	21	0.9	0.8%	8	3.8	2.8%	36	0.3	0.2%
Centaurea melitensis	17	2.3	1.7%	24	0.8	0.7%	10	3.6	2.7%	26	0.7	0.4%
Rhus integrifolia	18	2.2	1.7%	4	7.2	6.9%	29	0.8	0.6%	105	0.0	0.0%
Nassella lepida	24	1.3	1.0%	7	2.9	2.7%	25	1.0	0.8%	107	0.0	0.0%
Brassica nigra	25	1.2	0.9%	23	0.8	0.7%	31	0.7	0.5%	10	3.0	2.0%
Brachypodium distachyon	28	0.9	0.7%	122	0.0	0.0%	172	0.0	0.0%	8	4.2	2.8%
Ceanothus tomentosus	31	0.7	0.6%	8	2.8	2.7%	173	0.0	0.0%	109	0.0	0.0%
Eriodictyon crassifolium	32	0.7	0.5%	10	2.7	2.6%	174	0.0	0.0%	110	0.0	0.0%

Spatio-Temporal Dynamics





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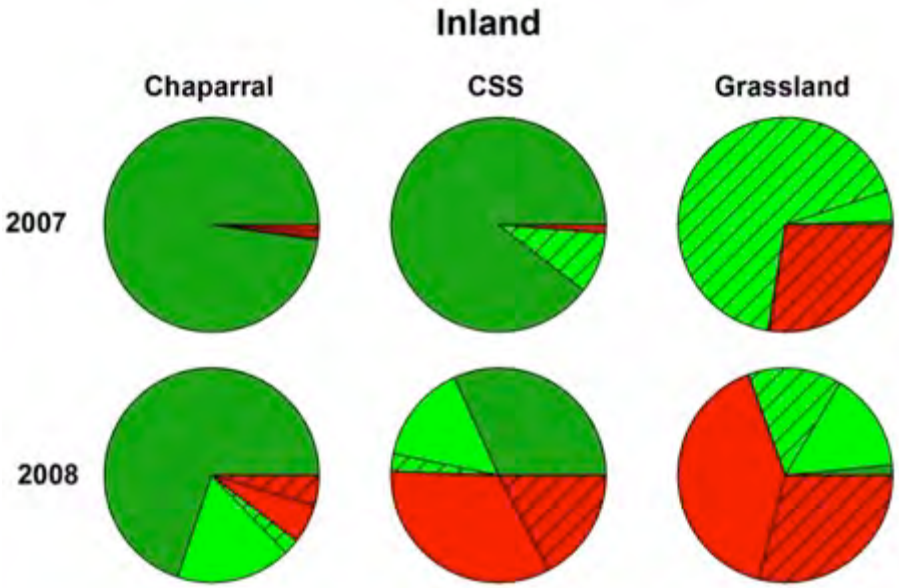

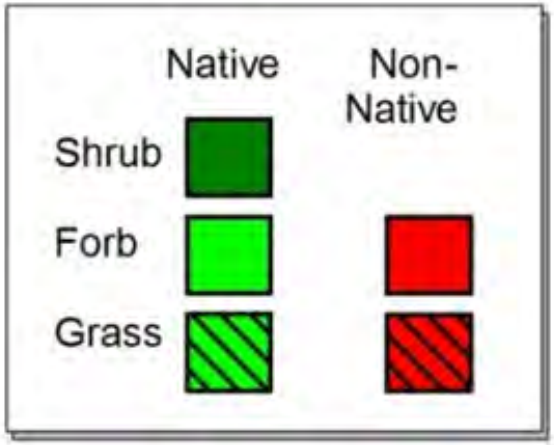

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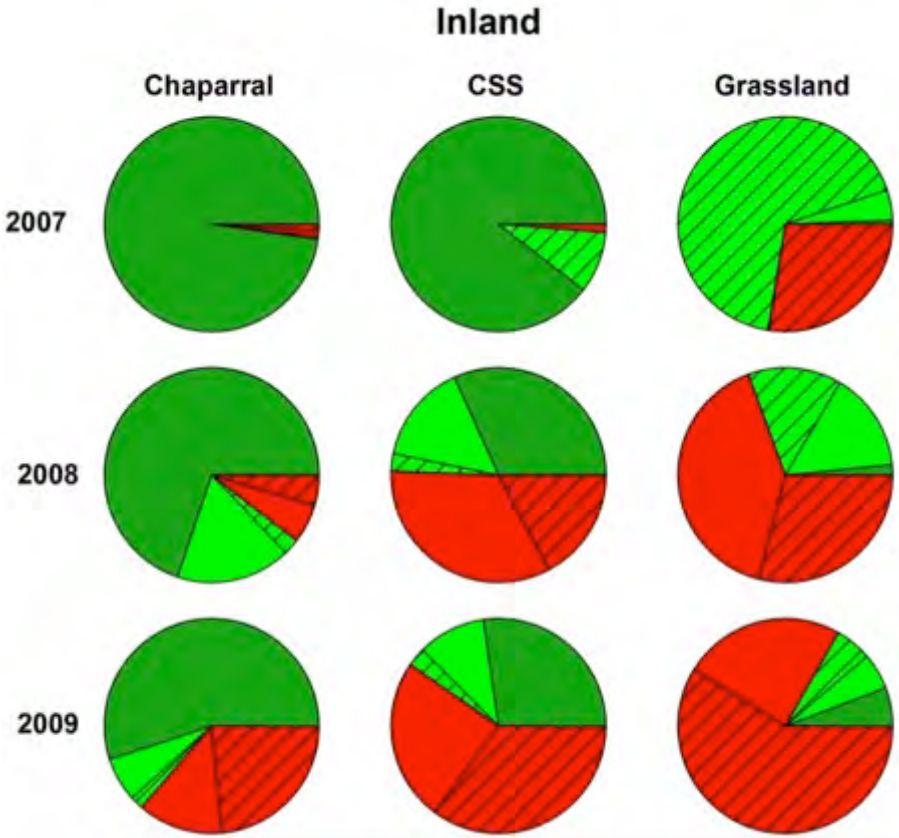

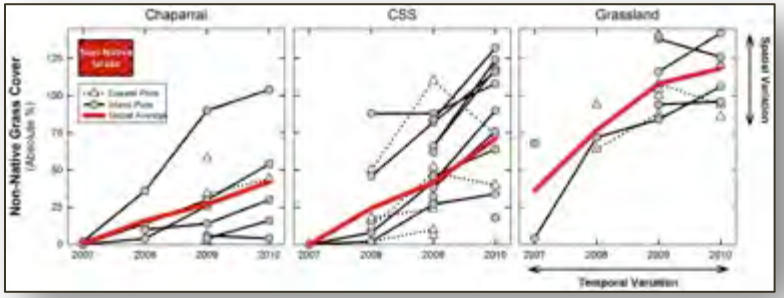

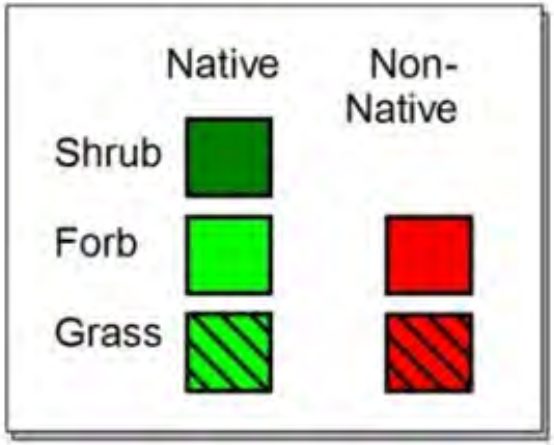

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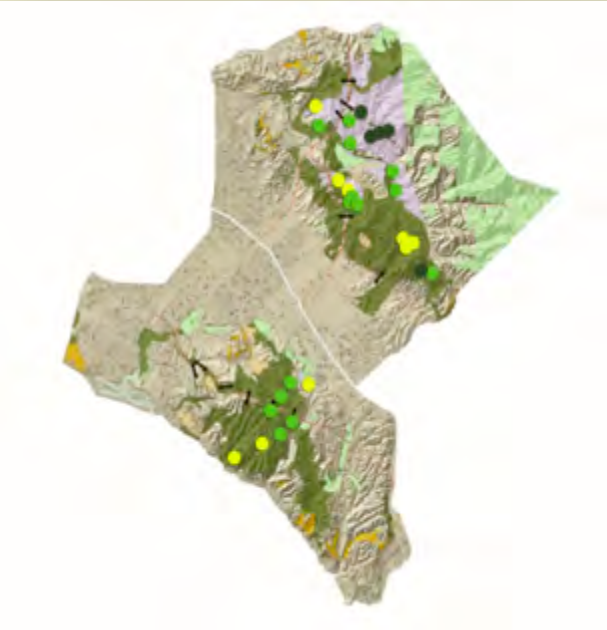

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Variance Components

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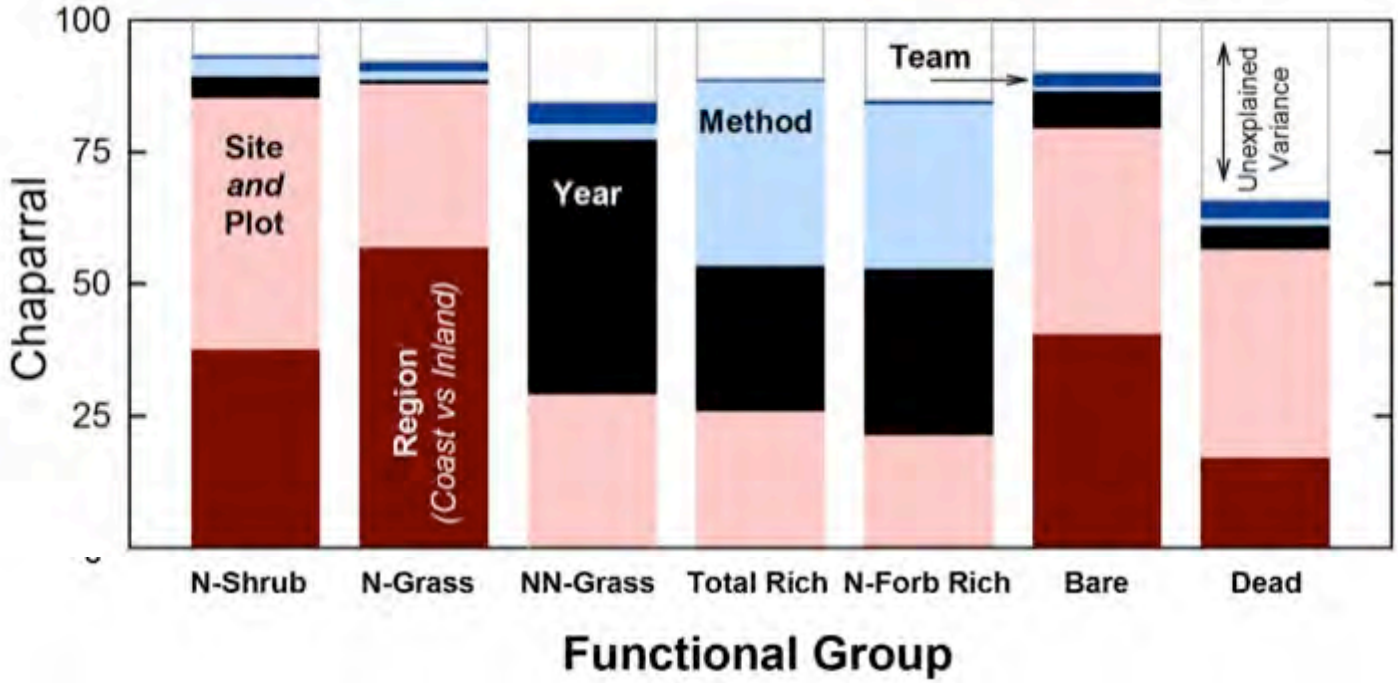
Sims et al. 2006.

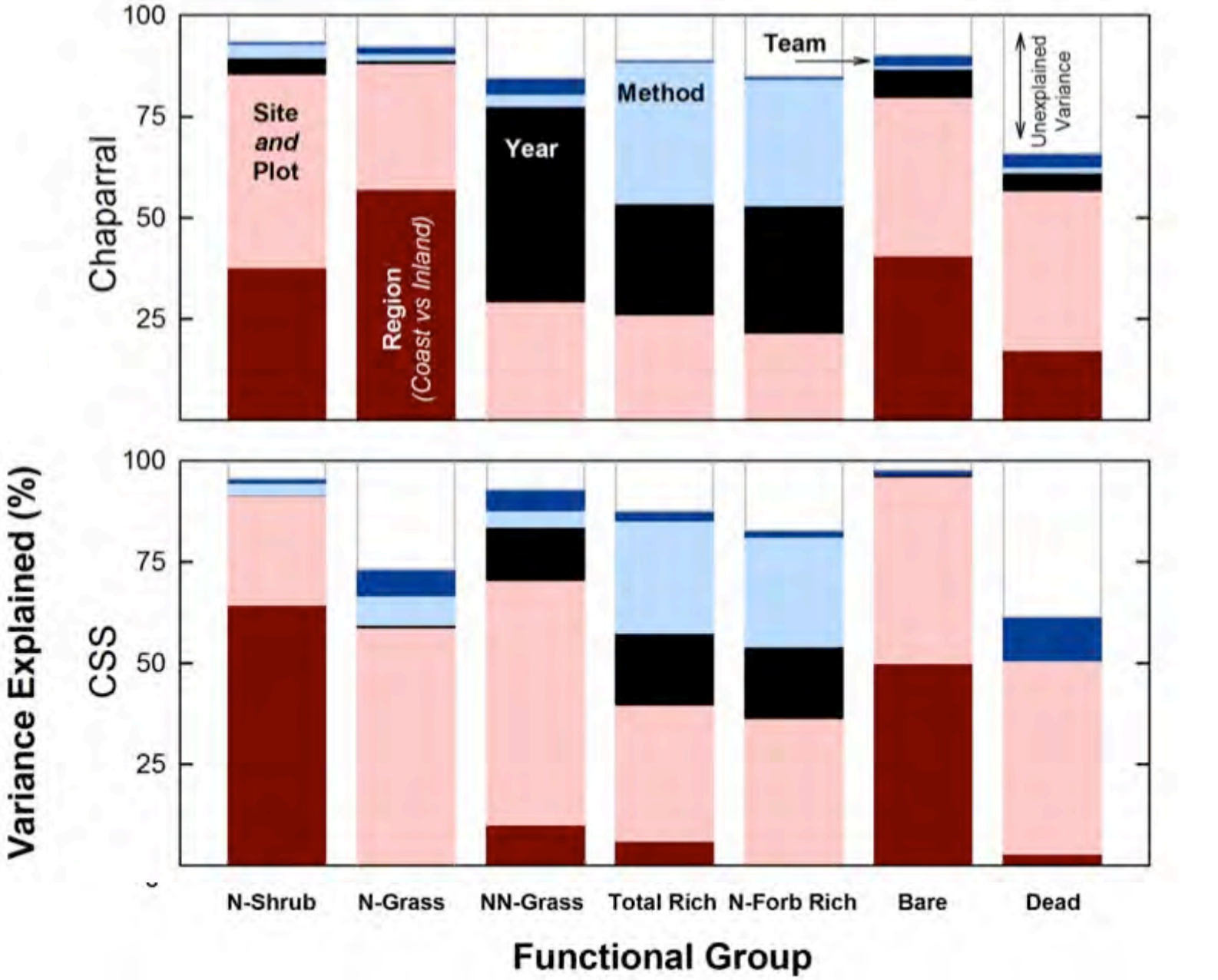
Evaluating the power of monitoring plot designs for detecting long-term trends in the numbers of common guillemots
J. Applied Ecology 43:537–546

We examined different sampling design options for monitoring common guillemots by evaluating the power to detect trends in abundance. …It is clear that some useful improvements could be made without a substantial increase in observer effort

Sources of Variability in Our Data

- **Temporal**
  - Inter-annual variation (driven by precipitation)
  - Sites burned in 2007 were excluded for this analysis
- **Spatial**
  - Vegetation Community
  - Site
  - Plot
- **Methodological**
  - Inter-Observer
  - Method


100
75
50
25
Chaparral
Site
and
Plot
Region
(Coast vs Inland)
Year
Method
Team
Unexplained
Variance
N-Shrub
N-Grass
NN-Grass
Total Rich
N-Forb Rich
Bare
Dead
Functional Group


Variance Explained (%)
Chaparral
CSS
100
75
50
25
Site and Plot
Region (Coast vs Inland)
Year
Method
Team
Unexplained Variance
N-Shrub
N-Grass
NN-Grass
Total Rich
N-Forb Rich
Bare
Dead
Functional Group

Power Analyses for Monitoring

Power analyses are formal way to design studies to achieve unambiguous results.

Despite their prevalence and reported utility, few of us have ever really done them.

(You know who you are)

Power Analyses

- Because data are often variable, and because statistical decisions are probabilistic, the result of a statistical test may be incorrect.
- The probability that we make the correct decision is usually described in a two-way table based on the statistical null hypothesis (H_0, The hypothesis of no difference)

Errors in Statistical Decision Making	**H_0 is True (No Change)**	**H_0 is False (Real Change)**
Statistical Test/Conclusion: Reject H_0	✗, Type I error (a)	☑, Power, 1-b
Statistical Test/Conclusion: Do not Reject H_0	☑	✗, Type II error (b)

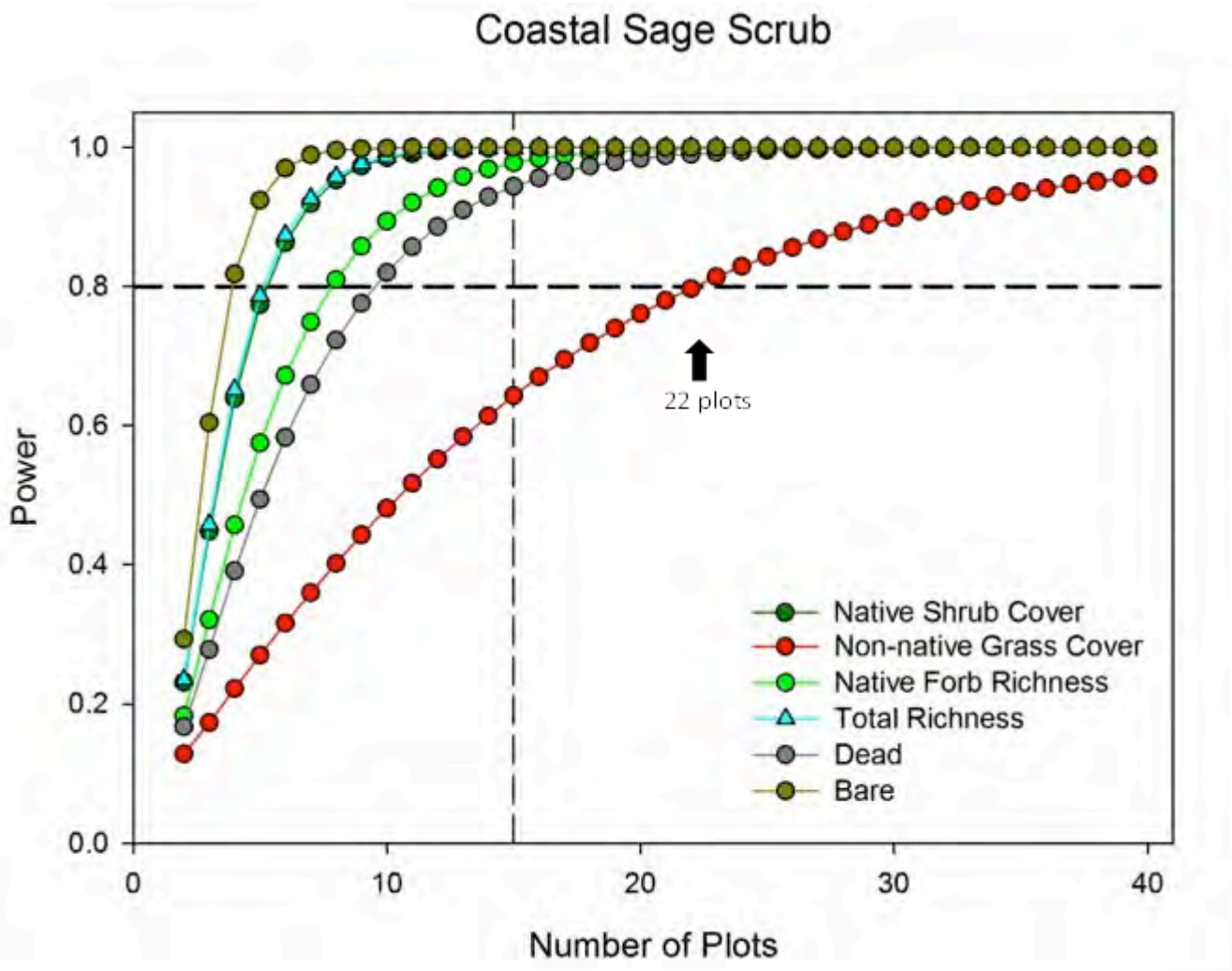
Power Analyses

- Power = 1 - β, and is related to the expected effect size (ES), the sample size (n), the sample variance (σ^2), the significance level of the test (α) and the statistic test used.
- The specific form of the relationship depends on the statistical method used
- A general relationship can be described as:

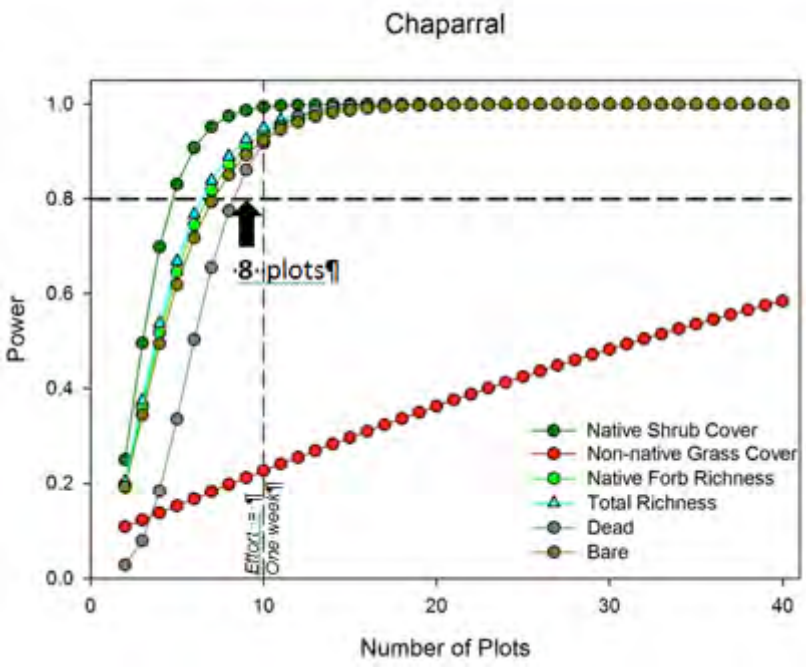
$$\text{Power} \propto \frac{\text{ES} \times \alpha \times \sqrt{n}}{\sigma}$$

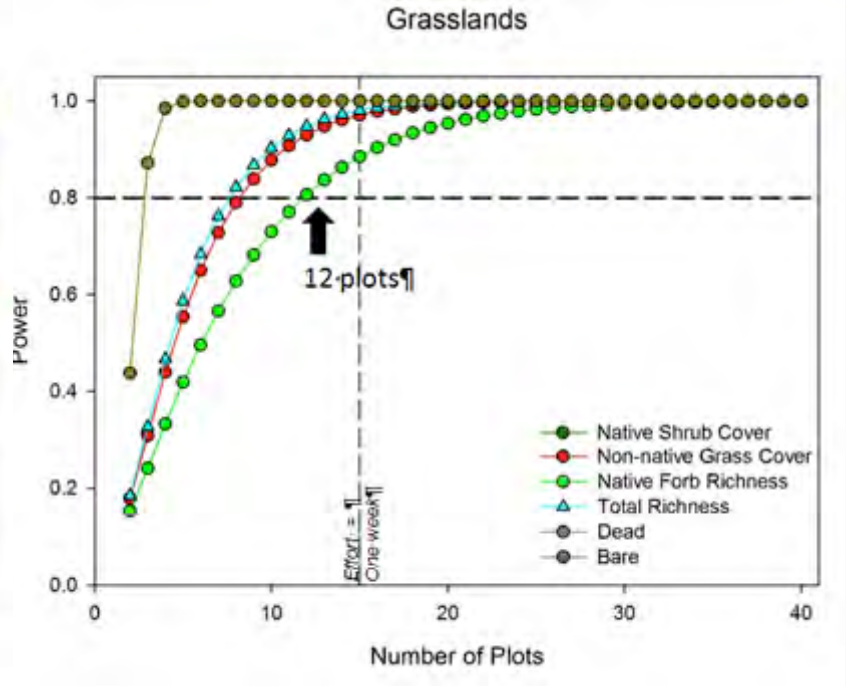
J. Di Stefano / Forest Ecology and Management 154 (2001) 141–153

Power Calculations



Power Calculations



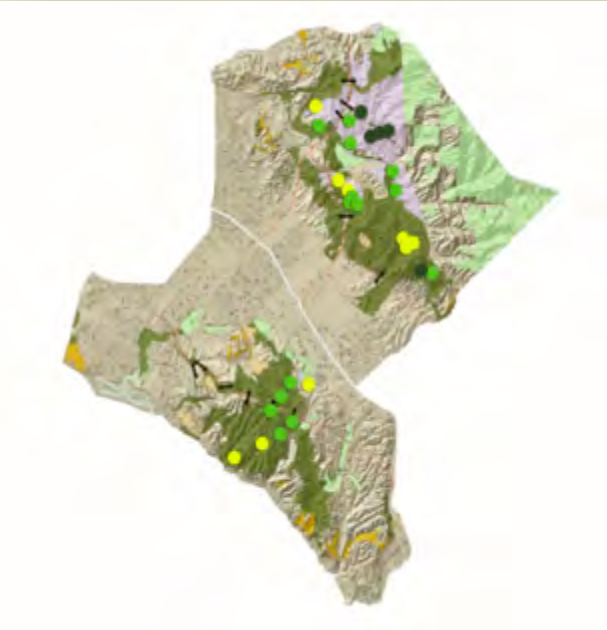


Power Calculations

Variable	Chaparral	CSS	Grassland
Recommended Sample Size [min, max]	8 plots [7 – 10]	22 plots [8 – 24]	12 plots [8 – 15]
Effort (2-person team) [min, max]	4 days [4 - 5]	9 days [4 - 10]	4 days [3 – 5]

Power at Recommended Sample Size	Chaparral	CSS	Grassland
Native Shrub Cover	98%	99%	-
Non-Native Grass Cover	20%	80%	93%
Total Species Richness	89%	99%	98%
Native-Forb Richness	87%	99%	81%
Standing Dead Material	99%	99%	-
Bare Ground	85%	99%	99%

Outline



- Monitoring in an Adaptive Management Framework
- Vegetation Monitoring in Orange County
  - Baseline Phase: Objectives, Pilot Testing
  - Results from Monitoring: CSS, Chaparral and Grasslands: Structure, Composition, and Dynamics
  - Analysis and Adaptation: Variance Components and Power Calculations
- Questions/Discussion

Ecological Research and Restoration in Orange County

Thanks

Professor of Biology,
Institute for Ecological Monitoring and Management
San Diego State University

IEMM

SAN DIEGO STATE UNIVERSITY

Monitoring in an Adaptive Management Framework

NCCP Monitoring Goals (County of Orange 1996b)
1. "Provide information on the overall status of target resources"
2. "Contribute to "basic knowledge of the reserve's biodiversity, dispersal and demography of "target species", community dynamics, and genetics"
3. "A baseline data collection and active management monitoring component will be included in all adaptive management activities"
4. "…management actions would be appropriate if monitoring shows long-term decline in a species or community, or if monitoring shows that a management activity is causing an unexpected result or is not efficiently achieving its goal"

Deutschman and Strahm. 2011. Four years of Vegetation Monitoring on the Nature Reserves of Orange County in Central Orange County, CA. 2010 Final Report.

Monitoring in an Adaptive Management Framework

TAC Monitoring Goals (NROC TAC 2000)
5. "Document the relationship between reserve management and the status and spatial distribution of native species and habitats"
6. "Monitor relationships in temporal trends between native and exotic species"
7. "Detect large scale changes in vegetation types, unique plant assemblages, sensitive-plant species, and exotic species of management concern"
8. "Maintain lists of native species and exotic species"
9. "Detect changes among core, edge and fragment sites within the NCCP"
10. "Detect factors threatening native species and habitats of management concern"

Deutschman and Strahm. 2011. Four years of Vegetation Monitoring on the Nature Reserves of Orange County in Central Orange County, CA. 2010 Final Report.

Monitoring in an Adaptive Management Framework

Data Analysis Guidelines (NROC TAC 2000, County of Orange 1996b)
11. "Analysis will include comparisons of current and previous year data, with greater emphasis on identifying long term trends rather than short term analysis"
12. "assess the effectiveness of the management effort, and… guide decisions on future management efforts"
13. Detect "a drastic 20% change between a pair of consecutive years" (β=80% α=10%)
14. Detect a "5% linear trend over 5 years" (β=80% α=10%)
15. Detect a "10% linear trend over 5 years" (β=80% α=10%)
16. "minimize effort while providing reliable measures of change in (1) vegetative composition and (2) vegetative structural diversity"
17. "Vegetative structural diversity will serve as an indicator of habitat quality and will be measured as the variance in height of woody plants and the variance in shrub cover"

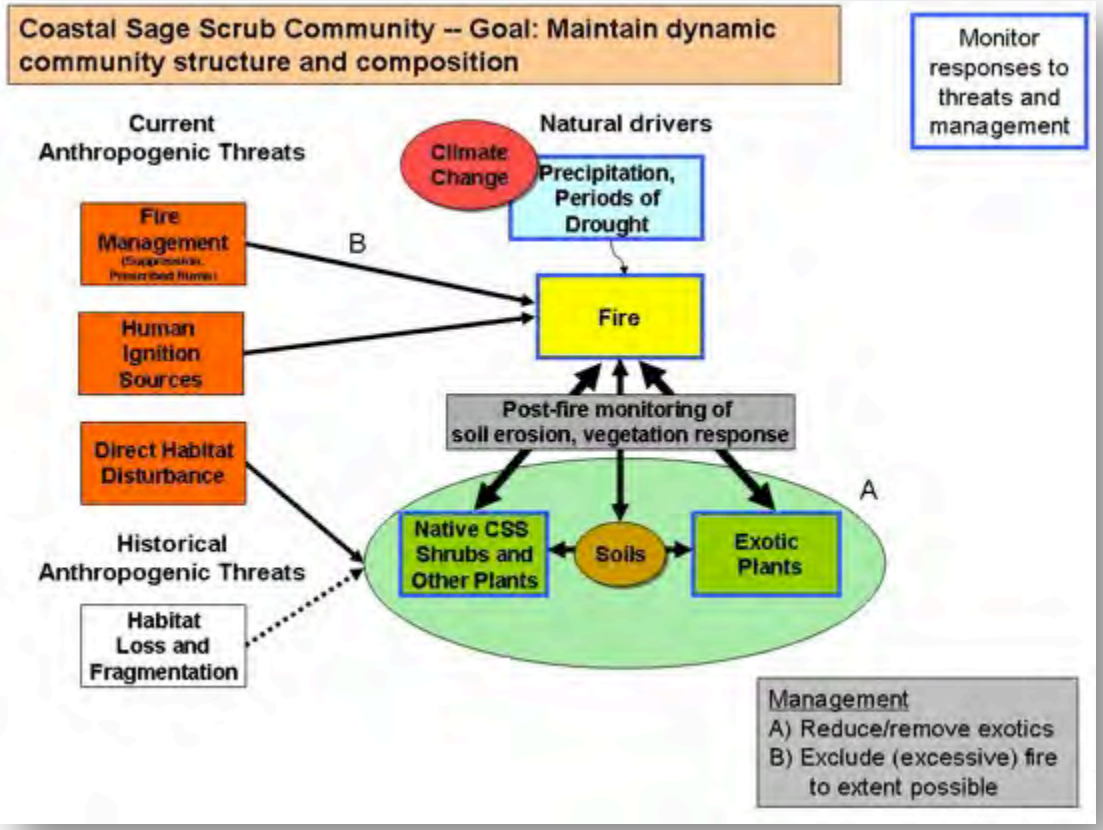
Deutschman and Strahm. 2011. Four years of Vegetation Monitoring on the Nature Reserves of Orange County in Central Orange County, CA. 2010 Final Report.

Goals and Objectives

To refine vegetation community monitoring methods by collecting data using a variety of protocols, describing spatial, temporal and methodological variability, and estimating power for functional indicators of community diversity and function over the course of 5 years.

- **S**pecific: CSS and other vegetation community functional indicators
- **M**easurable: Variance decomposition, effort, spatial pattern and change through time, power analysis
- **A**chievable: Yes
- **R**esults-oriented: Yes
- **T**ime-fixed: 5 years

Monitoring in an Adaptive Management Framework



Franklin et al. 2011. Planning, Implementing, And Monitoring Multiple-Species Habitat Conservation Plans. Am. J. Bot 98(3)559-571

Discussion

Critical Habitat Component	Species/ Taxa	Solution
Cover of a specific woody species	• Gnatcatcher • Cactus Wren • Hermes copper • Thorne's hairstreak	PI (Vis)
Cover of a Specific Herb	• Quino Checkerspot	QD (Special)
Bare ground/ mineral substrate	• Arroyo toad • Burrowing Owl • Reptiles • Burrowing animals	PI
Fuels	• Oaks • Tecate Cypress	PI
Non-native grass/ forb cover	• Stephen's Kangaroo Rat • Other small mammals	PI
Woody: Non-woody Ratio	• Birds	PI

Pilot Phase

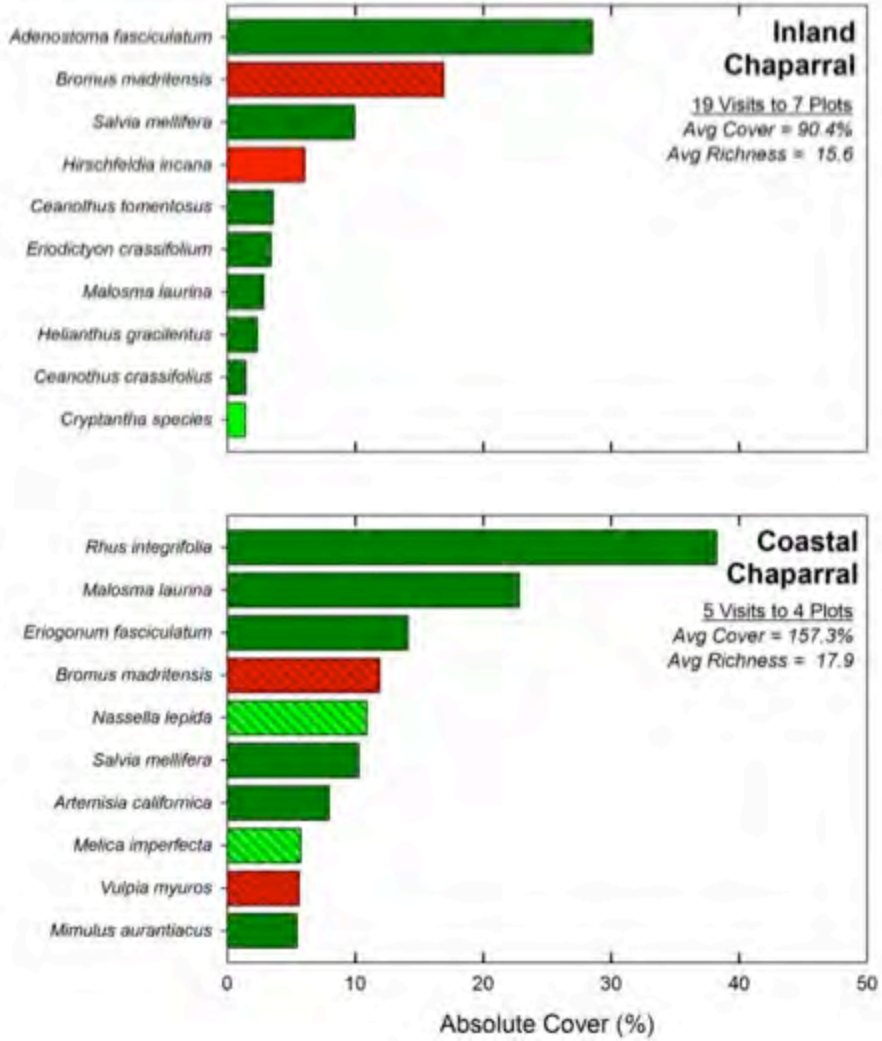
Inland	Total Plots	2007	2008	2009	2010	Total Visits
Chaparral	**7**	3	5	6	5	**19**
CSS	**17**	3	9	12	11	**35**
Grassland	**14**	2	6	9	6	**23**
Total	**38**	**8**	**20**	**27**	**22**	**77**

Coastal	Total Plots	2007	2008	2009	2010	Total Visits
Chaparral	**4**	-	-	4	1	**5**
CSS	**11**	-	5	10	4	**19**
Grassland	**5**	-	2	4	2	**8**
Total	**20**	**0**	**7**	**18**	**7**	**32**

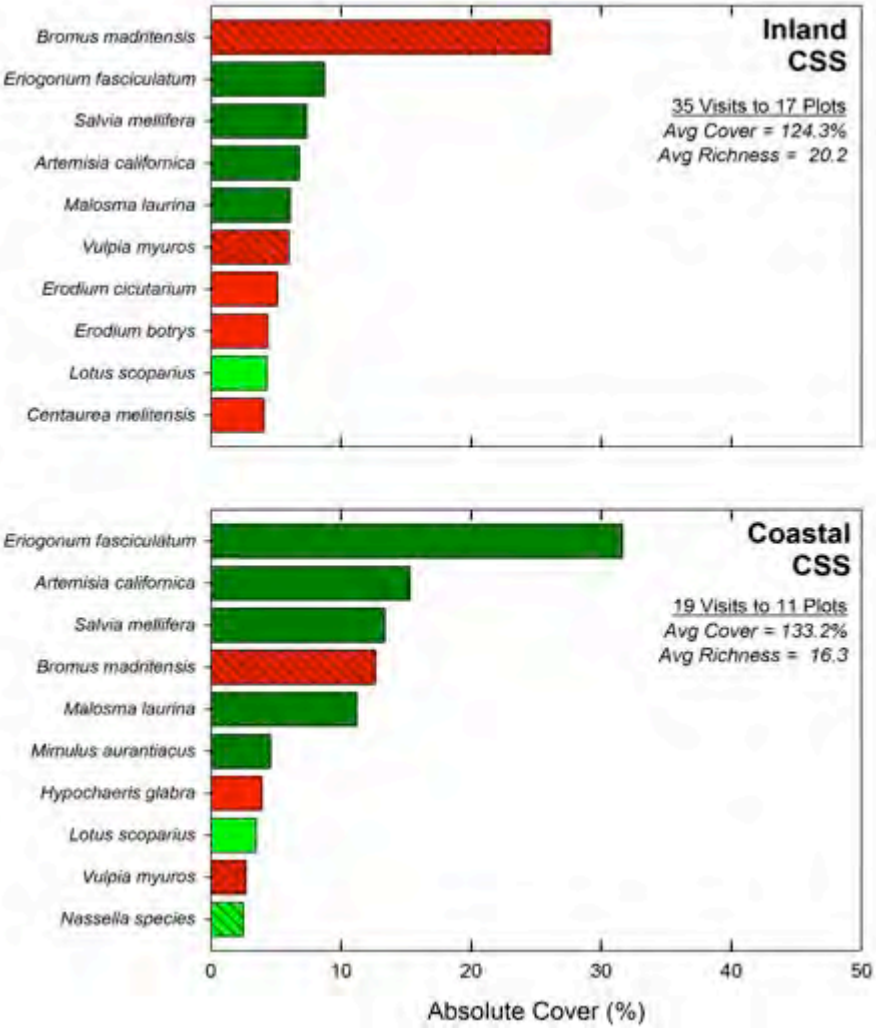
Composition

	Chaparral (52 plot visits)	CSS (109 plot visits)	Grassland (46 plot visits)
Number of Taxa (Species Richness)	**119**	**170**	**101**
# Species to reach 50% Cover	**4**	**5**	**4**
75% Cover	**10**	**16**	**11**
90% Cover	**25**	**38**	**21**
Dominant Species (in order)	*Adenostoma fasciculatum* *Bromus madritensis* *Salvia mellifera* *Rhus integrifolia* *Malosma laurina* *Hirschfeldia incana* *Nassella lepida* *Ceanothus tomentosus* *Eriogonum fasciculatum* *Eriodictyon crassifolium*	*Bromus madritensis* *Eriogonum fasciculatum* *Salvia mellifera* *Artemisia californica* *Malosma laurina* *Vulpia myuros* *Erodium botrys* *Lotus scoparius* *Erodium cicutarium* *Centaurea melitensis*	*Bromus diandrus* *Bromus madritensis* *Nassella pulchra* *Erodium botrys* *Lolium multiflorum* *Avena barbata* *Bromus hordeaceus* *Brachypodium distachyon* *Erodium cicutarium* *Brassica nigra*

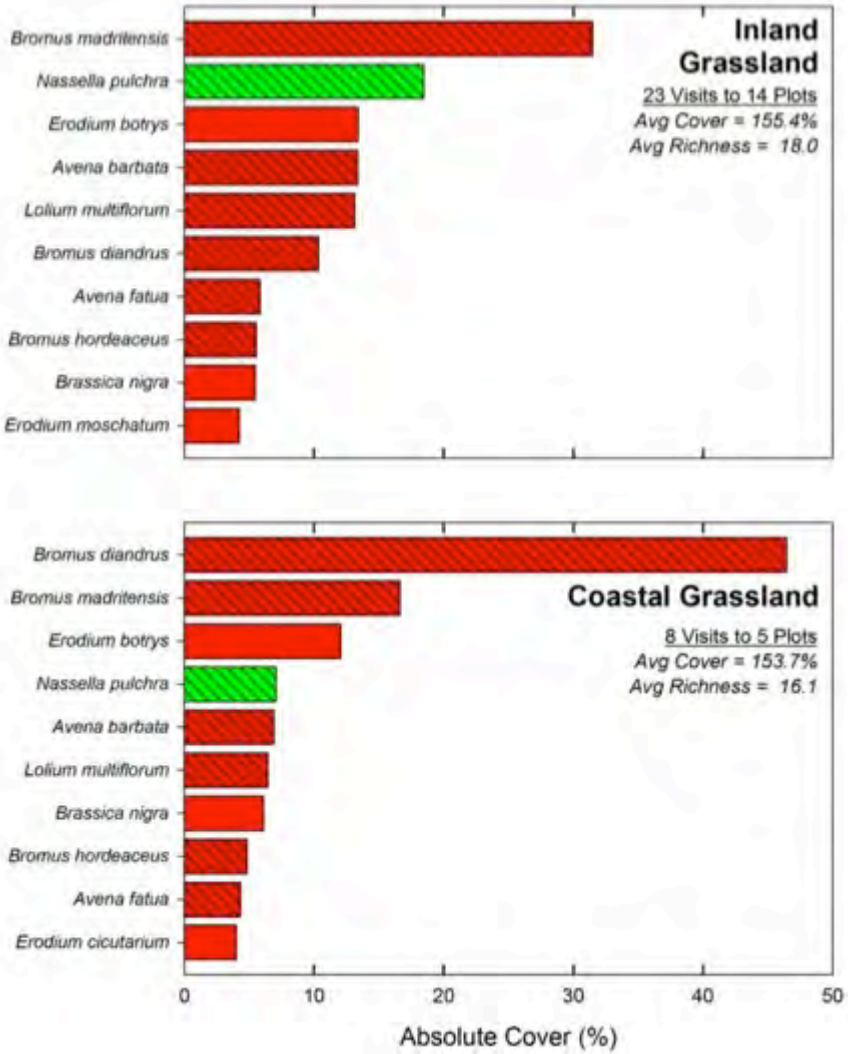
CSS, Chaparral and Grasslands



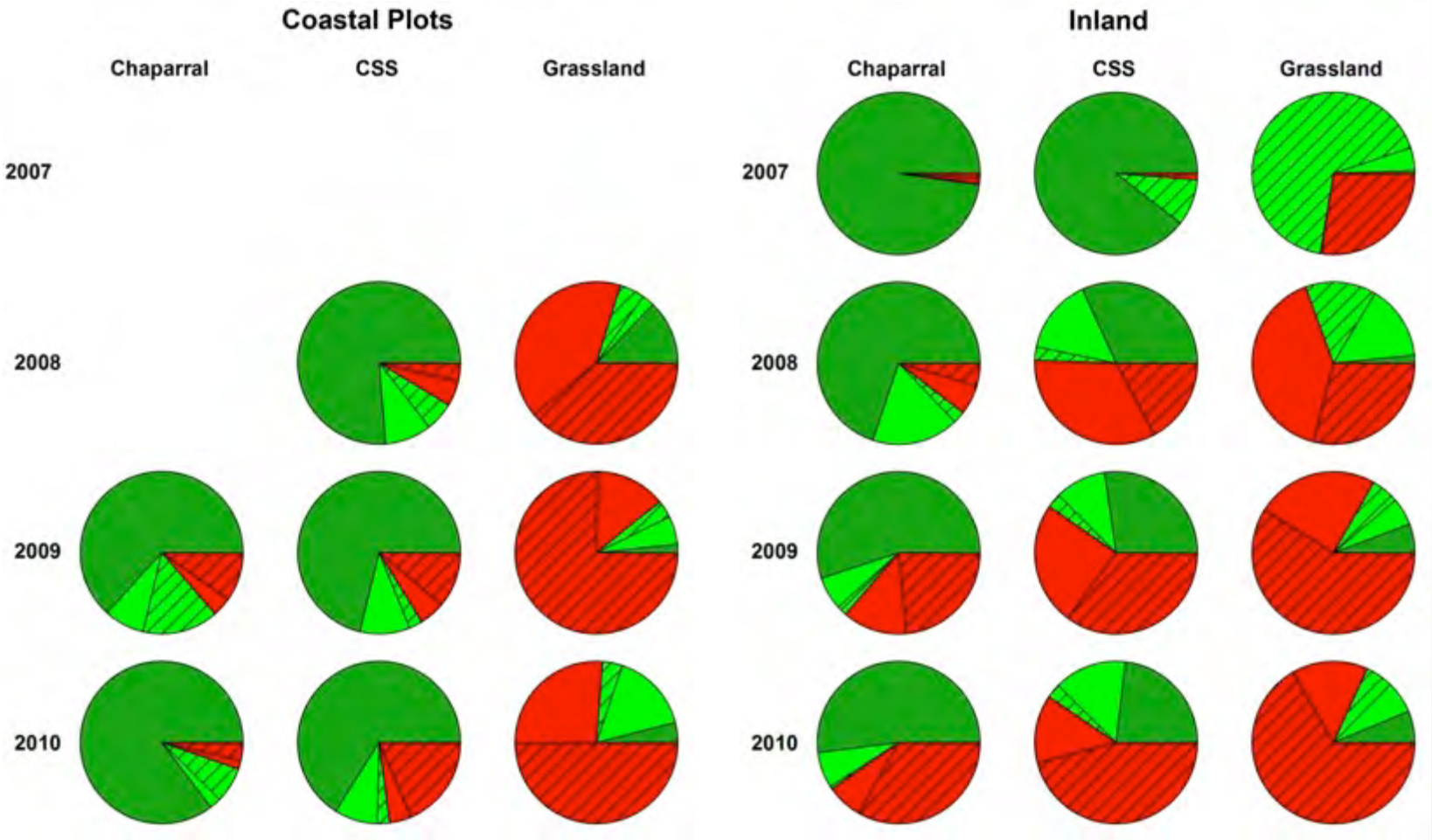
CSS, Chaparral and Grasslands



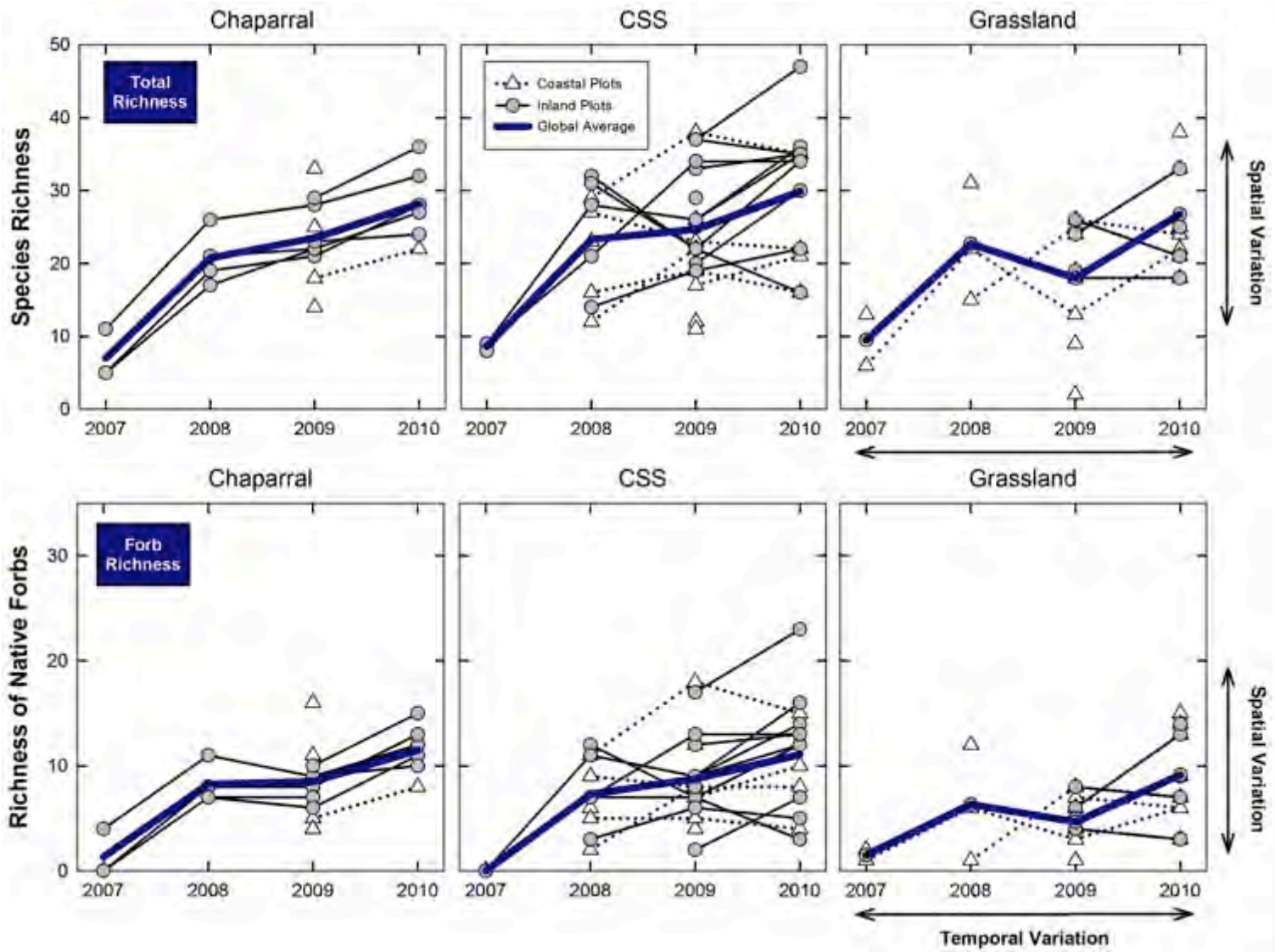
CSS, Chaparral and Grasslands



Spatio-Temporal Dynamics



Spatio-Temporal Dynamics



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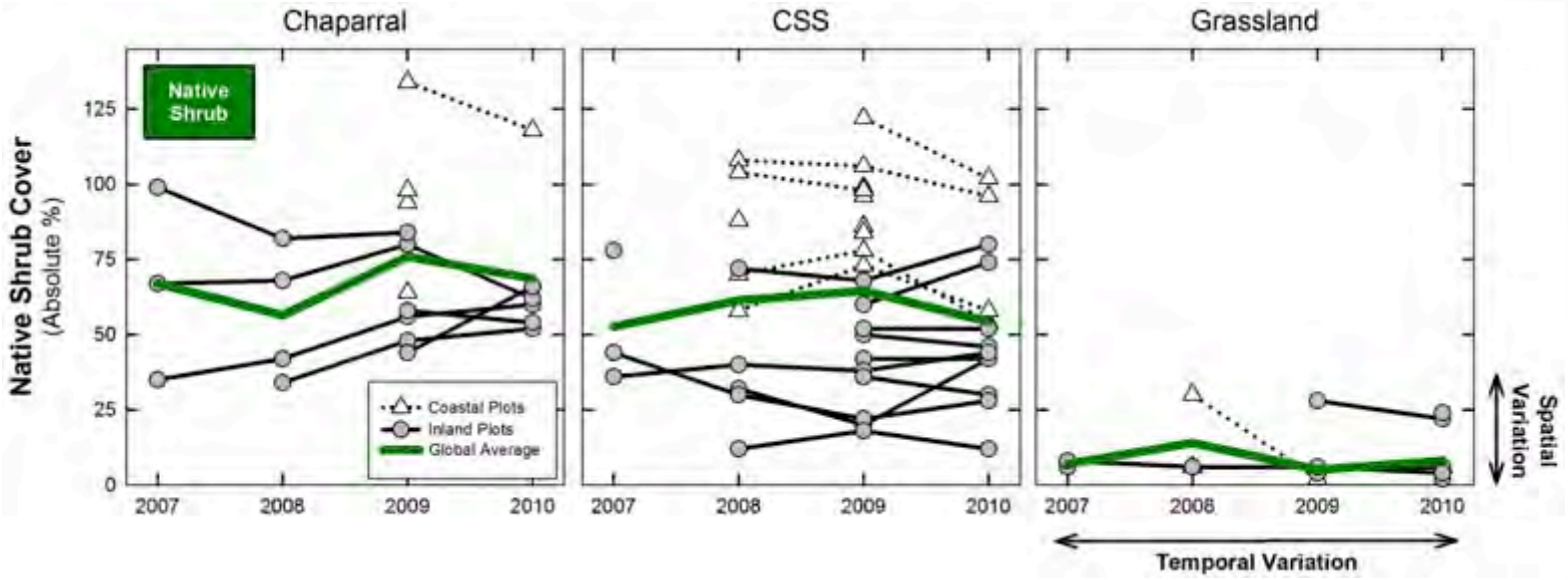

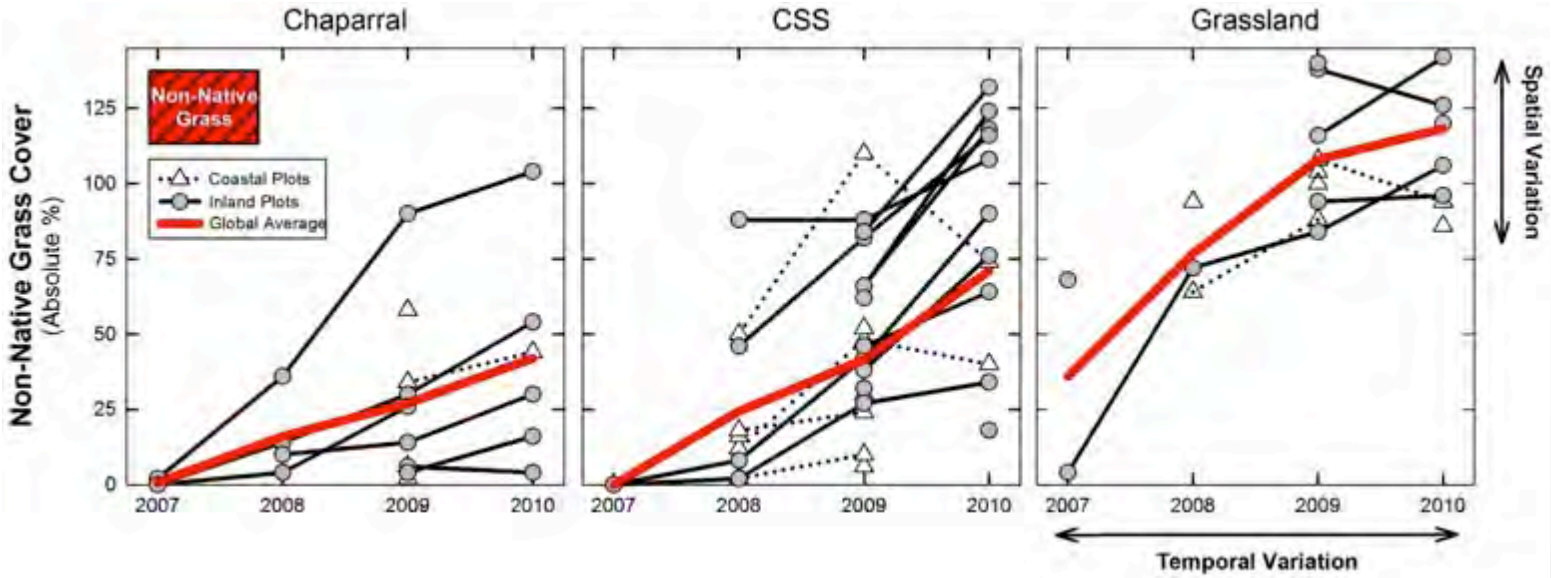

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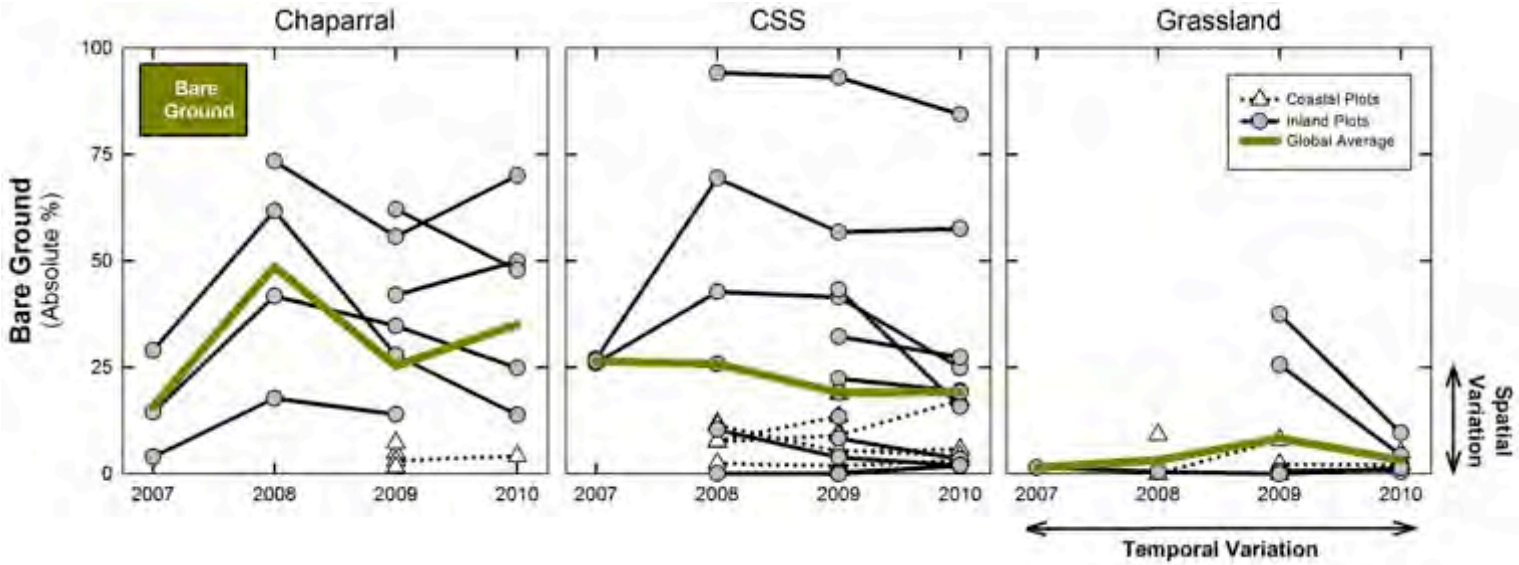

Trade-offs using this method

Pros

- Looks below the canopy
- Captures richness in herbs
- Distinguishes native from non-native species
- "boots on the ground"
- Can potentially capture rare species or emergent exotics
- Results can be interpreted across a range of experience levels
- Can answer a range of questions about habitat suitability using species specific data
- Conventional, easy to understand and replicate

Cons

- Time consuming
- Limited spatial extent
- Representativeness limited to conditions at plot locations
- Some field experience needed

Invasion and Disturbance

THE GROWTH-FORMS OF THE FLORA OF NEW YORK AND VICINITY[1]

1915

NORMAN TAYLOR

The Growth-Forms of the Flora of New York and Vicinity
Author(s): Norman Taylor
Reviewed work(s):
Source: *American Journal of Botany*, Vol. 2, No. 1 (Jan., 1915), pp. 23-31

In attempting to apply Raunkiaer's principles described above and to get the biological spectrum of the flora near New York, I have thrown out of the calculation all the 615 species of introduced weeds,