SAN DIEGO STATE UNIVERSITY

1/3/2012

TO: KEITH GREER

FROM: SPRINGSTRAHM

SUBJECT: CONTRACT 5001033, AMMENDMENT 3: "EVALUATION AND REFINEMENT OF VEGETATION MONITORING METHODS FOR THE SAN DIEGO MSCP"

DATE: JANUARY 3, 2012

CC: DOUGLAS DEUTSCHMAN, TATIANA BOSQUET

Mr. Greer,

We are pleased to report that Task 3 for "Evaluation and Refinement of Vegetation Monitoring Methods for The San Diego Multiple Species Conservation Program (MSCP)" has been completed. The results of our 5 year data analysis were presented to a general audience on Monday, December 12, 2011, in a talk entitled "Monitoring Practices for Vegetation: Pilot Studies to Power Analysis". A copy of the PowerPoint presentation is attached to this document. During this talk we detailed the last 5 years of work, which began in 2007 with a Local Assistance Grant from the California Department of Fish and Game, and continued from 2008 forward with SANDAG funding. We covered the process of setting monitoring goals and objectives; and described the pilot study, data visualization, variance decomposition, and power analysis as a case study for establishing a monitoring project in the San Diego MSCP. The presentation also contained specific recommendations about sample sizes and techniques when monitoring coastal sage scrub (CSS) and chaparral community types. The data collected over the course of this project is contained on the CD that accompanies this document.

In addition, Dr. Douglas Stow from the SDSU Geography Department and Ms. Caitlin Lippitt presented an introduction on Multiple End-member Spectral Mixture Analysis (MESMA) and a preliminary report on using MESMA for wall-to-wall monitoring applications in the MSCP (presentation also attached). This presentation largely deals with using novel remote-sensing techniques to provide full spatial coverage of the MSCP vegetation communities. While remote sensing will never address all vegetation monitoring needs, this technique has the potential to revolutionize our ability to create full coverage maps, which are necessary for managing the MSCP as a single reserve network.

We confirmed an attendance of over 37 individuals from 21 organizations, agencies and jurisdictions including consultant companies, non-profit organizations, city and county governments and state and federal agencies. A list of confirmed attendees can be found below.

In 2012 we will compare plot data to remotely-sensed data and discuss the relative costs and benefits of each approach for monitoring floristic composition and structure across a large region like the MSCP. It is our belief that in combination both methods could meet most broad scale vegetation monitoring needs. In order to understand the strengths and weaknesses of each approach we will make direct comparisons between plot-based work, the multiple endmember spectral mixture analysis, and the updated vegetation classification and mapping effort (AECOM). In addition, if time permits, we will include data collected by other projects (i.e. Fisher herpetofauna arrays and Winchell Gnatcatcher data sets) to increase our sample size on the ground.

We will develop a user's guide to these complementary protocols that use both remote sensing and field techniques to provide the most efficient vegetation community monitoring program possible. If the project is extended into 2013, we plan to validate the decision framework and protocols at new plots as the final test. Such validation will provide a scientifically credible monitoring method and guide that is useful from the very small scale to the very large scale.

Thank you for your time and continued support!

Spring Strahm, M.S.

and

Douglas Deutschman, PhD

SAN DIEGO STATE UNIVERSITY

1/3/2012

LIST OF ATTENDEES

Last	First	Association
Allen	Cara	DFG
Brennen	Chris	City of San Diego
Collada	Angela	Western Riverside MSHCP
Drennen	Karyn	Western Riverside MSHCP
Duke	Bryand	DFG
Fisher	Robert	USGS
Garcia	Joshua	City of San Diego
Gordon-Reedy	Patricia	CBI
Greer	Keith	SANDAG
Hillary	Richard	SERG
Humphrey	Rosanne	ES Associates
Johanson	Arne	CNPS
Lambert	Julie	SERG
Lawhead	David	DFG
Martin	John	FWS
MATHER	ELIZABETH	
McConnell	Patrick	CNLM
McGinnis	Nicole	City of San Diego
Miller	Betsy	City of San Diego
Miller	William	FWS
Norton	Jessica	San Diego County
Obernauer	Thomas	AECOM
Osborne	Meredith	DFG
Pelley	Sue	City of San Diego
Peregrin	Chris	State Parks
Price	Jason	DFG
Price	Jennifer	San Diego County
Principie	Zach	TNC
REMPEL	RON	SDMMP
Rihl	Stephanie	DFG
Rom	Catherine	City of San Diego
Silva	Gloria	Forest Service
Smith	Trish	TNC
Spears-Lebrun	Linnea	AECOM
Terp	Jill	FWS
Tracy	Jeff	USGS
Turner	Debbie	TAIC
Varner	David	San Elijo
White	Dana	

APPENDIX 1:

MONITORING PRACTICES FOR VEGETATION: PILOT STUDIES TO POWER ANALYSIS

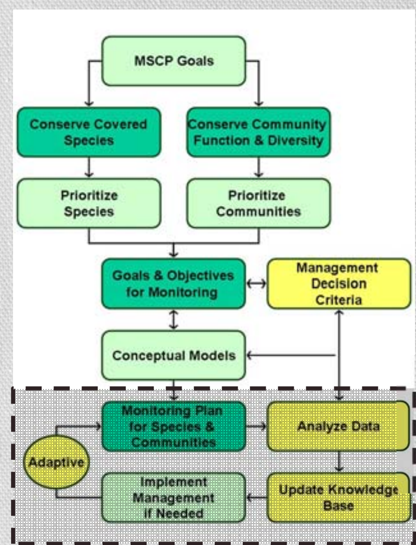
MONITORING PRACTICES FOR VEGETATION:

from Pilot Studies to Power Analysis

Outline

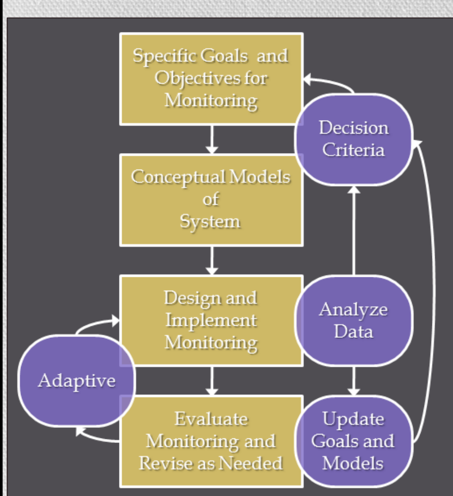
- Introduction
- Setting Goals and Objectives
- Pilot Study
- Data Visualization
- Variance Components Analysis
- Power Analysis
- Recommendations

Management and Monitoring



Our Monitoring Workshops Started Here:
Designing, implementing, and evaluating monitoring plans for species and communities.

Best Practices Conservation Monitoring



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, Ferretti 2009, Lindenmayer and Likens 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	Quinn & Keough 2002, DiStefano 2003 Legg and Nagy 2006, Mattfeldt et al 2009, Nielsen et al 2009
Adaptive Management	Atkinson et al 2004, Nicolas and Williams 2006, Bormann et al 2007, Lidenmayer and Likens 2009, McDonald-Madden et al 2010, Lindenmayer and Likens 2010

Goals and Objectives

- San Diego's Multiple Species Conservation Program (1996)

"Conserve the **diversity** and **function** of the ecosystem through the preservation and adaptive management of large blocks of interconnected habitat and smaller areas that support rare vegetation communities…"



Objectives

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

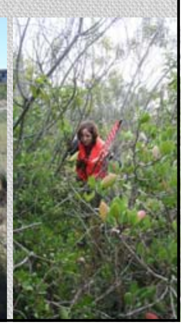
- **S**pecific: scrub community functional indicators
- **M**easurable: Variance decomposition, effort, power analysis
- **A**chievable: yes
- **R**esults-oriented: Yes
- **T**ime-fixed: 5 years

IEMM Goals and Objectives Workshop

What are these functional indicators?

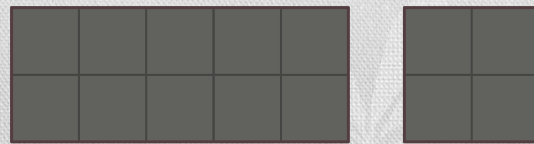
Indicator	Rational
Non-native Grass	Diffendorfer IBI
Non-native Forb Cover	Are these the same as NNG?
Native Shrub Cover	Diffendorfer IBI, Winchell
Richness	MSCP goal: “diversity”
Native Forb Cover	Drives richness, understory
Bare Ground	Habitat for plants and animals
Dead Material	Sponsor suggestion

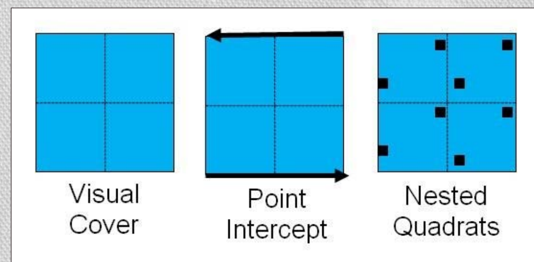
PILOT STUDY

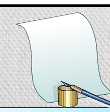


Methodology

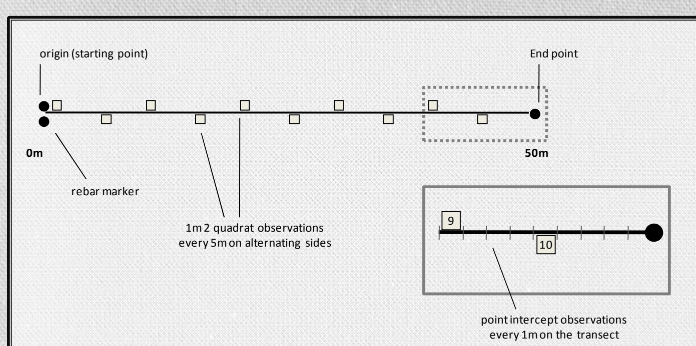
- Nested design
- 3 common protocols
- Multiple teams
- Post processed size





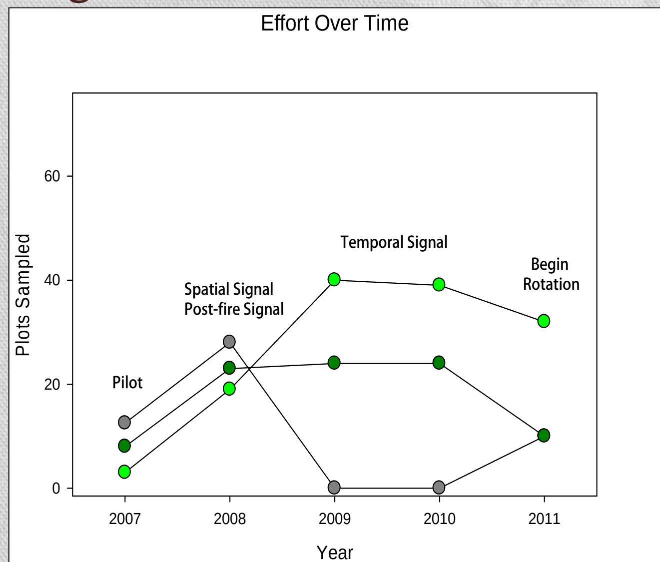


2008-2011 Response Design

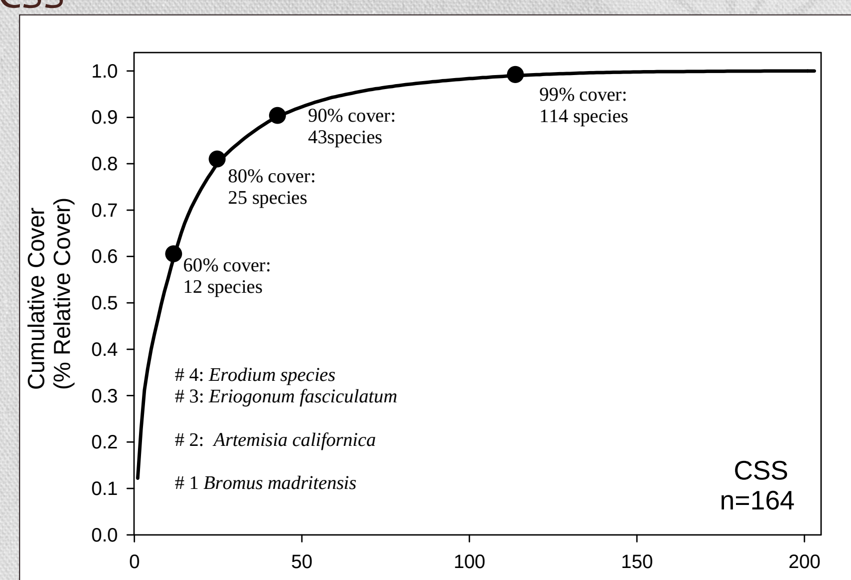


Sampling Design

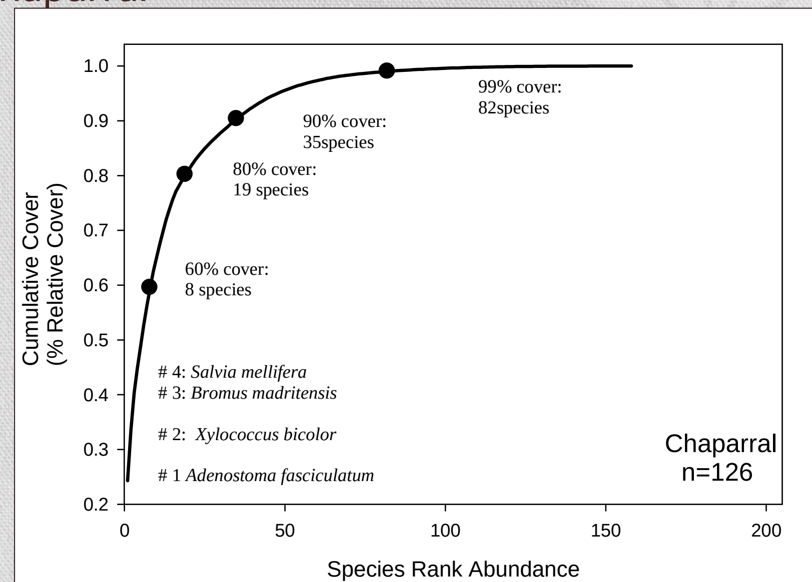
Year	Plots
2007	23
2008	70
2009	65
2010	64
2011	52



Species Accumulation Curve: CSS

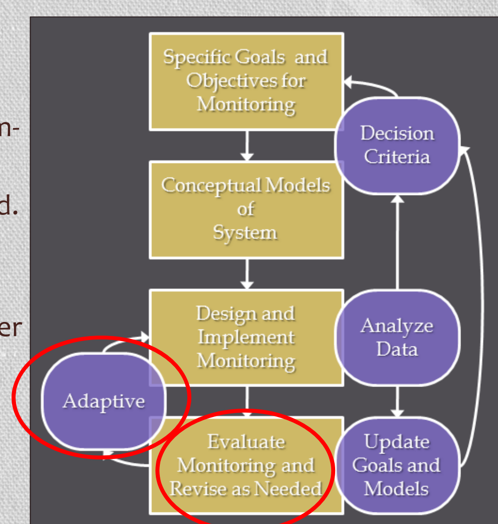


Species Accumulation Curve: Chaparral



Adaptation has happened!

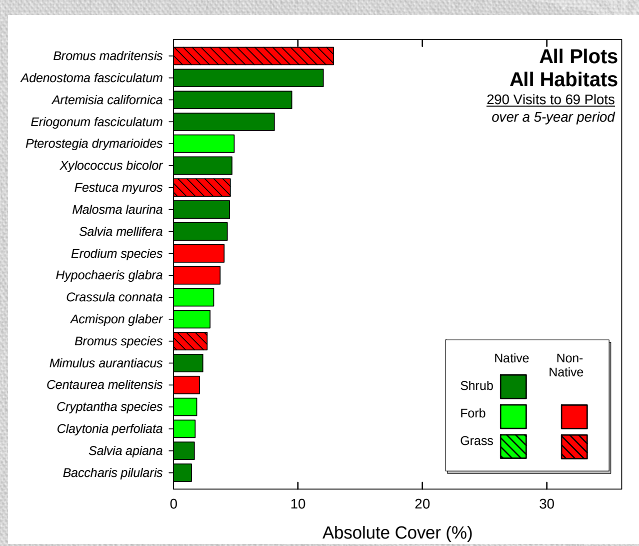
- 2 protocols do the work of 3
- Smaller plots work
- Training program reduces team-team variability.
- More spatial coverage required.
- If richness matters you need expert data collectors
- If cover matters you need fewer experts



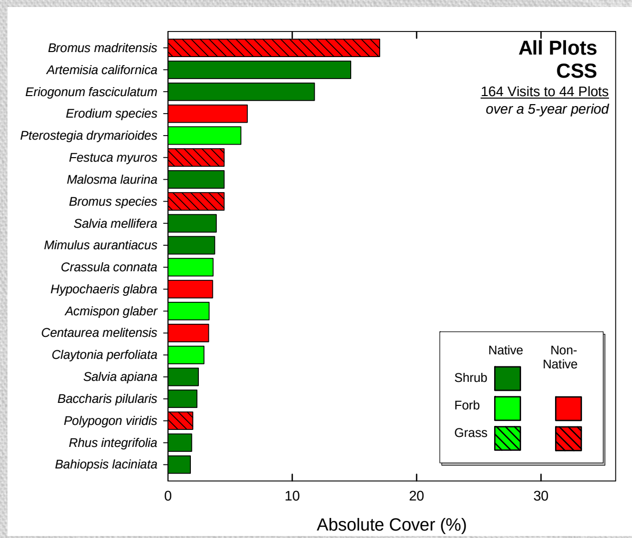
Building Intuition

DATA VISUALIZATION

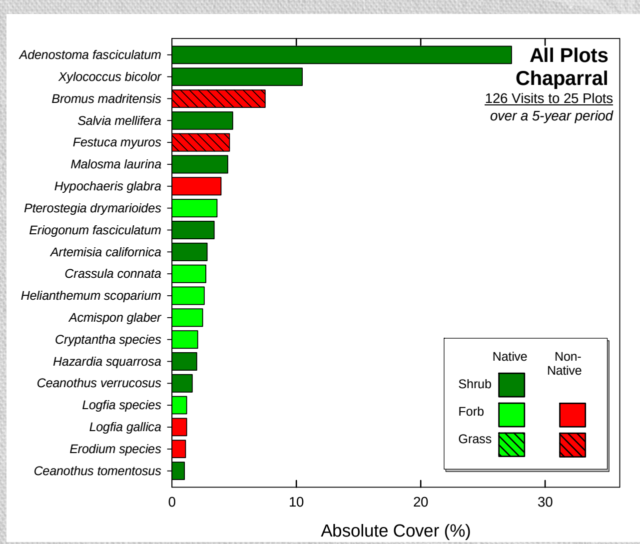
Vegetation Community Status



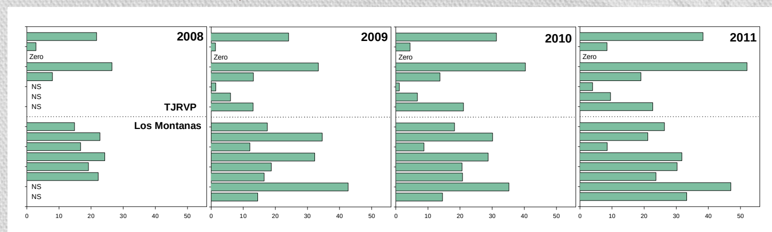
CSS Community Status

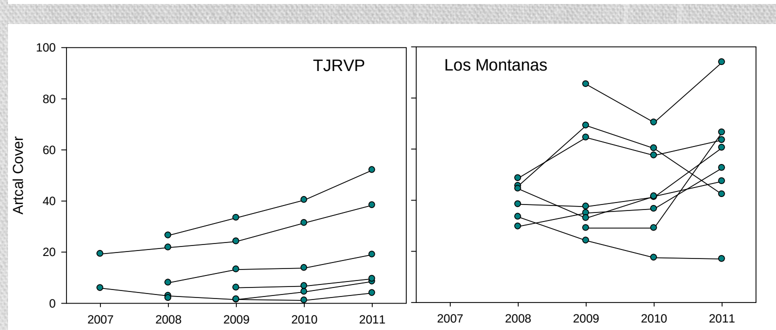


Chaparral Community Status

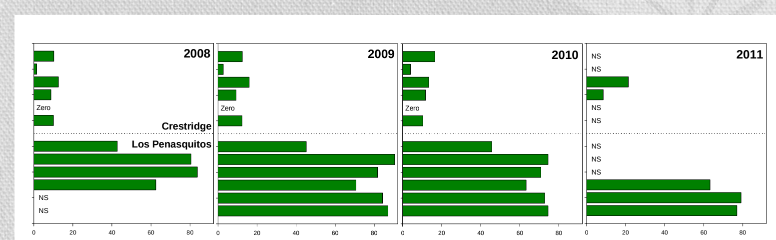


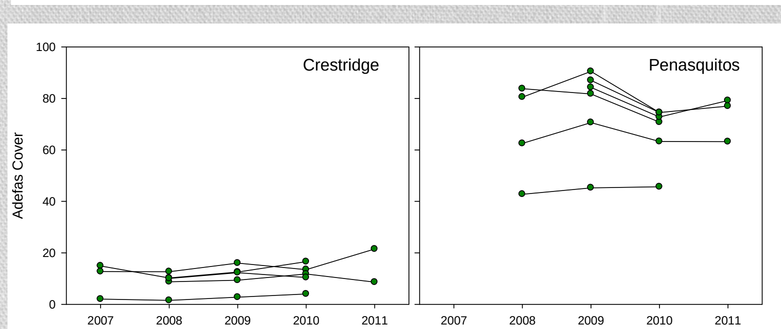
Artemisia californica



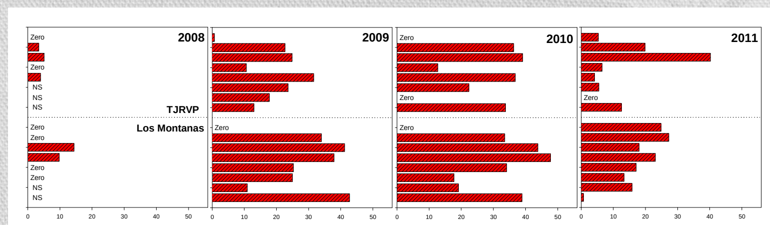


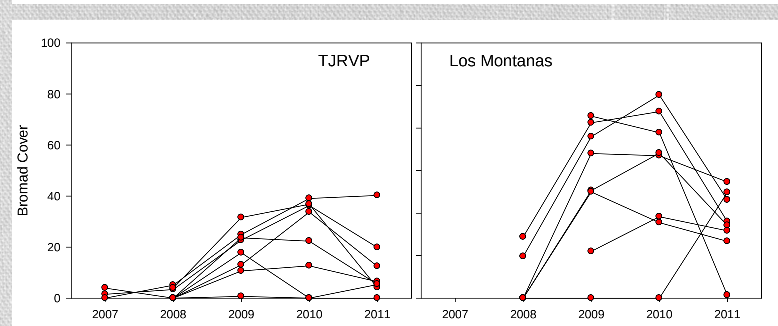
Adenostoma fasciculatum





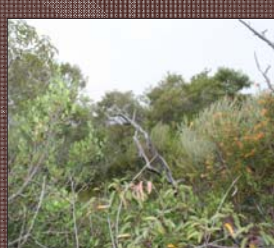
Bromus madritensis (in CSS)



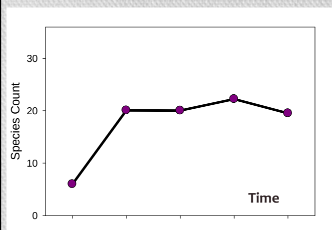


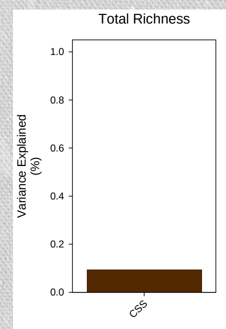
Measuring

SOURCES OF VARIATION

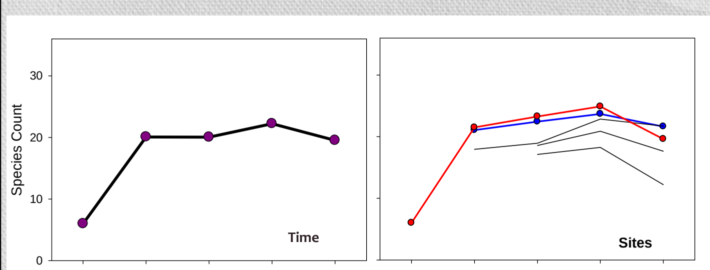


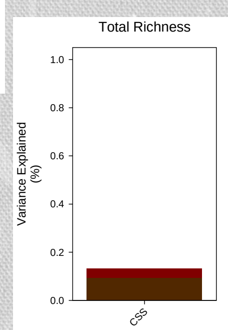
Example: Richness



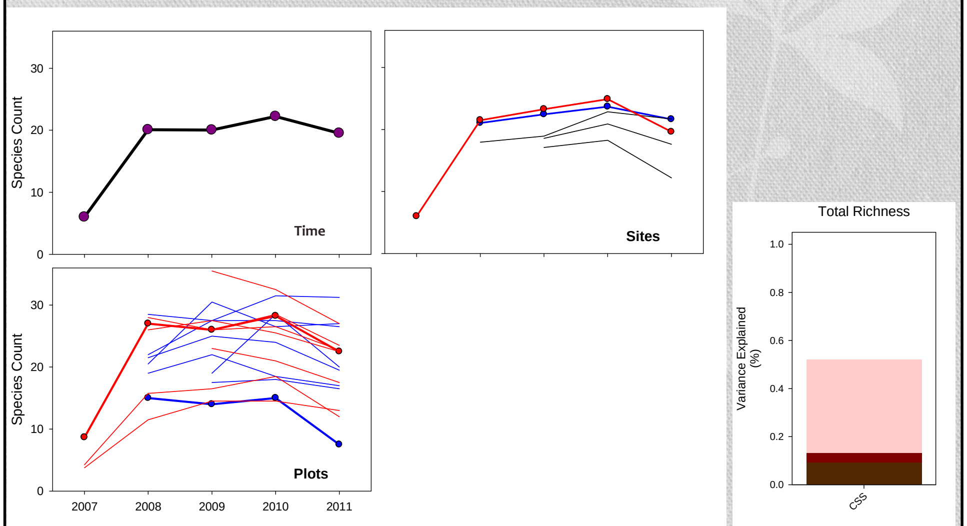


Sites

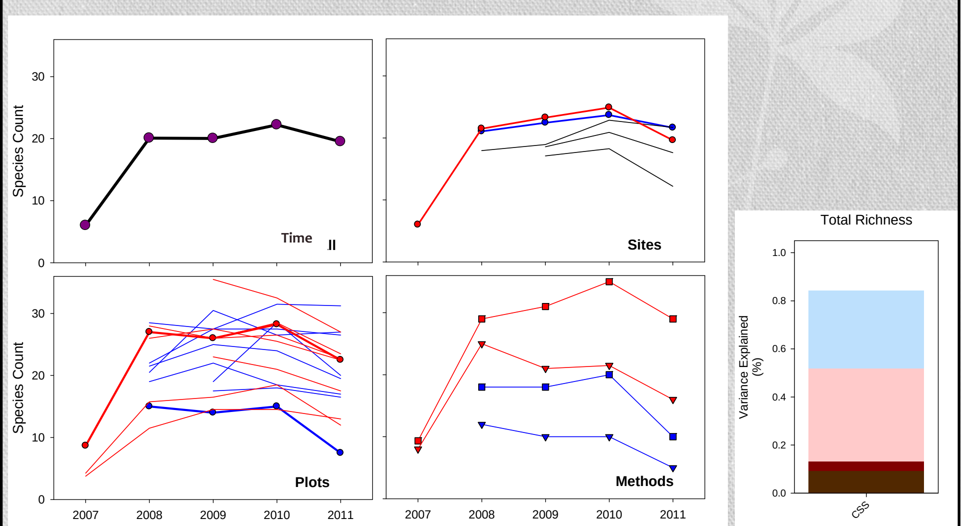




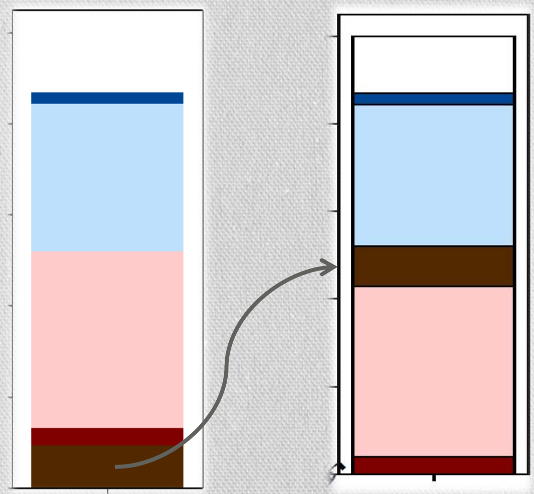
Plots



Methods

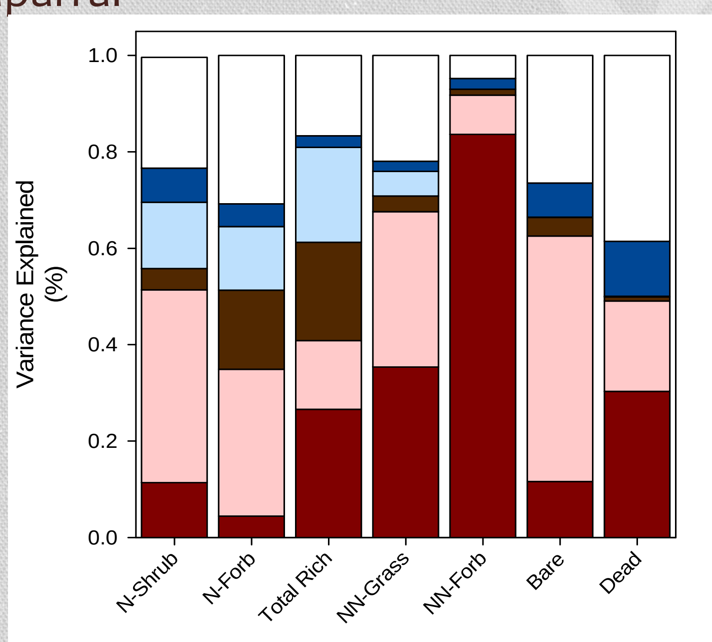


Teams

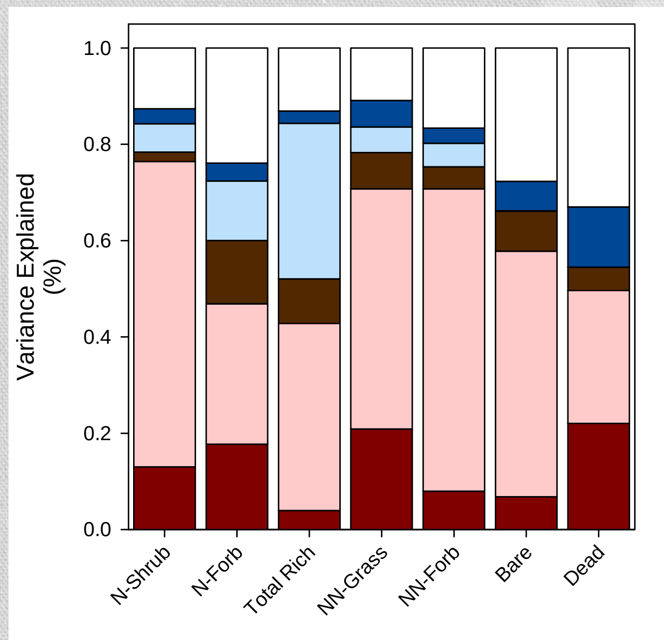


- Generally a small fraction
- Training minimizes it most of all

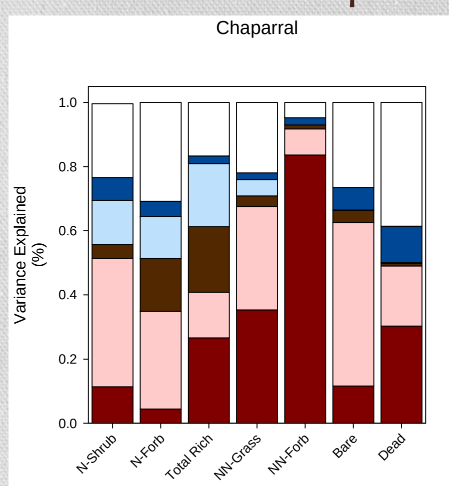
Chaparral



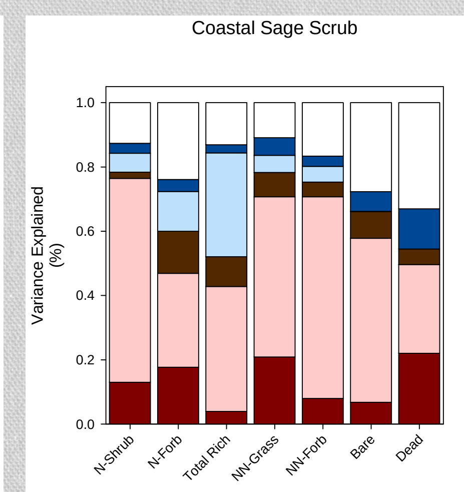
CSS



Variance Decomposition



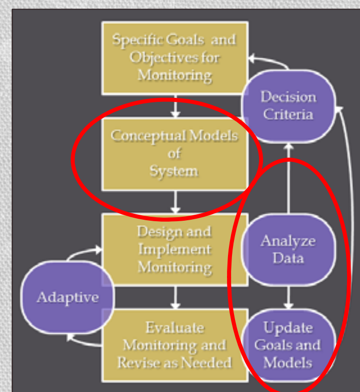
More Sites



More Plots

Results

- Now we are set up to design a study well AND
- We learned something
- CSS and Chaparral have different spatial signatures



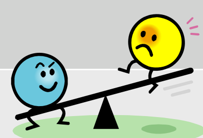
POWER ANALYSIS

What is Power?

- The probability of rejecting a hypothesis when it is false.
- E.G. **Detecting change when the system really is changing.**
- Ideally we want this to be as close to 100% as possible.
  - Generally 80% is a default

Power Calculations

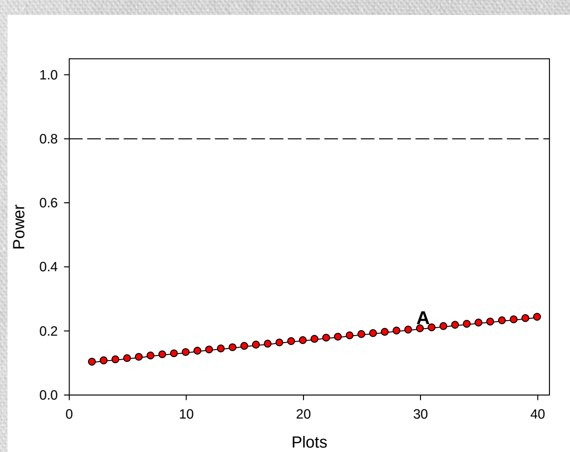
Parameter	Decision Making Factors	Example
a (Type I error)	False Positive. Generally set at 0.05 (=5%)	0.10
b (Type II error)	False Negative Generally set at 0.20 (Power = 80%)	0.20
Parameter Estimate and Variability	A credible estimate of the parameter of interest as well as a measure of its natural variation.	5-year long-term averages and (sd) from all unburned plots in San Diego.
ES (Effect size)	The effect size is the magnitude of the change that you want to be able to detect.	Determined by biological relevance, judgment, easement terms, etc.
Type of Statistical Analysis	Determined by the nature of the monitoring program and the question being asked.	1-sample t-test long term average V. change
Maximum Effort Possible	What is possible with the time and budget available.	2-man team, 2-weeks maximum per vegetation type.



Example Objective

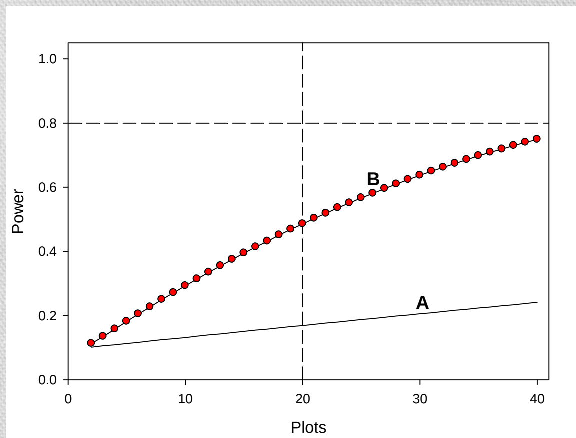
- To detect a biologically relevant change in average non-native grass cover in unburned chaparral next year, using two field people for two weeks and achieving 80% power and 10% false positive rate.
  - **S:** Non-native grass in unburned Chaparral
  - **M:** Measurable by point intercept and quadrat methods, statistically sound
  - **A:** Limit effort to two people over two weeks.
  - **R:** Presumably "biologically relevant" is a trigger for management
  - **T:** One year period
  - **E** (Effect size): "Biologically Relevant" ← could use some work.
  - **S** (Statistically significant): 80% power, 10% false positive rate
  - **T** (Testable): 1-sample t-test, 5-year long term averages available ←implied?

Example: NNG in Chaparral



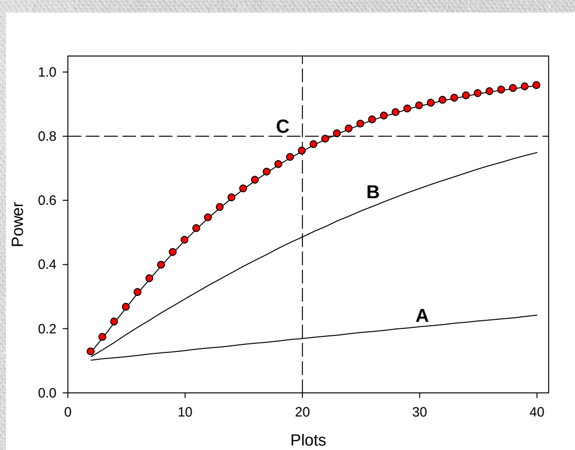
Non-native Grasses in Chaparral			
X=13.8, sd = 9.3, a=0.10			
Opt	Rel	Abs	N
A	**10.0%**	**1.4%**	--

Example: NNG in Chaparral



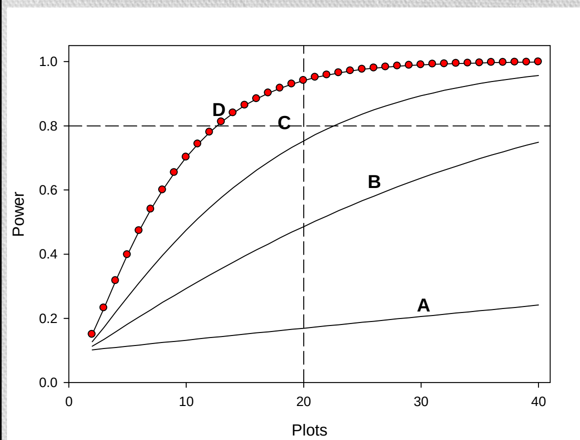
Non-native Grasses in Chaparral			
X=13.8, sd = 9.3, a=0.10			
Opt	Rel	Abs	N
A	10.0%	1.4%	--
B	**25.0%**	**3.5%**	**--**

Example: NNG in Chaparral



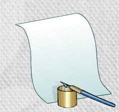
Non-native Grasses in Chaparral			
X=13.8, sd = 9.3, a=0.10			
Opt	Rel	Abs	N
A	10.0%	1.4%	--
B	25.0%	3.5%	--
C	**36.0%**	**5.0%**	**23**

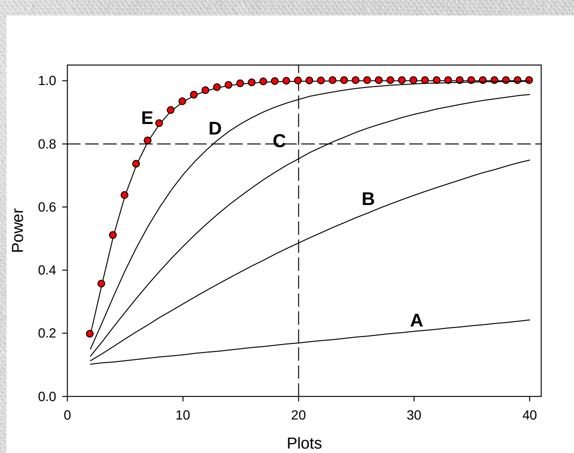
Example: NNG in Chaparral



Non-native Grasses in Chaparral			
X=13.8, sd = 9.3, a=0.10			
Opt	Rel	Abs	N
A	10.0%	1.4%	--
B	25.0%	3.5%	--
C	36.0%	5.0%	23
D	**50.0%**	**6.9%**	**12**

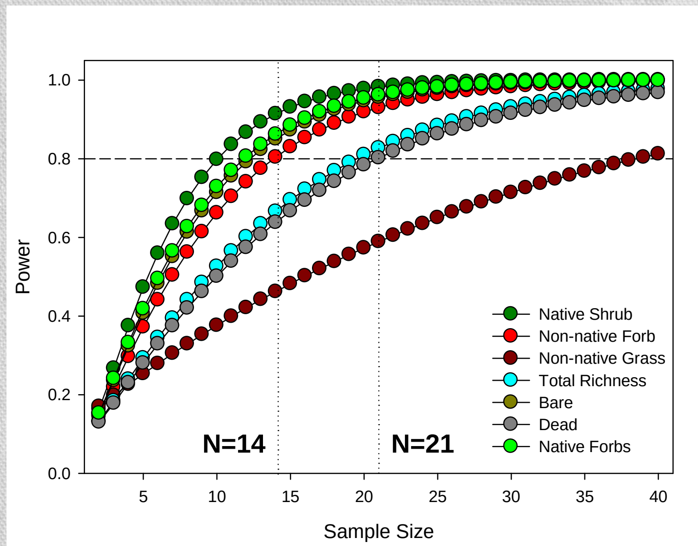
Example: NNG in Chaparral



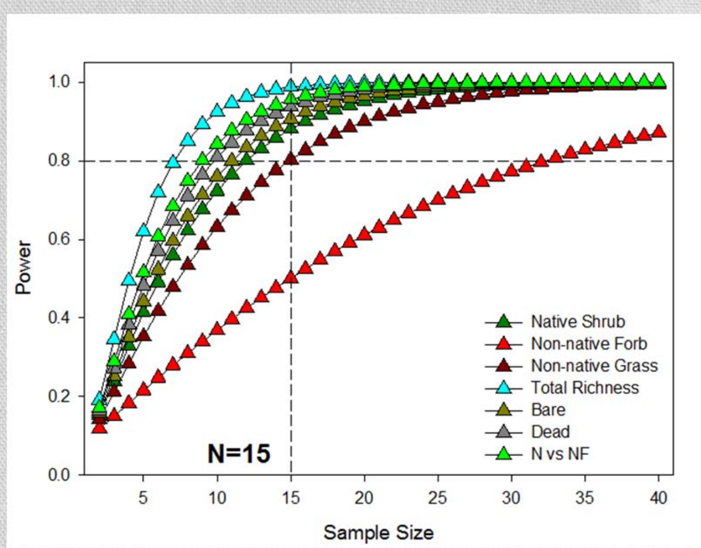


Non-native Grasses in Chaparral			
X=13.8, sd = 9.3, a=0.10			
Opt	Rel	Abs	N
A	10.0%	1.4%	--
B	25.0%	3.5%	--
C	36.0%	5.0%	23
D	50.0%	6.9%	12
E	**73.0%**	**10.0%**	**6**

Chaparral

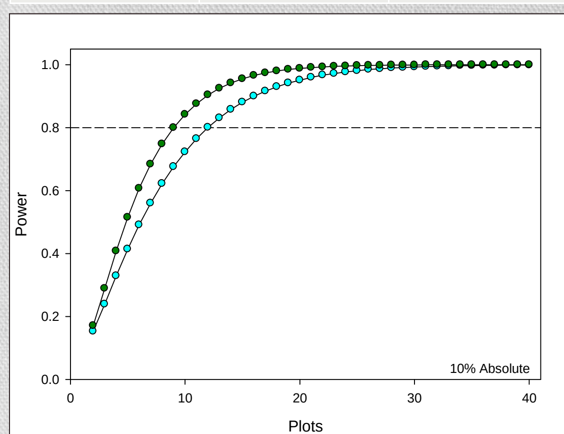


CSS



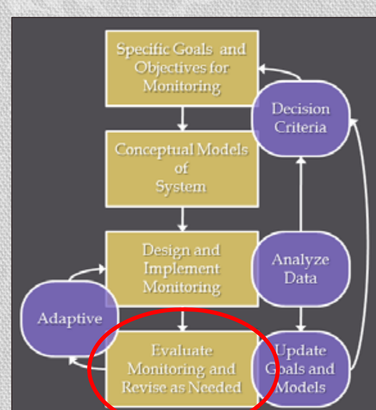
Artemisia californica (county wide)

	Average	sd
Artcal	14.7	15
Native Shrubs	57	11



That was the easy part!!

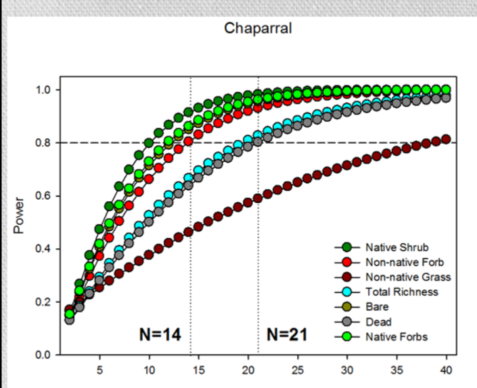
- What are the smartest objectives we can write?
- What are the numerical management triggers?
- When do we think in absolute or relative terms?

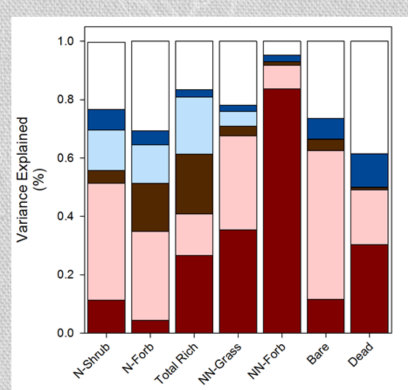


RECOMMENDATIONS

Chaparral

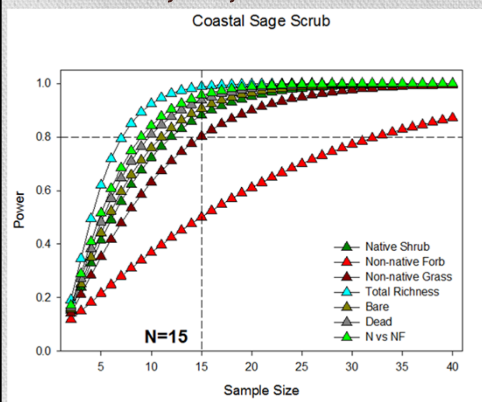
- Sample between 14 and 21 plots
- Focus on visiting sites, while providing replication with plots
- If you care about richness/ native forbs, sample yearly
- Return to some plots each year

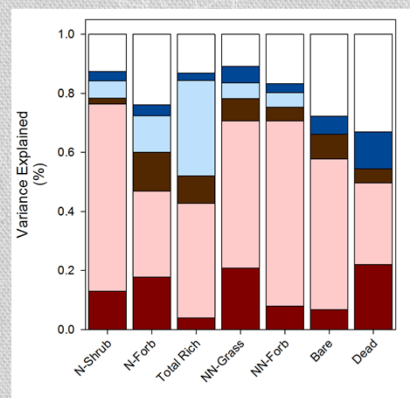




CSS

- Aim for 15 plots each year
- Monitor more plots per site than in chaparral
- Return to some plots each year
- Monitor yearly





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

Thank you

APPENDIX 2:

LIFEFORM-LEVEL VEGETATION COMPOSITION AND STRUCTURE

SANDAG Vegetation Monitoring

Lifeform-Level Vegetation Composition and Structure

San Diego State University

SANDAG

Caitlin Lippitt
Doug Stow
Lloyd Coulter

Objective

Investigate the effectiveness of a remote sensing approach for estimating fractional cover of shrub, subshrub, herb, and bare ground in coastal sage scrub and chaparral communities within the MSCP.

- Multiple endmember spectral mixture analysis (MESMA) using SPOT multispectral image data was tested for its effectiveness in estimating fractional cover.

Data Sources

MSCP species-level plots:	Years sampled:
Tijuana River Valley County Park	2007-2011
Los Montanas (SNDWR)	2008-2011
Mission Trails Regional Park	2009-2011
Rancho Jamul Ecological Reserve	2008
SDNWR (Sweetwater unit)	2008

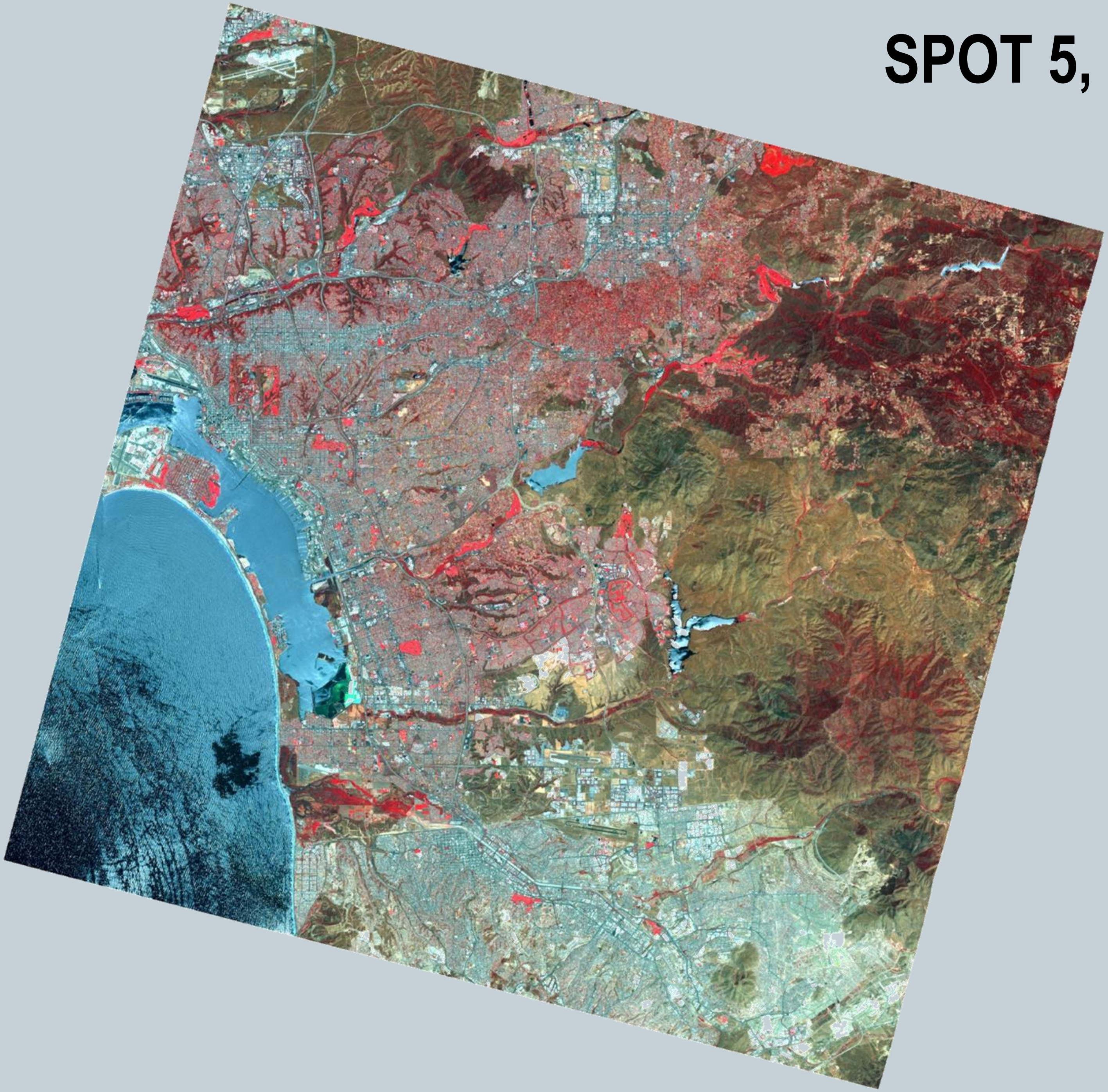
SPOT 5 Imagery:

- 10 m multispectral (Green, Red, NIR, MIR)
- 2008, 2010, 2011

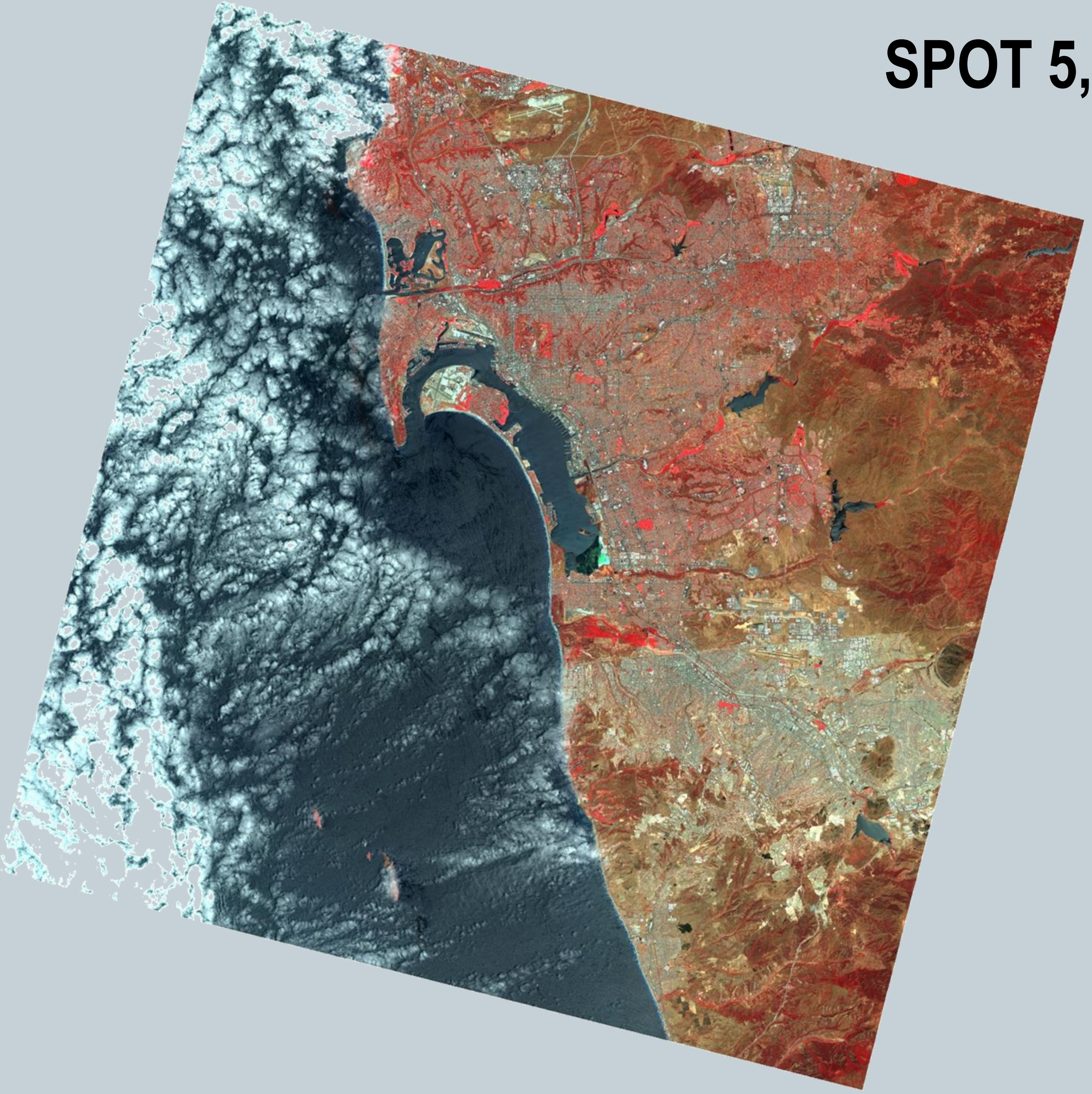
ADS40-II Imagery:

- 0.3 m color infrared and true color
- 2008

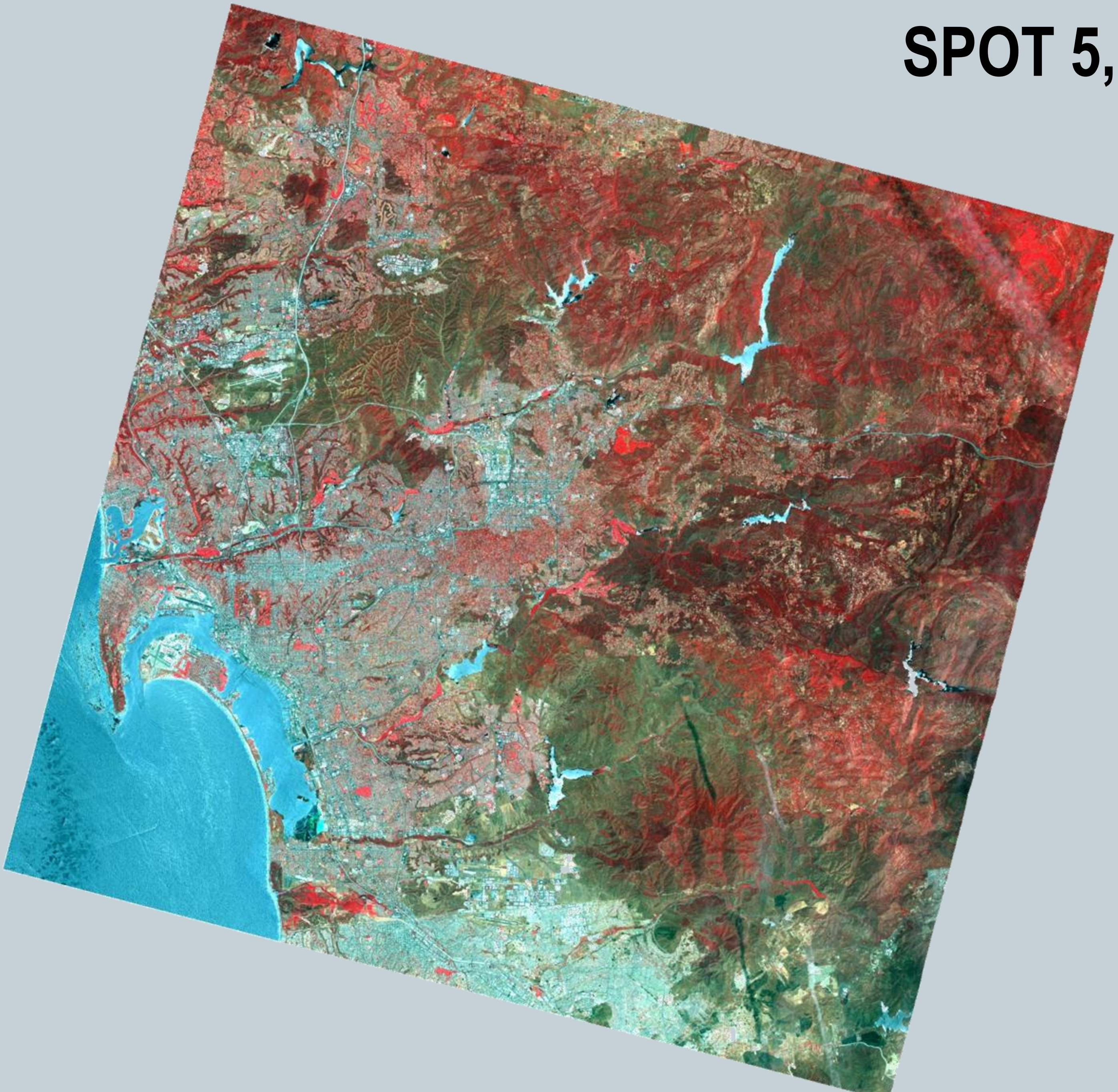
SPOT 5, 06/06/2008



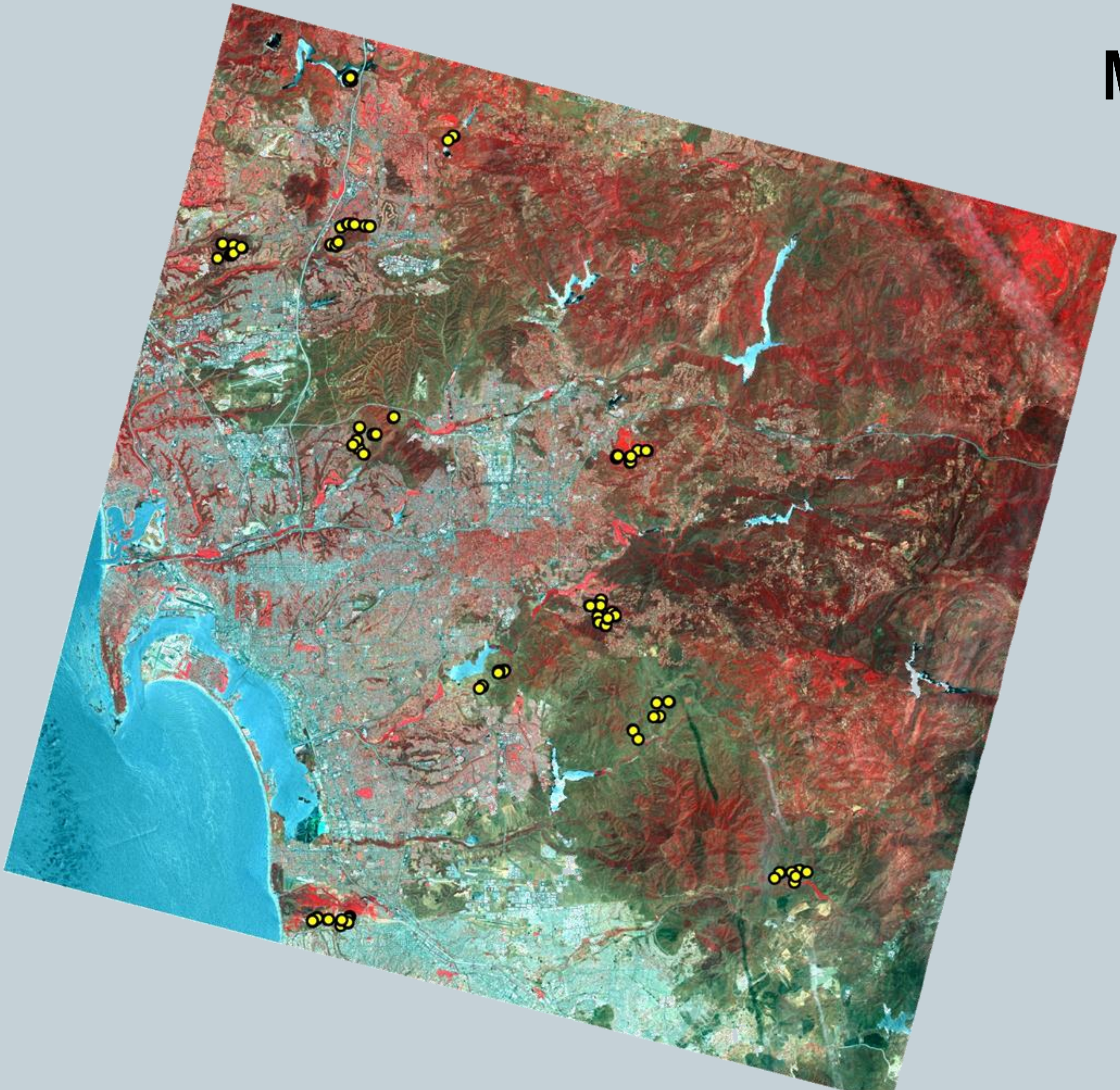
SPOT 5, 06/25/2010



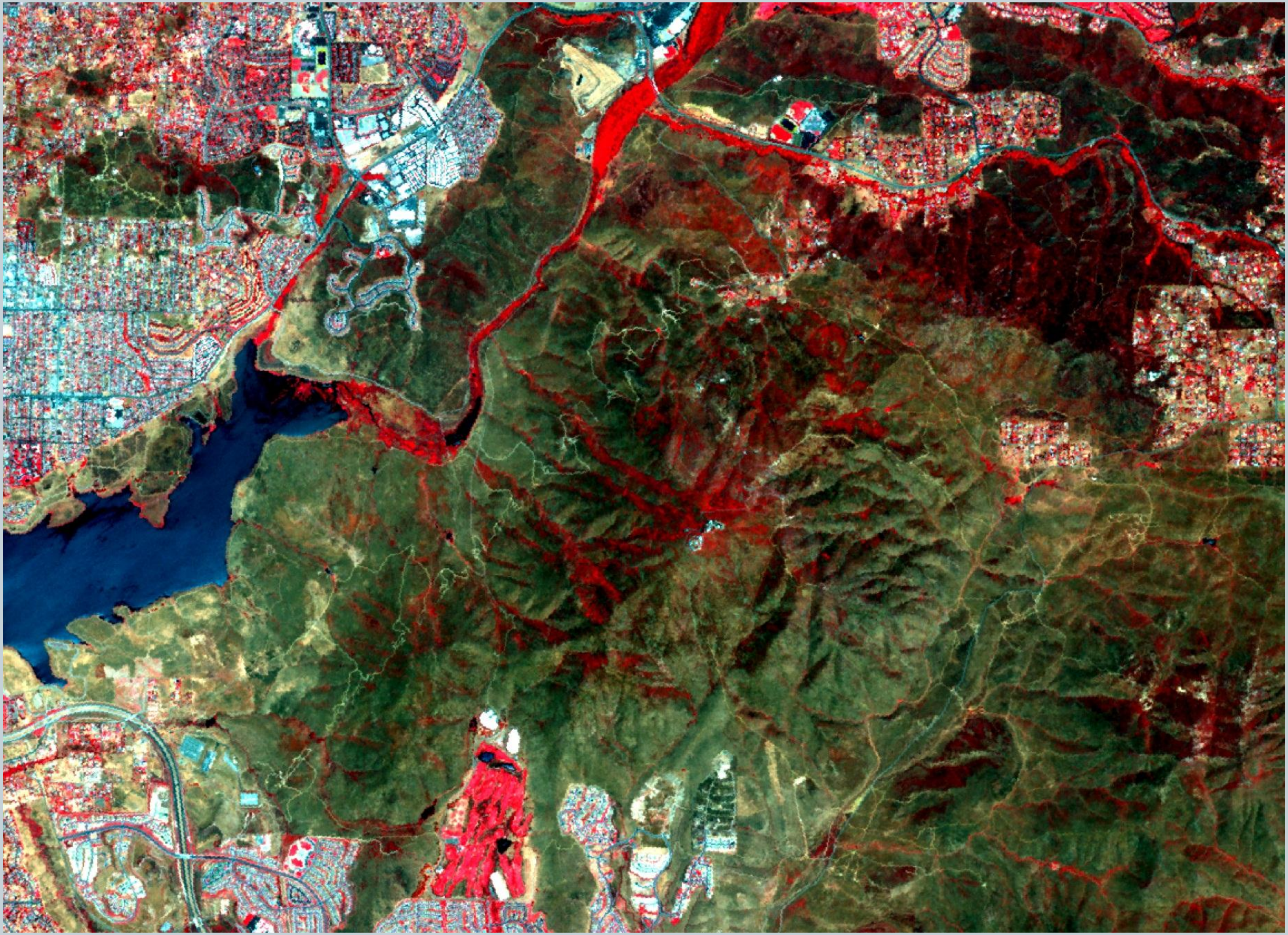
SPOT 5, 06/06/2011



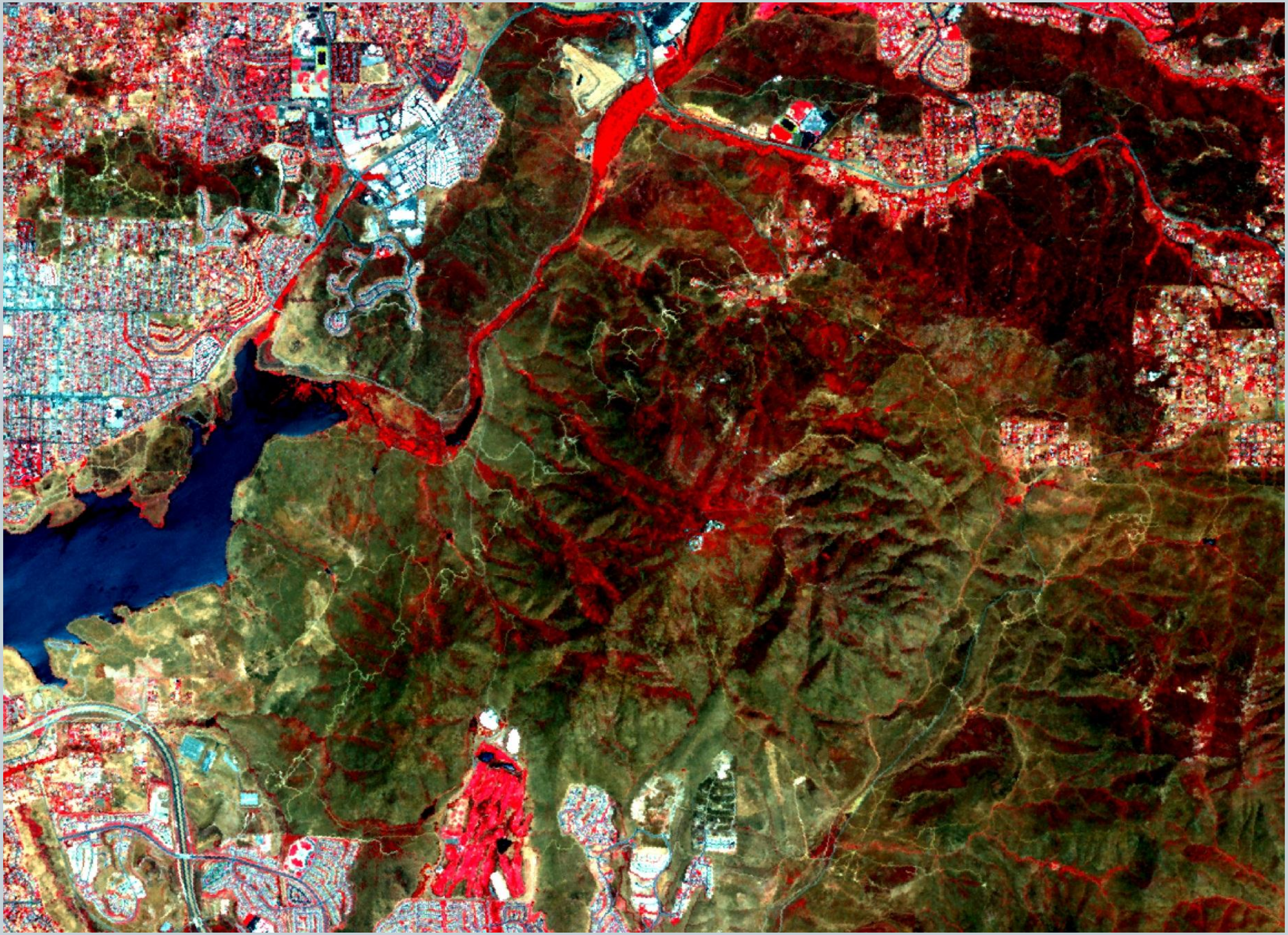
MSCP Plots



01/10/2010



06/25/2010



Mixed Pixel Problem

50 m

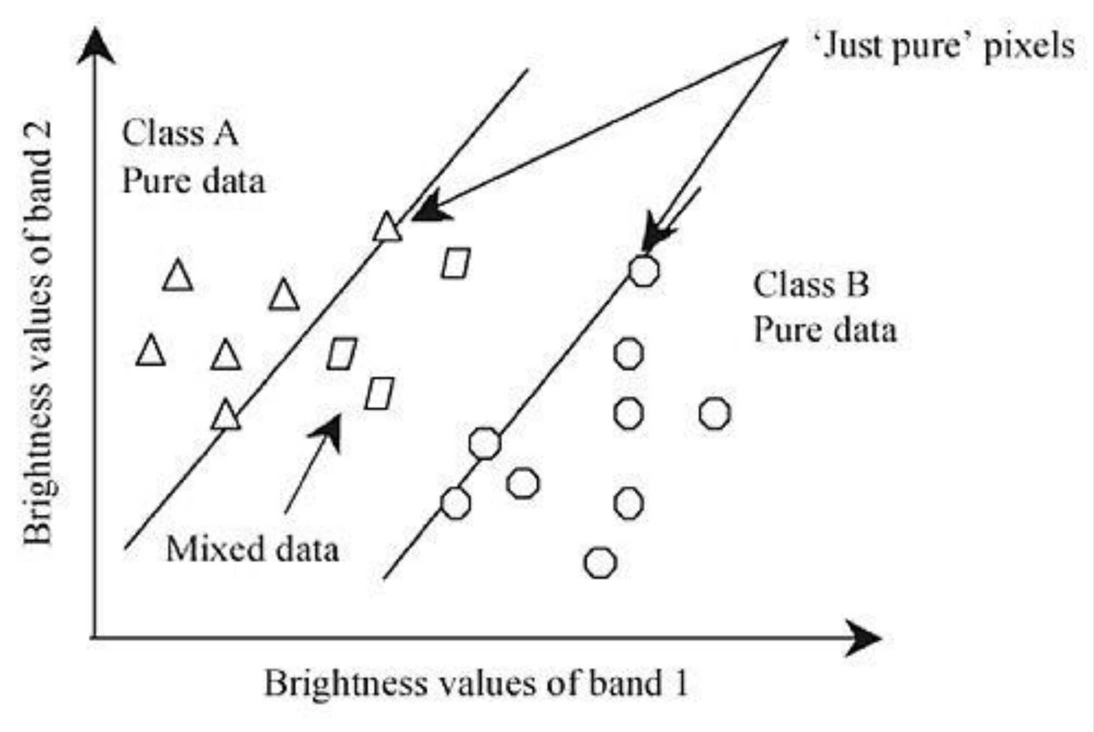
10 m

10 m pixel is a mixture of shrub, subshrub, herbaceous, and soil.

Spectral Mixture Analysis

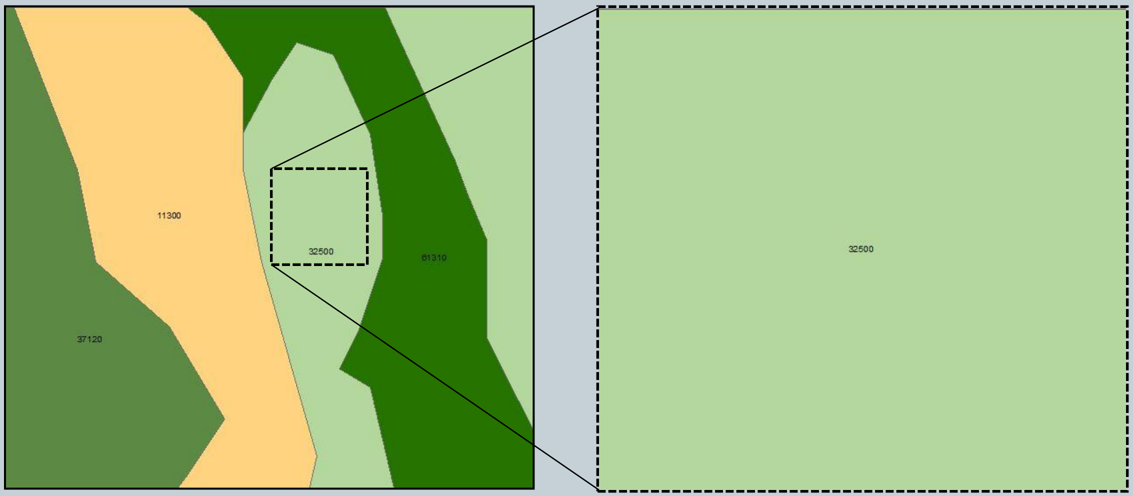
SMA: a pixel's spectrum is a linear combination of a number of spectrally distinct endmembers

- Resultant fraction images provide a sub-pixel estimate of EM abundance
- Proportional to the areal abundance of canopy cover



Spectral Mixture Analysis

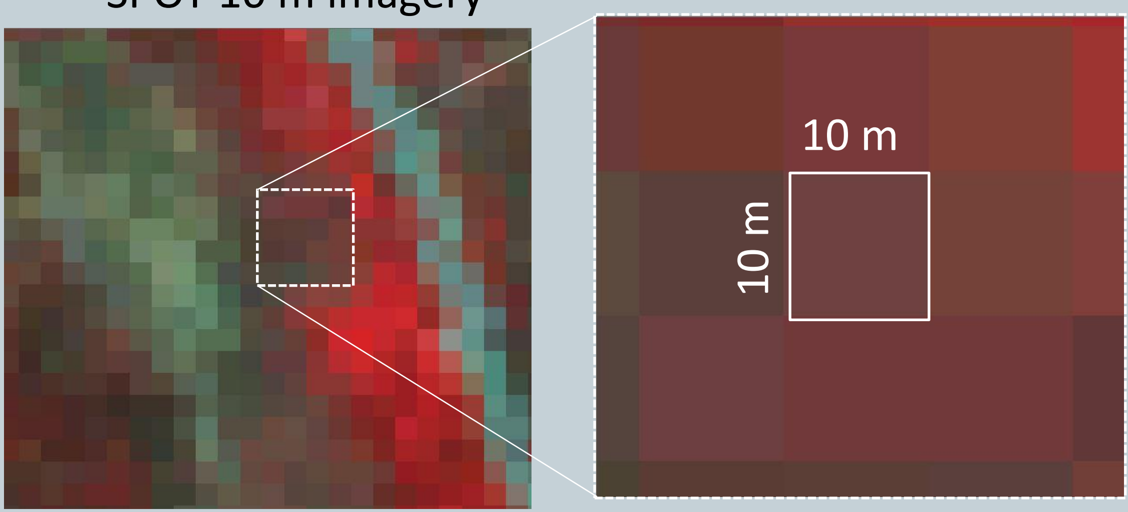
Typical Vegetation Map



Each pixel equal to one community-type.

Holland classification: 32500 (Coastal sage scrub)

SPOT 10 m imagery



For each pixel the fraction of green vegetation (GV), non-photosynthetic vegetation (NPV), and soil is estimated.

<u>Cover Fraction:</u>

GV (Shrub): 23.0

NPV (Subshrub/Herb): 77.0

Soil (Bare soil/rock): 0.00

Endmembers

Pure pixels representative of the life form classes of interest: True shrub, Subshrub, herbaceous, and soil/rock.

Endmembers:

Green Vegetation (GV) = True Shrub
Non-Photosynthetic Vegetation (NPV1) = Subshrub
Non-Photosynthetic Vegetation (NPV 2) = Herbaceous
Soil1= Bare Soil
Soil2 = Rock

Multiple Endmember Spectral Mixture Analysis (MESMA)

(1) Extraction of image-based endmembers from:
- MSCP transects
- Known locations, SDNWR, Otay Mtn.

(2) Refine and finalized endmembers
- True shrub, subshrub, herb, bare ground

(3) Three mixture model schemes were compared to determine the best model for each pixel.

(4) Among the best two-, three-, and four-endmember models, optimal model selected for each pixel (fewest endmembers, lowest error).

Workflow

Preprocessing

- Acquire image data
- Geometric registration
- Atmospheric correction

Spectral Mixture Analysis

- Endmember selection
- MESMA
- Model selection

Fractional Cover

- Compute fractional cover
- EM fractions averaged for each grid cell

Validation

Reference data generation:

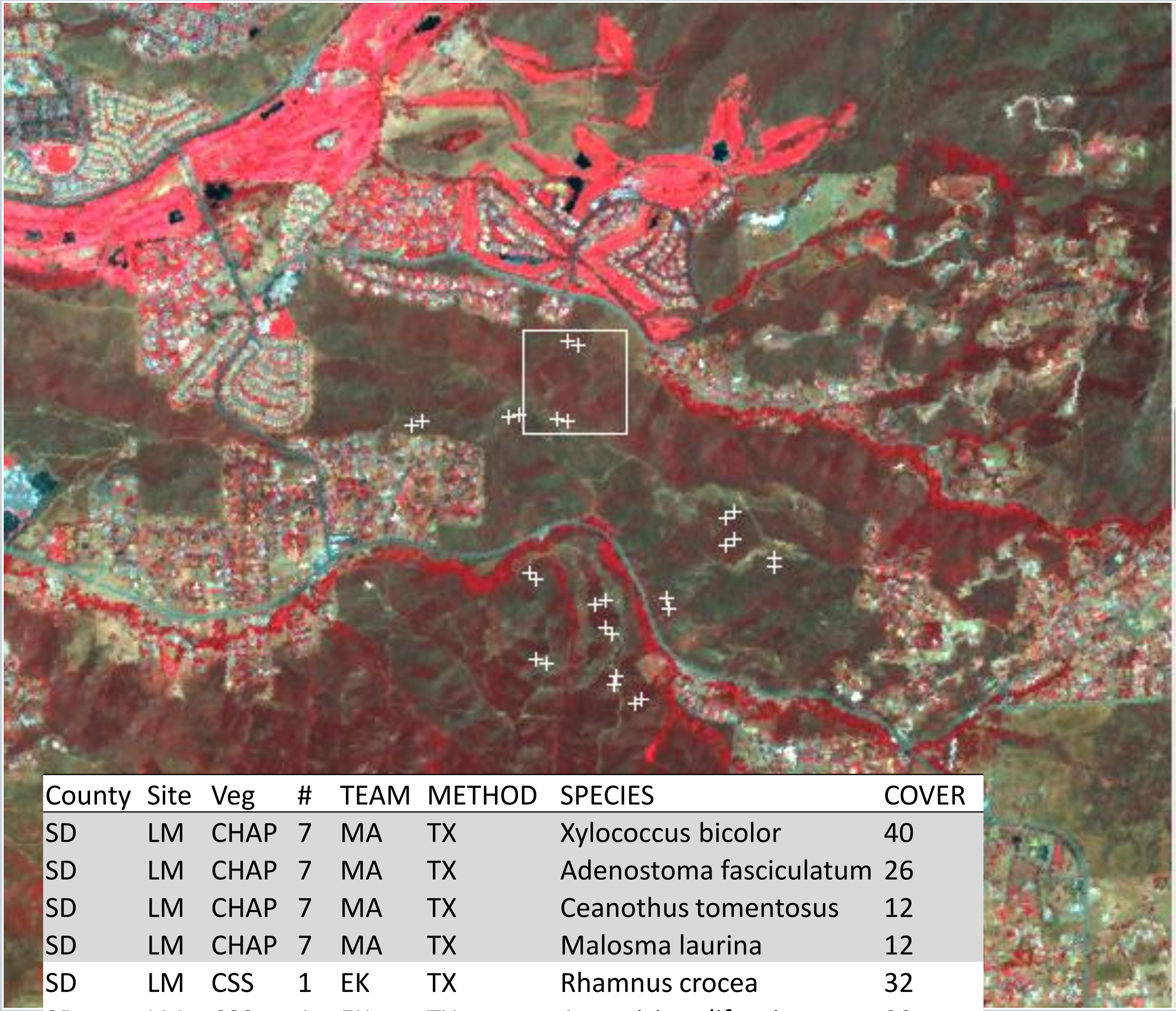
- MSCP plots
- ADS40-II imagery
- LOUIS imagery

Accuracy Assessment

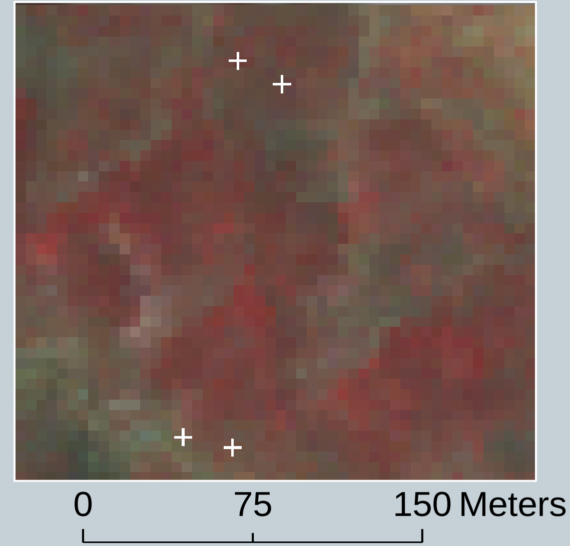
Predicted cover fractions assessed for accuracy:

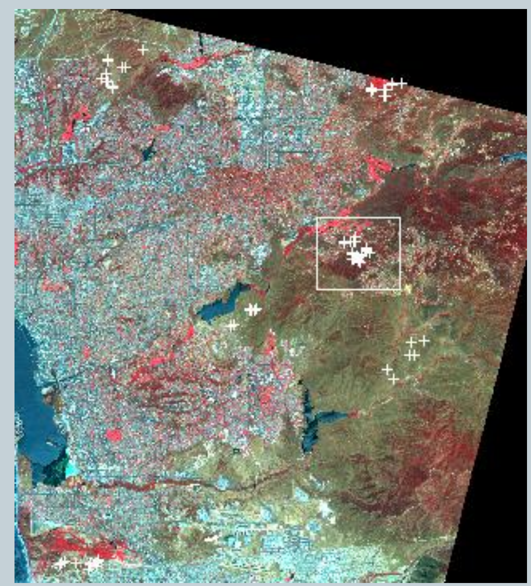
- ME, MAE, RMSE

Calibration

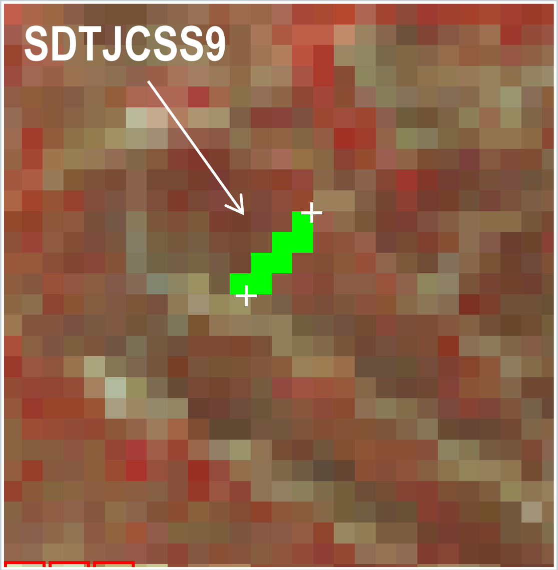


County	Site	Veg	#	TEAM	METHOD	SPECIES	COVER
SD	LM	CHAP	7	MA	TX	Xylococcus bicolor	40
SD	LM	CHAP	7	MA	TX	Adenostoma fasciculatum	26
SD	LM	CHAP	7	MA	TX	Ceanothus tomentosus	12
SD	LM	CHAP	7	MA	TX	Malosma laurina	12
SD	LM	CSS	1	EK	TX	Rhamnus crocea	32
SD	LM	CSS	1	EK	TX	Artemisia californica	22
SD	LM	CSS	1	EK	TX	Malosma laurina	20
SD	LM	CSS	1	EK	TX	Eriogonum fasciculatum	14

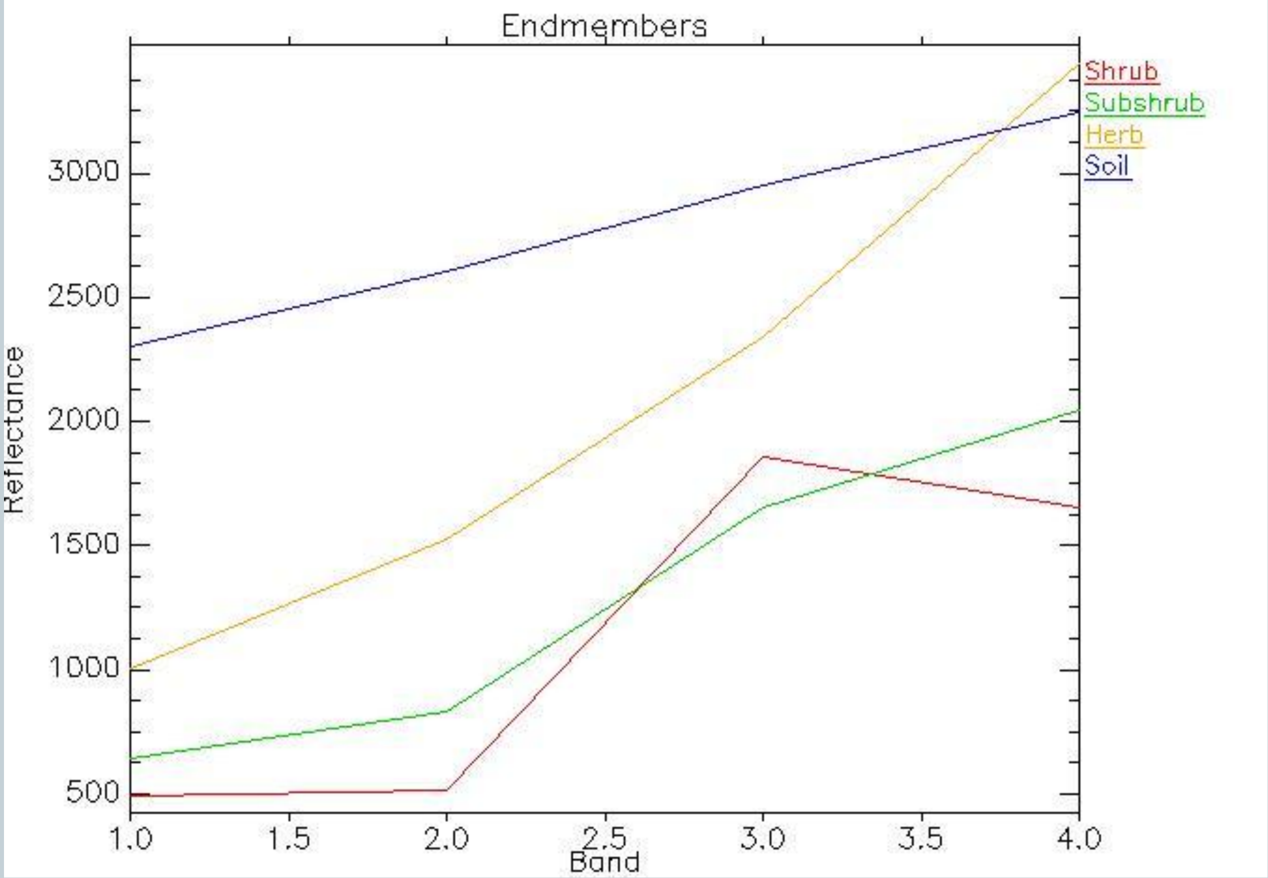




Endmember Selection



Endmember Spectral Signatures



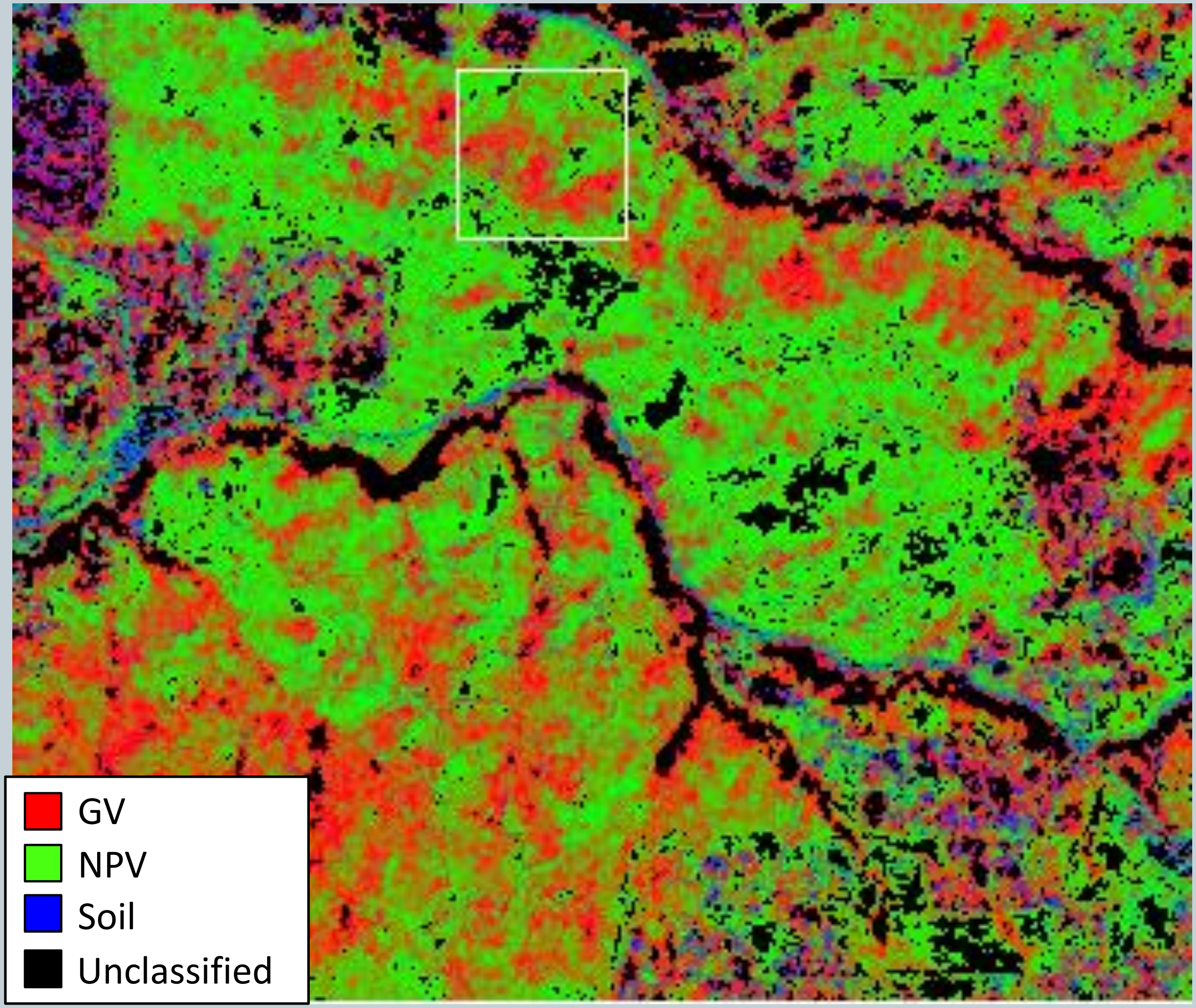
Endmembers:

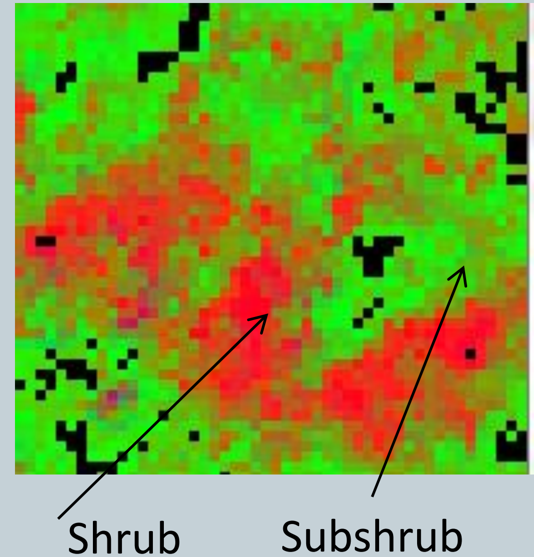
GV (green vegetation): True shrub

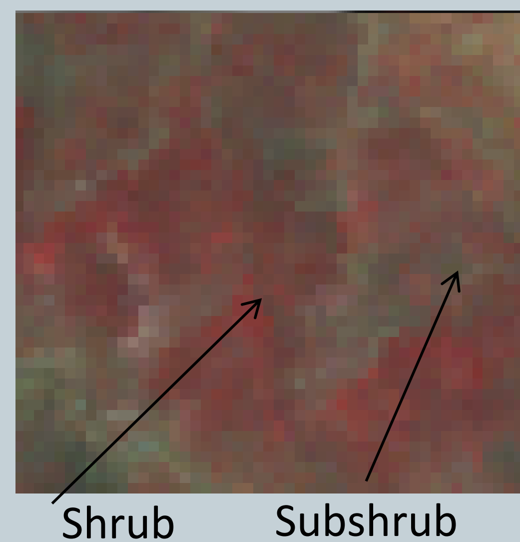
NPV (non-photosynthetic vegetation: Subshrub and Herb

Soil: bare ground, rock

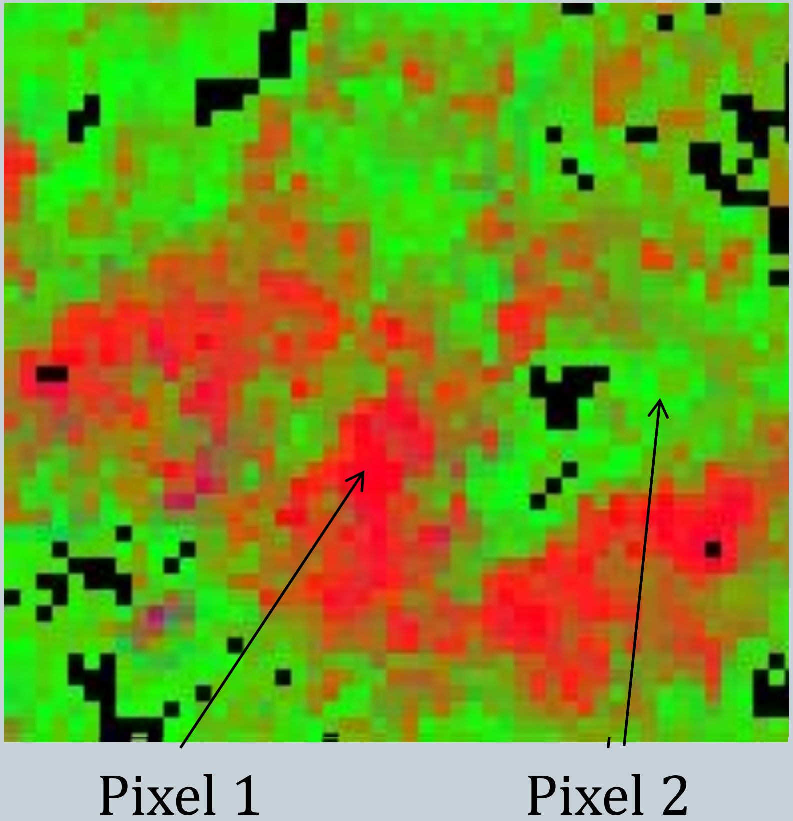
MESMA Fractional Cover







MESMA Fractional Cover



Pixel 1Cover Fraction :

GV (Shrub): 84.0

NPV (Subshrub/Herb): 16.0

Soil (Bare soil/rock): 0.00

Model #90:

BRCHAP4
SDLMCSS4
LOVELANDROCK1
SHADE

Pixel 2 Cover Fraction:

GV (Shrub): 11.0

NPV (Subshrub/Herb): 88.0

Soil (Bare soil/rock): 1.0

Model#: 353

SDLMCHAP2
SDRJHERB2
LOVELANDROCK2
SHADE

Fractional Cover Assessment

Reference data:
MSCP plots
2008 ADS40-II imagery
High spatial resolution LOUIS UAV imagery

(1) Aggregate EM fractions to 5x5 pixels (50 m x 50 m)

(2) Aggregate species-level transect data to life form level

(3) Overlay 50 m grid onto high resolution imagery

(4) Extract reference plots with a range of cover fractions

(5) Estimate cover fractions from high resolution imagery

(6) Compare fraction estimates to cover estimates

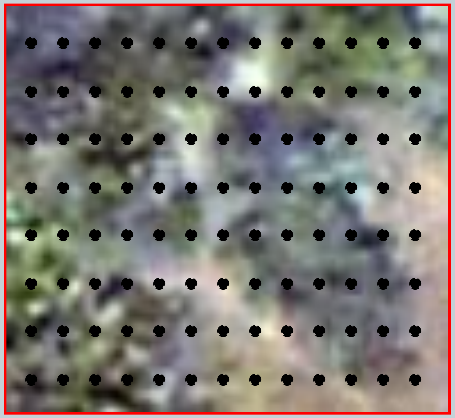
LOUIS UAV

Flight Duration: 20-25min
Altitude Ceiling: 750m/2500ft
Max Airspeed: 55kph/35mph
Coverage area/flight: 2.5-5^2 km/1-2 miles^2

LOUIS imagery
06/19/2011
RGB

50 x 50 m

5 x 5 m



TerraPan Labs LLC

Next Steps

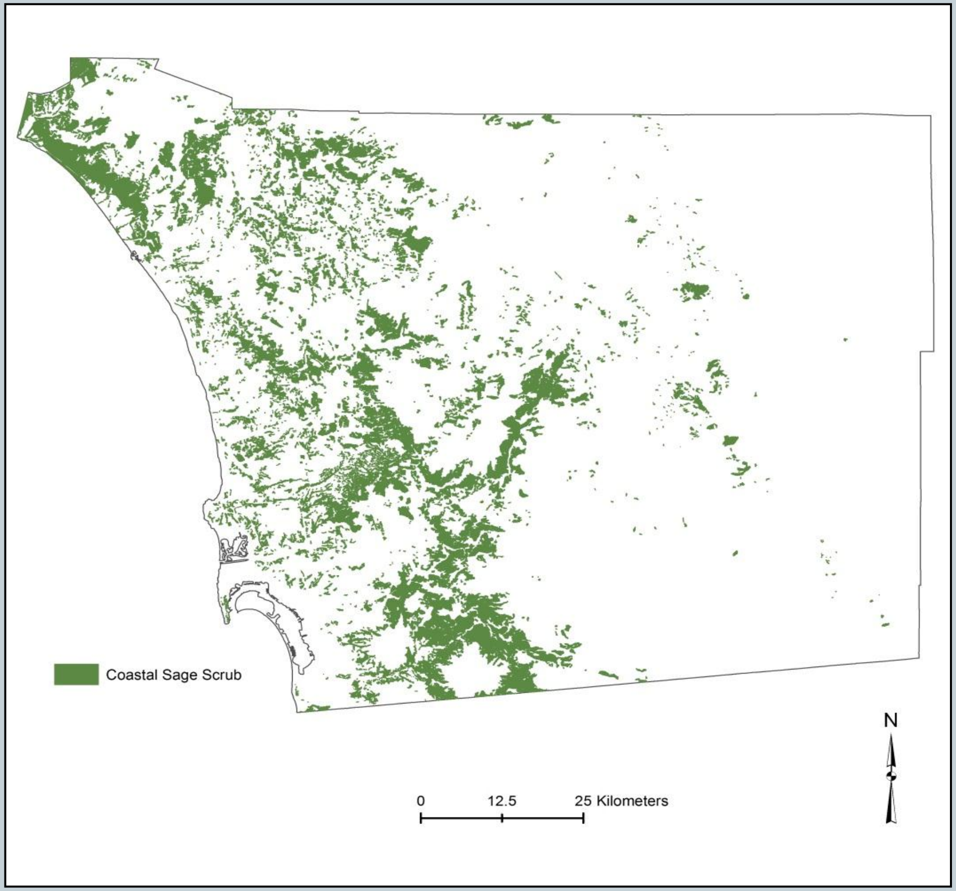
- Assess accuracy/reliability of SPOT estimates of life form cover.
- Evaluate stability of SPOT estimates of life form cover over time.
- What magnitude of cover change should we be able to quantify with high certainty.
- Evaluate intra-annual fraction variation

Spectral-temporal mixture analysis of moderate resolution imagery for herbaceous cover mapping in shrubland habitats

Nonnative annuals are well-adapted to the drought and fire cycle of California.

- tolerates repeated disturbances
- long-distance seed dispersal
- rhizomatous rooting strategies
- early germination

Rationale



Coastal sage scrub distribution, San Diego County, CA.

No existing method in place for monitoring herbaceous cover in CSS habitat over an extensive area.

Remote sensing techniques supplement field measurements

- provide large area vegetation mapping and monitoring capability

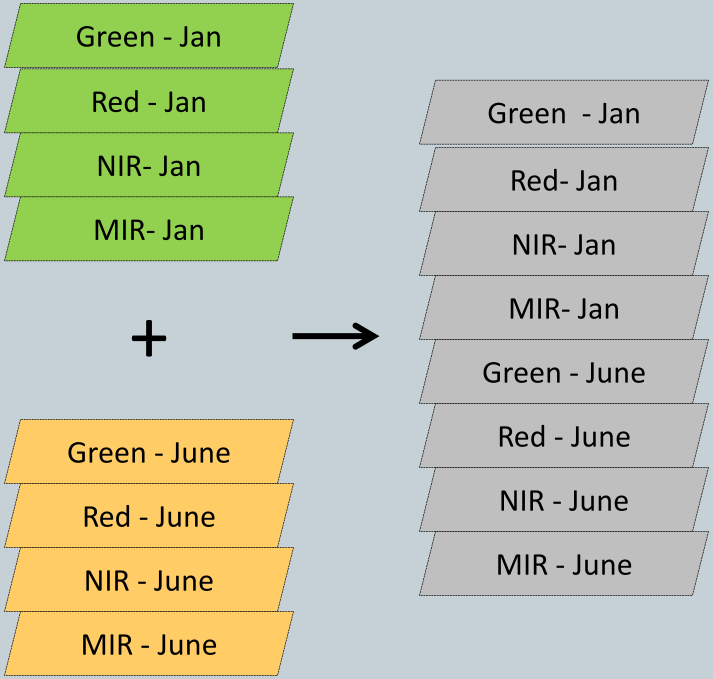
Spectral Temporal Mixture Analysis (STMA)

Phenological metrics:
- germination
- duration of growth
- rate of vegetation green-up and senescence

- Can be derived from remotely sensed time-series data to discriminate between vegetation with differing phenologies (Bradley and Mustard 2005, Huang and Asner 2009).

- Potential for exploiting offsets in phenophases of native and nonnative herbaceous, shrub, and subshrub vegetation.

Spectral Temporal Mixture Analysis (STMA)



(1) Multidate image composed of eight SPOT spectral bands

(2) EMs from single-date MESMA

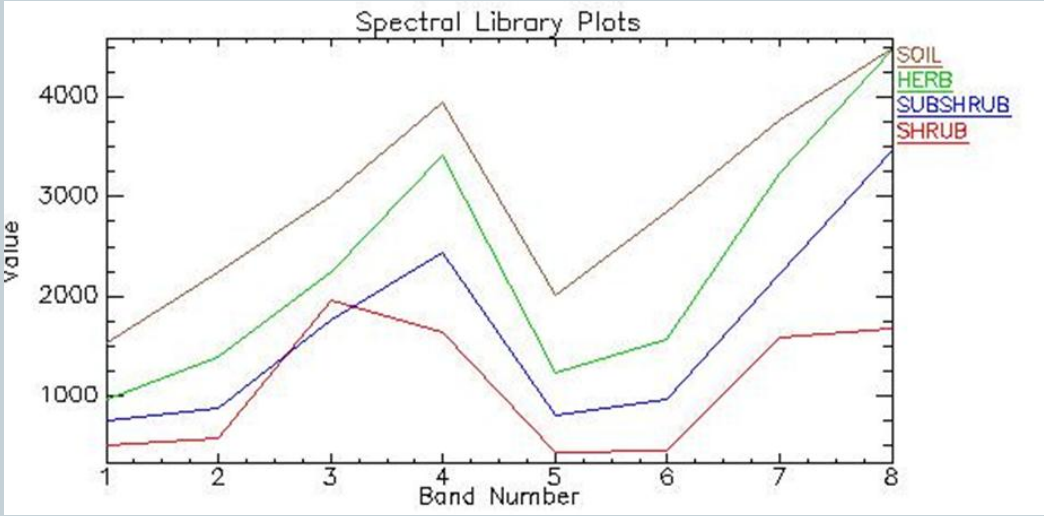
(3) Run 2, 3, 4 EM models

(4) Compare multidate fractional cover estimate with single-date estimate.

Spectral Temporal Mixture Analysis (STMA)

Identify CSS with high herbaceous fraction

- Nonnative herbaceous monitoring and/or removal
- Native vegetation restoration
- High risk fire areas



Questions?