Presentation:

Detecting Man-Induced Changes in Shrub Cover using New Image Processing Techniques versus Old Line-Intercept Techniques in Arid Landscapes

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Bechtel Nevada

SERDP
Strategic Environmental Research and Development Program

Project

- Project was funded by the Strategic Environmental Research and Development Project (SERDP)
- Cooperative Research between Bechtel Nevada, the U.S. Department of Energy, Fort Irwin, Charis Corporation, Center for Environmental Management of Military Lands, and contributing Universities.
- Four-year project that focused on developing new techniques for detecting vegetation change in aridlands.

Objectives

- Describe the natural variability in climate in desert lands that contributes to cycles of change in desert vegetation.
- Describe conventional methods of sampling vegetation cover in arid lands.
- Describe new techniques of sampling vegetation cover that provide greater accuracy and applicability to Geographic Information Systems on military lands.
- Inform scientists of workshops, users manuals and other sources of information about newly developed techniques.

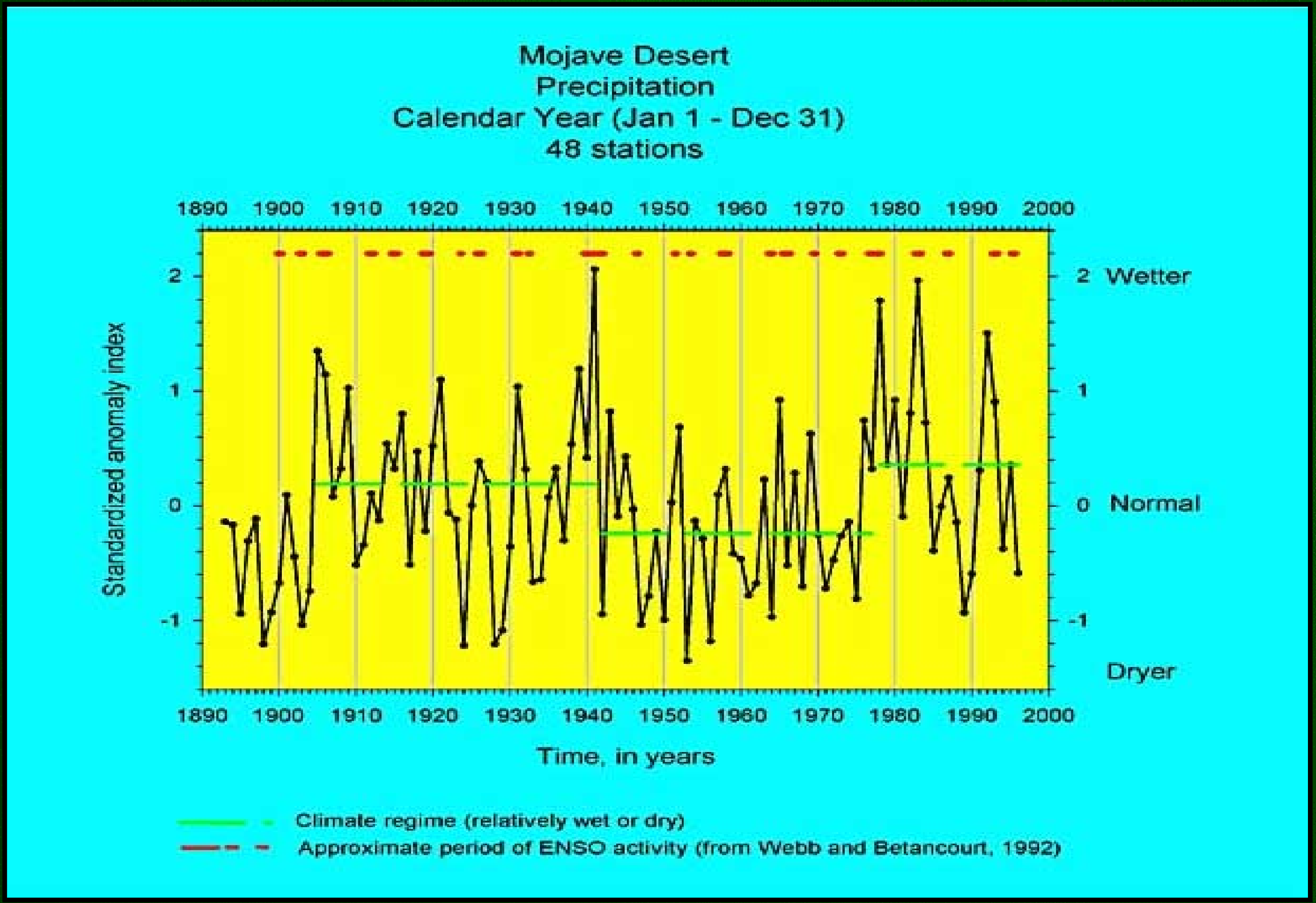
Desert

- Climate in the Mojave Desert is known for its variability, cyclic droughts, and dust storms.

- Precipitation and temperature are known for their extremes (the driest and hottest in the North America).

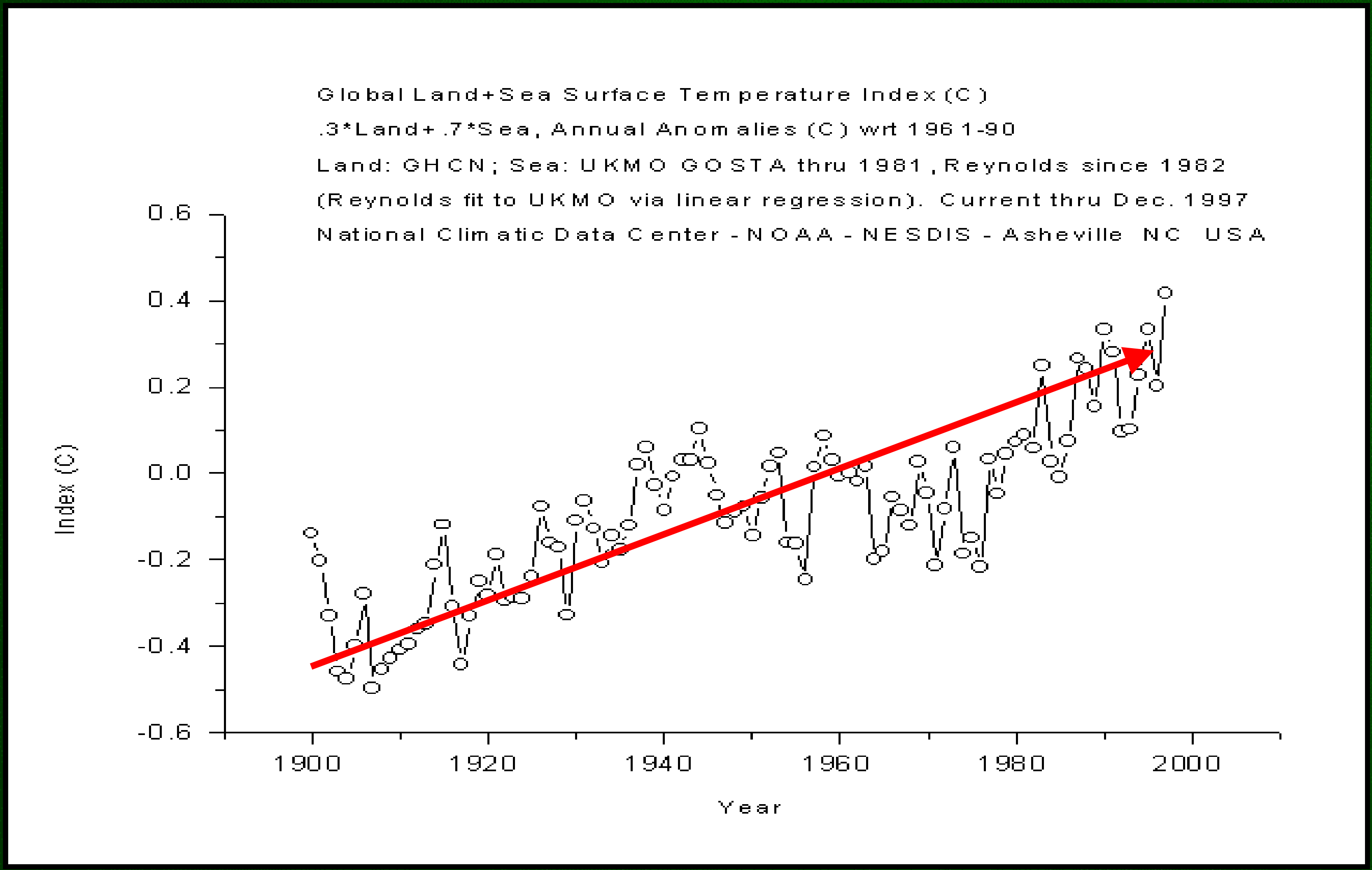
Precipitation

(Data from Hereford and Longpré, 2002)



Long-term

Increasing Temperatures



Weather

Freezing Temperatures

Flash Flooding

Dust Storms, Droughts, and Heat

Climatic

Hottest Air Temp. = 134° F

Ground Temp. > 200° F

Coldest Temp. = 15° F

Avg. Precip. < 1.5 in. / Yr.

Avg. Temp. / Year = >90° F

Avg. Evap. / Year = 128 in.

1994 had 31 days with

Temperatures > 120° F

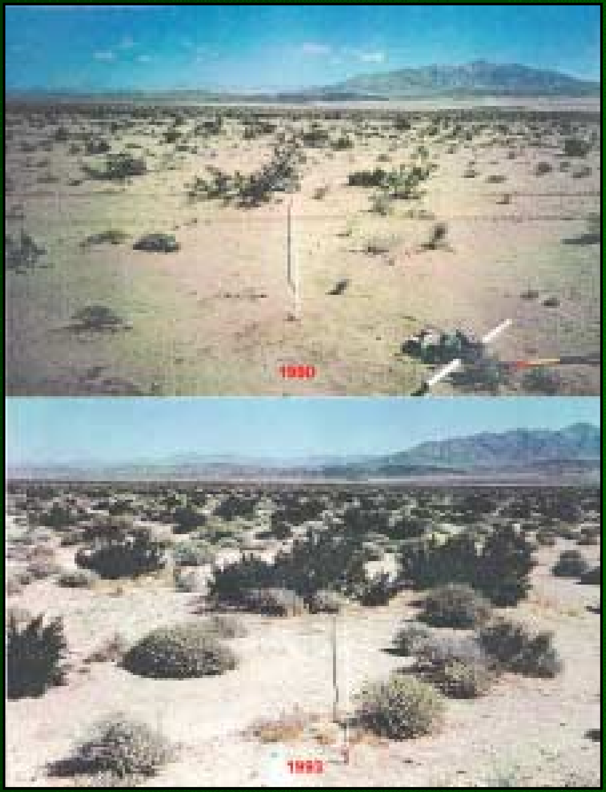
Effect on

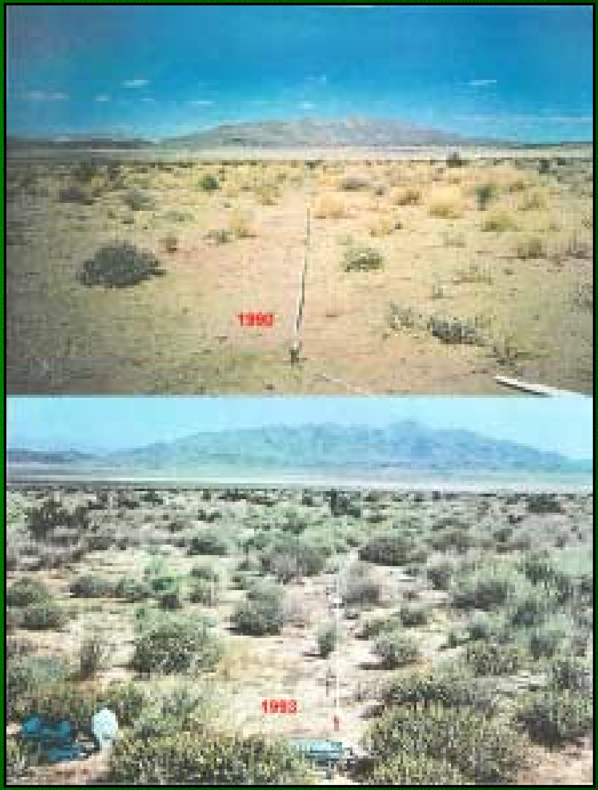
- Plant morphology is altered to adjust to climate
- Plants anatomy is altered, for example leaves and fine roots are abscised during drought
- Inter-plant spacing is adjusted due to competition
- Reproduction is frequently by vegetative means
- Plant establishment is relatively rare and only during optimal climatic conditions

Vegetation

Cover Changes from

1990 to 1993





The National Training Center at Fort Irwin, California

Measuring

(Canfield, 1941)

The Line Interception Method is one of the most commonly used means of measuring plant canopy cover in the desert.

% Cover = 100 x

length of plant intercept shown in red / total length of the tape shown as red and white

Assumptions

(Canfield, 1941)

- Plants should have solid rounded crowns with high foliar density and little overlap of adjacent species
- Measurements should be made within a short time frame during near seasonal maximum values
- Tape should be read from a vertical position to reduce observer errors
- Observations should be read on windless days
- Many randomly-located short transect lines are preferred to long (e.g., 100 m) transects

Problem

- Canopy cover is mixed with other species.

- Canopy is not well defined.

- Seasonal variation occurs.

Sampling

- How much natural variation is there in canopy cover in Mojave Desert plant communities?
  - How much variation is attributed to precipitation seasonally and over several years?
  - How much variation is attributed to spatial variation in community structure?
  - How much variation is there due to differences in observers?

Yucca

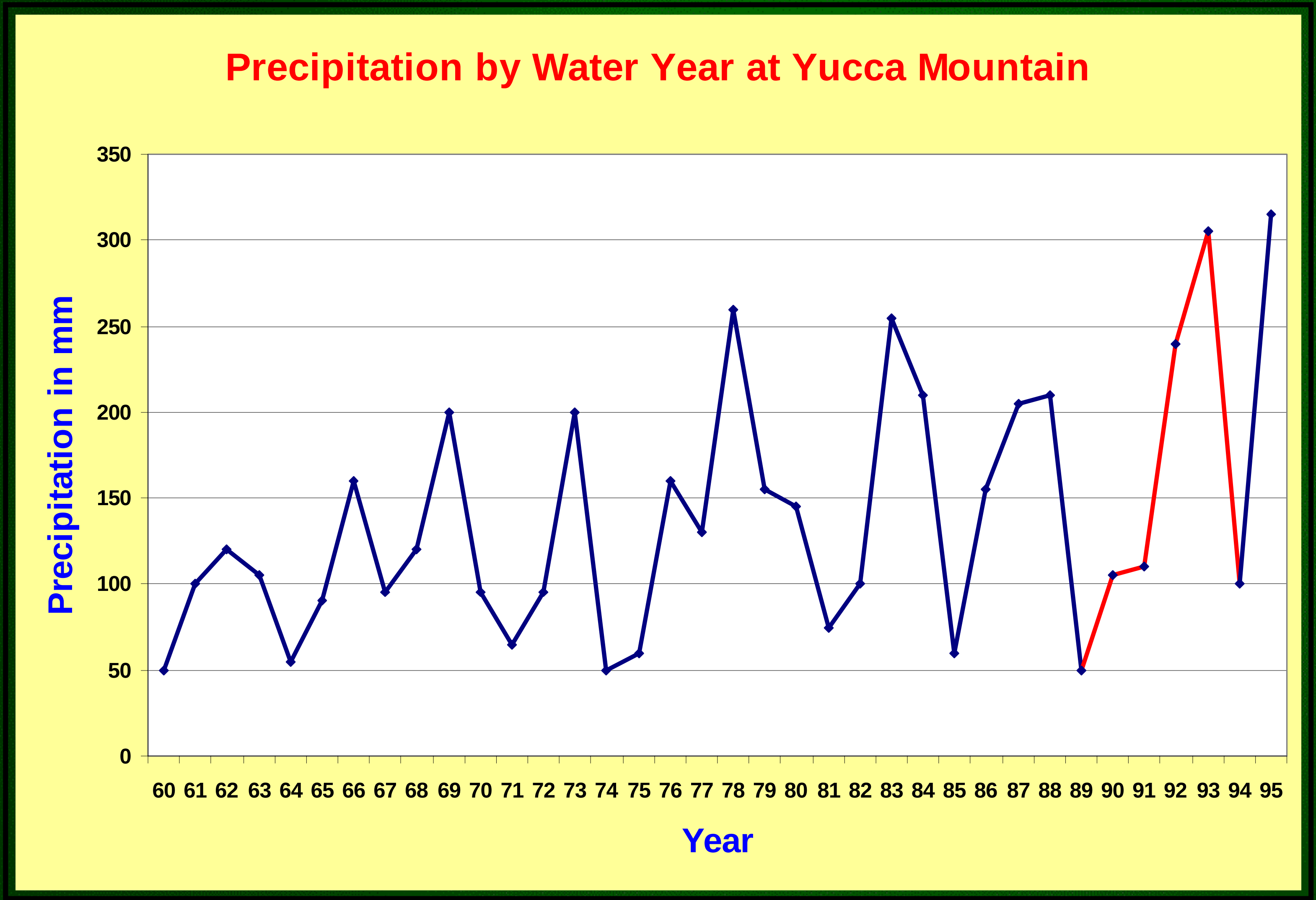
- 48 Ecological study sites within associations were studied over a from 1989 to 1994.
  - Creosote-Bursage (*Larrea-Ambrosia*)
  - Creosote-Hopsage (*Larrea-Lycium-Grayia*)
  - Wolfberry-Hopsage (*Lycium-Grayia*)
  - Blackbrush (*Coleogyne*)

Study Design

- 4 Plant associations (PA)
- 48 Ecological Study Plots (ESP)
  (12 ESP per PA)
- 10 50-meter transects per ESP
- Each 50-m transect had 50 points
  (1,000 points per ESP)
- Plots were sample once per year during peak production and cover

Precipitation

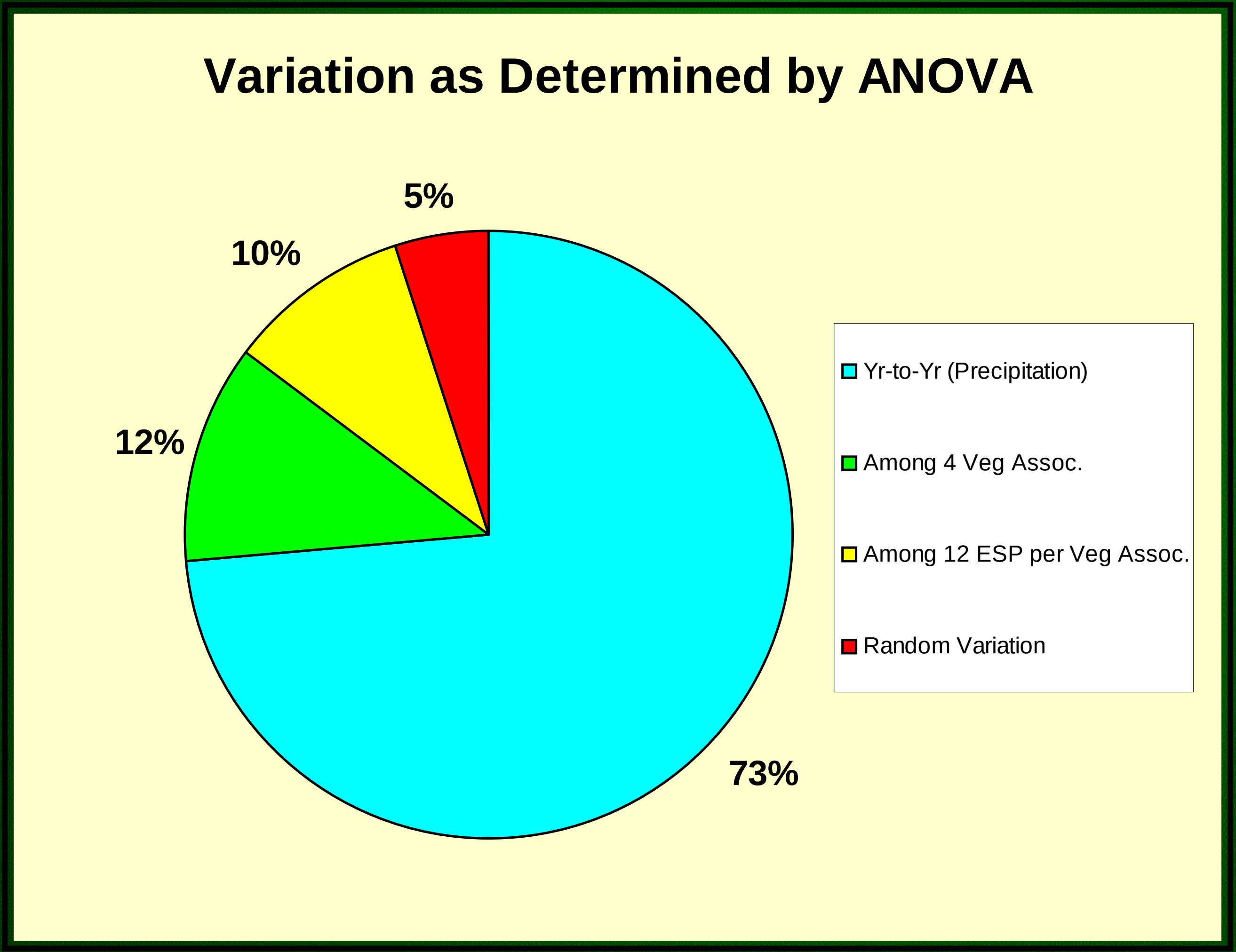
1989 to 1994



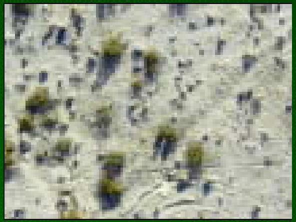
Analysis of

(TRW, 1996)

Yucca Mountain Sampling Variation



Findings



- Average percent cover ranged from 15 to 28 percent during the 6-year study.
- Plant density ranged from 62 to 139 individuals per 100 m^2
- Above-ground production ranged from 0.72 to 479 kg ha^{-1}.
- Precipitation explained approximately 58 percent of variation in cover and 80 percent of the variation in production.

Additional Studies

- According to Brun and Box (1963)

  14 15-m transects were required to sample the sagebrush-grass type (8 person-hours).

  100 15-m transects were required to sample the sagebrush-shadscale type to be within 10% of the mean (92 person-hours).

- According to Hansen and Ostler (2002)

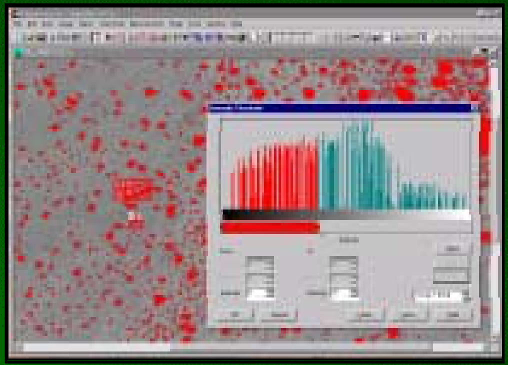
  16 15-m transects were required to sample creosote bush-bursage communities (undisturbed, relatively uniform) to be within 10% of the mean (7 person-hours).

Conclusion

The Line Interception Method is:

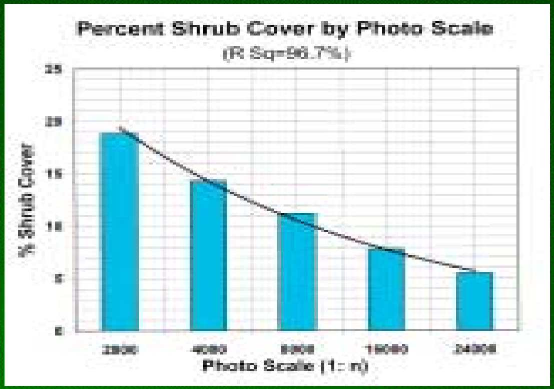
inadequate for measuring plant canopy cover over large areas of a military training area because of the large number of transects needed to achieve adequacy of sampling. A new more cost-effective method is needed to gather data in a timely manner.

New Methods



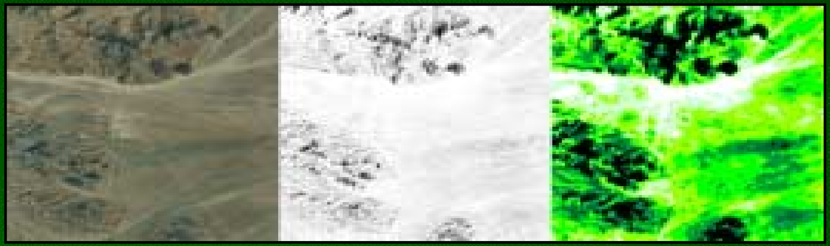
A new diagnostic technique was developed by Bechtel Nevada using new image- processing software that permits the rapid measurement of shrub canopy cover over large areas. It can be used to display information as Geographic Information System themes on site maps.

Requirements



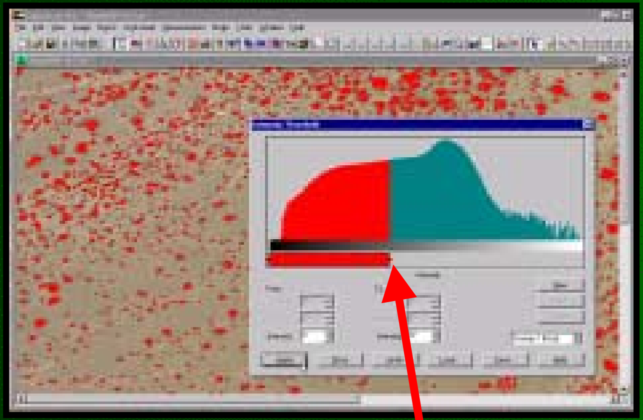
- Digital imagery at scales of 1:2000 to 1:24000.
- Image processing software used in medical research.
- Recently developed techniques as described by Hansen and Ostler (2002).

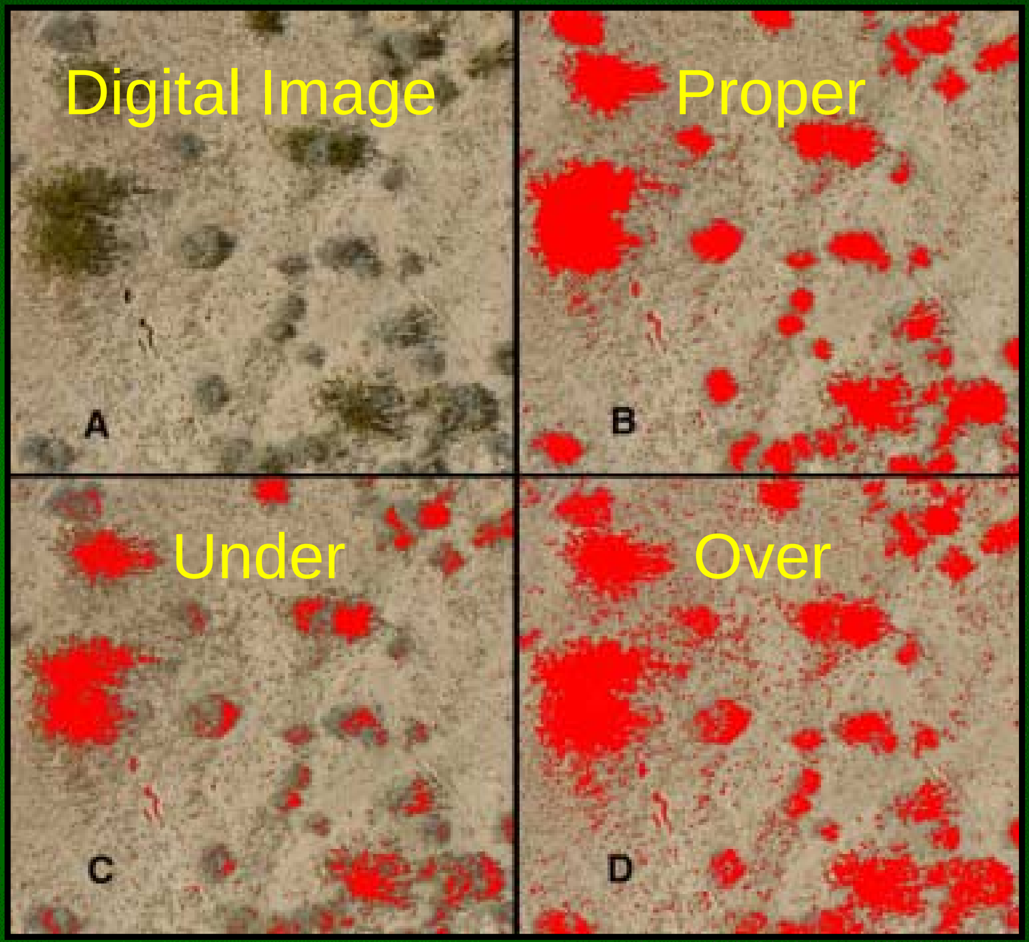
Procedures



- Spectral thresholds are set that match the silhouette of shrub canopies (cover).
- Masks are created for shrub silhouettes
- Shrub silhouettes are converted into maps of shrub cover classes
- Shrub cover class maps are imported into ArcView as TIFF World File images.

Spectral Thresholds

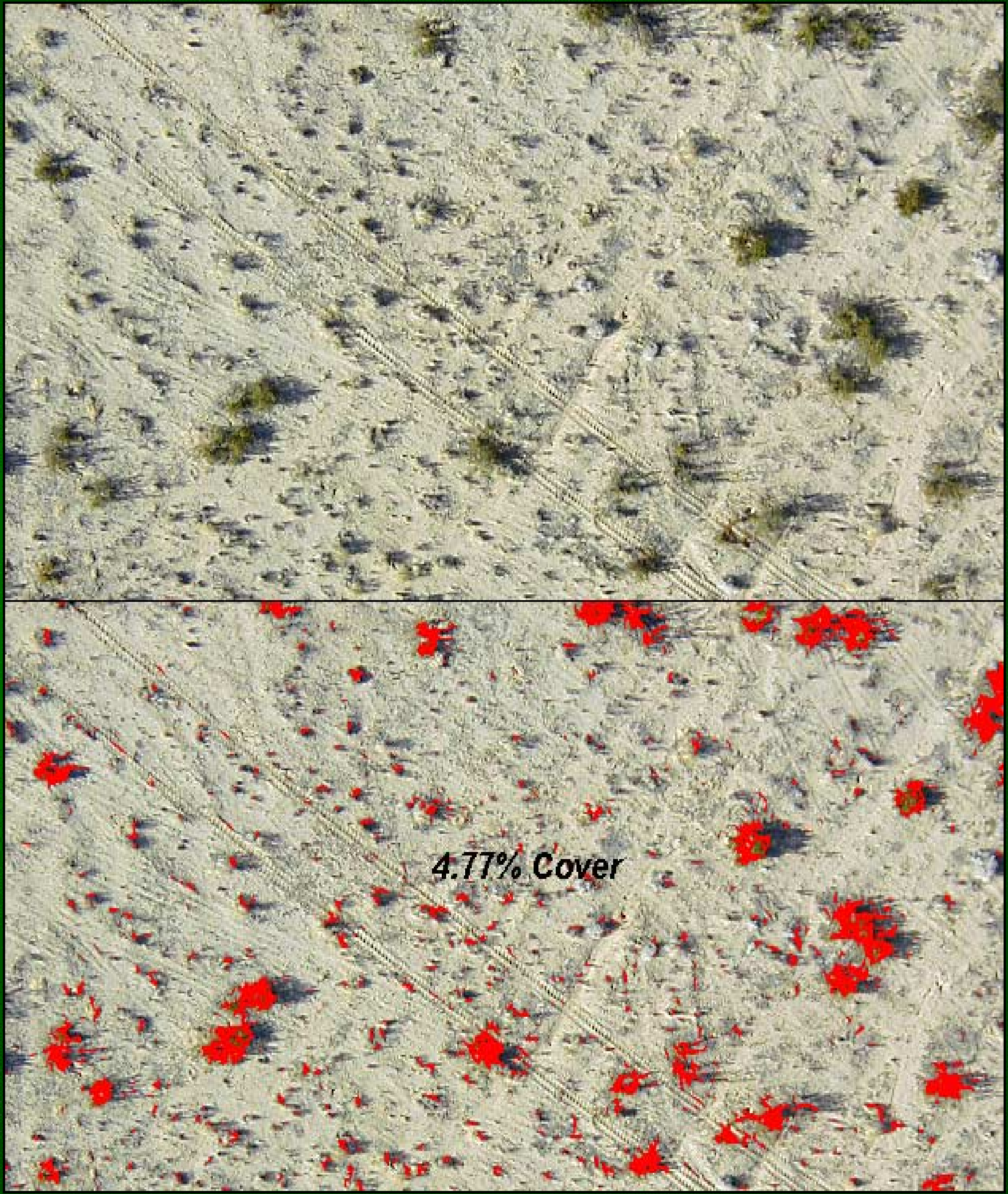




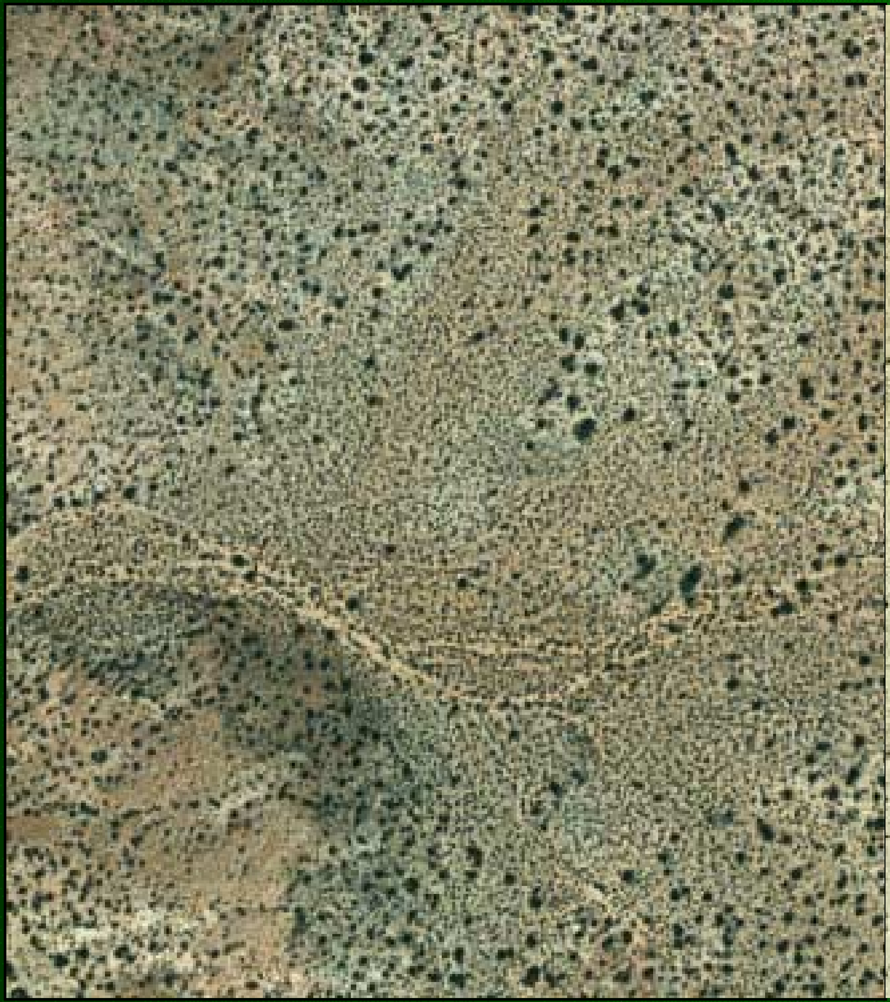
Thresholds are set for color values that correspond to shrub canopy cover

Color Thresholding

Color Thresholding to Eliminate Shrub Shadows



Aerial Photos of Training Disturbance

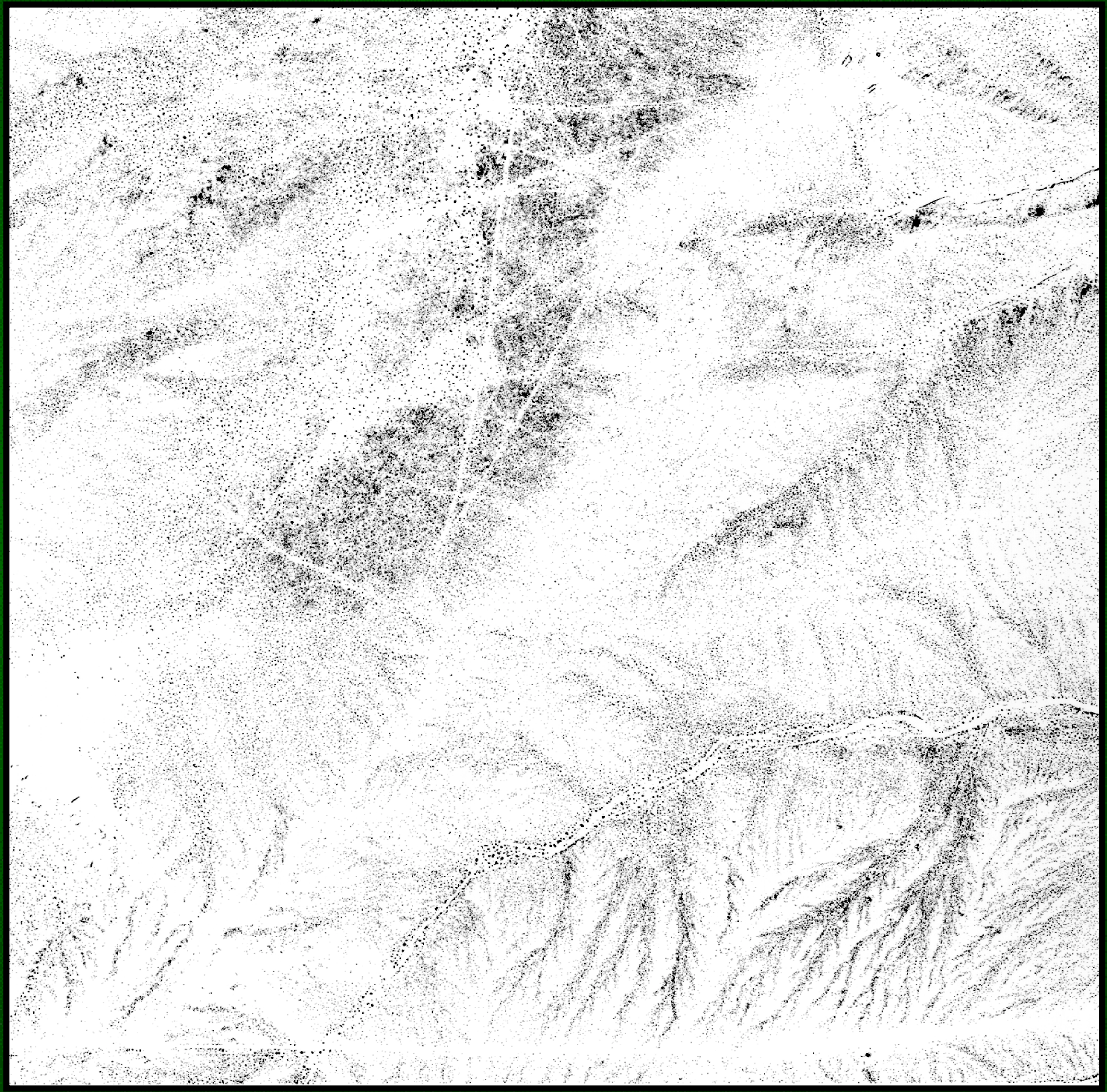


Undisturbed

Disturbed

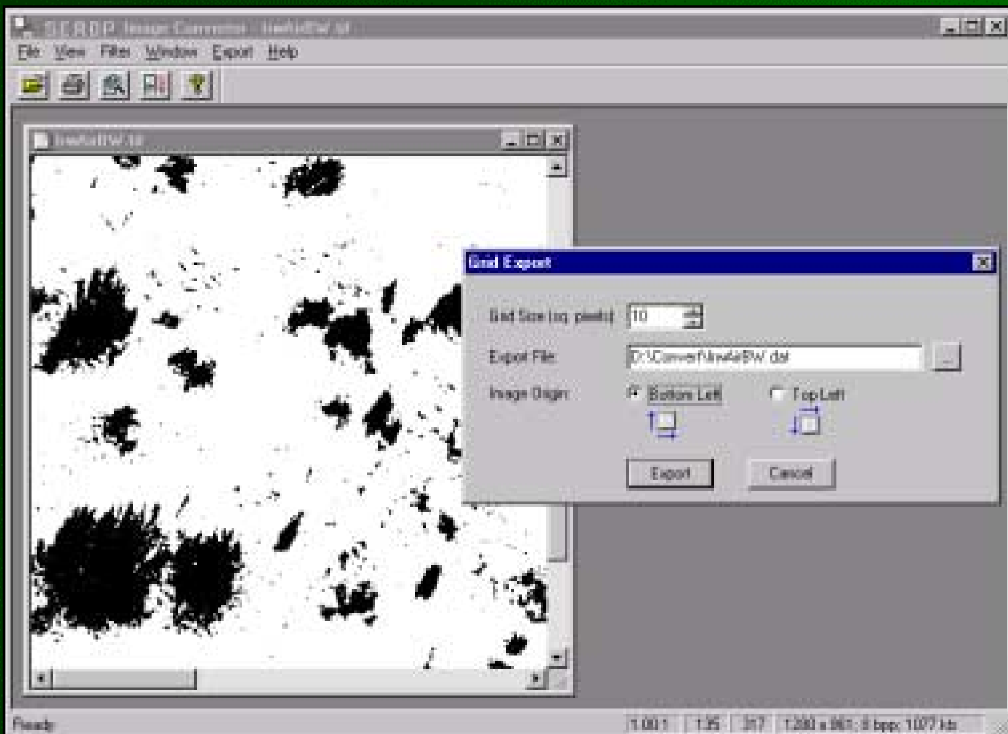
Silhouette Masks

A mask of shrub silhouettes is made that closely represents canopy cover

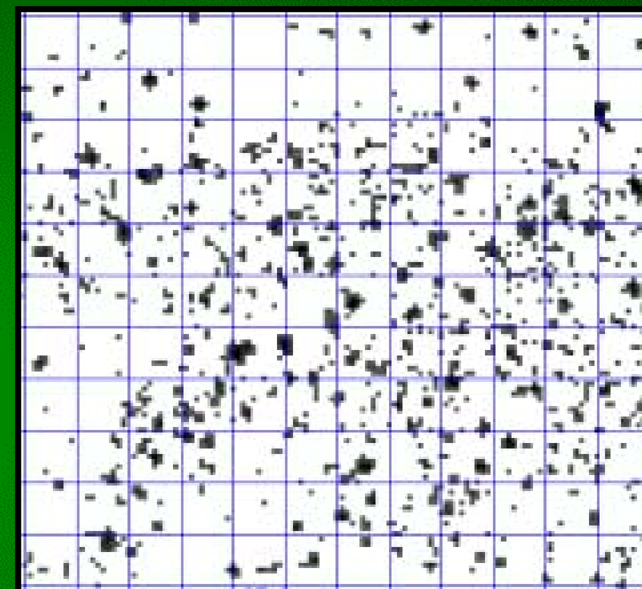


SERDP

The silhouette mask is converted to Surfer files



Using SERDP Image Converter Software



Surfer® Files

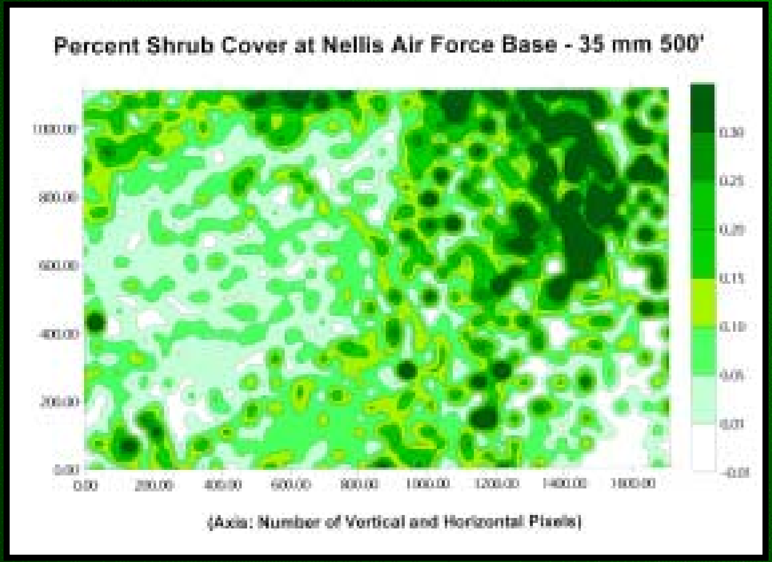
X	Y	Z
000	001	0.07
000	002	0.12

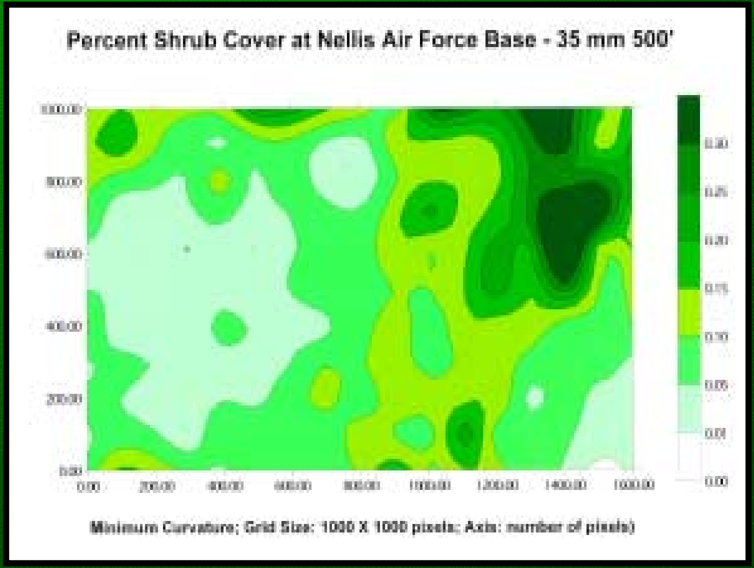
Surfer® Software

User can select the best grid scale to communicate site conditions

High Resolution

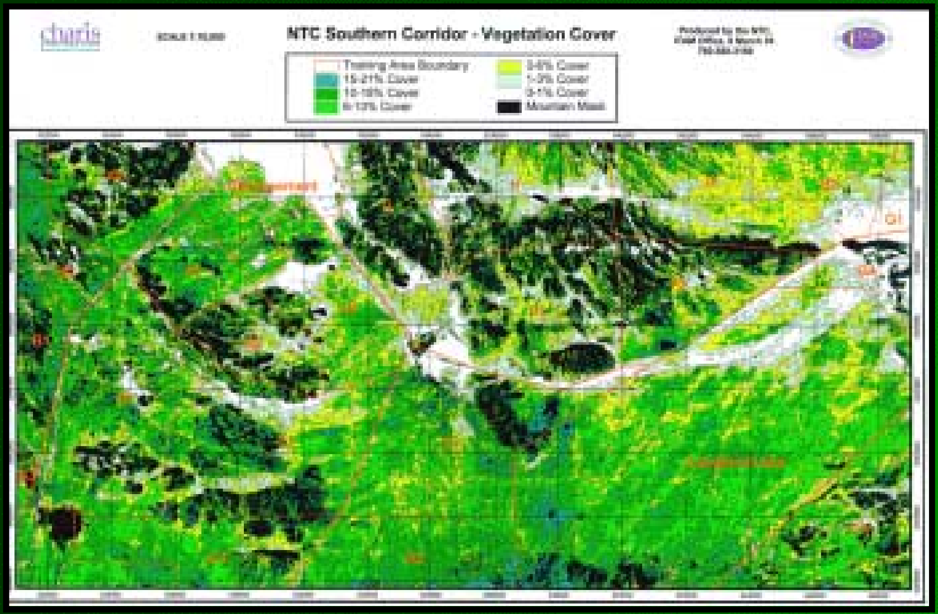
Low Resolution



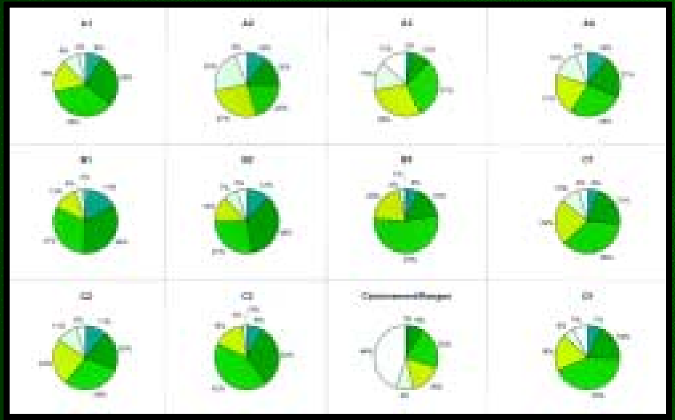


Mosaicked Images

Images are combined in to one GIS theme and queried for reports



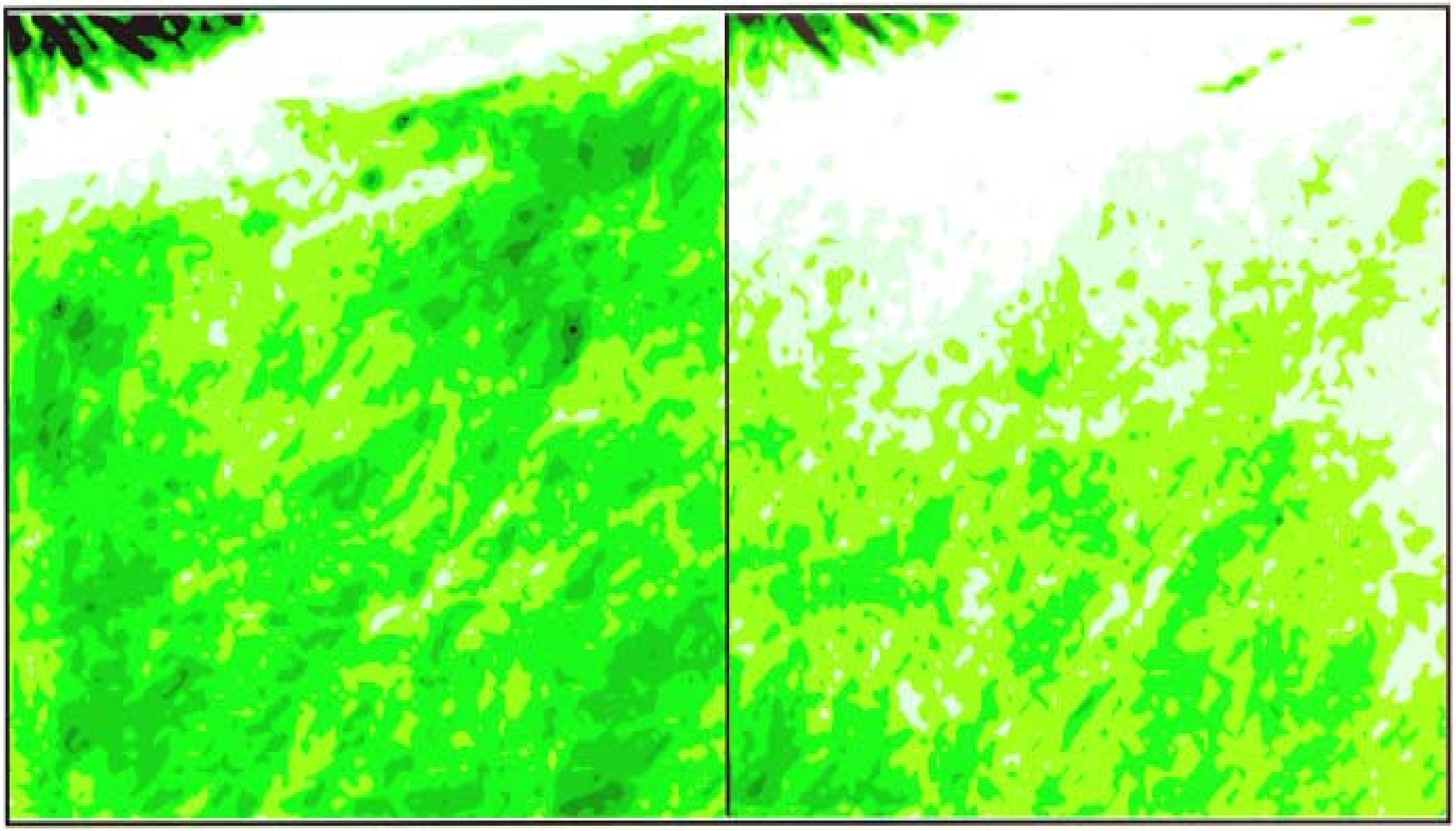
GIS Coverage



Training Range Conditions

ArcView® Theme

Images are imported into ArcView® as TIFF World File (*.twf) images



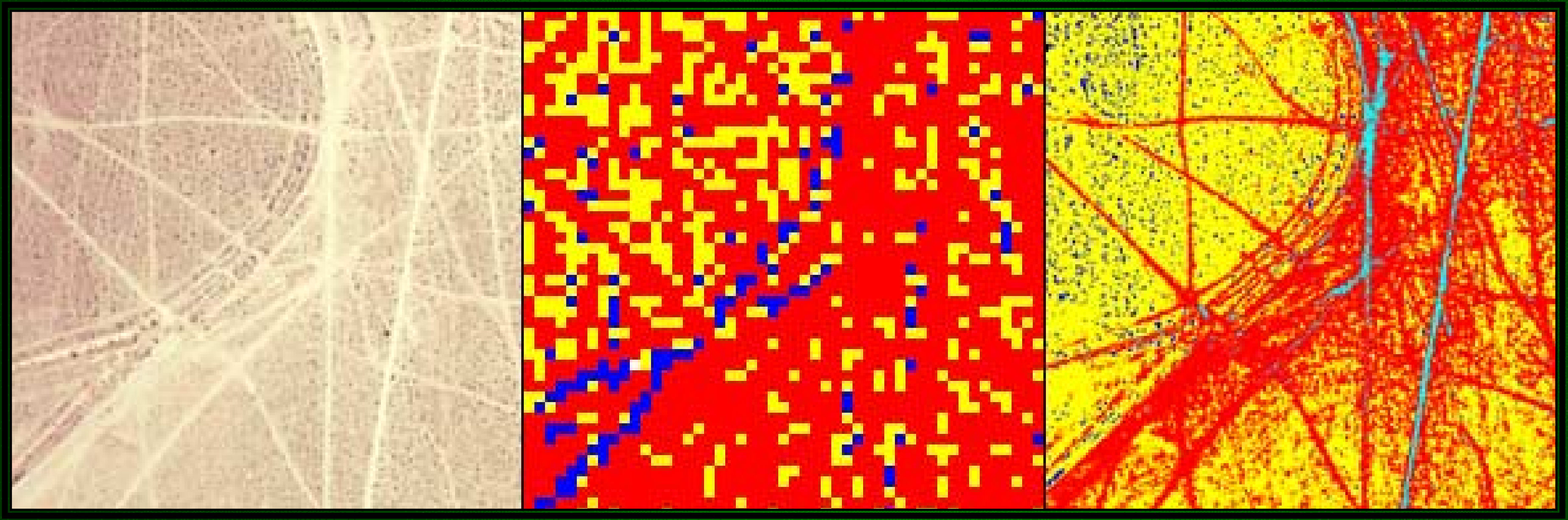
Percent shrub cover in increasing intervals of green from 0% (white), 1, 3, 6, 10, 15, to >21% (black)
Left image from photo taken in 1996. Right image from photo taken in 1999.

Image Processing

National Training Center at Fort Irwin

Aerial Photography, Satellite Imagery, and

Rapid Assessment of Vegetative Structures



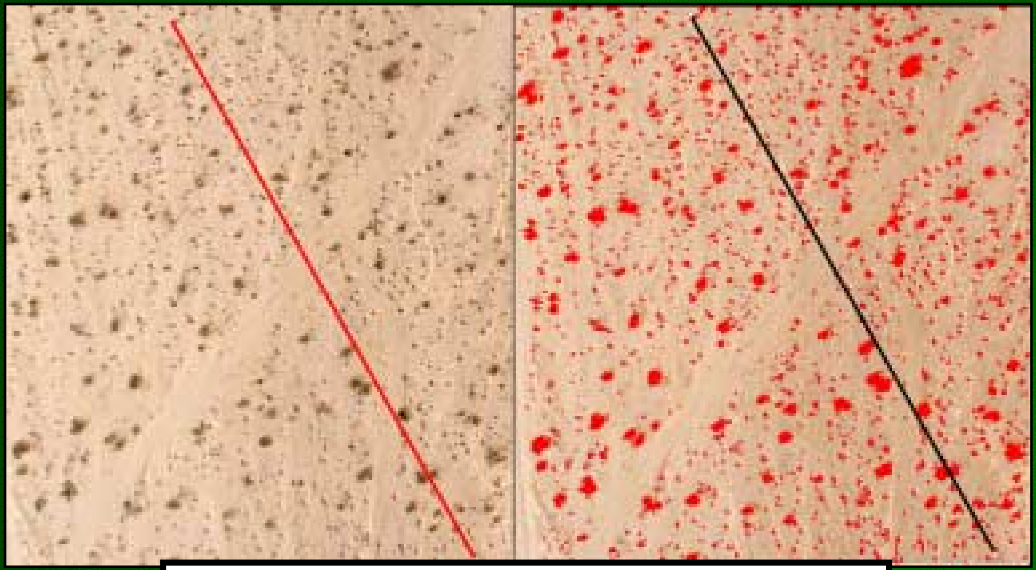
Aerial Photo **Satellite Image** **RAVS**

64 grids (each 500-meters X 500-meters) were evaluated

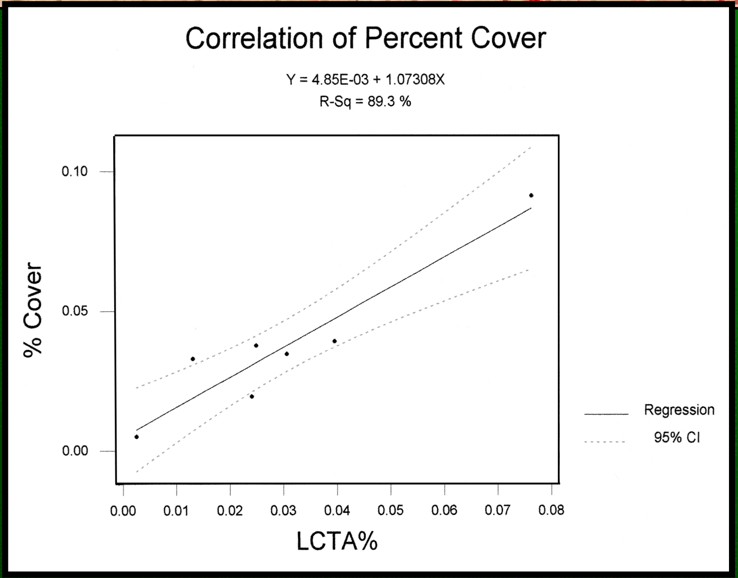
How does it compare?

LCTA vs. RAVS at Fort Irwin

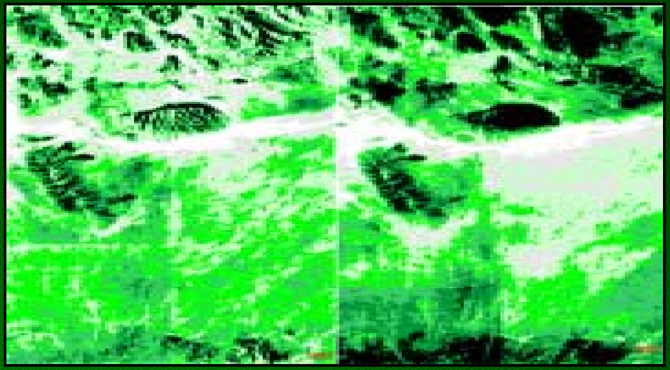
Conventional Line Intercept



RAVS



Conclusions



- New technique is highly correlated with results from Land Condition and Trend Analysis
- It is accurate to within about 5 to 20 percent of the mean (depending on photo scale)
- It provides an excellent means of comparing changes in shrub canopy cover from year to year
- It provides a new tool for managers to help evaluate training impacts on vegetation

For More Information

- DOE/NV/11718—729 **Vegetation Change Analysis User's Manual**:

Full text web viewable (black and white) PDF (22137K)

http://www.osti.gov/gpo/servlets/purl/801915-X5dWul/webviewable/

Full native text format (color) PDF (65014K)

http://www.osti.gov/gpo/servlets/purl/801915-YSI3xi/native/

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Literature Cited

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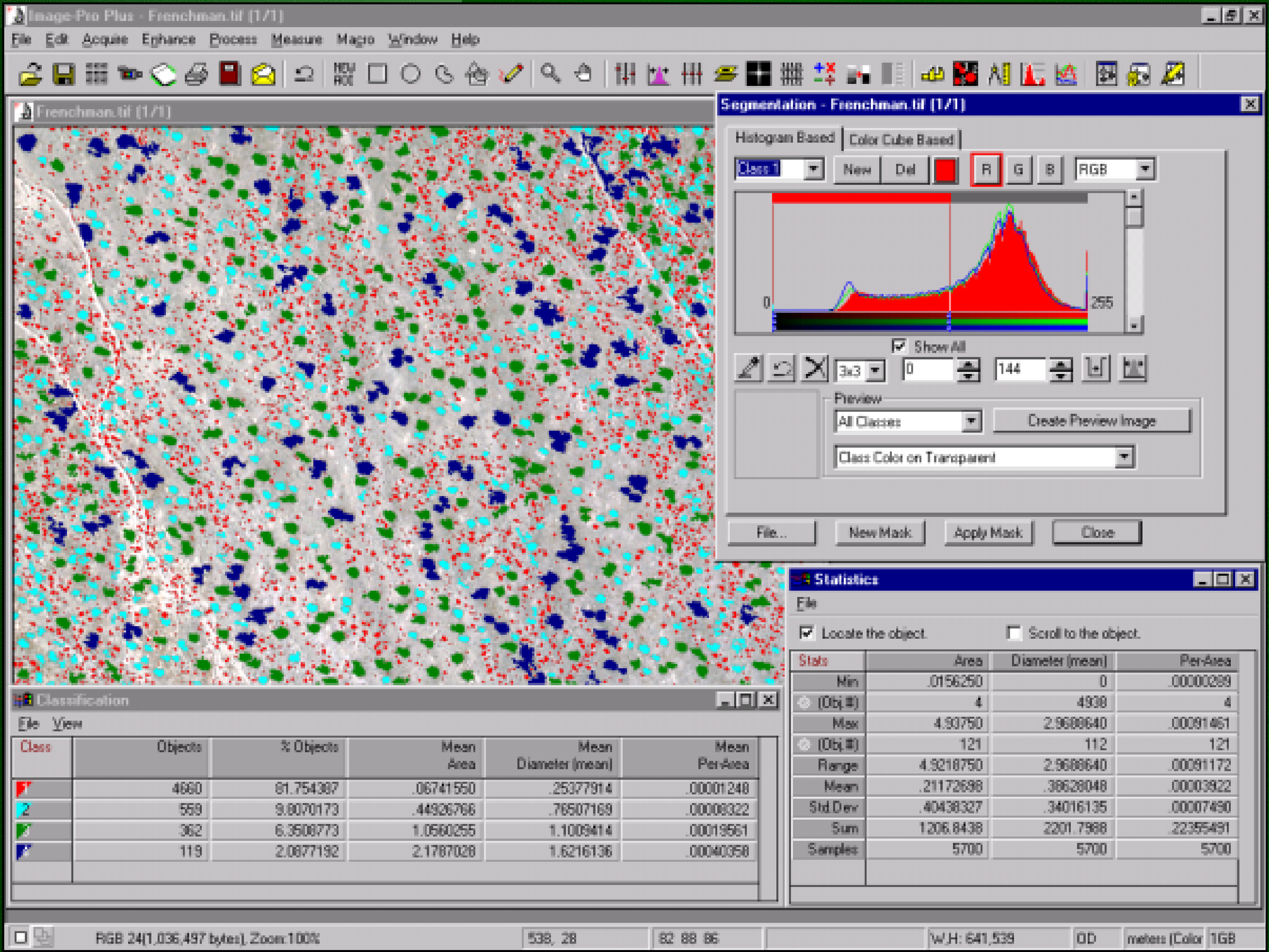
- TRW. 1996. The Vegetation of Yucca Mountain: Description and Ecology. (SCPB: N/A) B00000000-01717-5705-00030 REV 00. TRW Environmental Safety Systems Inc., Las Vegas, Nevada.

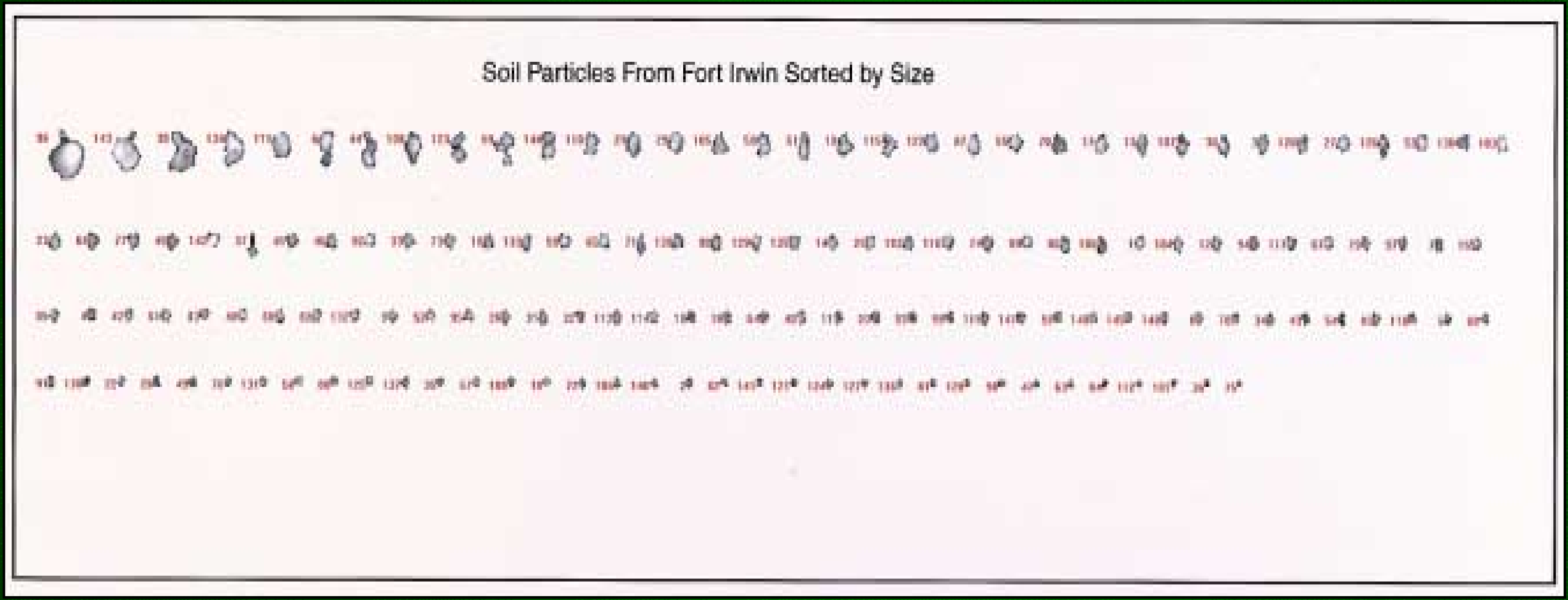
Other Applications:

- Shrub size class measurements
- Soil particle size measurements
- Seed sizes measurements
- Species spatial differentiation

Determine Shrub Size-Class Measurements



Measure Soil Particle Sizes

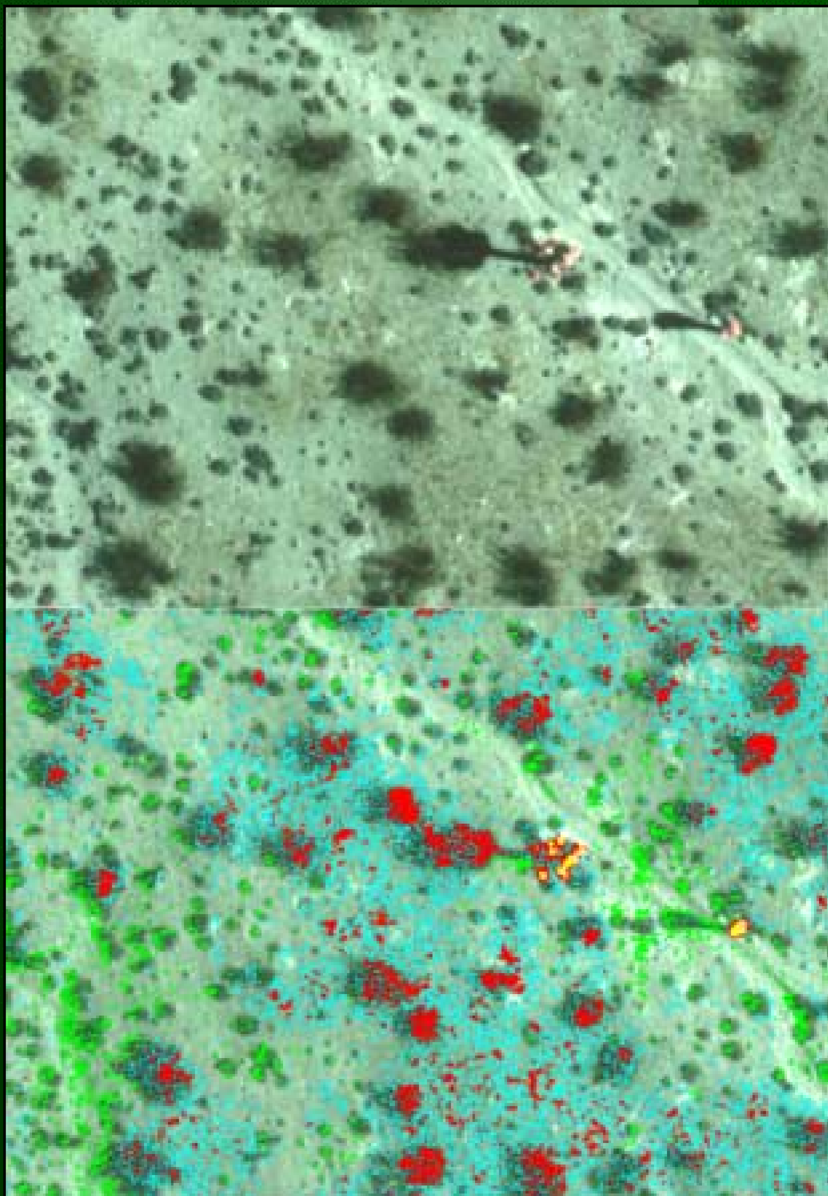


Sand, Silt, and Clay Particles Sorted by Size

Measure Native Seed Sizes

Indian Rice Grass Seed Measurements

Identify Selected Plant Species



Added Discriminate Power

- Different colors
- Different sizes
- Different phenology
- Plant parameter correlations