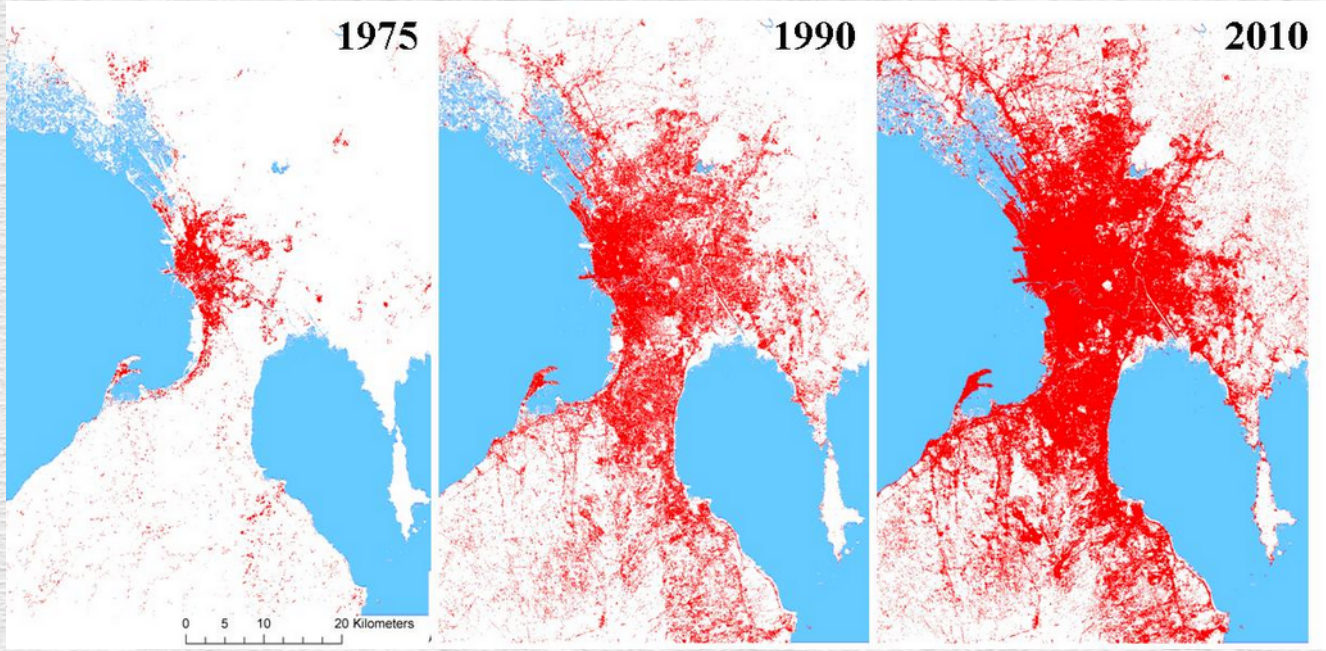
Change detection



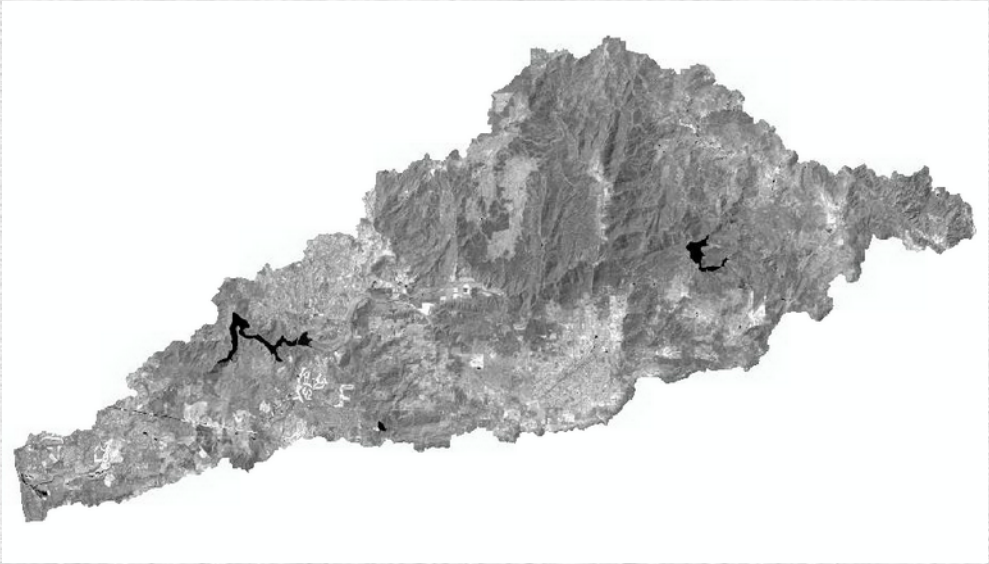
Detecting change is fundamental to monitoring

- The purpose of monitoring is to determine the status of the system of interest now, and how it's changing over time
- A single remote sensing scene can tell us what the status is now
- Comparisons among scenes from different time points can tell us about the trend

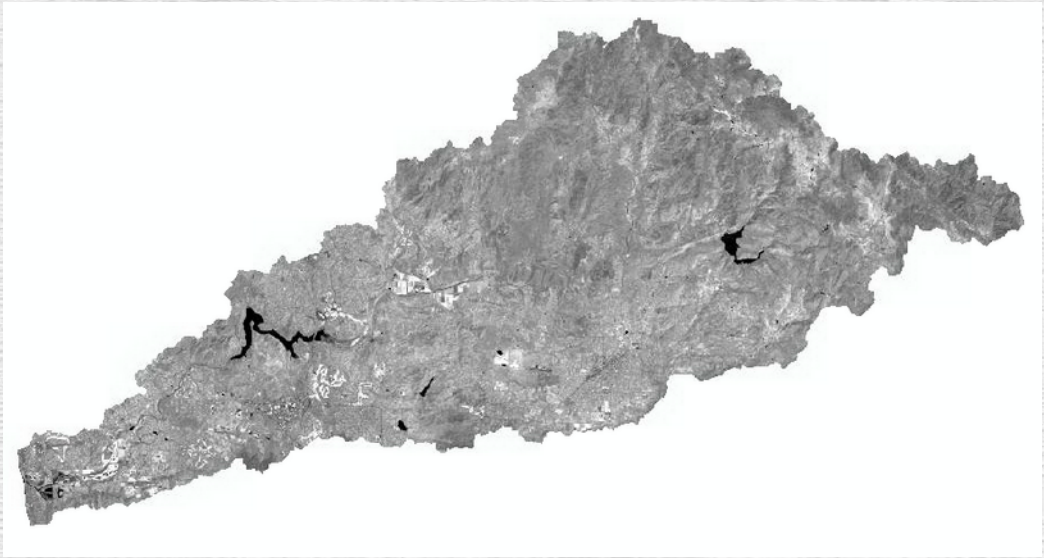
Four basic approaches

- Differences in raw data
  - Differences in DN
  - Differences in radiance
  - Differences in reflectance
- Differences in an index (vegetation index)
  - First calculate an index of vegetative cover for two scenes
  - Difference, compare between index values
- Manual interpretation
- Differences between cover types
  - First classify cover types from imagery, then compare cover types between time periods

Differencing a single band: NIR for Sp 1984 and Sp 2011

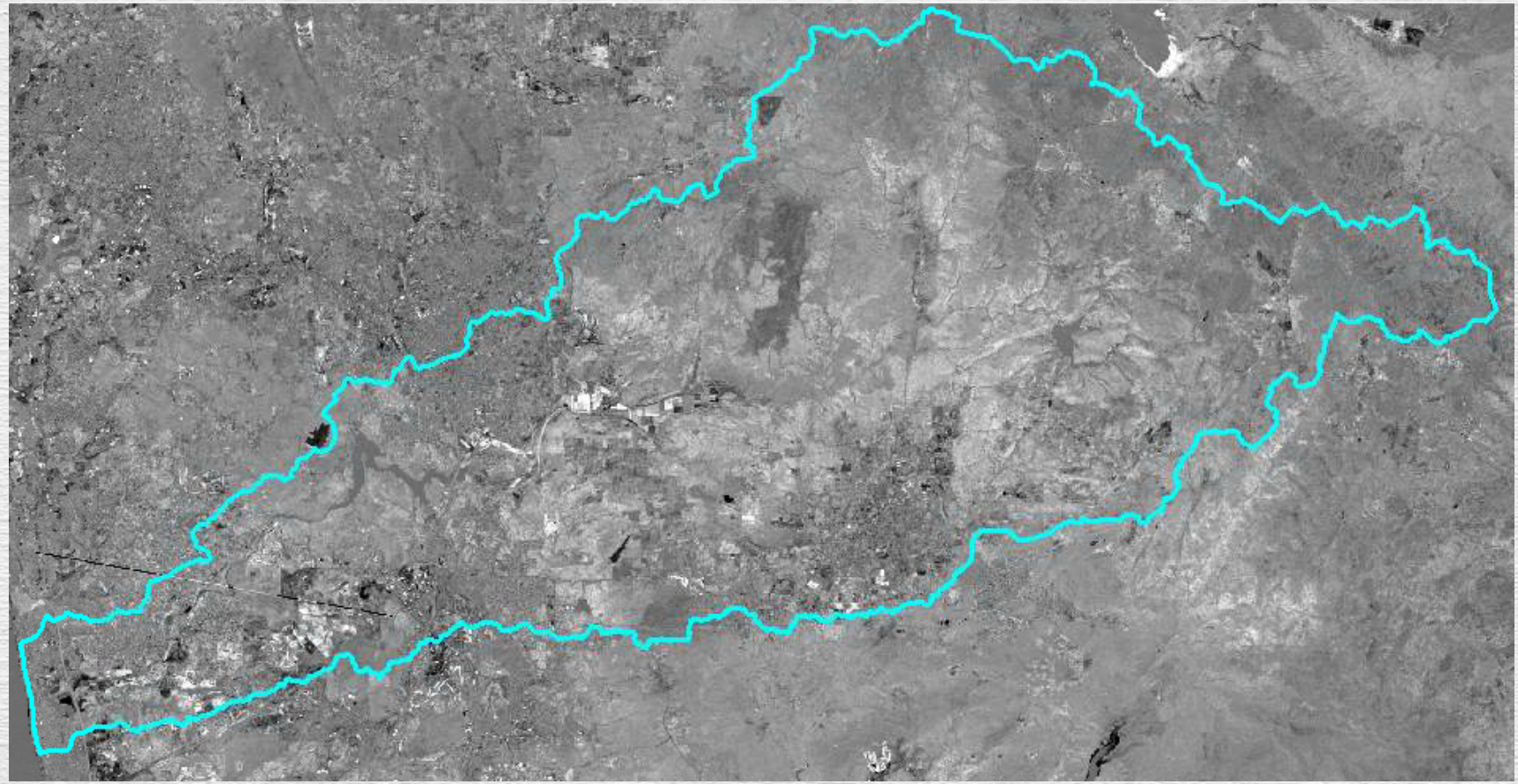


Spring 1984



Spring 2011

Difference: Sp 2011 – Sp 1984



Advantages

- Based just on measurements
  - No cover typing, so no cover typing error
  - Just focused on the difference in a measurement, no prediction/classification step
- Quick and easy

Disadvantages

- Interpretation – what do the differences mean? Urbanization? Agricultural development? Ecological succession?
- Sensitivity to registration differences
  - Registration = aligning an image with the landscape
  - Two scenes taken at two different times won’t have the pixels in exactly the same locations
  - This can lead to differences in pixel values due to differences in alignment, rather than cover type change

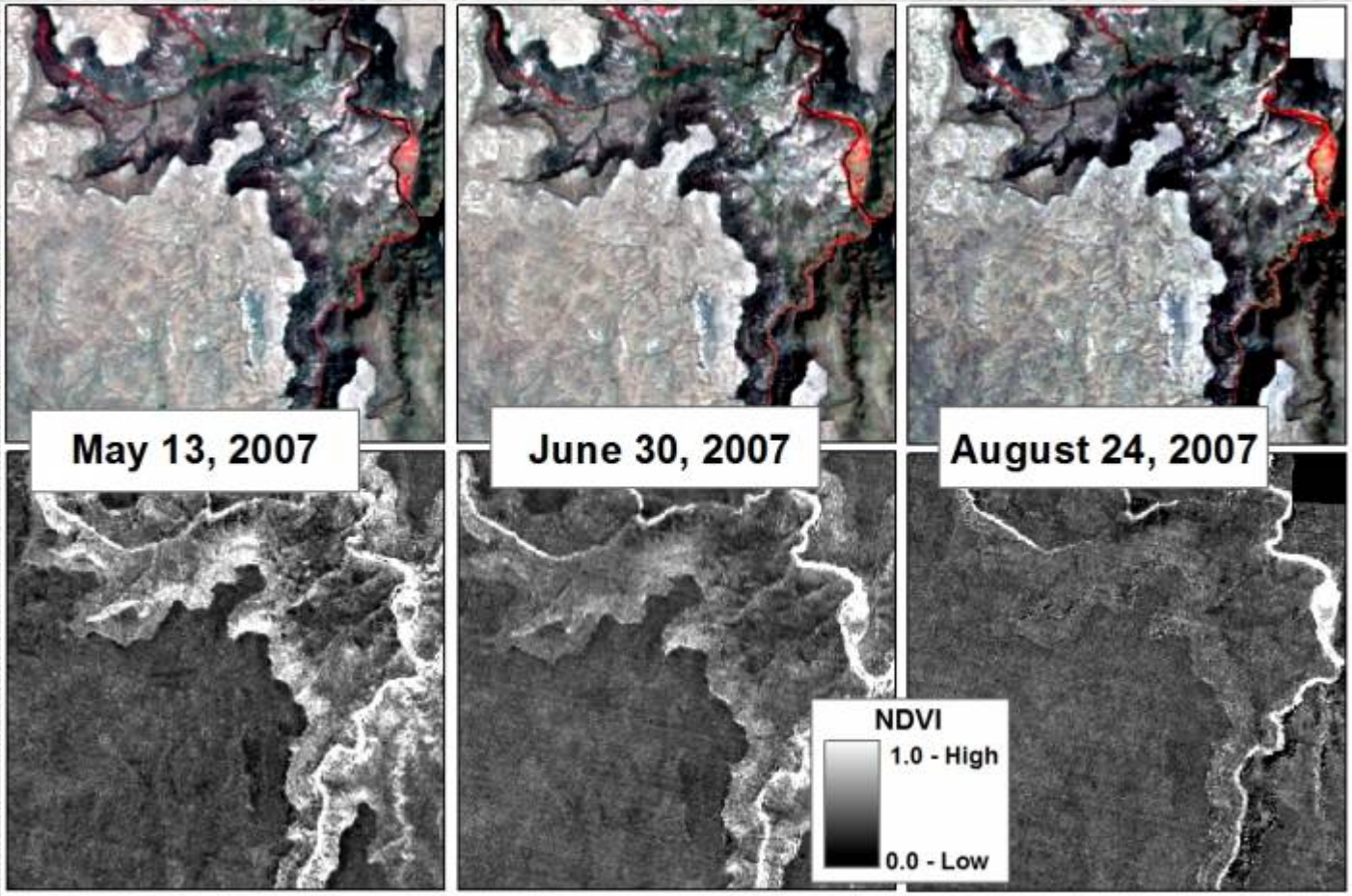
Differences in vegetation index values

- Can calculate an index (like NDVI, or tasseled cap), and difference those values
- Changes in greenness presumably indicate a difference in cover

Seasonal changes in NDVI in Owyhee County, ID

False-color composites

NDVI



http://wiki.landscapetoolbox.org/doku.php/remote_sensing_methods:normalized_difference_vegetation_index

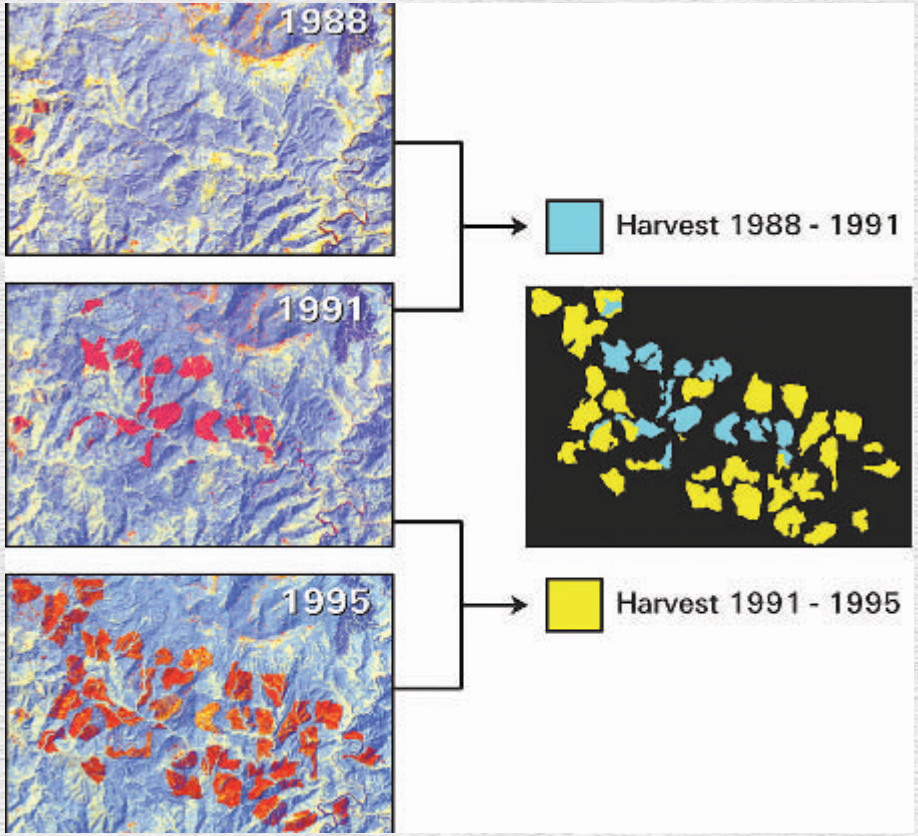
Comparing the Tasseled Cap index between pairs of images

Tasseled cap:

Derived from bands 1-5, 7

Results in three layers: brightness, greenness, wetness

Three independent components of the spectrum



From Cohen and Goward, 2004

Figure 3. Landsat Thematic Mapper imagery representing three dates for a small (3-kilometer [km] by 5-km) section of forestland in western Oregon and a map of forest harvest activity derived from these data. Images are displayed as tasseled cap indices of brightness, greenness, and wetness (red, green, and blue, respectively).

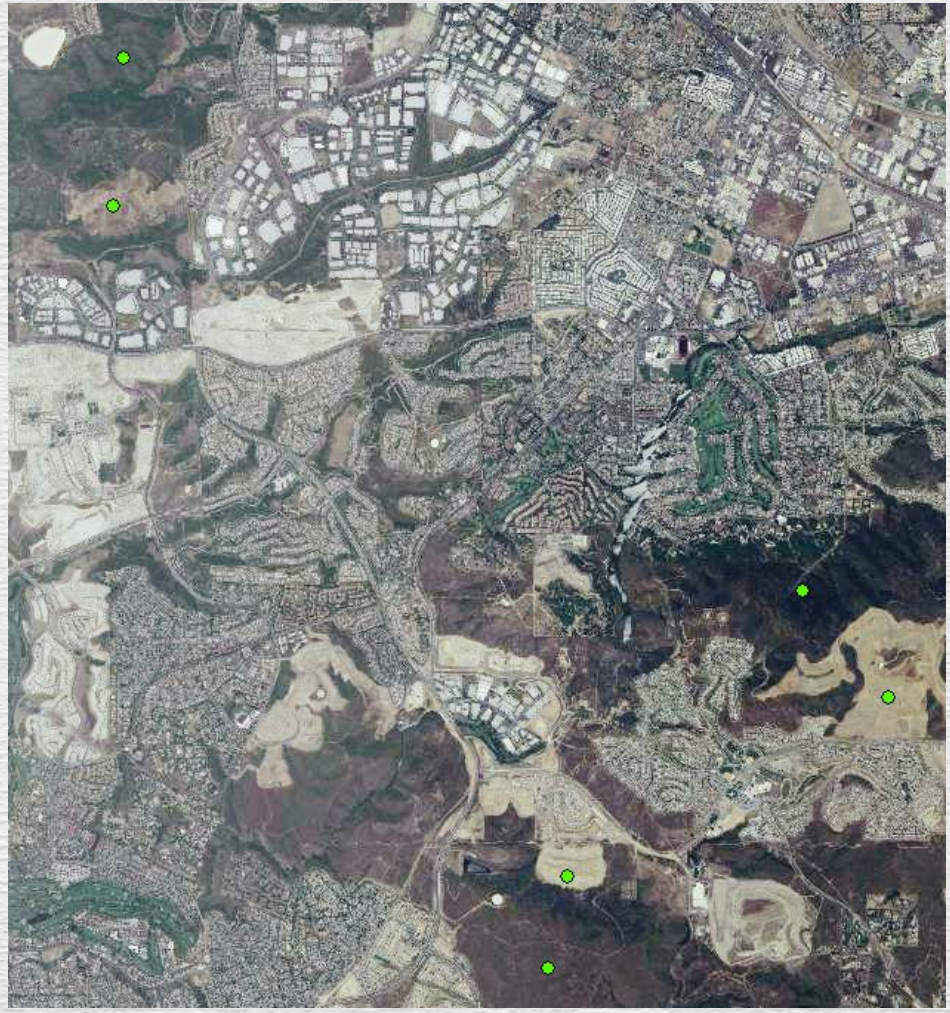
Advantages

- Differences are more interpretable – NDVI means something, so differences in NDVI mean something
- Can be assessed quickly over a large area
- Fairly straightforward calculation from the raw data, no classification/prediction step

Disadvantages

- Changes in vegetation index values don't intrinsically indicate the nature of the change
  - Urbanization? Agricultural development? Succession?
- Registration problems can still be an issue

Observe land cover at the same locations at two time points



Los Peñasquitos Creek

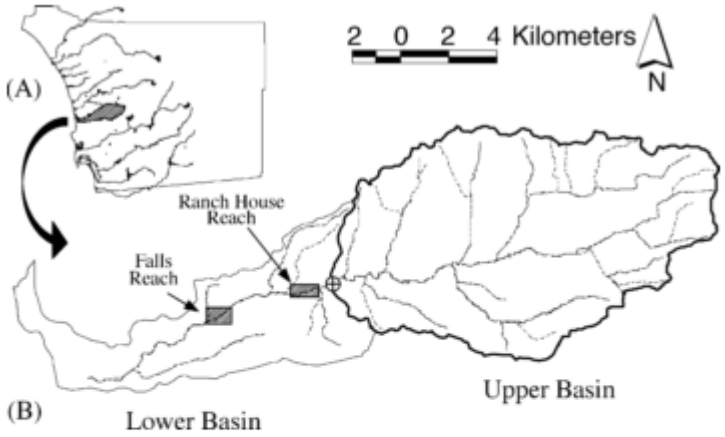
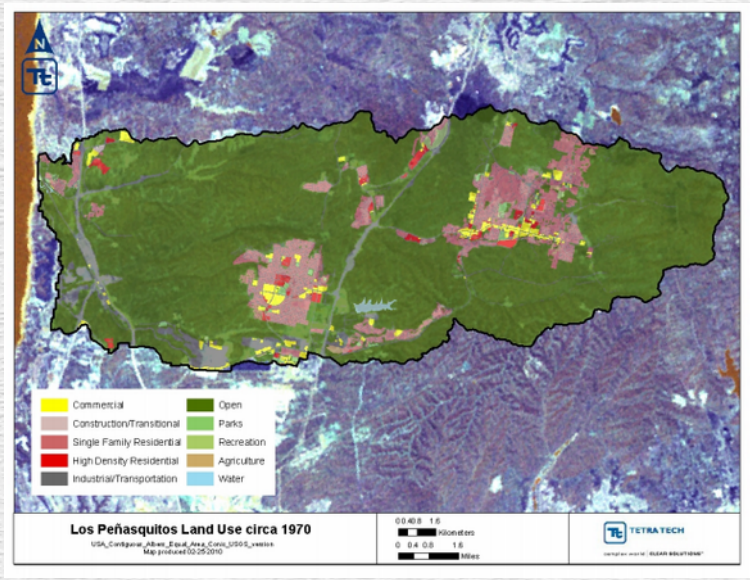
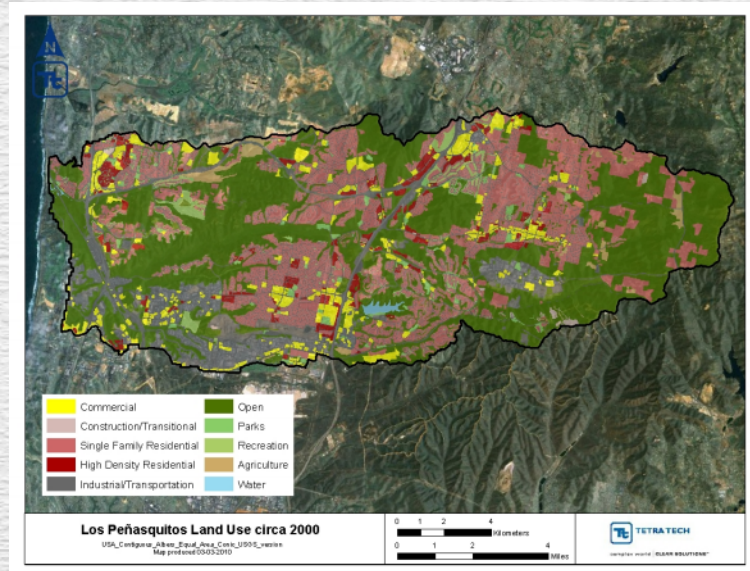


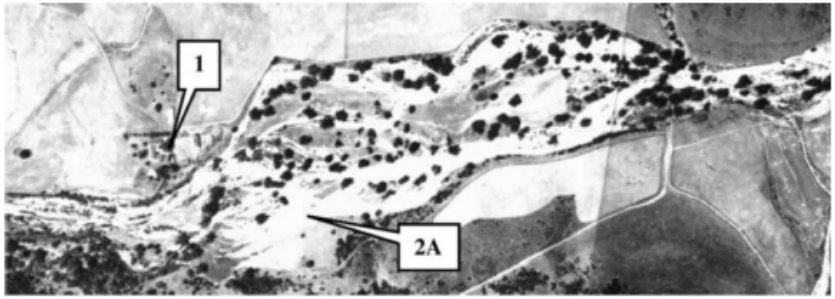
Fig. 1. (A) Location of the Los Peñasquitos Creek watershed within San Diego County, California. (B) Detailed view of the watershed, showing the boundary between the upper and lower basins and the location of the stream gage (cross symbol). The two rectangular cross-hatched areas are the Ranch House and Falls reaches. Changes in urbanization were measured in the upper basin, and riparian vegetation changes were measured in the lower basin.

From White and Greer, 2006
Greer and Stow, 2003
Tetra Tech, 2010



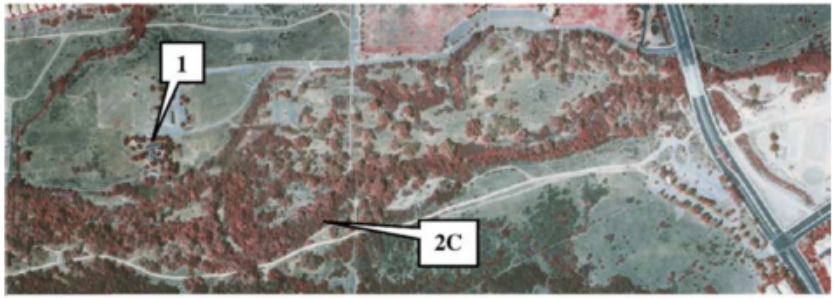


The "urban drool" problem?



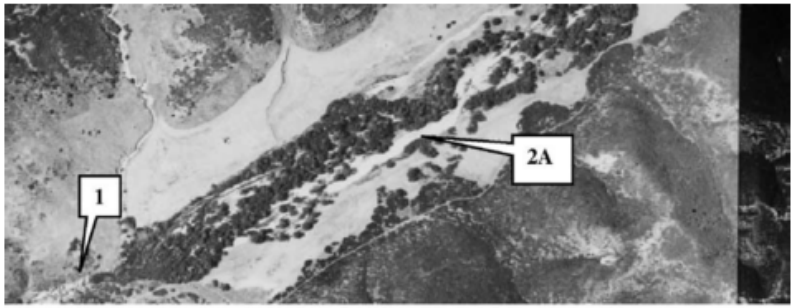
A. 1928

B. 1969



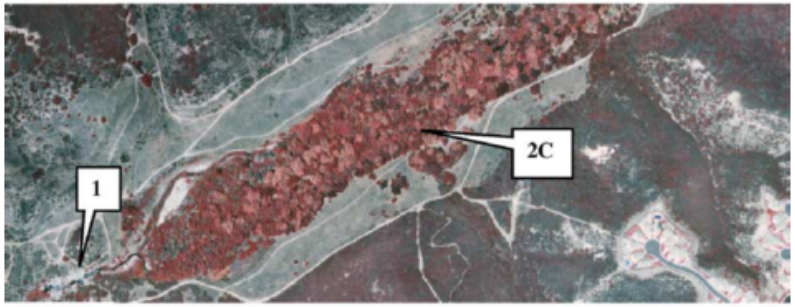
C. 2000

Fig. 7. Aerial photographs of the Ranch House reach of Los Peñasquitos Creek from: 1928 (A), 1969 (B), and 2000 (C), showing changes in channel characteristics and the distribution of riparian vegetation. (1) Ranch House buildings; (2A) sparsely vegetated, braided channel; (2B) narrow channel with riparian vegetation along the margins; (2C) narrow channel with dense riparian vegetation.



A. 1928

B. 1969



C. 2000

Fig. 8. Aerial photographs of the Falls reach of Los Peñasquitos Creek from 1928 (A), 1969 (B), and 2000 (C), showing changes in channel characteristics and the distribution of riparian vegetation. (1) The rock outcropping that forms the Falls; (2A) unvegetated channel; (2B) vegetation established in unvegetated channel; (2C) dense riparian vegetation obscures channel.

Advantages:

Very interpretable

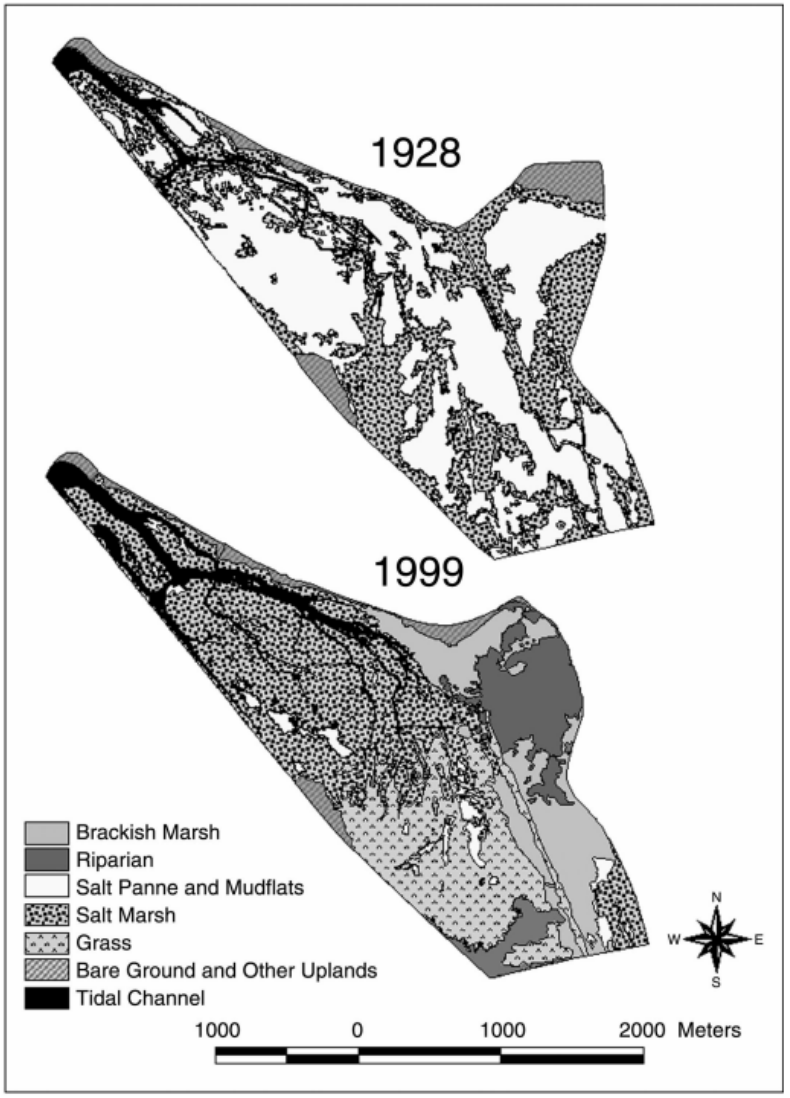


Figure 4. Generalized vegetation types for the Los Peñasquitos Lagoon study area for 1928 and 1999.

Disadvantages:

Need cover type maps (time/money)

Observing the differences is not quantitative – amount of change not clear

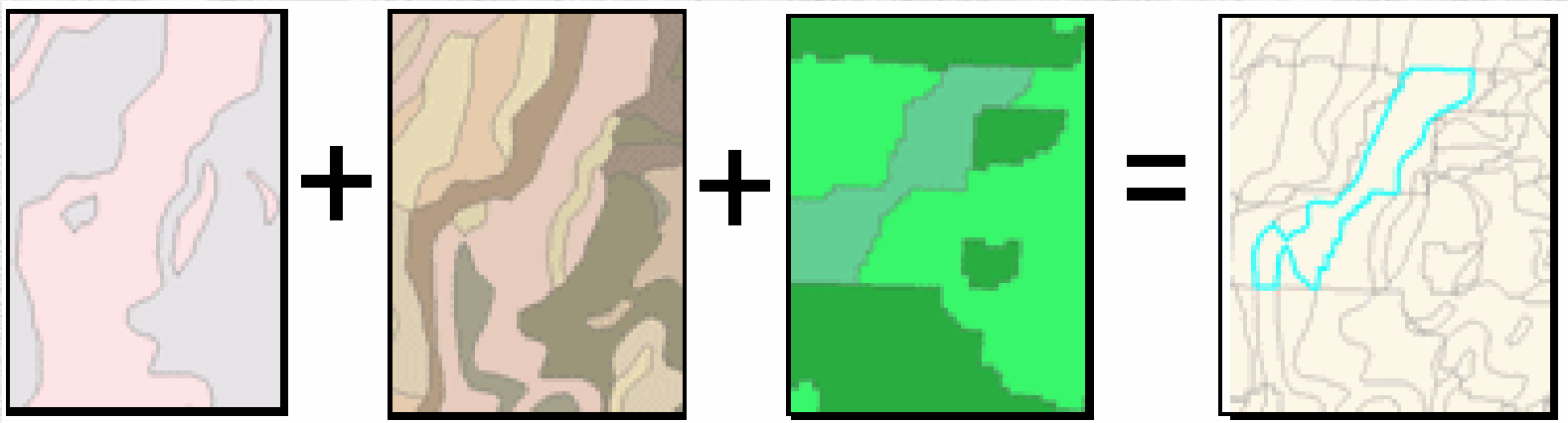
Differences between cover type maps

- We can analyze change between raster or vector cover type maps
- Need two cover type maps that were done in the same way
  - Same classification system
  - Data from the same season (or independent of season)
  - Using same mapping methods (same MMU)
- Maps can then be compared, and transition from one set of cover types to others can be quantified

Comparing cover type maps

- Spatial overlay = overlay the two maps from two different time points
- A cross-tabulation of the cover classes gives you a "transition matrix"
  - Vector = perform a union operation on the maps, then cross-tabulate the cover types in the resulting attribute table
  - Raster = just cross-tabulate the cover types in matching pixels
- From the transition matrix, can see how much area has changed, and what it has changed to

Overlaying GIS layers



	FID	Shape*	FID_soils	CODE	CLASS	FID_sl	SLOPE	FID_veg	DET_TYPE
	3039	Polygon	508	38F	6	0	60	117	A
	3040	Polygon	508	38F	6	0	60	119	SS
	3041	Polygon	508	38F	6	0	60	157	U
	3042	Polygon	508	38F	6	0	60	158	A
	3043	Polygon	508	38F	6	0	60	160	FC

Example transition matrix

- Cover type in 1984 in the rows, cover type in 2011 in the columns
  - Percents of rows – percent of 1984 cover that is in each category in 2011
  - If there were no changes, every cover type would have 100% in the main diagonal, and 0% everywhere else
- Do we have reason to suspect some cover types are mis-classified in one or both of the images?

	Urban	Water	Wetland	Golf course	Chaparral	Forest
Urban	**62%**	0%	19%	2%	17%	0%
Water	1%	**52%**	44%	1%	2%	1%
Wetland	45%	0%	**37%**	2%	15%	0%
Golf course	44%	0%	12%	**9%**	34%	0%
Chaparral	11%	0%	9%	1%	**74%**	6%
Forest	3%	0%	4%	0%	51%	**42%**

Advantages

- Maximally interpretable
  - The cover type maps are thematic – already interpreted as cover type
  - Transition matrix gives us the nature of the change (from what to what)
- Cover type maps are generally useful things → big bang for the buck
  - Land use planning
  - Fire risk assessment
  - Ecological studies
- Less sensitive to registration errors
  - Interiors of polygons all treated as homogeneous, single thing
  - Mismatch at the edges of polygons will be small compared to the sizes of the overlapping areas

Disadvantages

- The assessment is only as good as the cover type maps
- Good cover type maps are expensive and labor intensive to produce
  - Generally introduces a lag – the data may be several years old by the time the maps are ready
- Rapidly produced maps are often not very good
  - Classifying with spectral signatures without ground truthing → many classification errors
  - Sloppy digitizing → poor agreement between maps

Conclusions

- Land cover change detection is an important activity
- There are many different approaches
- The results depend on the approach
- Expect new developments in this area