Lessons Learned on Border Area Projects

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Geography Water Management/RS/GIS Faculty

Richard Wright – GIS, cartography, Tijuana River Watershed Atlas, water resource policy

Trent Biggs – Watershed hydrology modeling, hillside erosion (e.g., Goat Canyon) and estuarine sedimentation processes (e.g., TJ Estuary), remote sensing

Kathleen Farley – land use change effects on ecosystem services (grasslands and shrublands), policy effects on watershed land use change (e.g., TJ River watershed)

Allen Hope – Watershed hydrology modeling, post-burn recovery of chaparral, invasive plants and their effects on stream hydrology, remote sensing

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Geography Water Management/RS/GIS Faculty/Staff

Piotr Jankowski – GIS, spatial decision support systems, sensor networks, water resource management

Lloyd (Pete) Coulter – remote sensing, image processing, survey GPS, habitat and fire management, urban water demand, border law enforcement

Doug Stow – remote sensing/image processing, habitat, fire fuel and invasive plant monitoring, land cover/land use change

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SDSU Geography Border Water Projects

GIS Mapping Project for Bi-national Coordinated Land-Use Planning and Education in the Tijuana River Watershed

Funding Agency: NOAA [collaboration w/ INEGI and COLEF]
PI: Richard Wright, Co-Is: Profs. Allen Hope, John O'Leary, Doug Stow

San Diego County-Baja California Water Quality Prediction and Monitoring Program

Funding Agency: California State Water Resources Control Board
PI: Richard Wright, Co-Is: Rick Gersberg, Allen Hope, Doug Stow

Sediment and Erosion in Urban Tijuana: Socioeconomic Interactions with Sediment Budgets Under Rapid Urbanization of Marginal Lands

Funding Agency: Southwest Consortium for Environmental Research and Policy
PI: Trent Biggs

Particle Size and Accumulation Rates of Sediment Within Fluvial and Feeder Canyon Depositional Environments of the Tijuana Estuary Reserve

Funding Agency: NOAA
PI: Trent Biggs

Linking Land Use and Policy in the Tijuana River Watershed

Funding Agency: U.S. EPA/Southwest Consortium for Environmental Research and Policy
PI: Kathleen Farley

Other SDSU Geography Border or Water Remote Sensing Projects

Regional Hydrological Response of Semi-Arid Mediterranean Climate Watersheds to Land-Cover/Land-Use Variability

Funding Agency: NASA LCLUC

PI: Allen Hope, Co-I: Doug Stow

Fire, Land Cover and Climate Change: Impacts on River Flows in Semiarid Shrubland Watersheds

Funding Agency: NASA LCLUC

PI: Allen Hope, Co-I: ChristinaTague

Spatial Decision Support System for Border Security

Funding Agency: NASA REASoN

PI: Doug Stow, Co-Is: Allen Hope, Piotr Jankowski, Ming Tsou, John Weeks

Spatial-temporal Patterns of Smuggling and Migration: National Center for Border Security and Immigration

Funding Agency: DHS Science & Technology

Center PI: Jay Nunamaker, U. Arizona, SDSU PI: Doug Stow

Lessons Learned:
Bi-national Cooperative Projects

- Watersheds can span international borders
- Access to and sharing of new data sets
- Variable data standards and formats
- Protocols for cooperation and communication
- Cultural sensitivities
- Cross-border travel issues
- Transfer of funds
- Rewarding  Challenging

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Department of Geography
San Diego State University

Lessons Learned:
Resource Agency - University Cooperative Projects

- High expectations (e.g., accuracy, cost, etc.) by user agency personnel
- University driven by research and education; not always sensitive to user needs
- Agency funds limited for capital investments in remote sensing technology investments
- Difficult to achieve operational implementation of remote sensing technology

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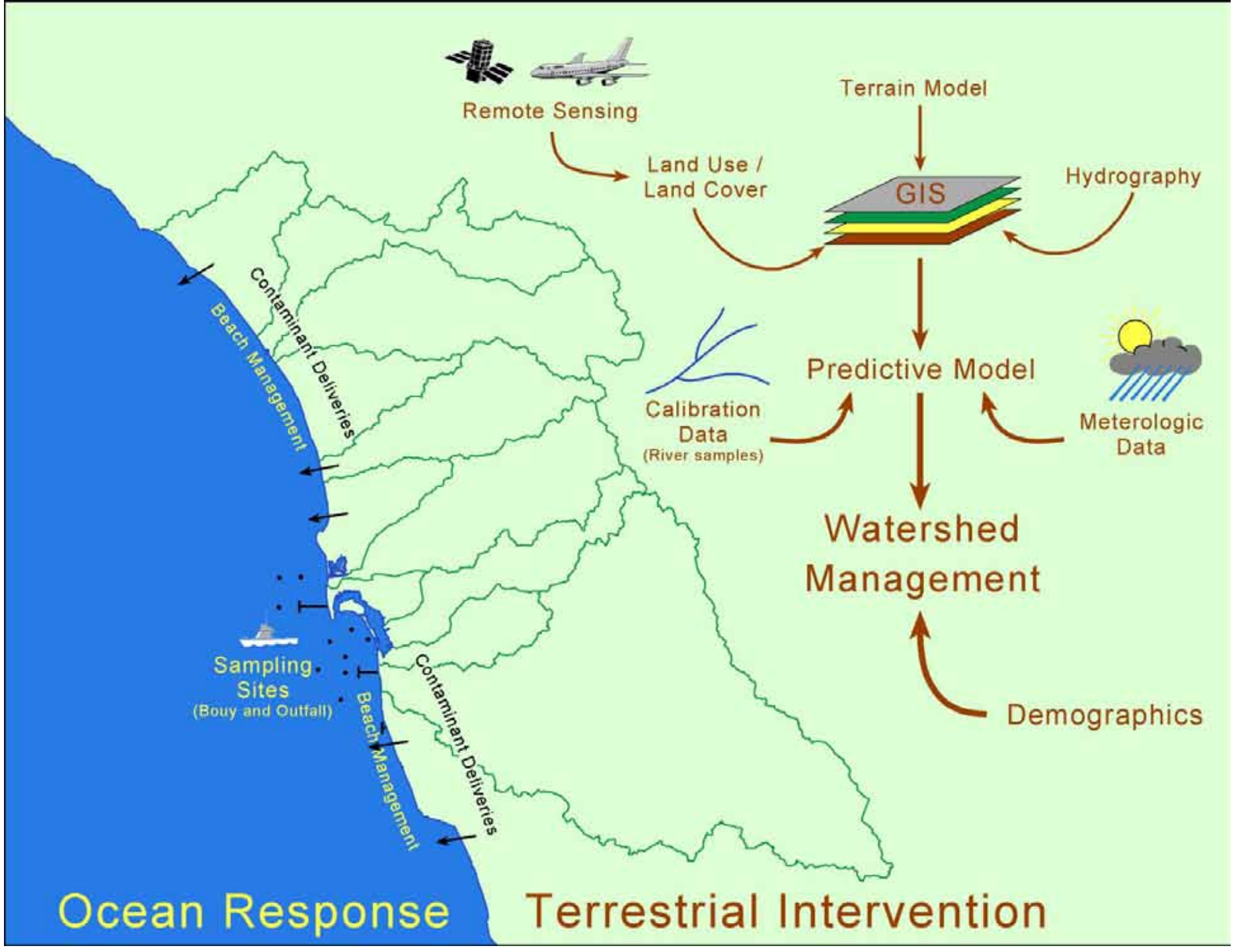
Role of Remote Sensing in Water Management

- Land cover/land use and topographic data for watershed modeling (quantity and quality)
  - vegetation cover, type, structure (ET, infiltration, streamflow)
  - impervious surfaces (runoff coefficients)
  - digital elevation data (slope gradient and aspect)
- Irrigated lands assessment
  - agriculture (water demand, unregulated usage)
  - urban (landscaping, parks)
- Vegetation mapping/monitoring
  - invasive plants (water demand)
  - wetland and riparian vegetation composition and condition
  - groundwater extraction/exploration (geobotanical indicators)
- Water quality mapping/monitoring
  - sediment/turbidity
  - chlorophyll/eutrophic status
  - pollutants (normally surrogate relationships with optical properties)

San Diego County-Baja California Water Quality Prediction and Monitoring Program

Funding Agency: California State Water Resources Control Board

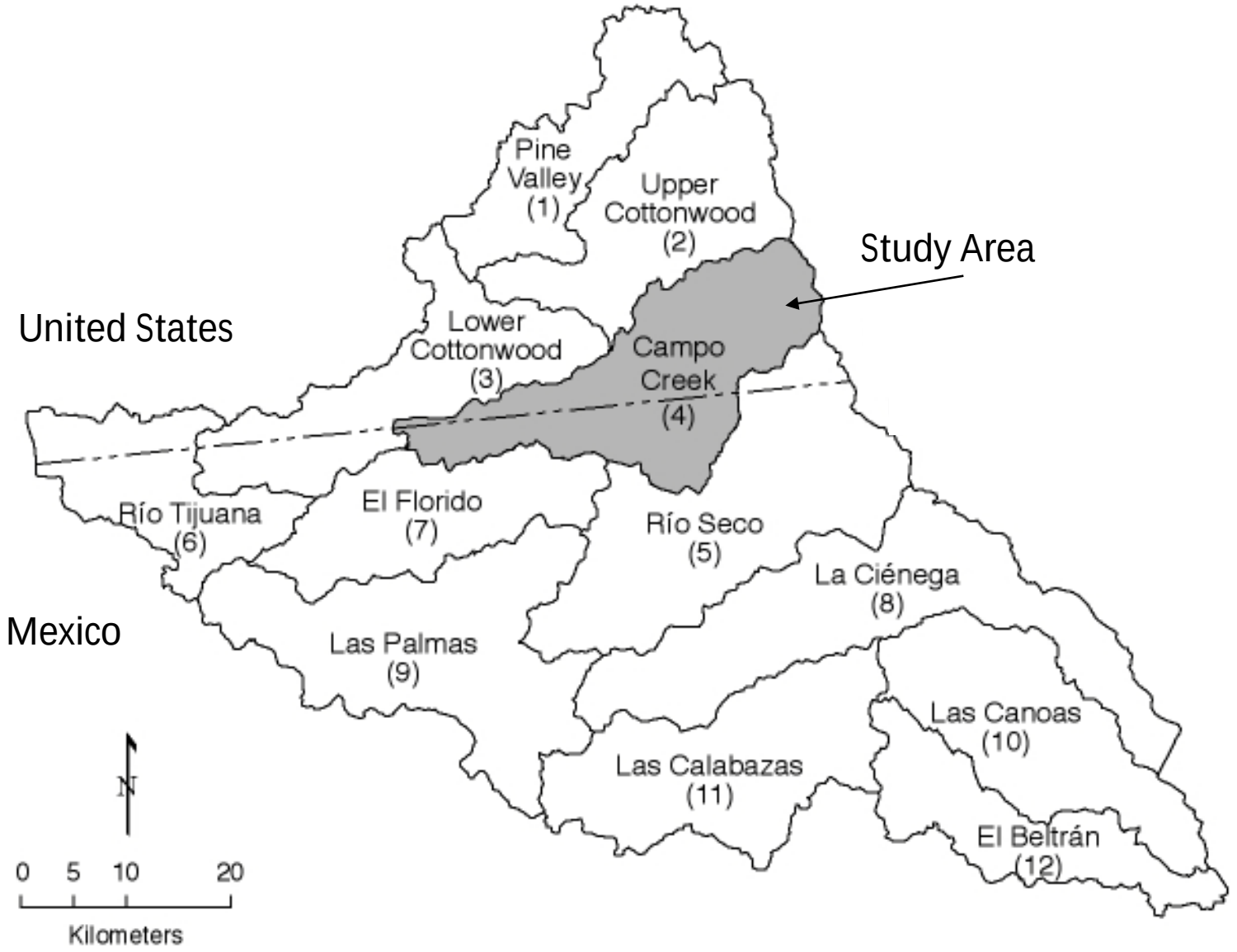
PI: Richard Wright, Co-Is: Rick Gersberg, Allen Hope, Doug Stow


Remote Sensing
Terrain Model
Land Use /
Land Cover
GIS
Hydrography
Beach Management
Contaminant Deliveries
Calibration
Data
(River samples)
Predictive Model
Meterologic
Data
Watershed
Management
Sampling
Sites
(Bouy and Outfall)
Contaminant Deliveries
Beach Management
Demographics
Ocean Response
Terrestrial Intervention

Investigate Utility of TM and IKONOS Satellite Data to Map and Identify Land Use for Water Quality Modeling

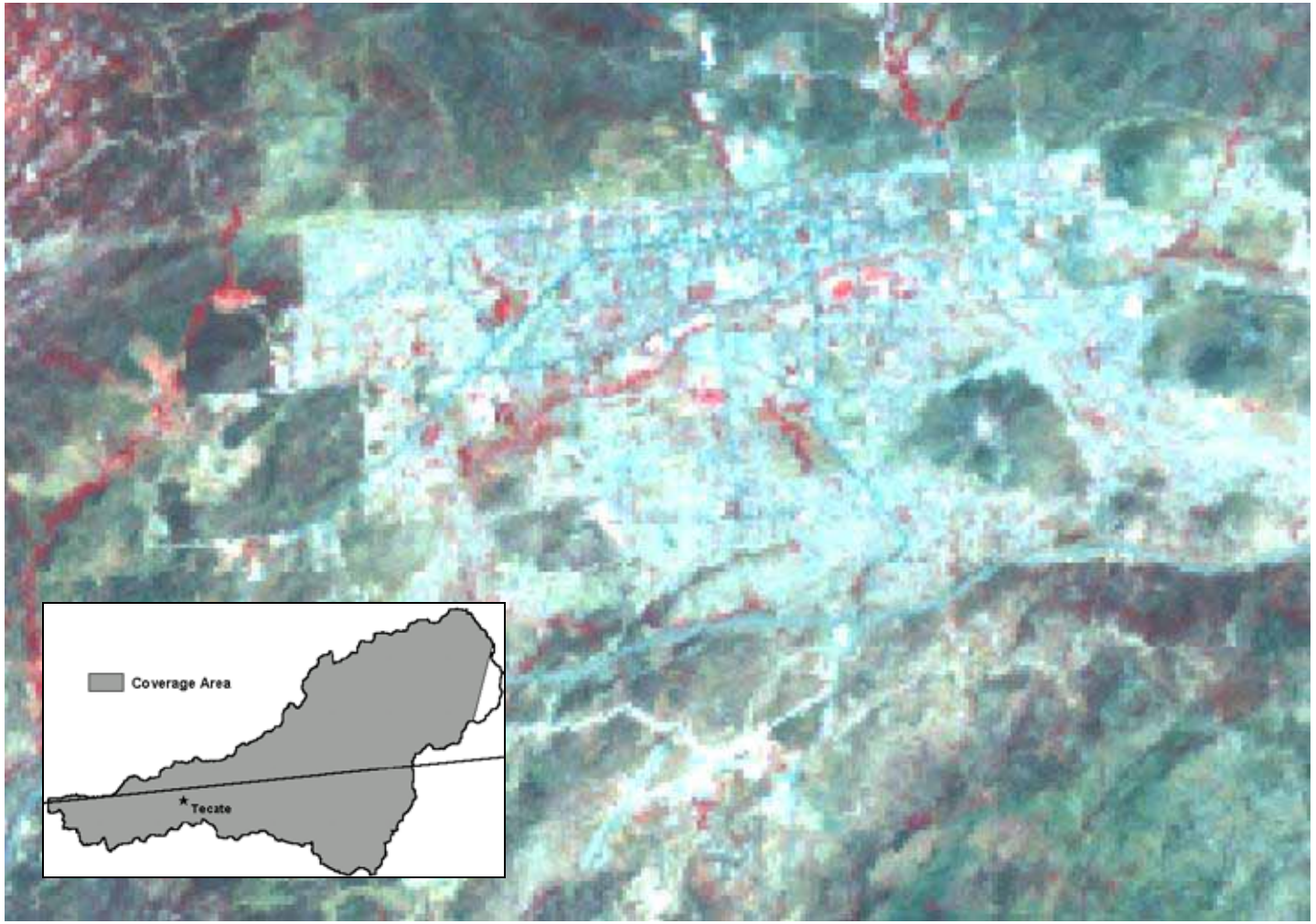
Determine utility of classifying land use and land cover (LU/LC) with several remote sensing imagery types in the context of providing LU/LC inputs to water quality models such as BASINS and the core hydrologic model in BASINS, HSPF (Hydrologic Simulation Program-Fortran).

Campo Creek Watershed

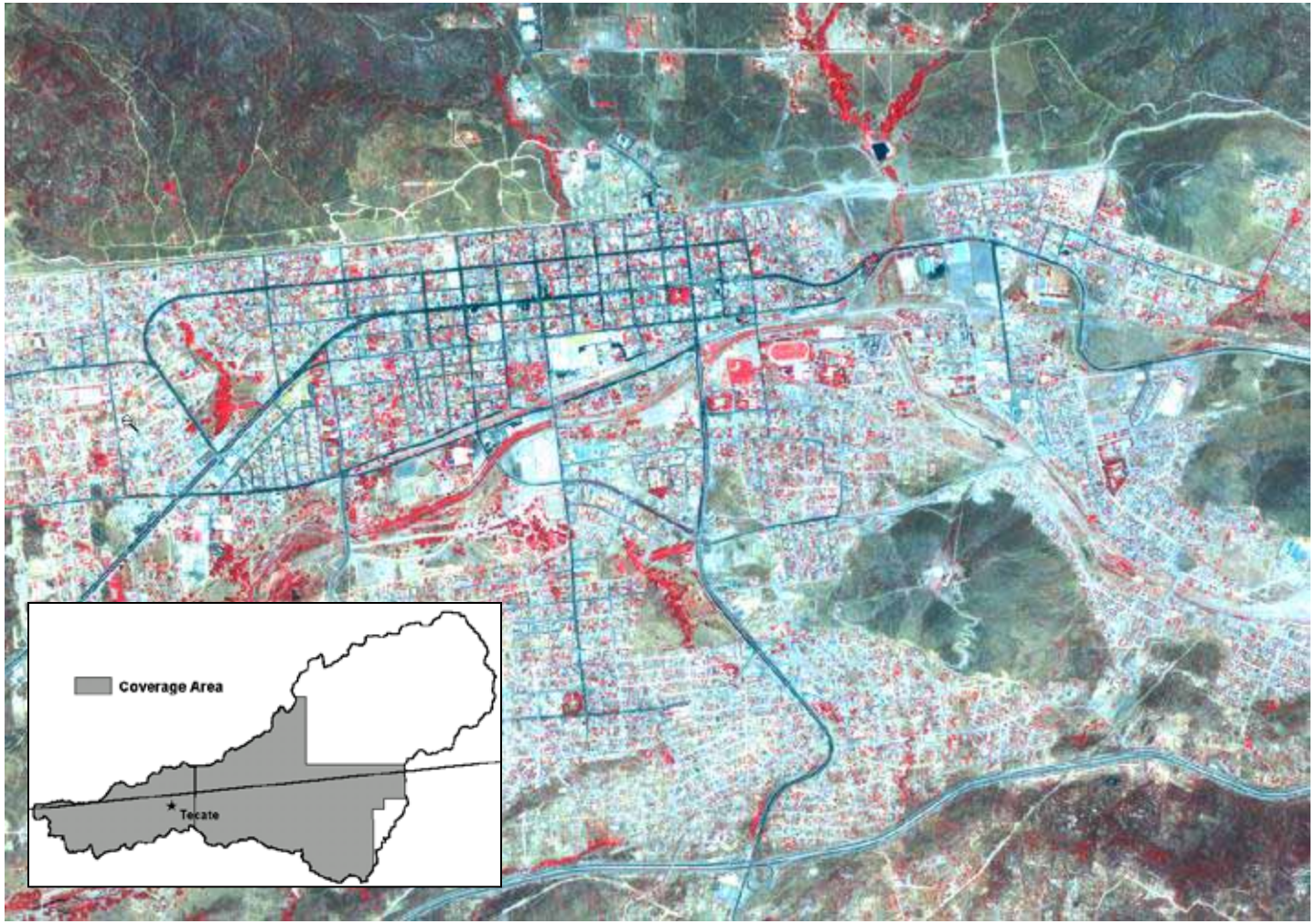


LU/LC Classification System

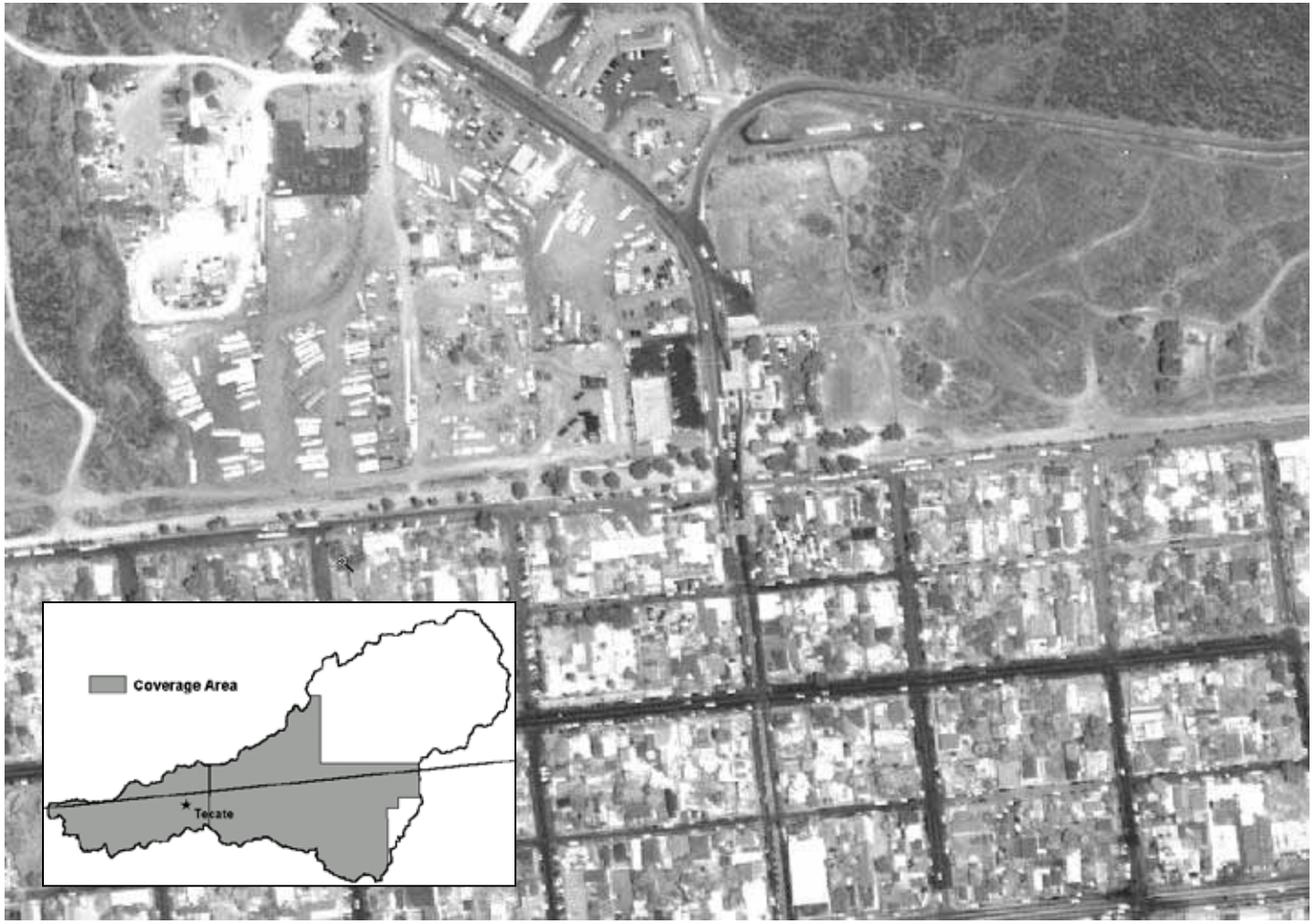
Commercial
Industrial
Agriculture
Rangeland
Domestic livestock
Barren land
Mixed urban or built up
High-density residential
Low-density residential



Landsat Thematic Mapper (TM) satellite imagery with 30 m spatial resolution

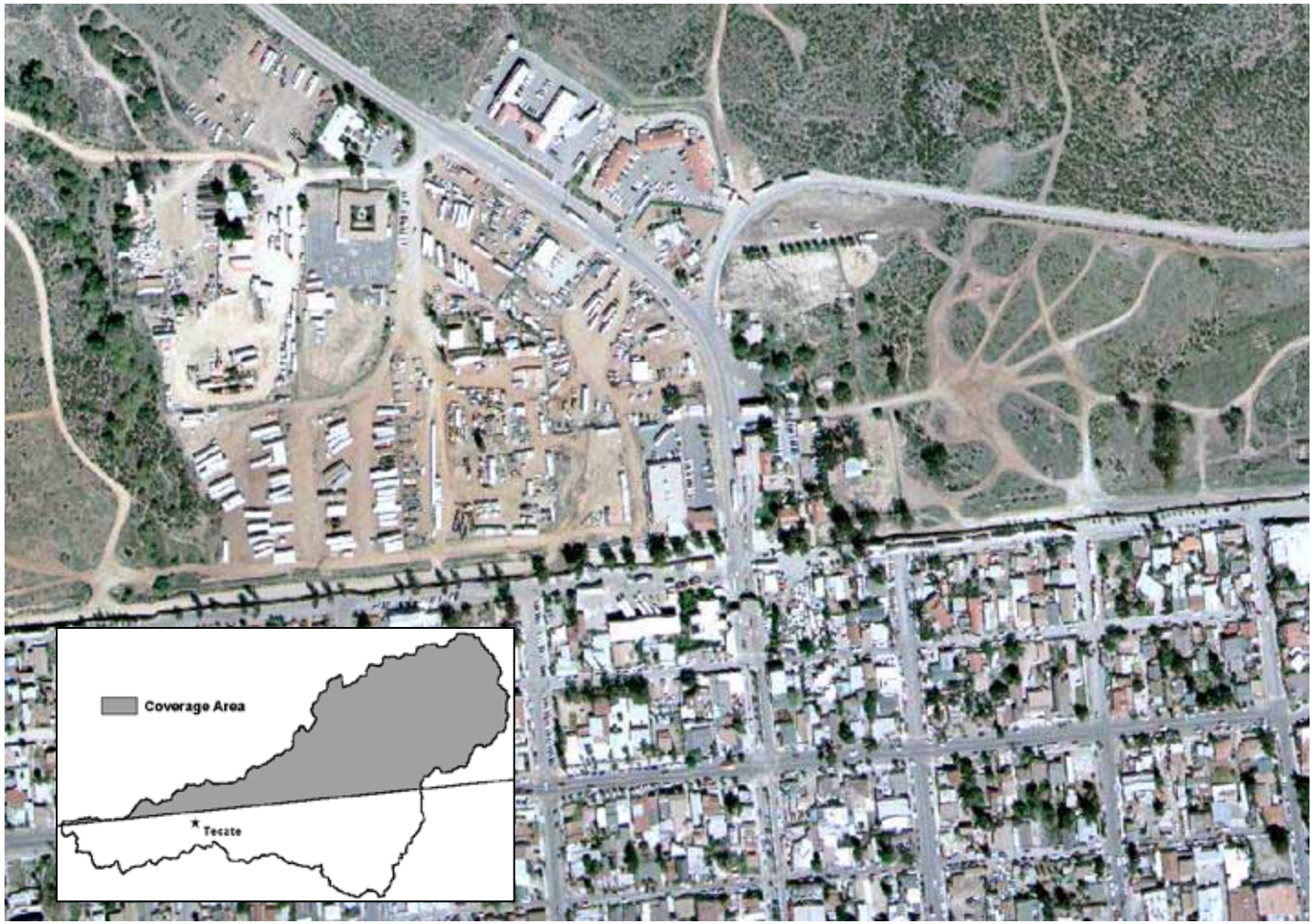


IKONOS multispectral with 4 m spatial resolution



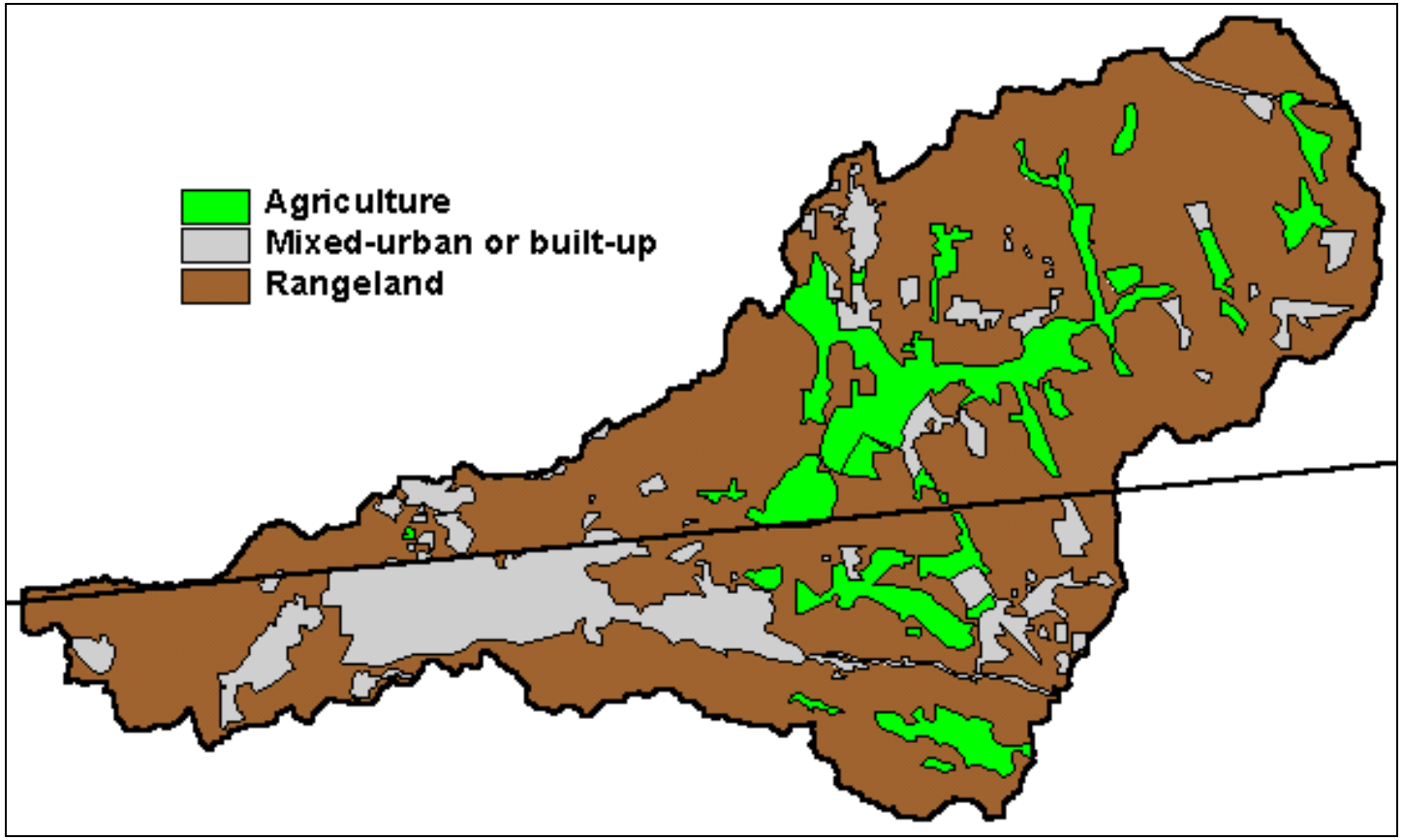
- IKONOS panchromatic with 1 m spatial resolution

Fusion of IKONOS multispectral 4 m spatial resolution and panchromatic 1 m spatial resolution images

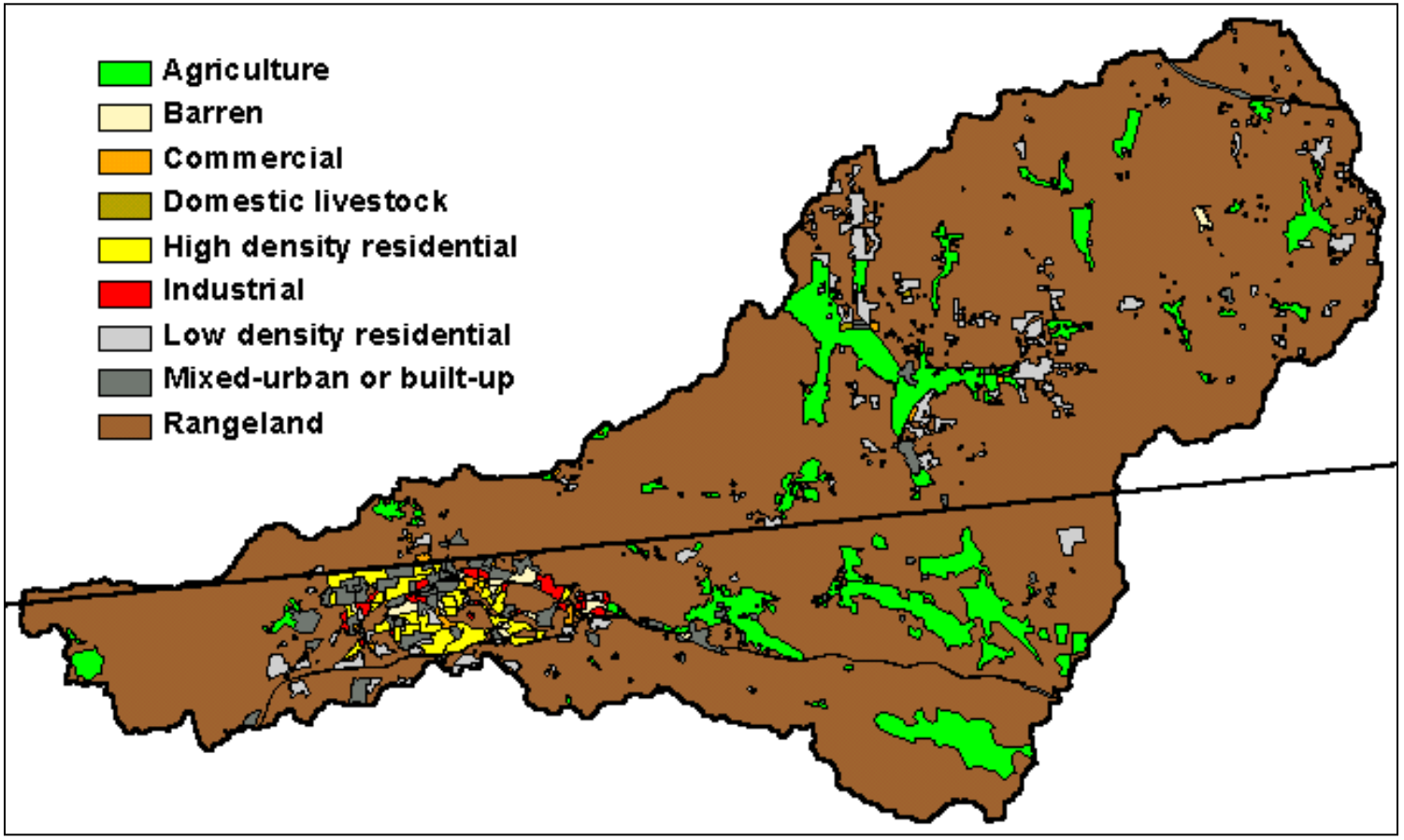


Color infrared digital orthophotography (DOQQ) image data with 2 ft. (0.6 m) resolution

LU/LC for Tecate Creek Watershed
Landsat TM (30 m)



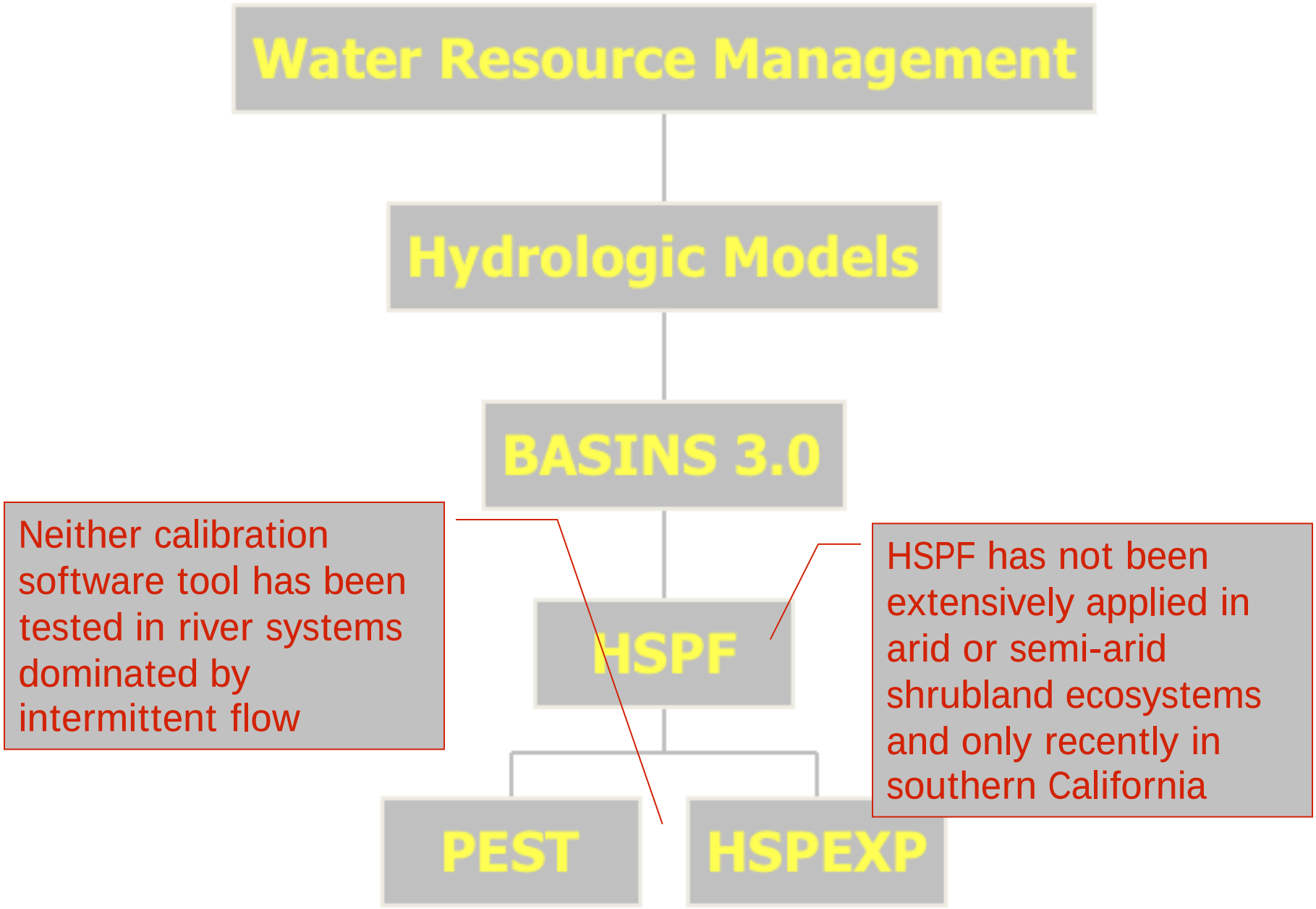
LU/LC for Tecate Creek Watershed- IKONOS



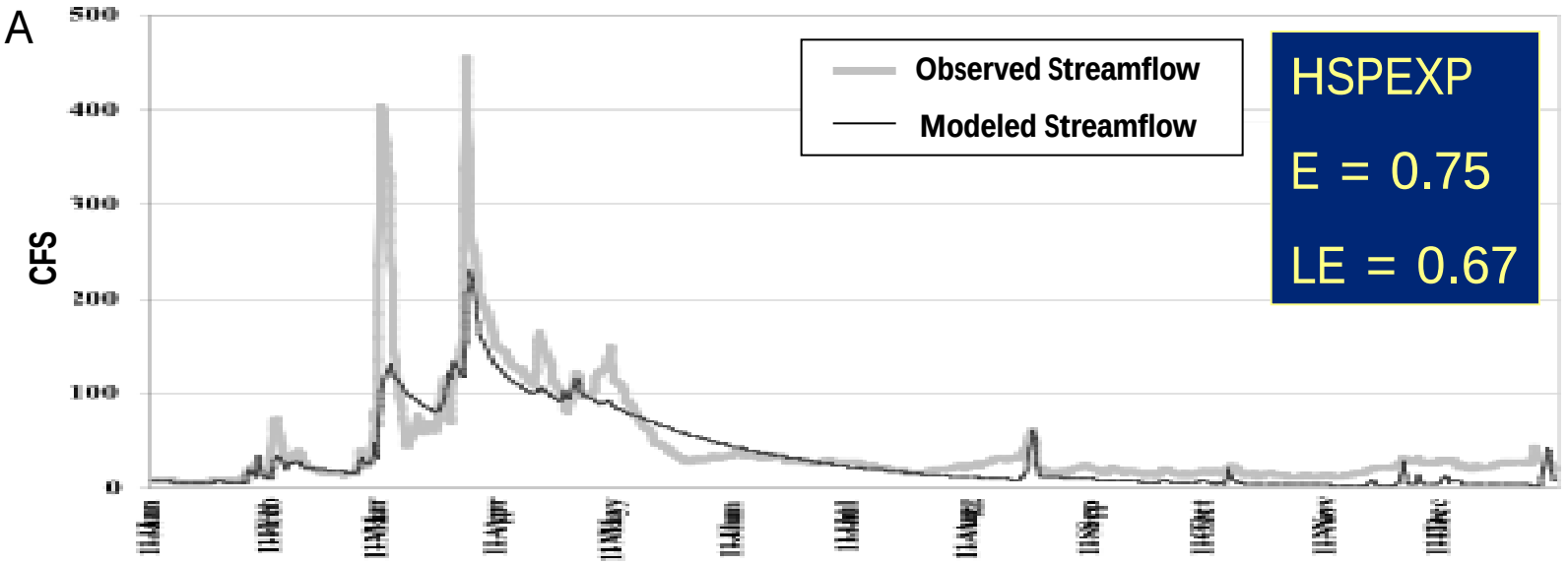
Accuracy Assessment Results

- Landsat TM (30 m) land cover/use classification product yielded an overall accuracy of 61%.

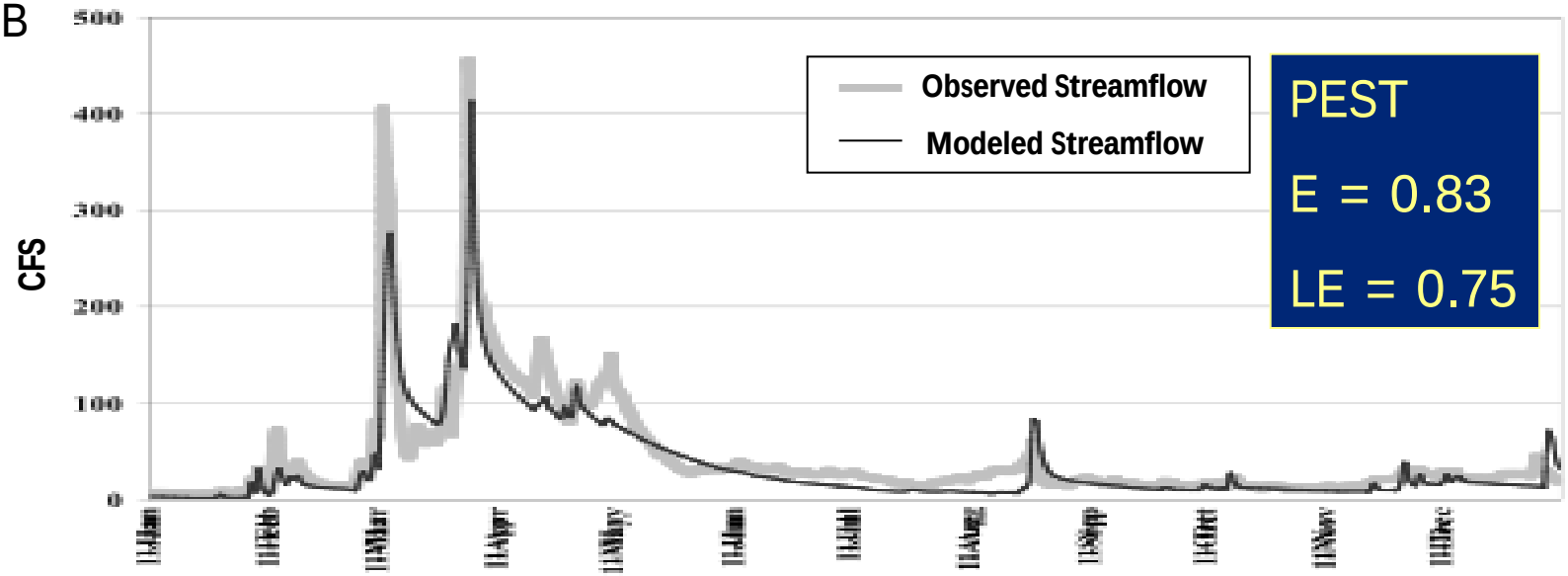
- IKONOS (4 m) product yielded an overall accuracy of 85%


Water Resource Management
Hydrologic Models
BASINS 3.0
HSPF
PEST
HSPEXP
Neither calibration software tool has been tested in river systems dominated by intermittent flow
HSPF has not been extensively applied in arid or semi-arid shrubland ecosystems and only recently in southern California

A


CFS
500
400
300
200
100
0
Observed Streamflow
Modeled Streamflow
HSPEXP
E = 0.75
LE = 0.67

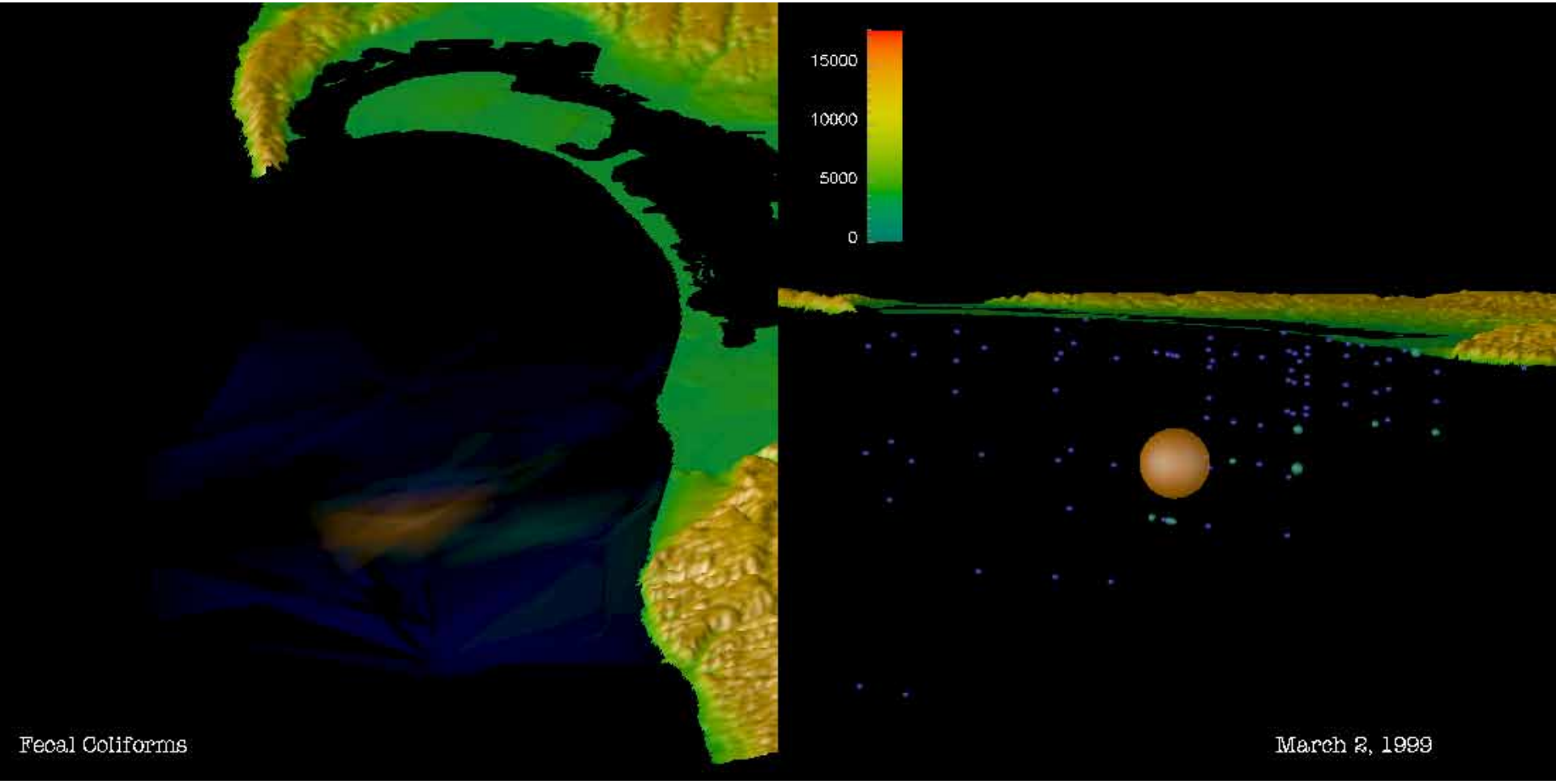
B


CFS
500
400
300
200
100
0
Observed Streamflow
Modeled Streamflow
PEST
E = 0.83
LE = 0.75

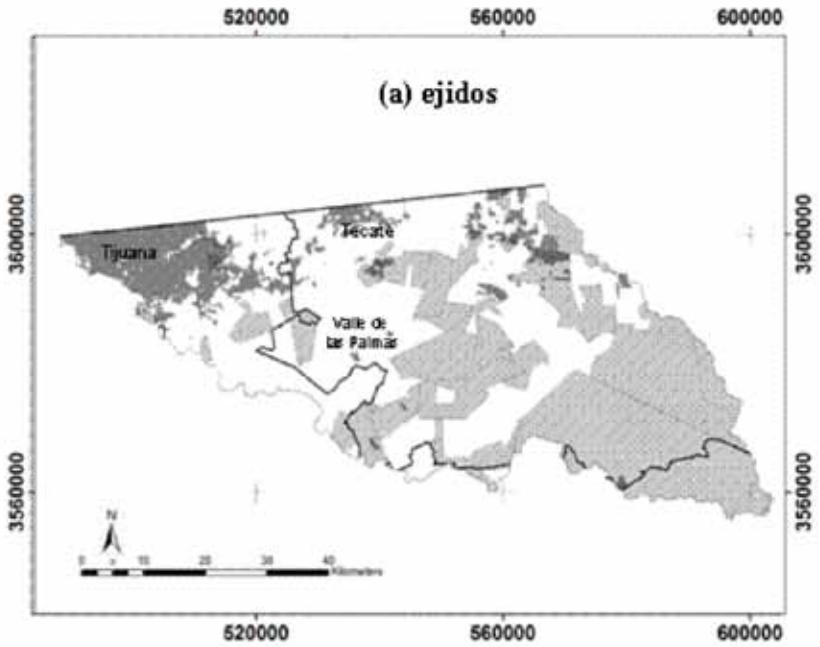
Three-Dimensional Visualization of Bacterial Indicators at Shore and Ocean Stations of the International Treatment Plant Monitoring Program

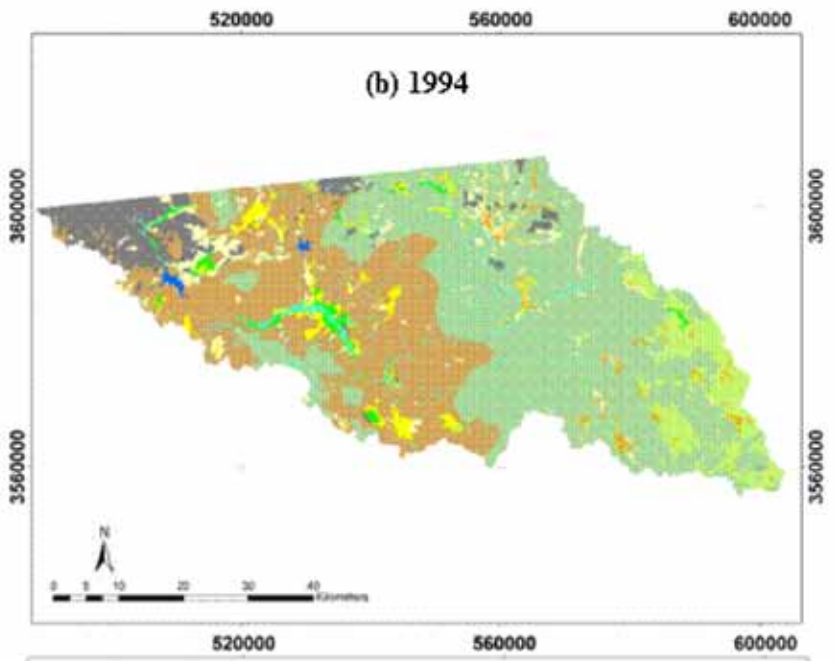
Rick Gersberg & H. Johnson

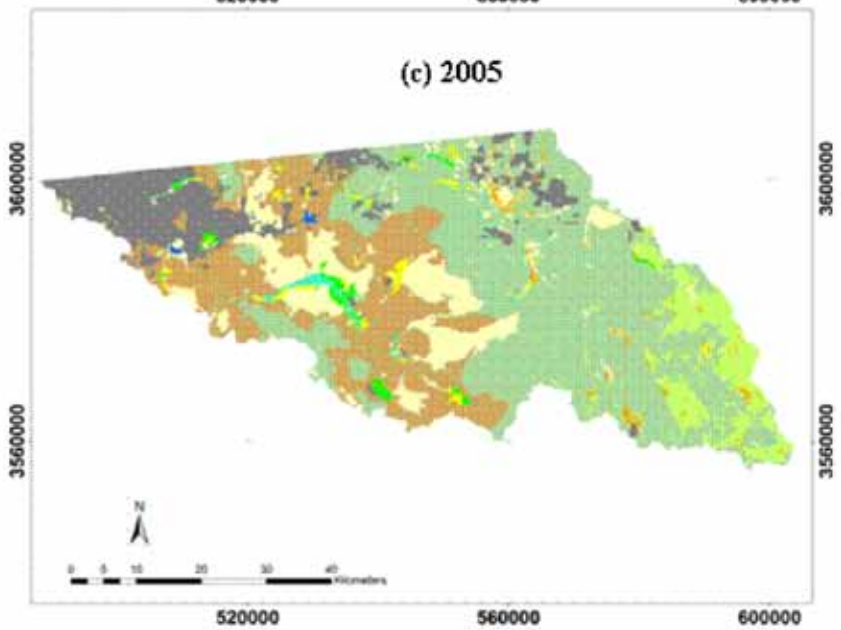
3-D Visualization of Bacterial Indicators at Shore and Ocean Stations of the International Treatment Plant Monitoring Program



Land Use/Cover Change Tijuana River Watershed: 1994 - 2005







(a) ejidos

- Ejidos
- Municipal limits
- Urban Areas

Land use/cover
(b) 1994 and (c) 2005

- Irrigation agriculture
- Rainfed agriculture
- Juniper scrub
- Chaparral
- Coastal sage scrub
- Mountain meadows
- Grassland
- Urban
- Riparian vegetation
- Dams

Lina Ojeda, COLEF
Kathleen Farley, SDSU

Land Use/Cover Transitions TJ River Watershed: 1994 - 2005

	2005									
Land cover/use	**Juniper Scrub**	**Chaparral**	**Coastal Sage Scrub**	**Riparian vegetation**	**Mountain Meadows**	**Grasslands**	**Irrigated Agriculture**	**Rain-fed Agriculture**	**Urban**	**Reservoirs**
Juniper Scrub	225.63	0.06	-	0.04	0.54	0.29	0.04	0.01	1.90	-
Chaparral	0.33	1,359.31	0.02	0.67	0.15	59.46	0.06	0.08	47.85	-
Coastal Sage Scrub	-	0.04	689.28	0.31	-	212.30	0.27	0.02	47.99	0.28
Riparian vegetation	0.00	0.20	0.13	73.75	0.00	0.51	0.75	0.18	4.34	-
Mountain Meadows	0.11	0.27	-	0.00	29.35	0.34	0.08	0.06	0.93	-
Grasslands	0.03	0.36	0.04	0.08	0.26	73.01	2.33	0.05	56.21	-
Irrigated Agriculture	0.00	0.06	0.07	0.26	0.04	4.69	22.25	2.79	4.05	-
Rain-fed Agriculture	0.00	0.23	0.04	1.07	0.00	47.15	7.26	27.94	3.57	-
Urban	-	0.02	0.46	0.02	0.01	0.18	0.05	0.00	220.28	0.05
Reservoirs	-	-	0.08	0.02	-	3.38	-	-	0.16	3.76

Lina Ojeda, COLEF and Kathleen Farley SDSU

Irrigated Vegetation Assessment in Urban Environments

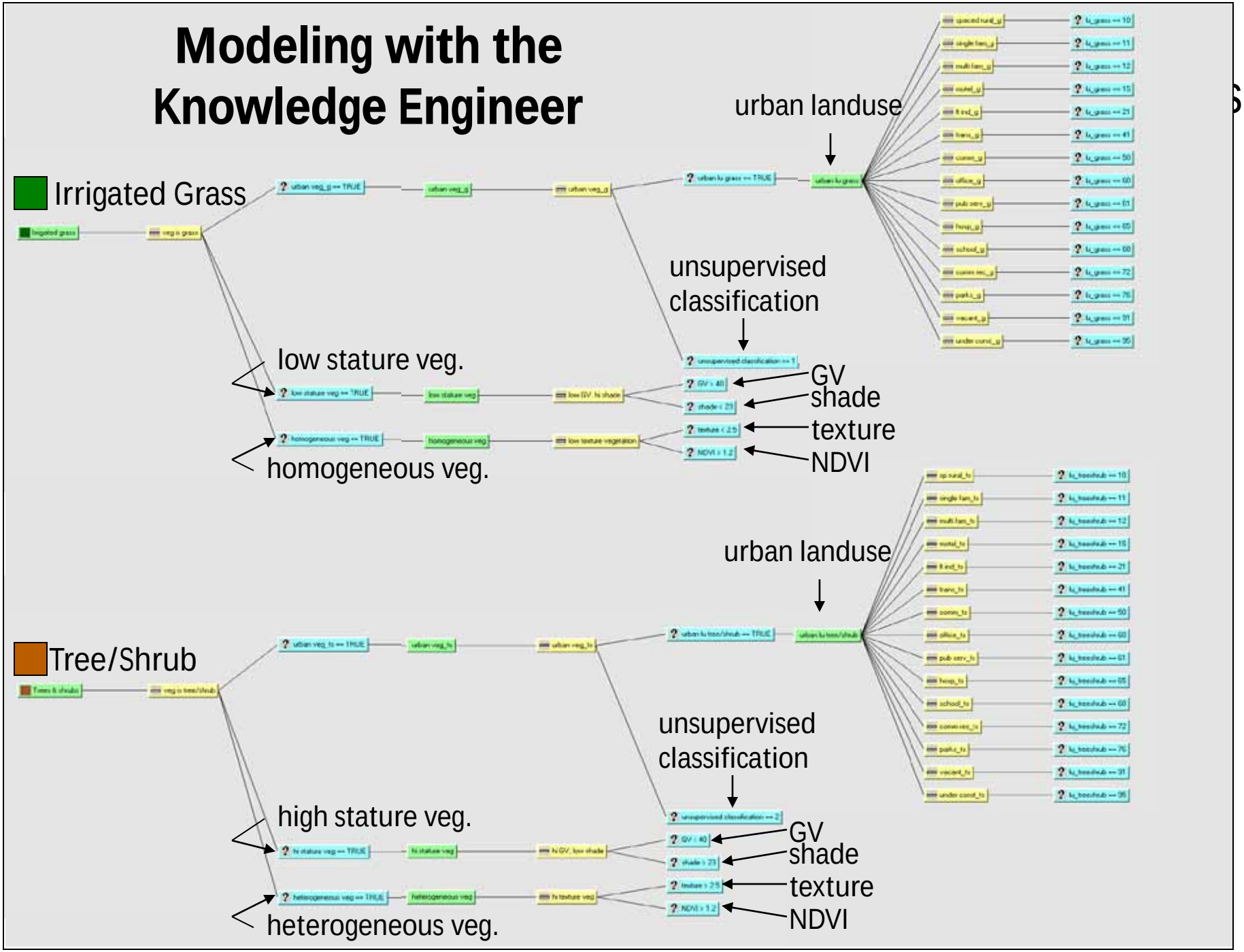
Ikonos

ADAR 5500

AgriCast

SDSU

Modeling with the Knowledge Engineer



Irrigated Vegetation Cover from Ground Observations and 1 m NDVI Threshold Image

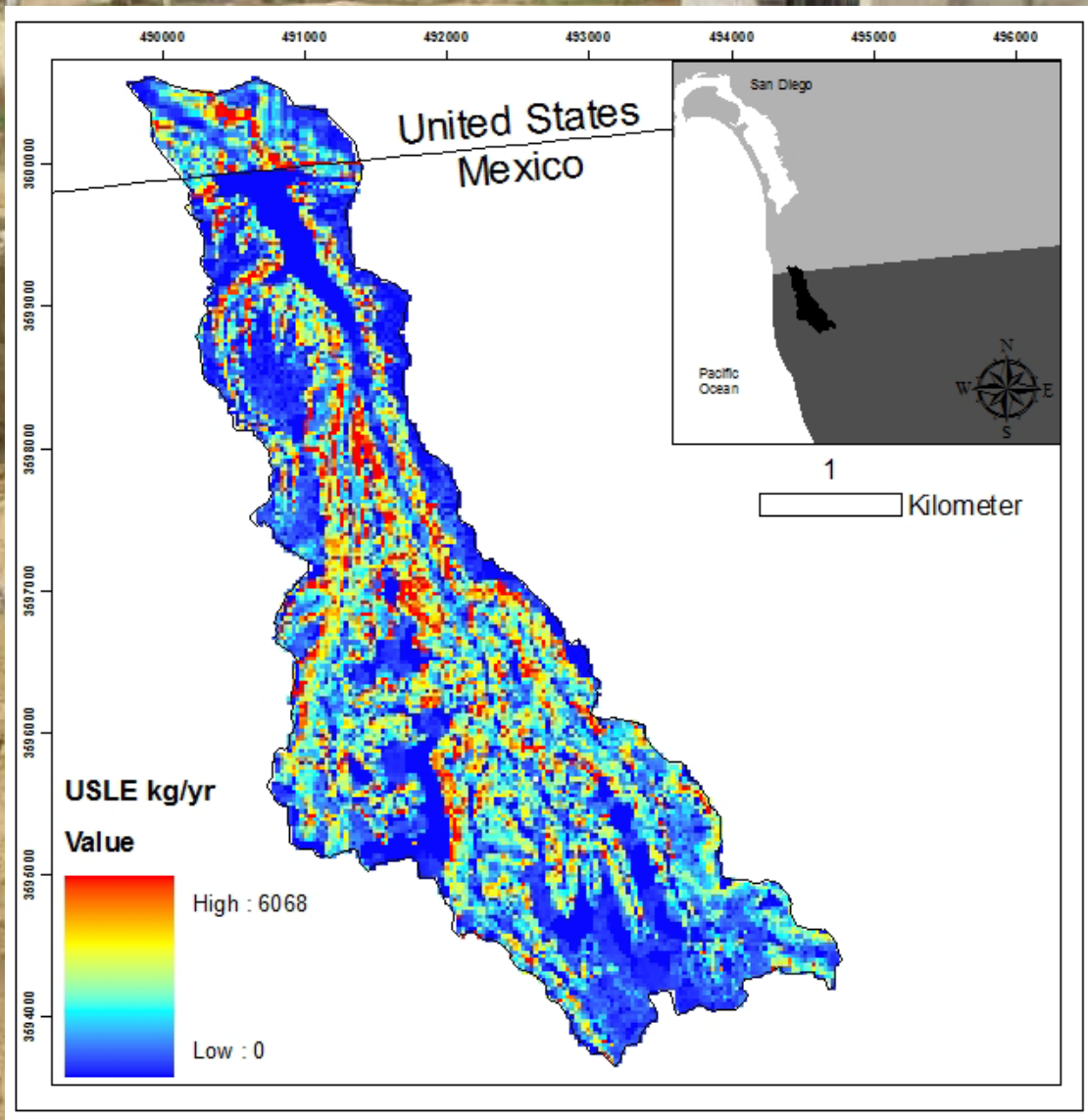
Sample Unit	Ground Reference	1 m NDVI Threshold	Error
S 1	33%	42%	8%
S 2	12%	31%	19%
S 3	36%	30%	6%
S 4	33%	34%	1%
S 5	21%	25%	5%
S 6	39%	31%	8%
S 7	48%	44%	3%
S 8	33%	28%	5%
V 1	56%	50%	6%
V 2	40%	32%	8%
V 3	36%	36%	0%
V 4	42%	37%	5%
V 5	36%	50%	14%
V 6	56%	55%	1%
V 7	40%	24%	16%
V 8	20%	28%	8%
S Aggregated	32%	33%	1%
M Aggregated	41%	39%	2%

AgriCast

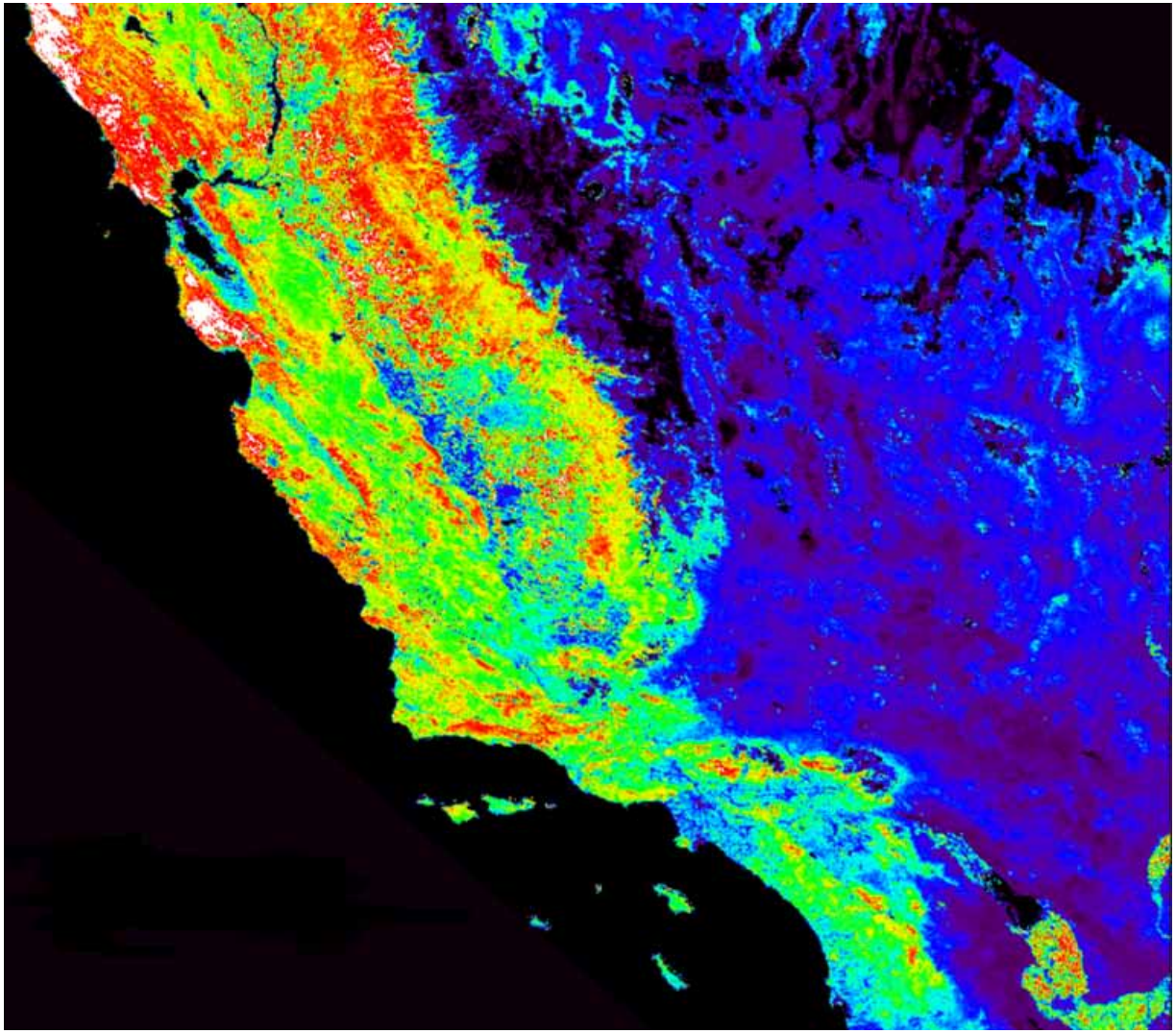
SDSU

Integration of Fieldwork, Remote Sensing and Modeling for Sediment Studies

PI: Trent Biggs



Hydrological Similarity of California Watersheds Based on MODIS Imagery

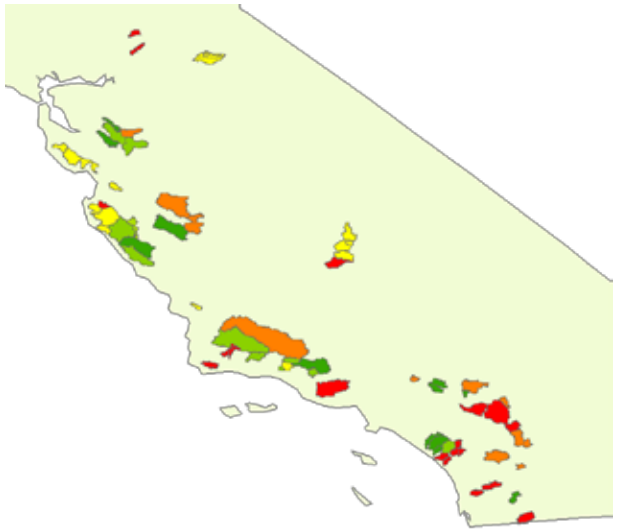


Regional Hydrological Response of Semi-Arid Mediterranean Climate Watersheds to Land-Cover/Land-Use Variability

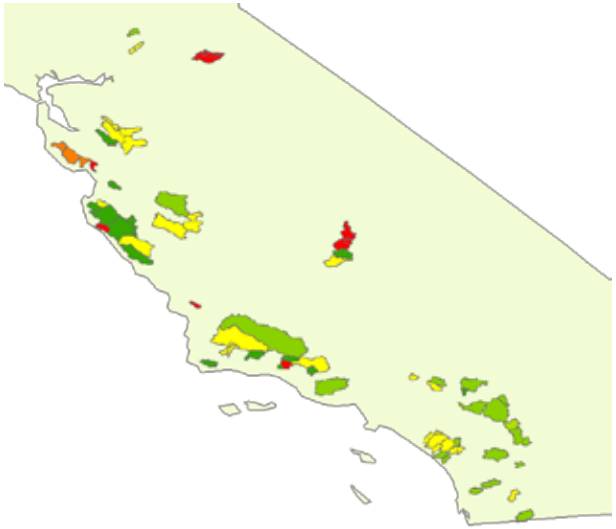
Funding Agency: NASA LCLUC, PI: Allen Hope, Co-Is: Doug Stow

Watershed Similarity Based on NASA MODIS Products

SOM

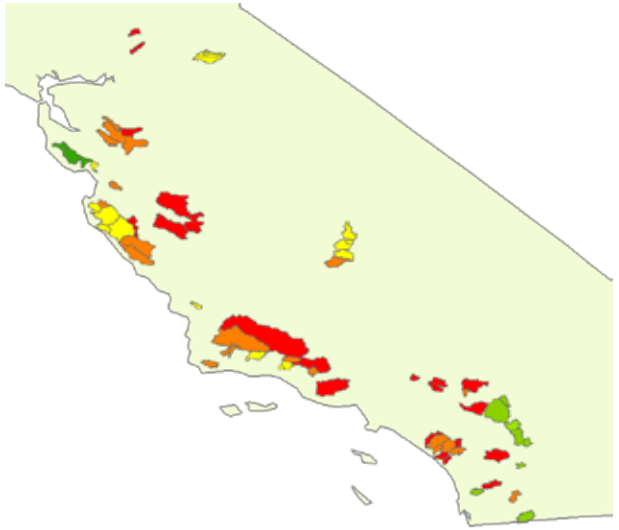


All Products

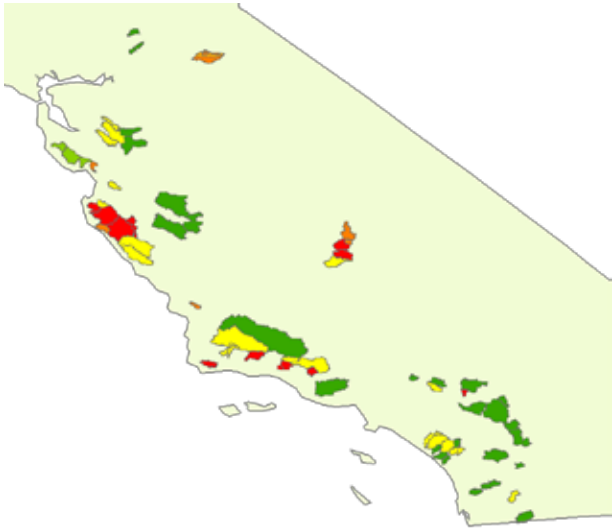


EVI

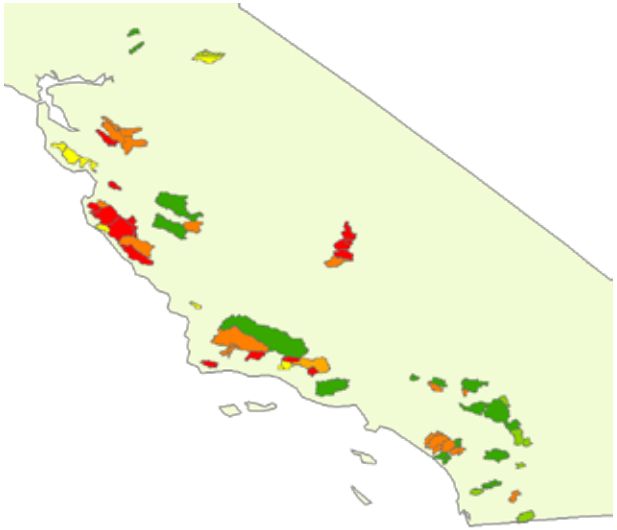
NDVI



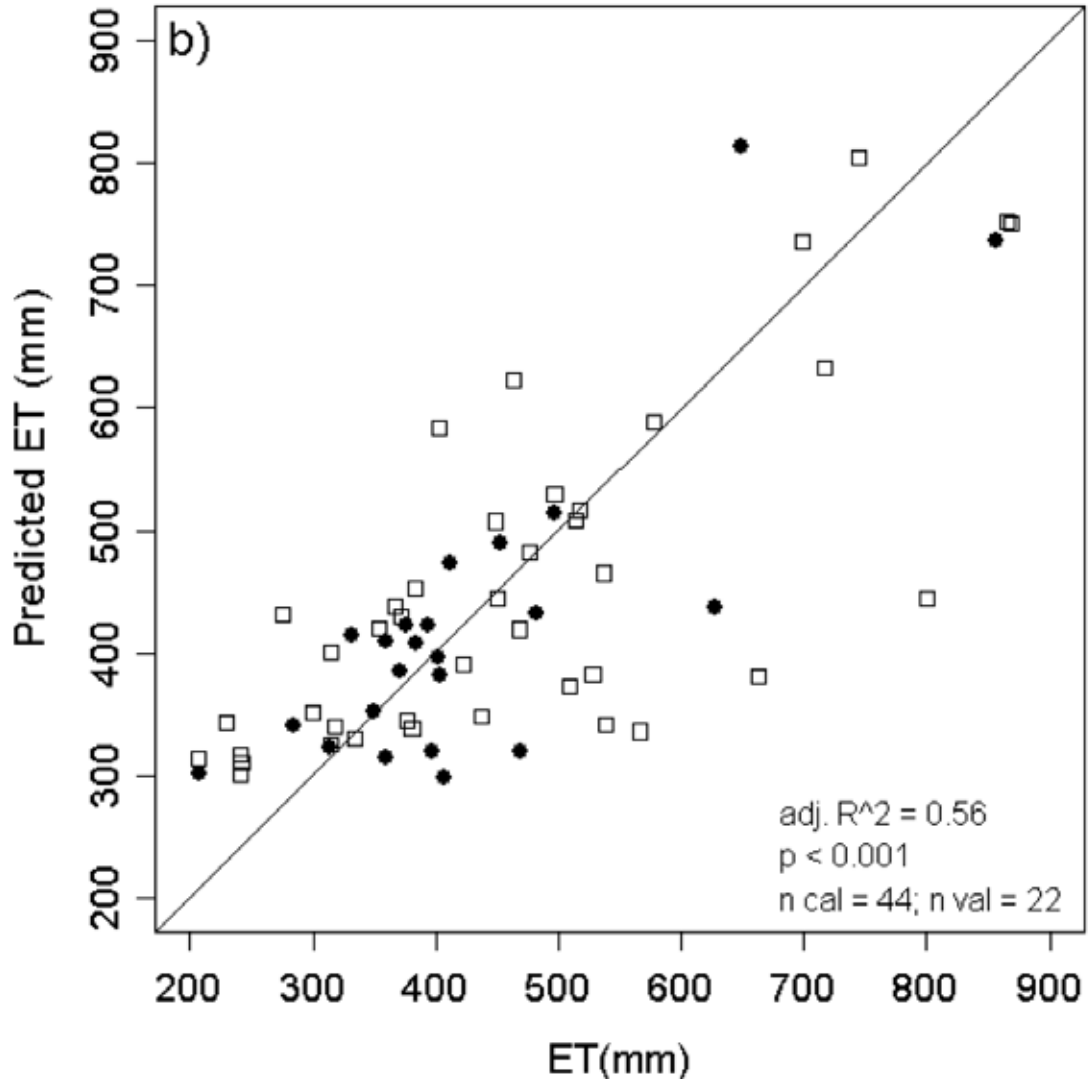
LAI



fPAR

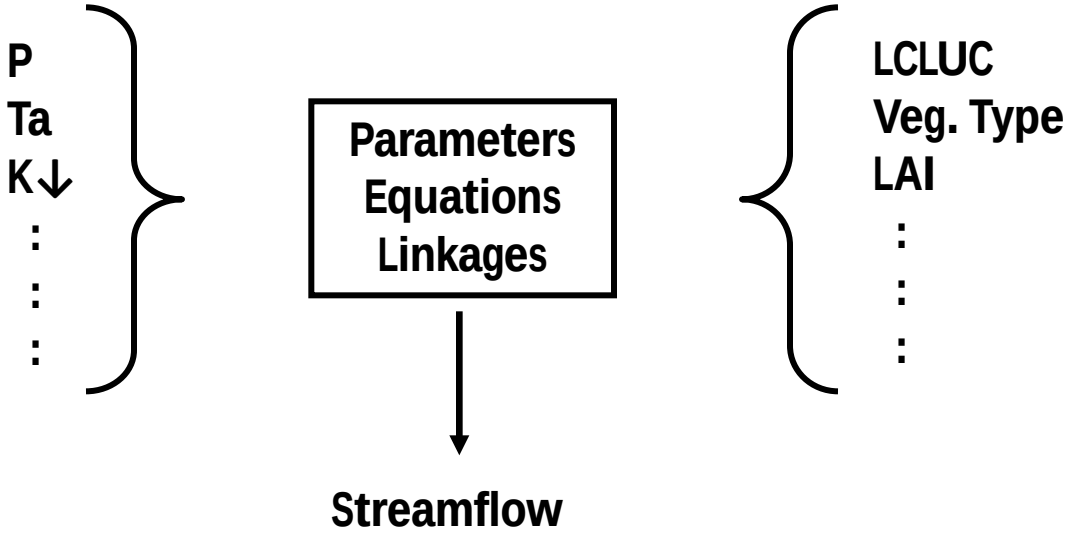


MODIS LAI Predicted ET vs. Watershed ET = P-Q for 66 Gauged Watersheds in Southern/Central California



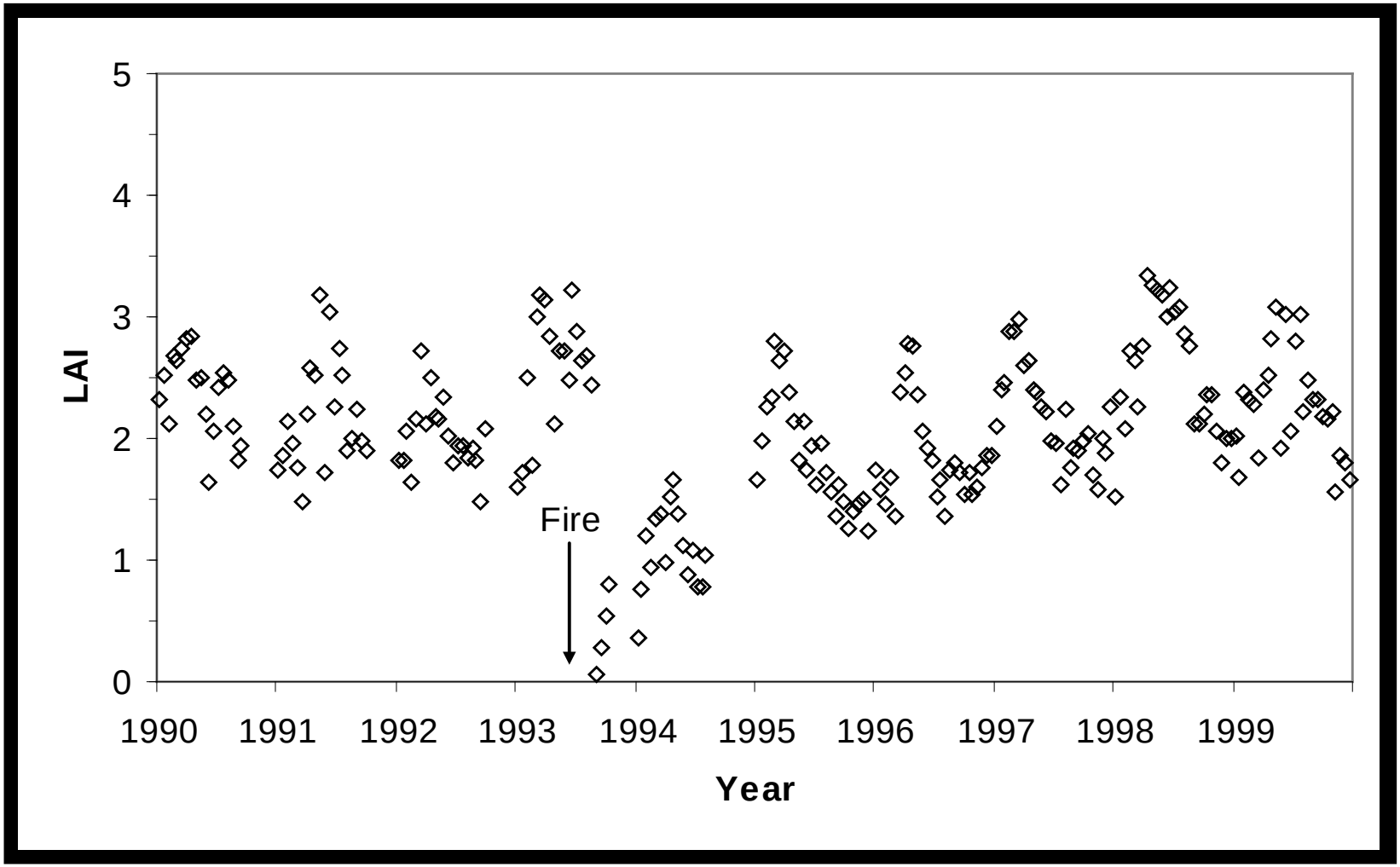

Hydrologic Process Modeling

Spatially Explicit Process Modelling Experiments

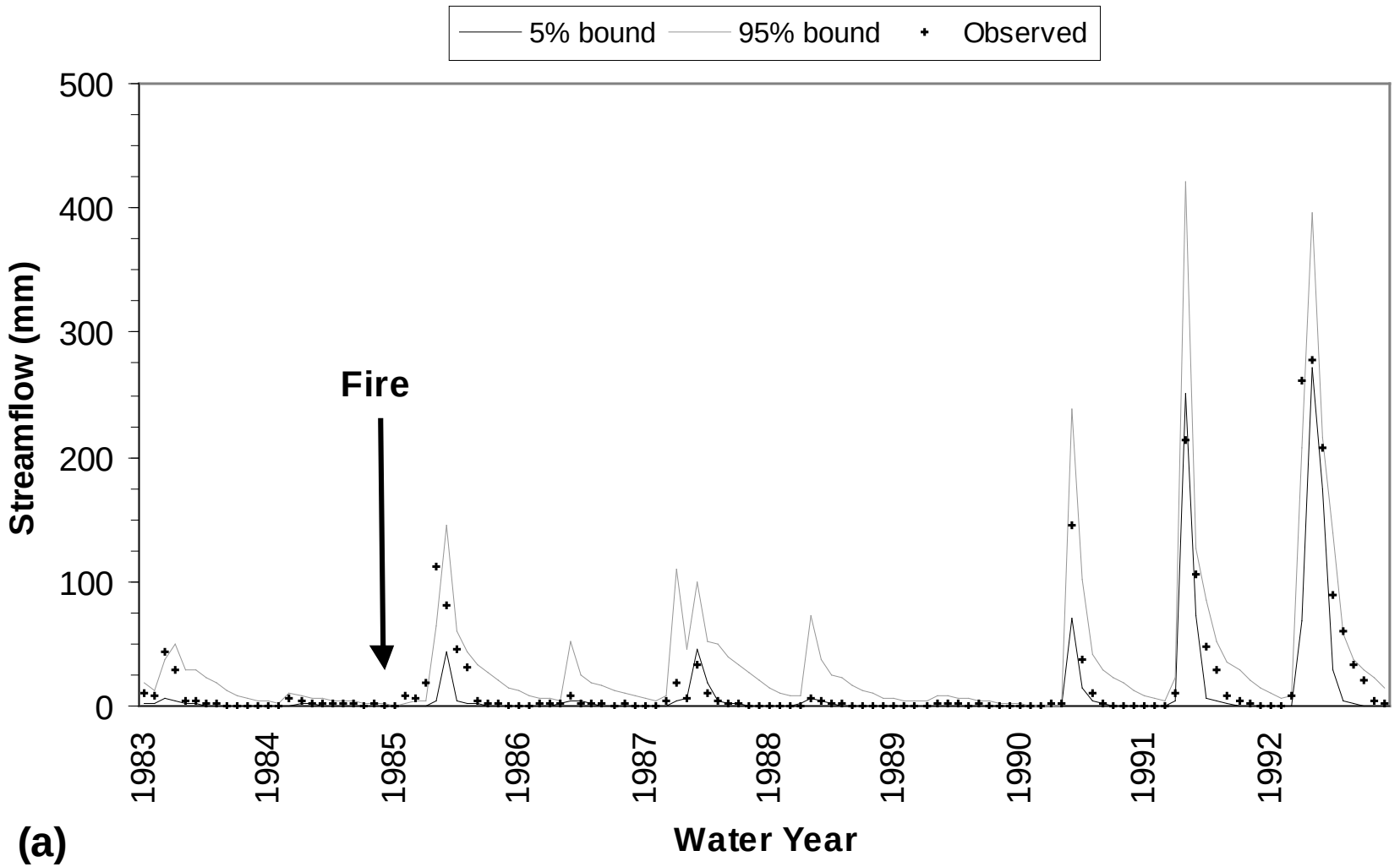


Examples: MIKE-SHE Pitman
RHESSys ACRU IHACRES

Chaparral Recovery Curve



Uncertainty Bounds



Border Security: Decision Support System

MODELS

Terrain
Visibility
Vehicle/Foot Trafficability
Origination/Destination
Vegetation Structure/Condition
Wildfire Risk
Weather Severity
Tunnelability

Data

MEASUREMENTS

Terra (ASTER/MODIS)
AQUA (MODIS)
Landsat-7(ETM+)
LIDAR / SRTM
Aircraft multispectral
Aircraft hyperspectral

Information Products, Predictions, and Data from NASA ESE Missions and Models:

- Trails and illegal crossings
- Transborder trafficability
- Weather/humanitarian Safety (freeze/dehydration)
- Land cover change
- Wildfire risk
- Transborder hideouts
- Clandestine runway locations
- Potential tunnel locations
- Border susceptibility
- Critical habitat impacts
- Hazard/bio-terrorism risks

DECISION SUPPORT

Border Security

***Analysis*:**
- Monitor route changes
- Track smuggler speed and direction,
- Immigrant origination and destination maps
- Resource assessment
- Predict weather related risk
- Forecast wildfire risk
- Map apprehension locations
- Map illicit crops and drug laboratories

***Management Decisions*:**
- Rescue/recovery plans
- Tactical/strategic plans
- Resource allocation
- Counter-drug intelligence
- Plan sensor locations
- Multi-agency cooperation
- Habitat mitigation response

***Additional factors*:**
- Improves border agencies relations/cooperation
- Link SDSS to field via real-time communications

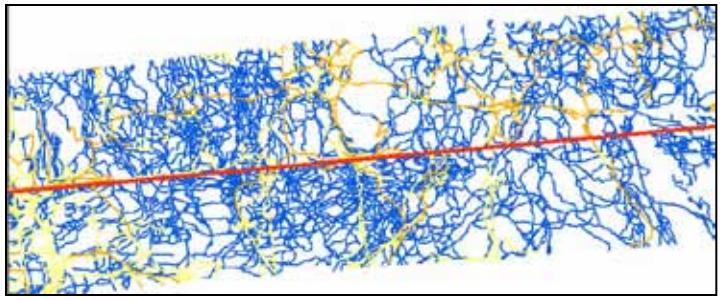
VALUE & BENEFITS

- Improve border security
- Reduce loss of life
- Reduce drug traffic
- Improve siting of border personnel/sensors/assets
- Reduce threats to US agents/citizens near border
- Increase confidence in border security agencies and policies
- Minimize impacts to endangered habitat and wildlife
- Reduce negative economic impacts upon local law enforcement agencies, judicial systems, and local economies
- Improve trans-border relations/cooperation
- Expand technologies to other border locations

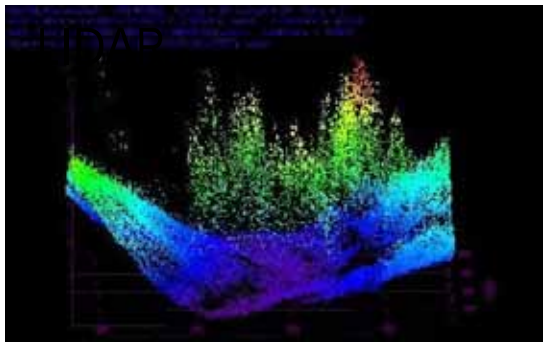
Adapted from NASA's Earth Science Applications Network: http://www.esnetwork.org

High Resolution Image-based Monitoring

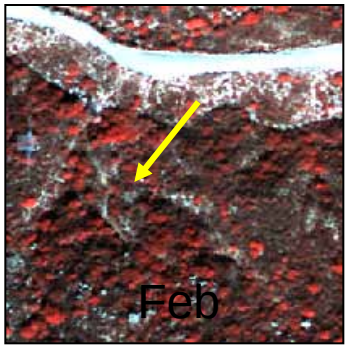
Imagery Specifications

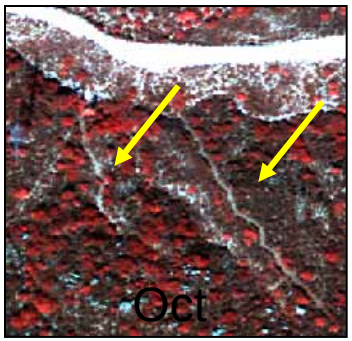


Trail Mapping

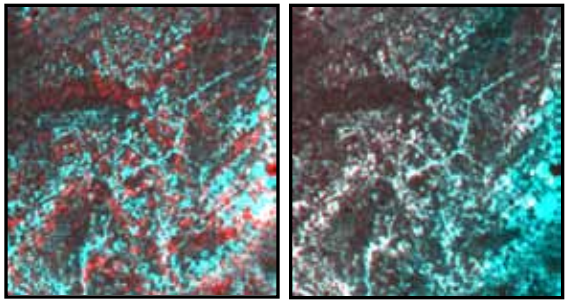


Advanced Imagery Methods

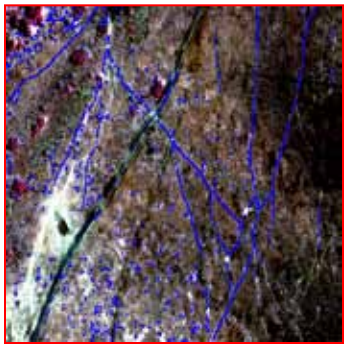




Change Detection



Registration



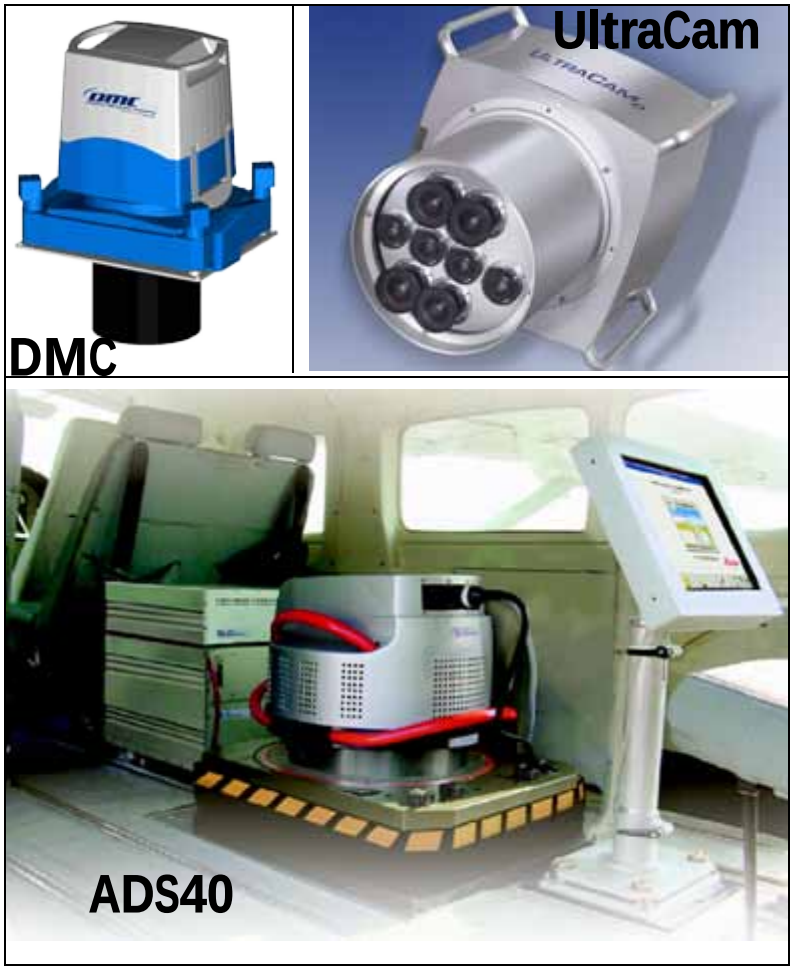
Automated Feature Extraction

REASoN Project

San Diego State University

COMMAND & CONTROL INTELLIGENCE COORDINATION CENTER

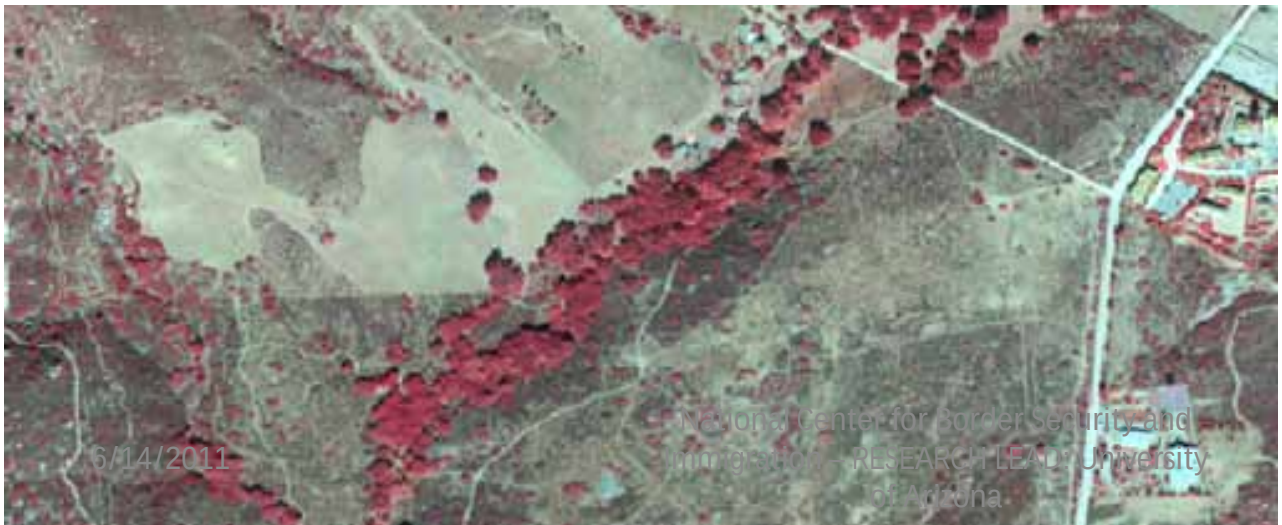
Large Format Digital Imaging Systems & U.S. Land Border Imagery Collection



NGA, USGS, USBP 2008/2009 Imagery

- Nationwide land borders
  - 30 miles into US
  - 10 miles into Mexico/Canada
- 1 ft spatial resolution
  - 6” for ports of entry
- 3-band true color (RGB)
- Separate near-infrared (NIR) band
- Currently collecting/processing
- 3001, Inc. leading effort, many subs
  - DMC and ADS40 systems

NGA - U.S. Land Border Imagery Collection



Large Format Imagery
- large area coverage
- high resolution
  (10-100 cm)

Spatial Coverage
100 - 10000 km^2

ADS40 DMC

U.S. Border Imagery Collection – ADS40 Imagery

1 Ft Resolution

Low-cost, flexible and mobile aerial platforms

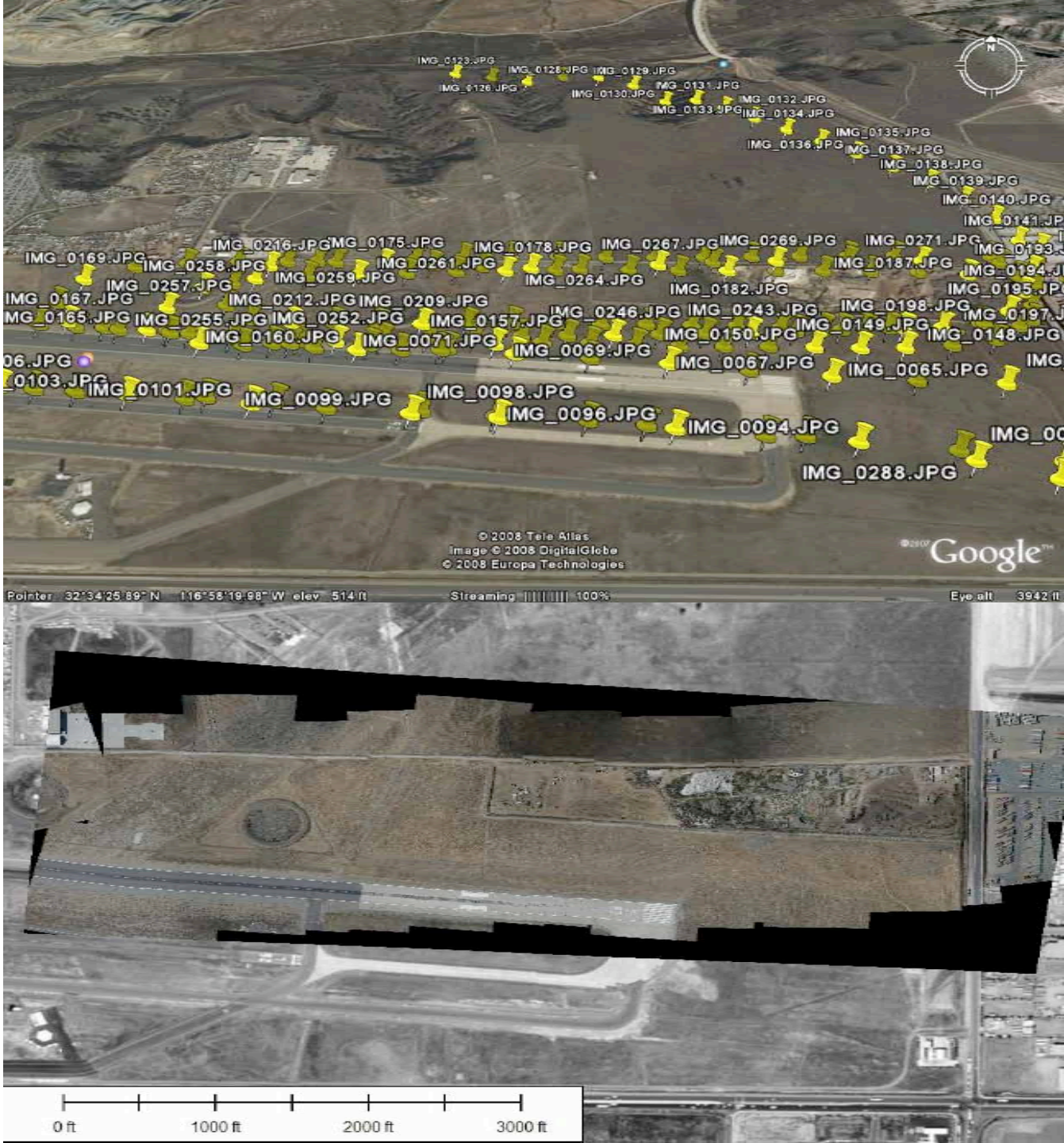
Micro-UAS

Light sport aircraft (LSA)

LOUIS

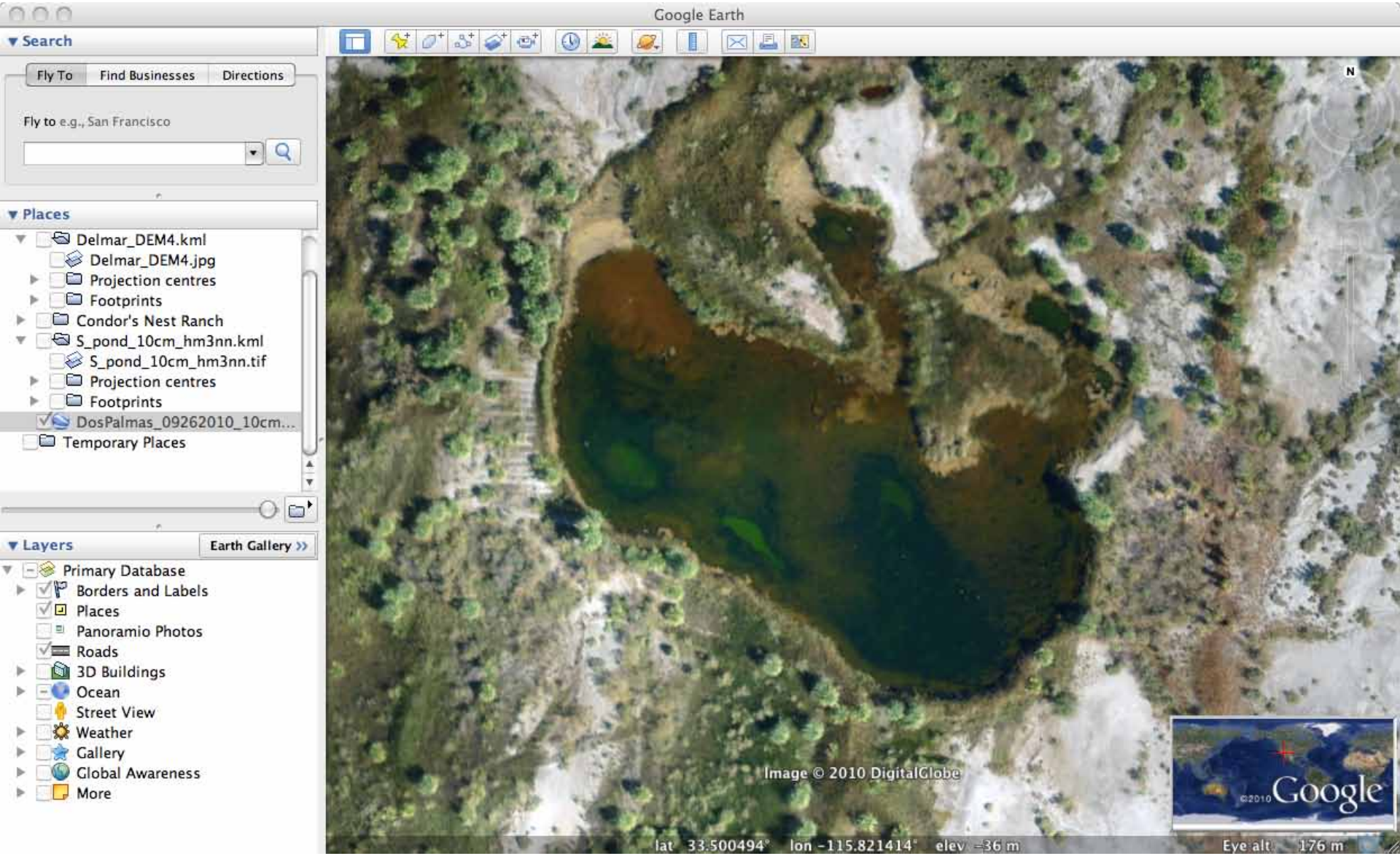
The Low Cost Unmanned Imaging System

Minimize and Automate Pre-processing of LOUIS UAS imagery

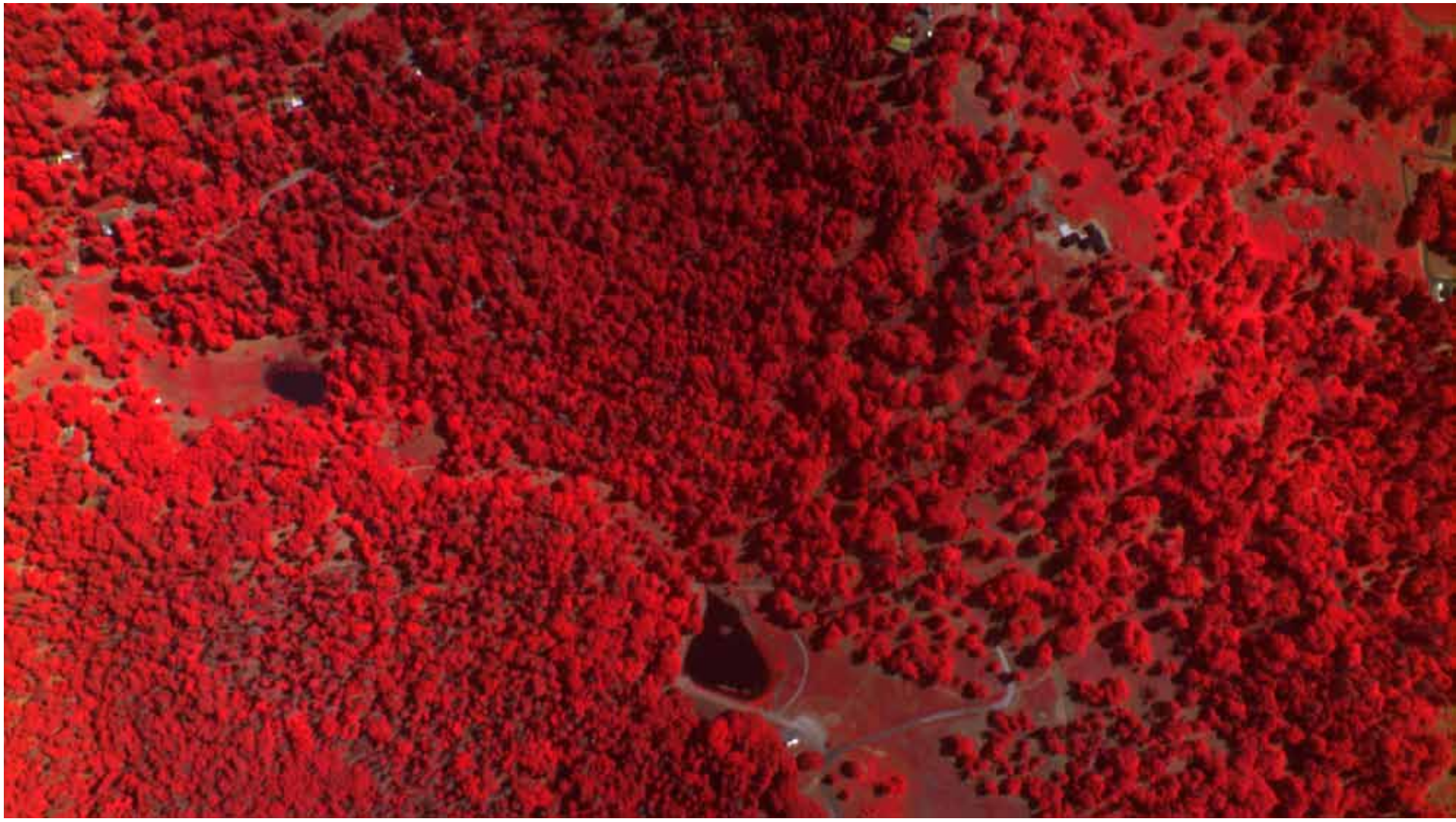


Low-cost autonomous imaging systems for resource reconnaissance and calibration/validation of satellite RS data

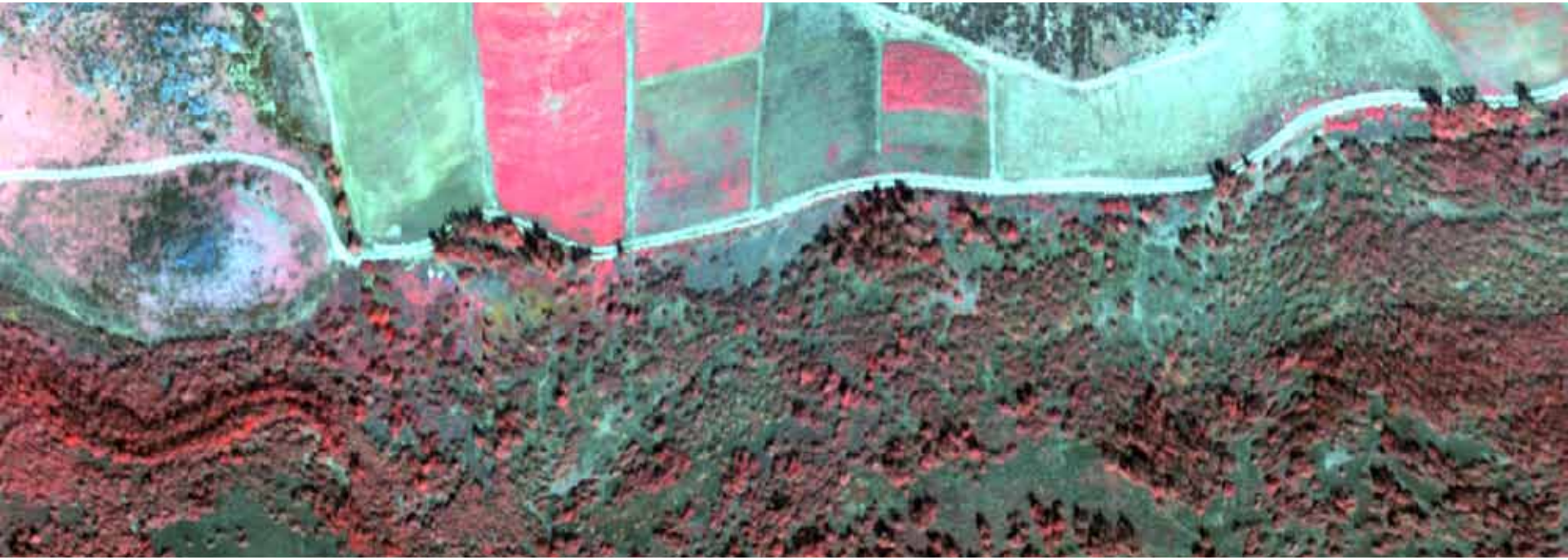
LOUIS UAV Color Imagery – Dos Palmas Preserve, Salton Sea Recreation Area



NEOS Mosquito – MS/4100 CIR Digital Camera



SOC-700 Hyperspectral Imagery
Invasive Plant Mapping -- Lake Hodges Site



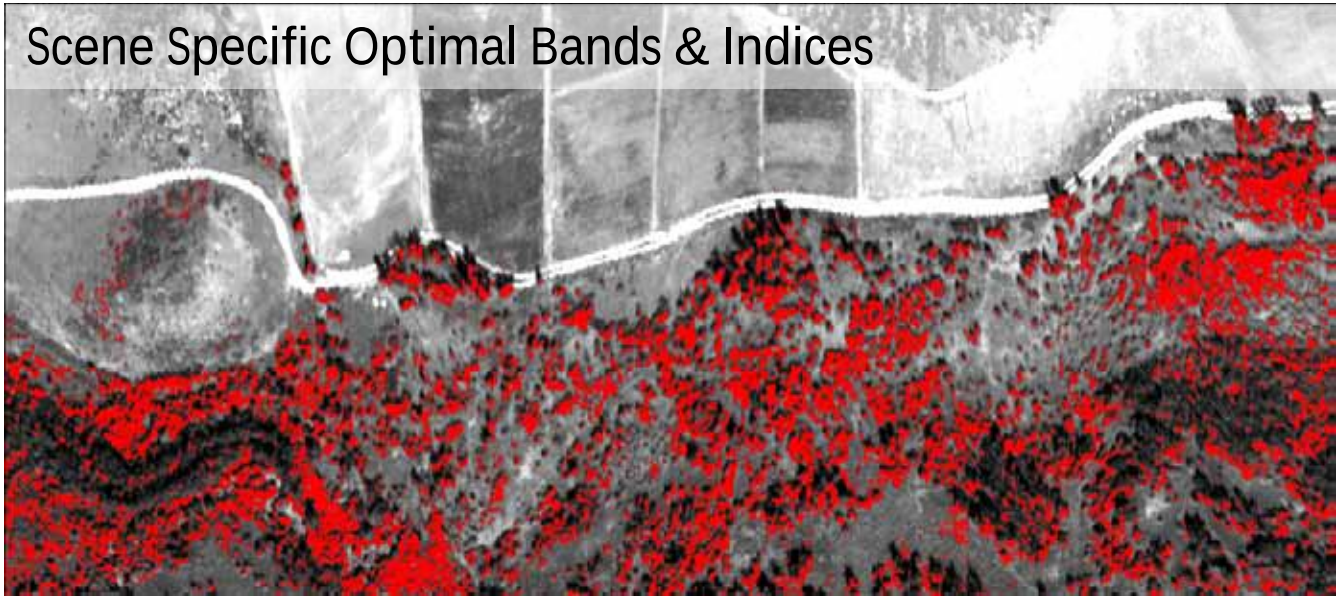
#80 (779 nm), #60 (694 nm), #25 (548 nm)

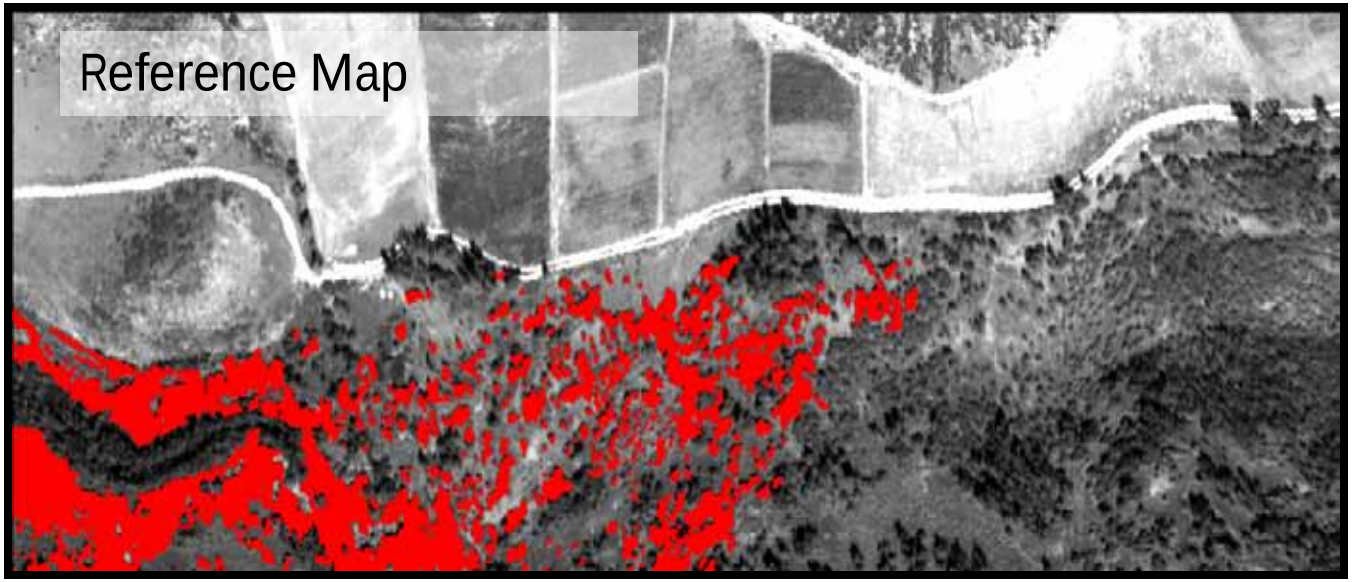
NASA

Surface Optics

San Diego State University

Classification Products (*Tamarix spp.*)





How can we help water managers/agencies?

Research/development and technology transfer pertaining to:

- Optical remote sensing/image processing
- GIS data base development (web and mobile GIS)
- Sensor networks
- Spatial decision support systems
- Land use/land cover mapping and change analysis
- Watershed modeling
- Sedimentation studies
- Water resources policy

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