Geospatial Technology for Disaster Response: Mapping, Assessment, Service

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Acknowledgement and Outline

- **Purdue: Ejaz Hussain, Jae Sung Kim; KyoHyouk Kim, Larry Biehl**
- **Wuhan University: Deren Li, Zuxun Zhang, Jianya Gong**
- **Data used: National Agricultural Statistics Service; IDHS, USGS, FEMA, NWS, IN.Gov**

- **Our work**
  - **Flood mapping**
  - **Damage assessment**
  - **Web service**
- **Wenchuan eqrthquake**
- **Experience**

Katrina flood mapping

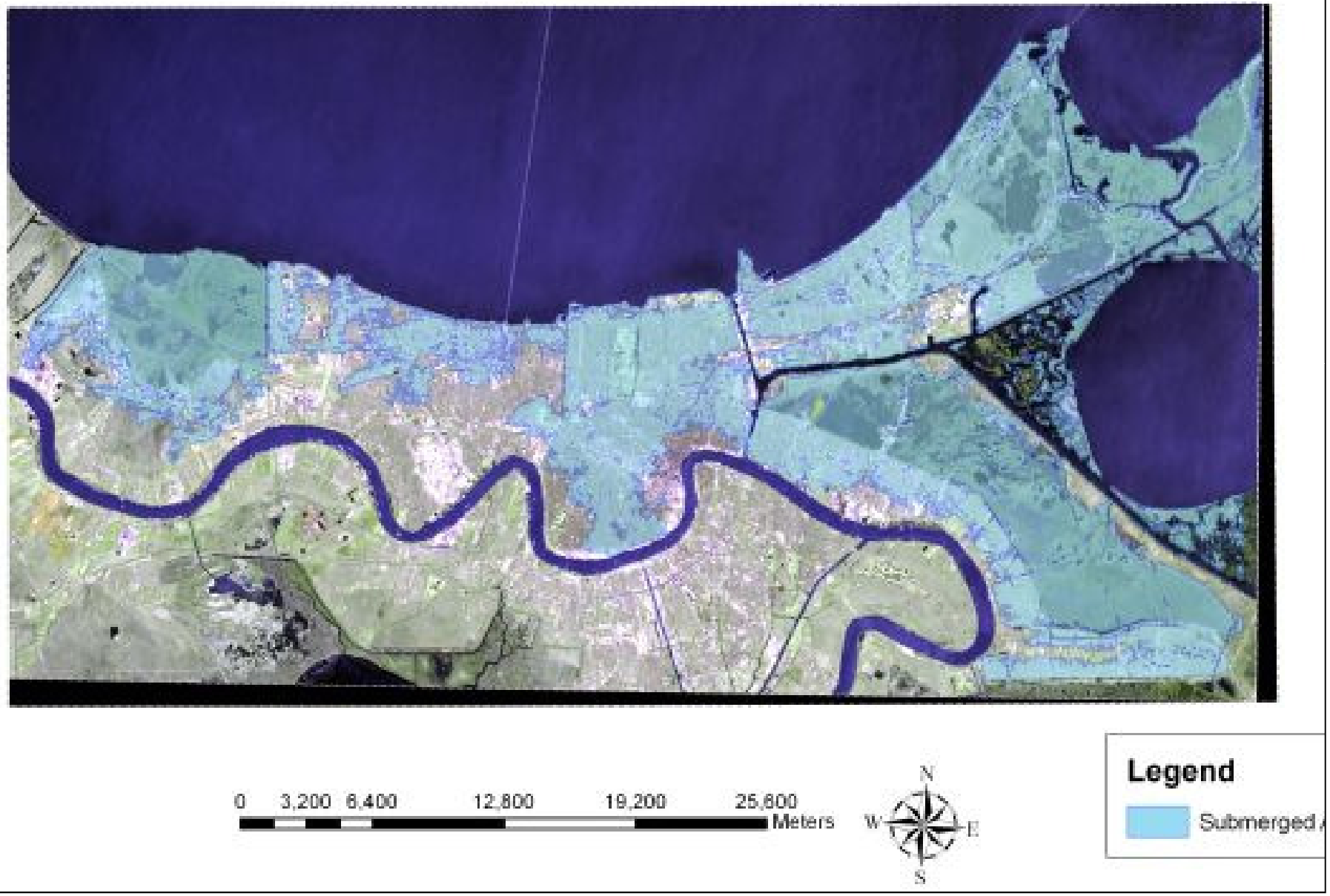
August 29, 2005

New Orleans, Louisiana

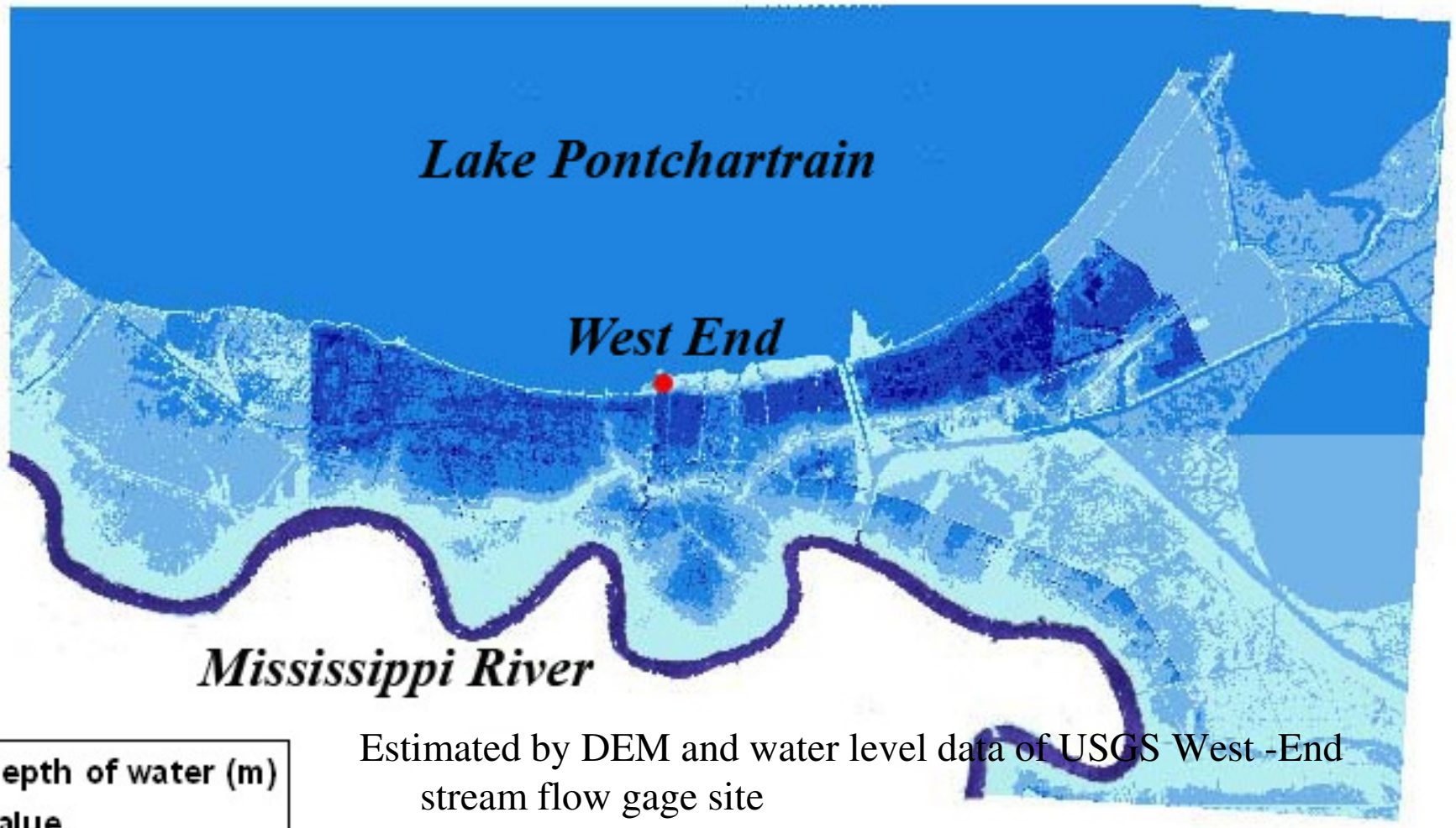
Submergence estimation

- Water distribution
  - Input images of pre & post Katrina were clustered by gray levels (Landsat band 5)
  - Water class of pre- Katrina was clipped out from post-Katrina class
  - The total submerged area was ~511 sq. km
- Water depth
  - NED DEM
  - Water level at West End gage
  - Max depth about 10 meters

Submergence Area



Distribution of Water Depth



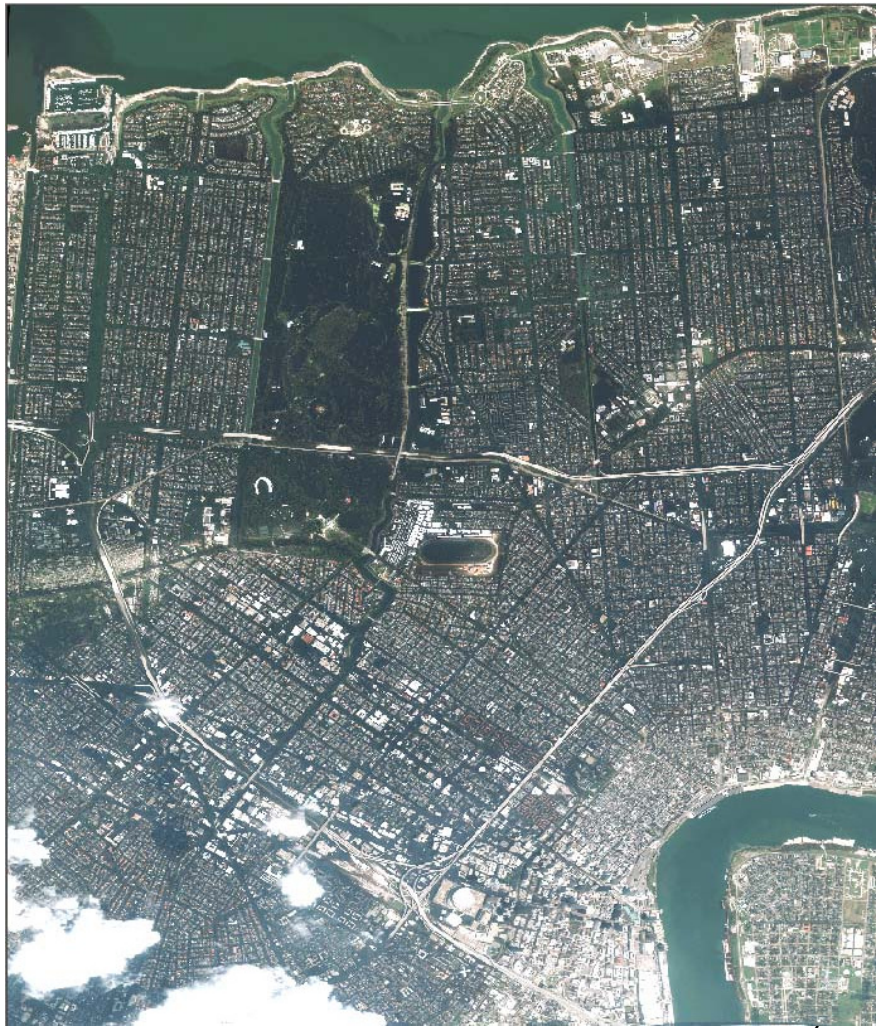
Depth of water (m)
Value
High: 10
Low: 0

Estimated by DEM and water level data of USGS West -End stream flow gage site

0 3 6 12 18 24
Km

Damage Assessment in New Orleans

Quickbird images (March ‘04 & Sep. 03 ‘05); GSD: 2.45m

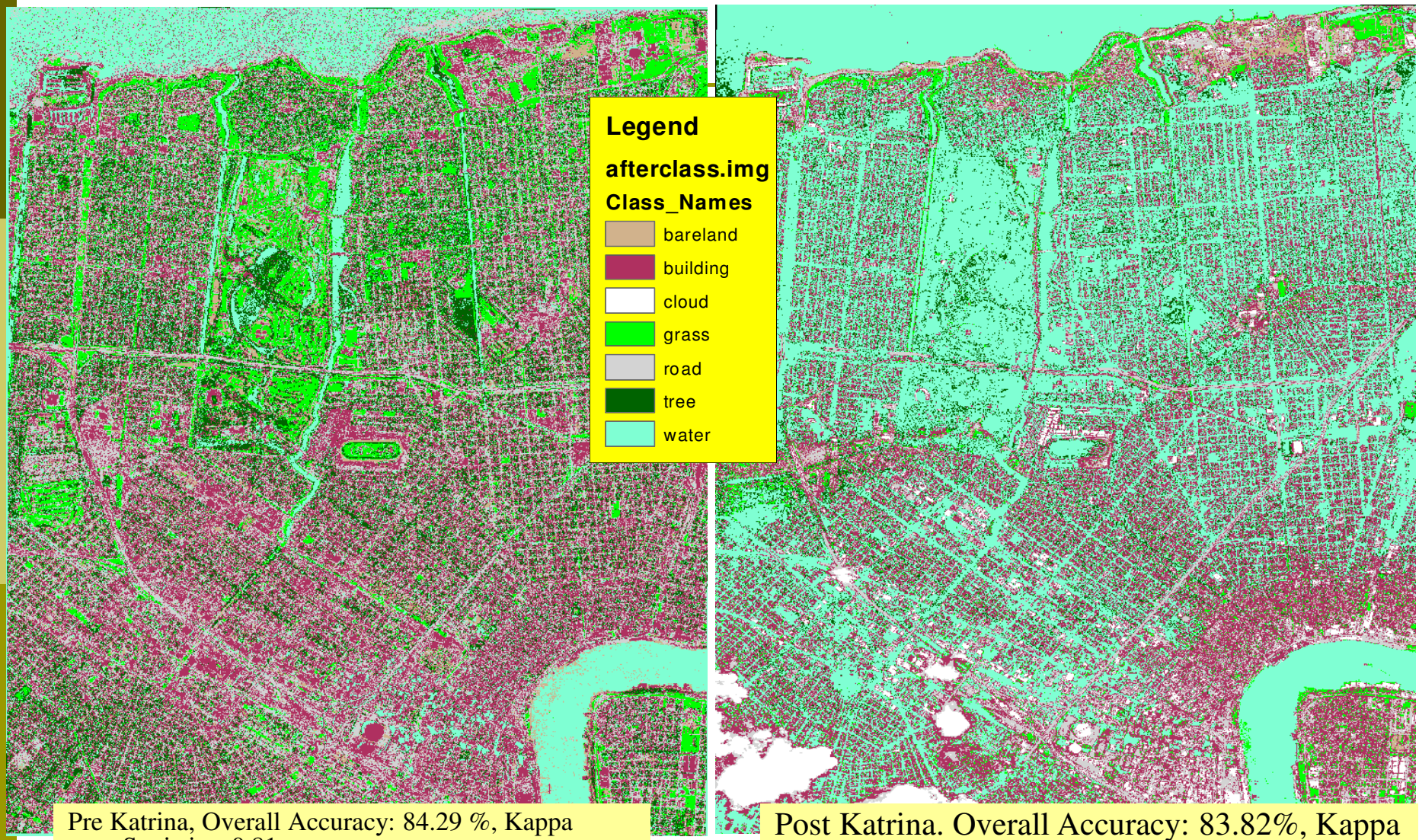


Damage Assessment - QuickBird

- Training
  - Training sample areas are selected for each class
  - 100+ sample areas of different building roofs
- Overall accuracy 83%, kappa 0.80

- Most roads (~60%) were submerged
- The submerged building cells are low level structures e.g, single story building or lower building edge
- Most of low elevation classes such as road, grass, tree, and bare land are submerged by 56-73%.
- Submergence is more severe at northern New Orleans

Damage Assessment – QuickBird



Pre Katrina, Overall Accuracy: 84.29 %, Kappa Statistics: 0.81

Post Katrina. Overall Accuracy: 83.82%, Kappa Statistics: 0.80

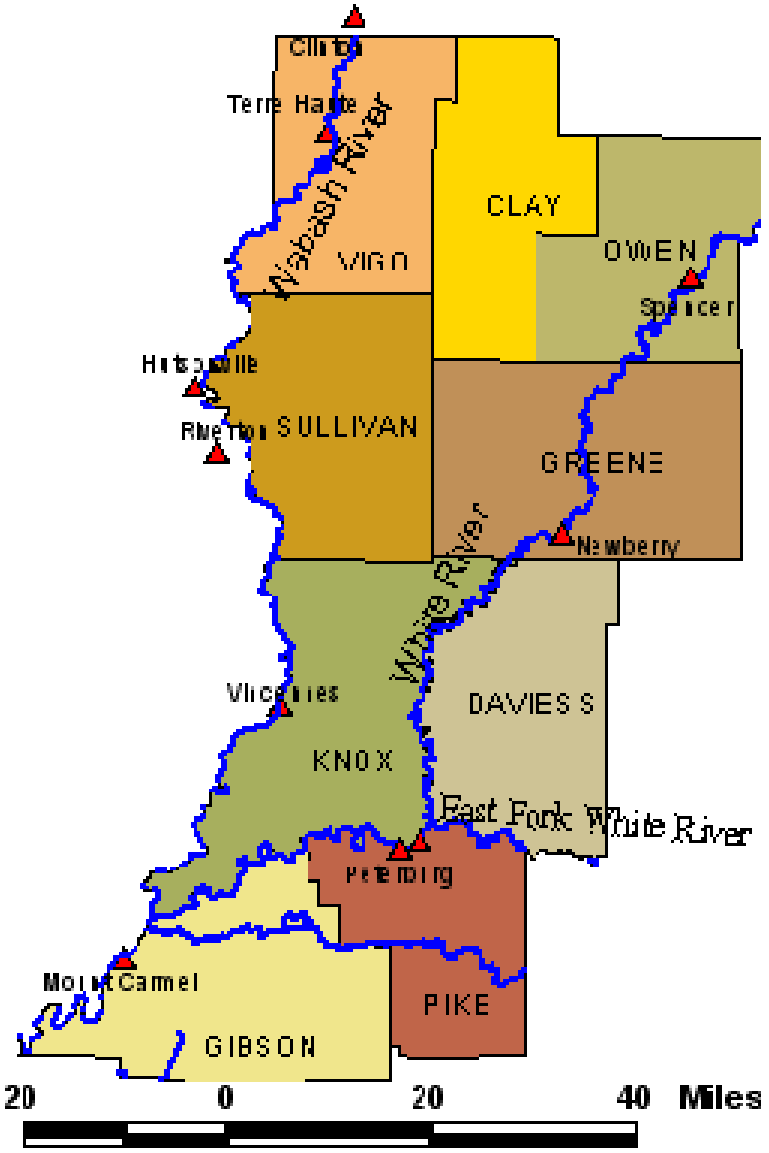
Southern Indiana flood

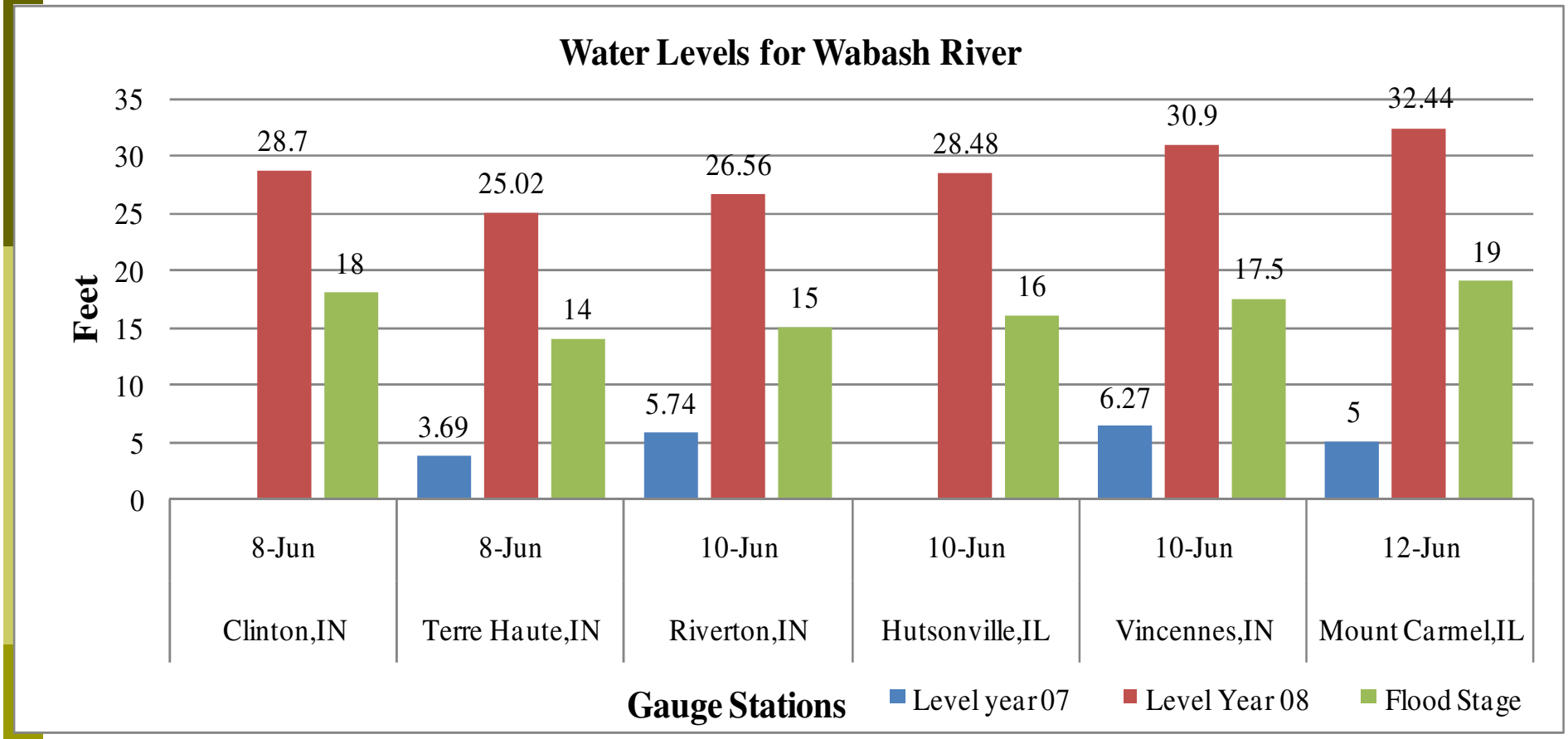
June 2008

Southern Indiana

JUNE 2008 RAINFALL

- June 1 -7, 2008 about 7-10 inches of rain in Clay, Owen and Greene
- This week-long rain caused flooding in the Wabash and White rivers
- Average June rainfall of 8 inches, about 4 inch above normal
- Disaster areas
  - State of emergency in 23 counties declared by the Governor
  - 39 counties in central Indiana declared as major disaster by the President
  - About 51 counties were affected by the flood
- Initial Estimated loss of about $126 M to $1 B
- 3 (three) persons dead

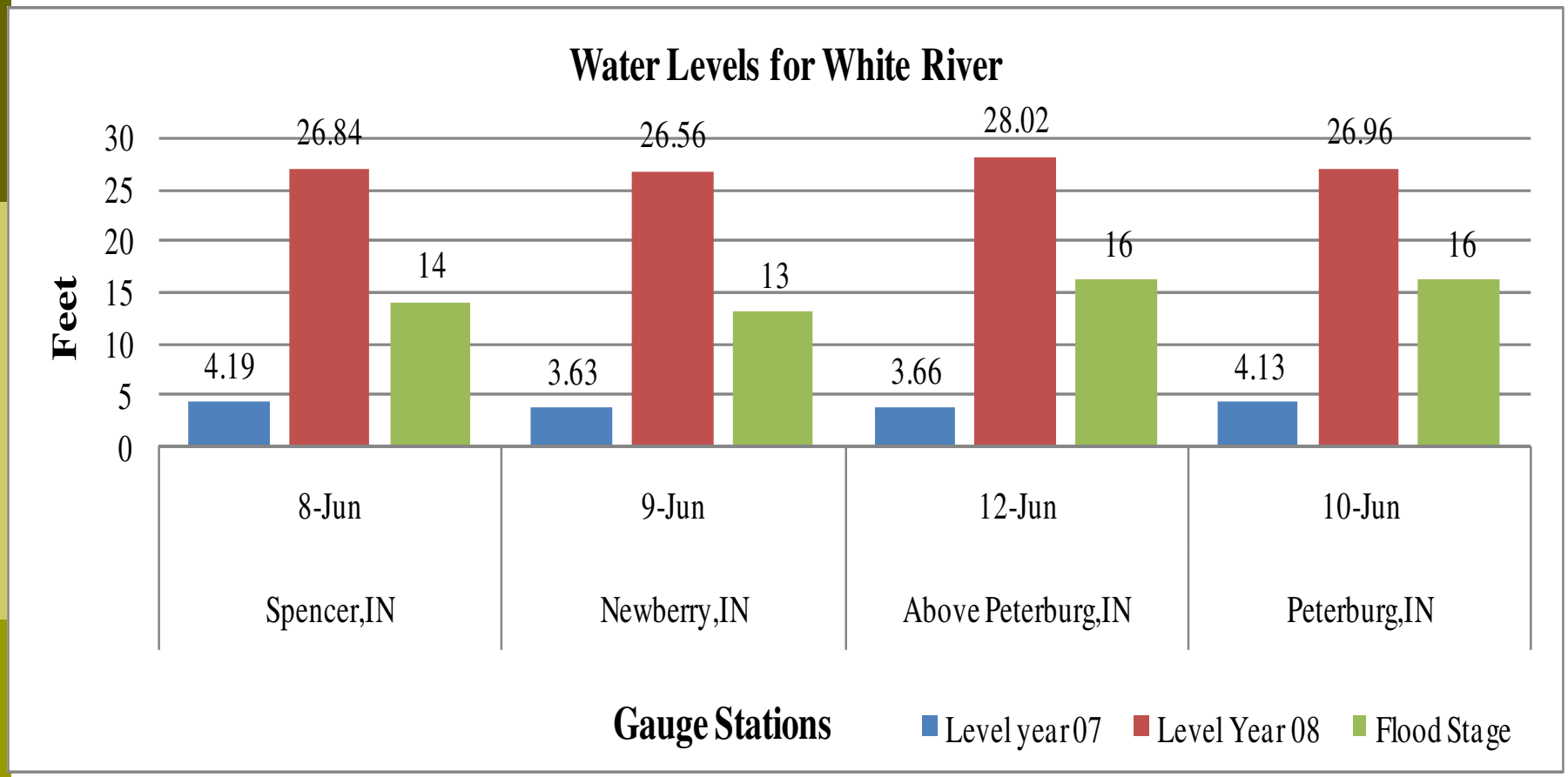




- **An average of about 12 feet water level increase in about five days**

Courtesy USGS

- **Highest water level recorded Mt Carmel, IL June 14,2008- 33.24 feet (remained 8 days above the flood stage)**

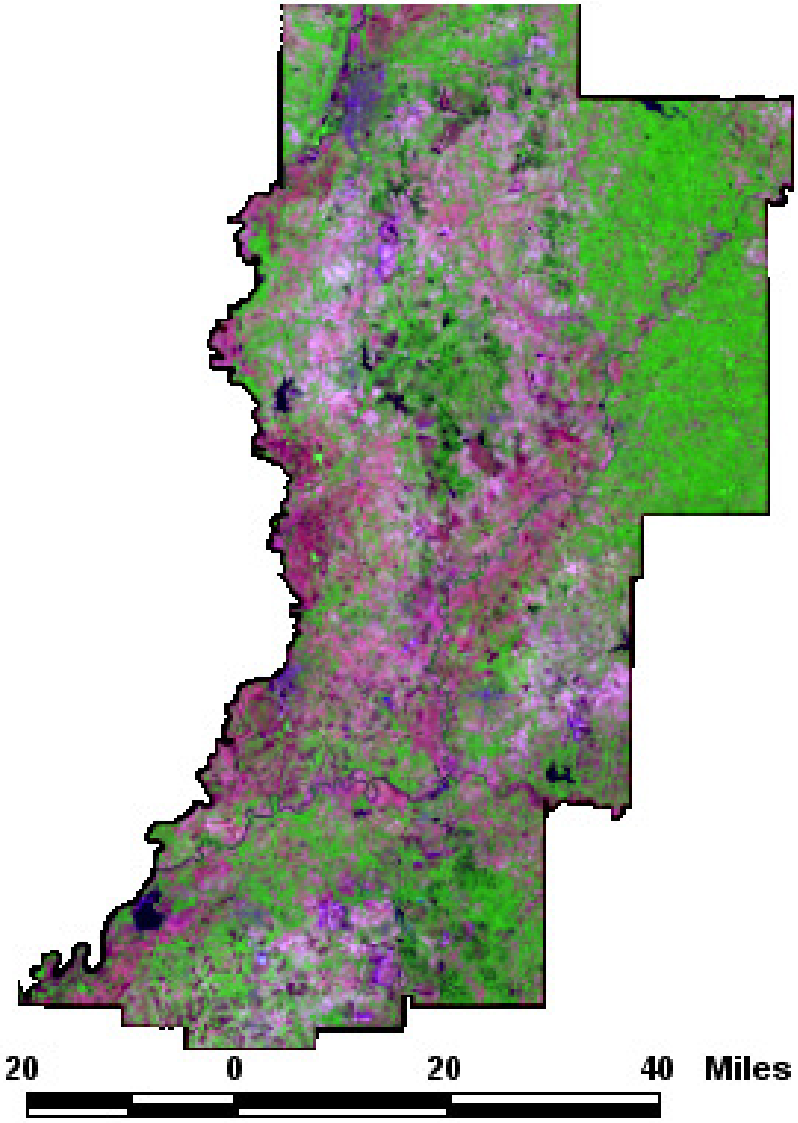


Courtesy USGS

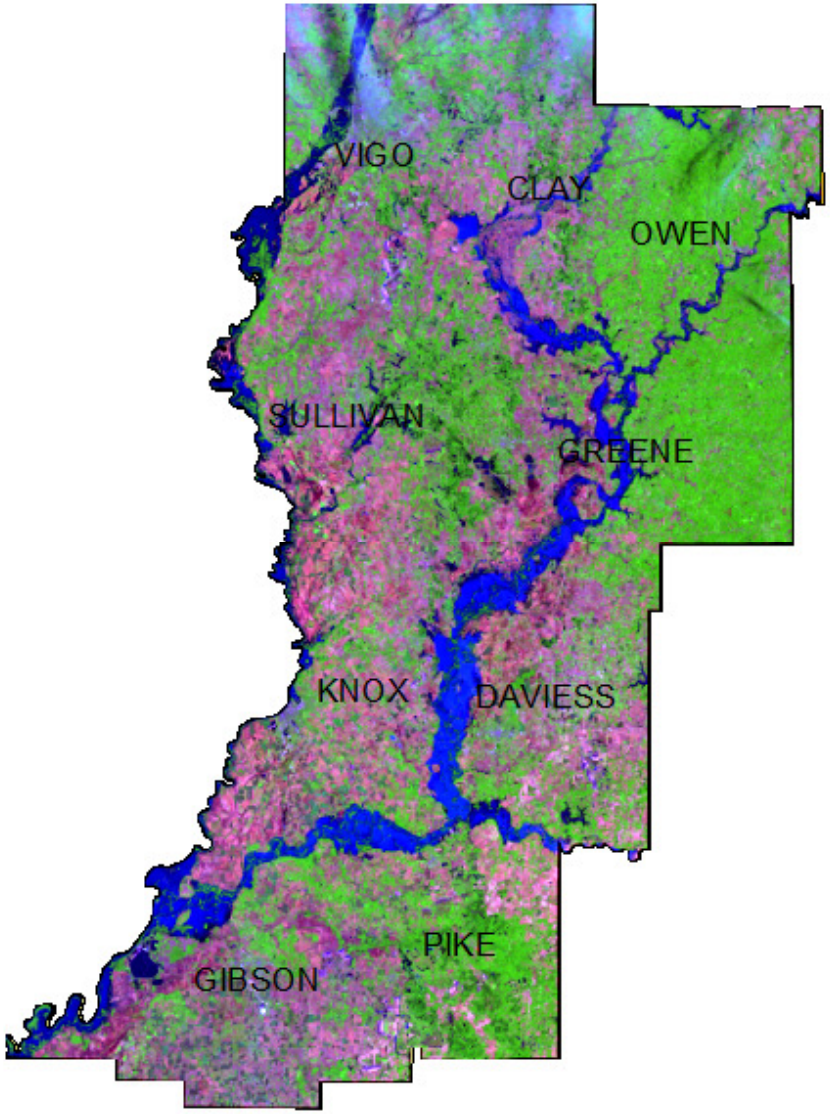
DATASET

- **Landsat 5 TM Images, June 9, 2007 and June 11, 2008**
  - **Coverage: South West Indiana**
  - **Resolution-30 M, 7 Bands (Used 6 bands)**
  - **Four scene of the same area for each year**
- **MODIS Images**
  - **Pre flood -May 28, 29 - Two scenes**
  - **Post flood- June 8 to June 19, 2008 – 14 scenes(seven cloud covered)**
  - **Resolution-500 m, 7 Bands**
- **USDA cropland data layer-2007**
- **Indiana GIS data- county boundaries, rivers, streams and floodplains**
- **INDOT roads and streets data 2005**

STUDY AREA LANDSAT IMAGES



LANDSAT TM_JUNE 09, 2007

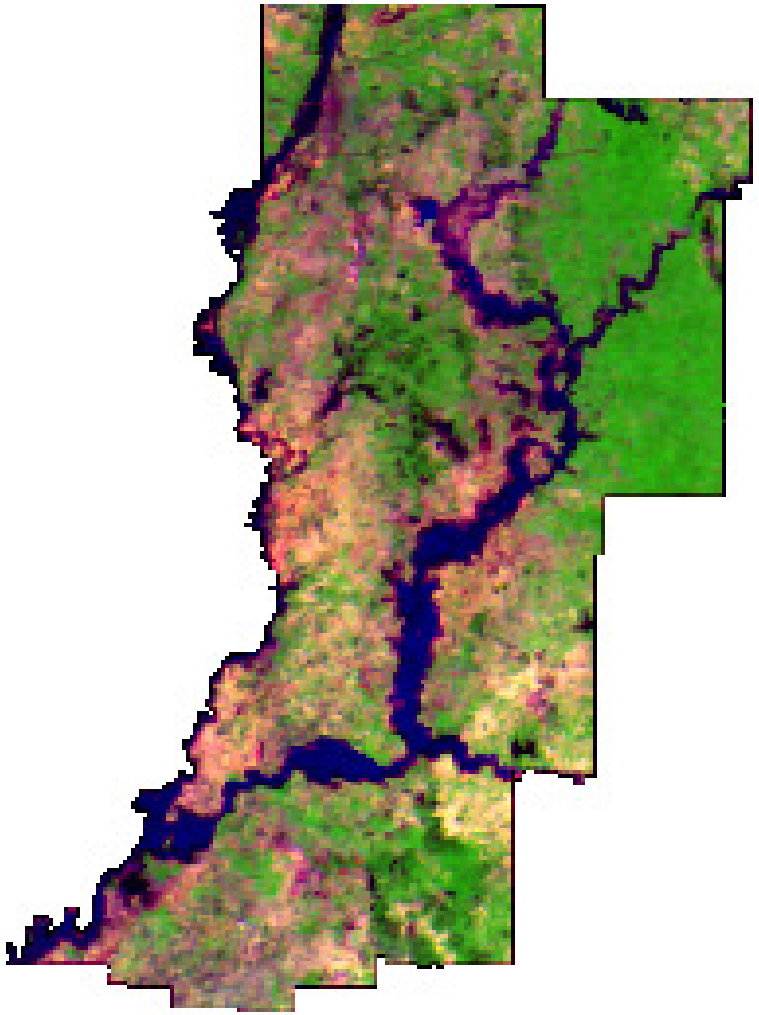


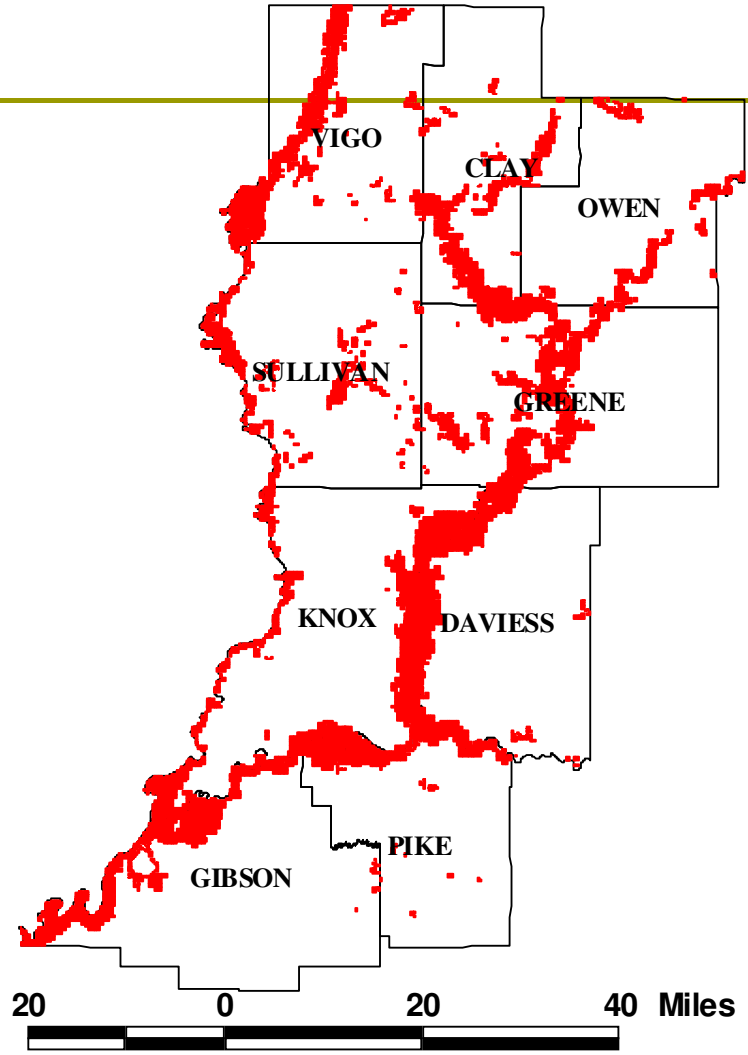
LANDSAT TM- JUNE 11,2008

IMAGE CLASSIFICATION

- **Two steps Analysis**
  - **Segmentation: divide the image to spatially contiguous and homogeneous regions**
  - **Classification: Classification of image objects rather than individual pixels, fuzzy rule based technique**
- **Possible use of spectral, contextual & texture features for classification**
- **Classification of 2007 and 2008 Landsat data**
  - **Water, Vegetation, Open Area, Wet Land Area, Built Up Area**
- **For flood extent assessment**
  - **Water**
  - **No water**

MODIS IMAGE FLOOD EXTENT

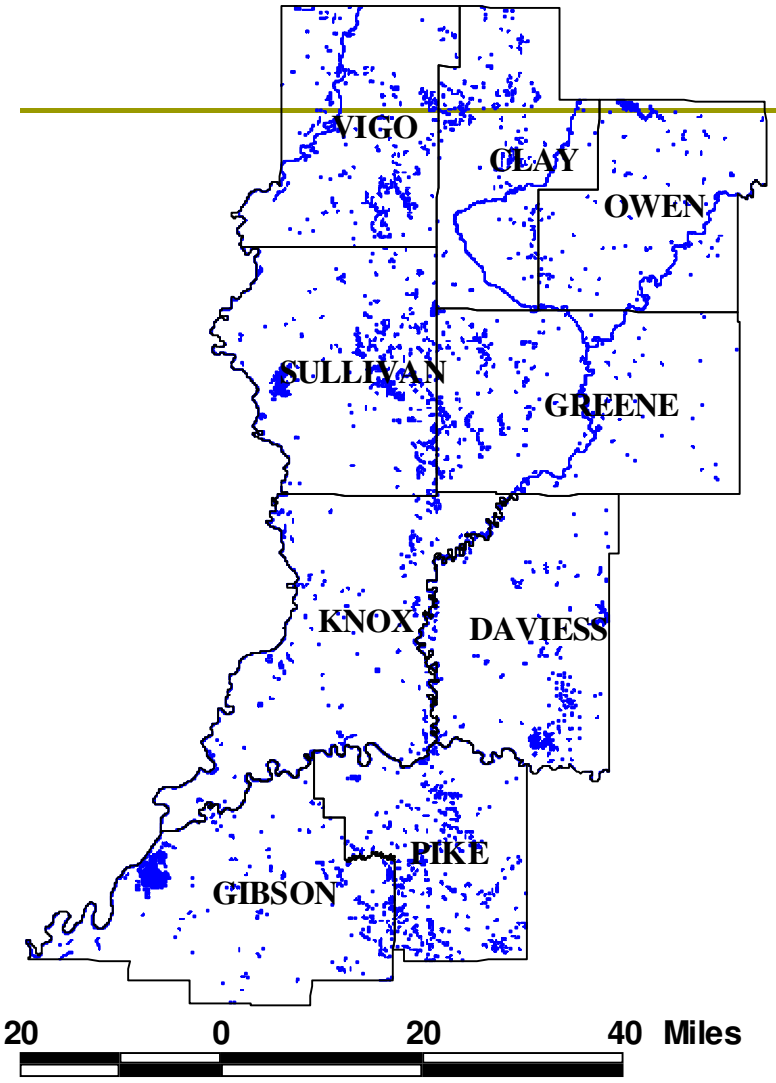




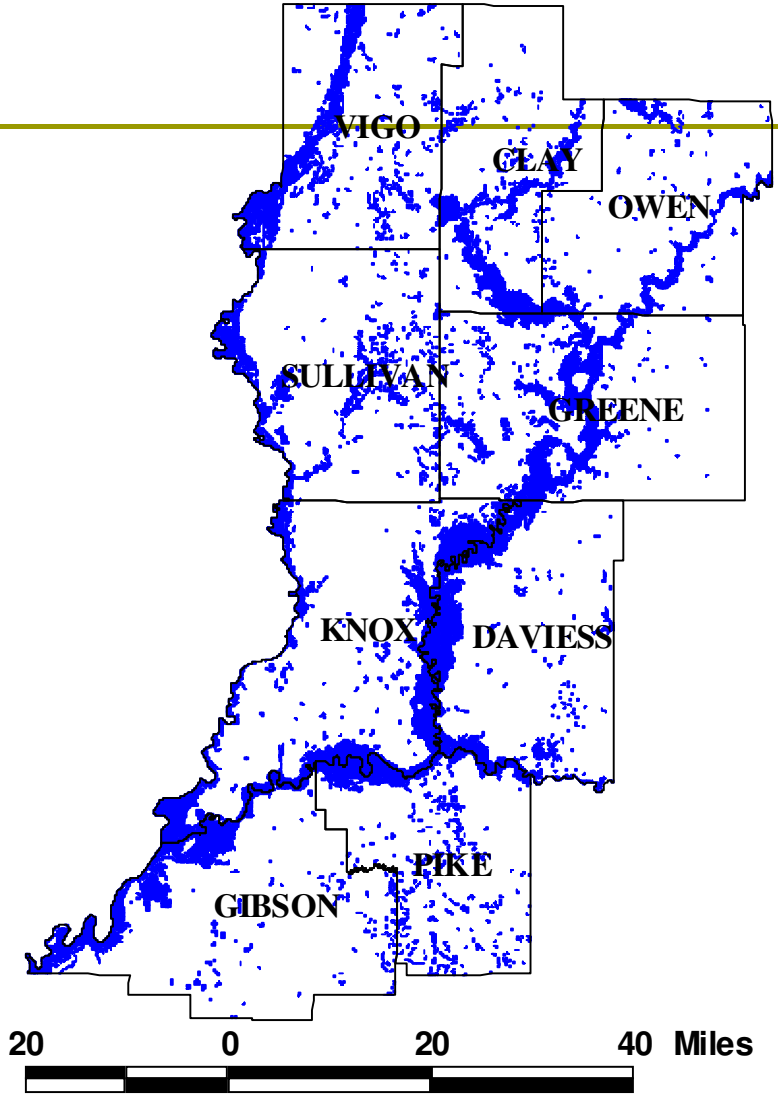
MODIS 2008

MODIS FLOOD WATER

LANDSAT CLASSIFICATION RESULTS



WATER_2007

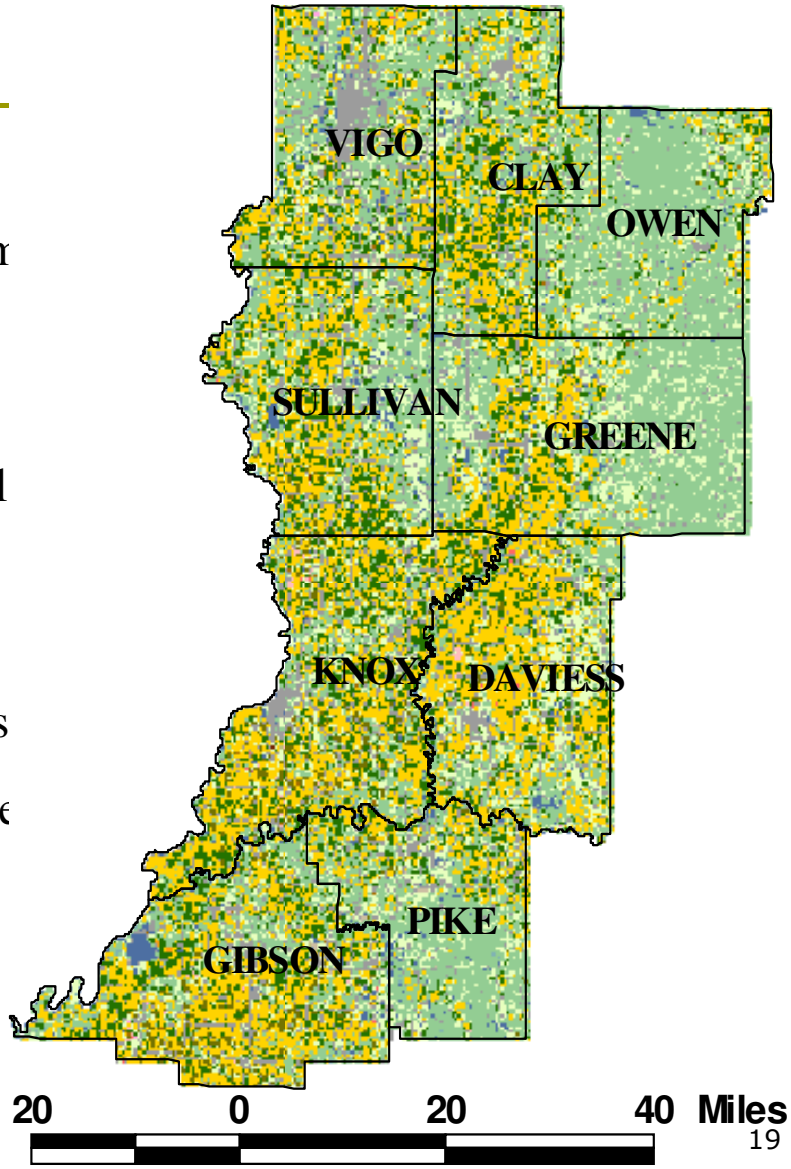


WATER_2008

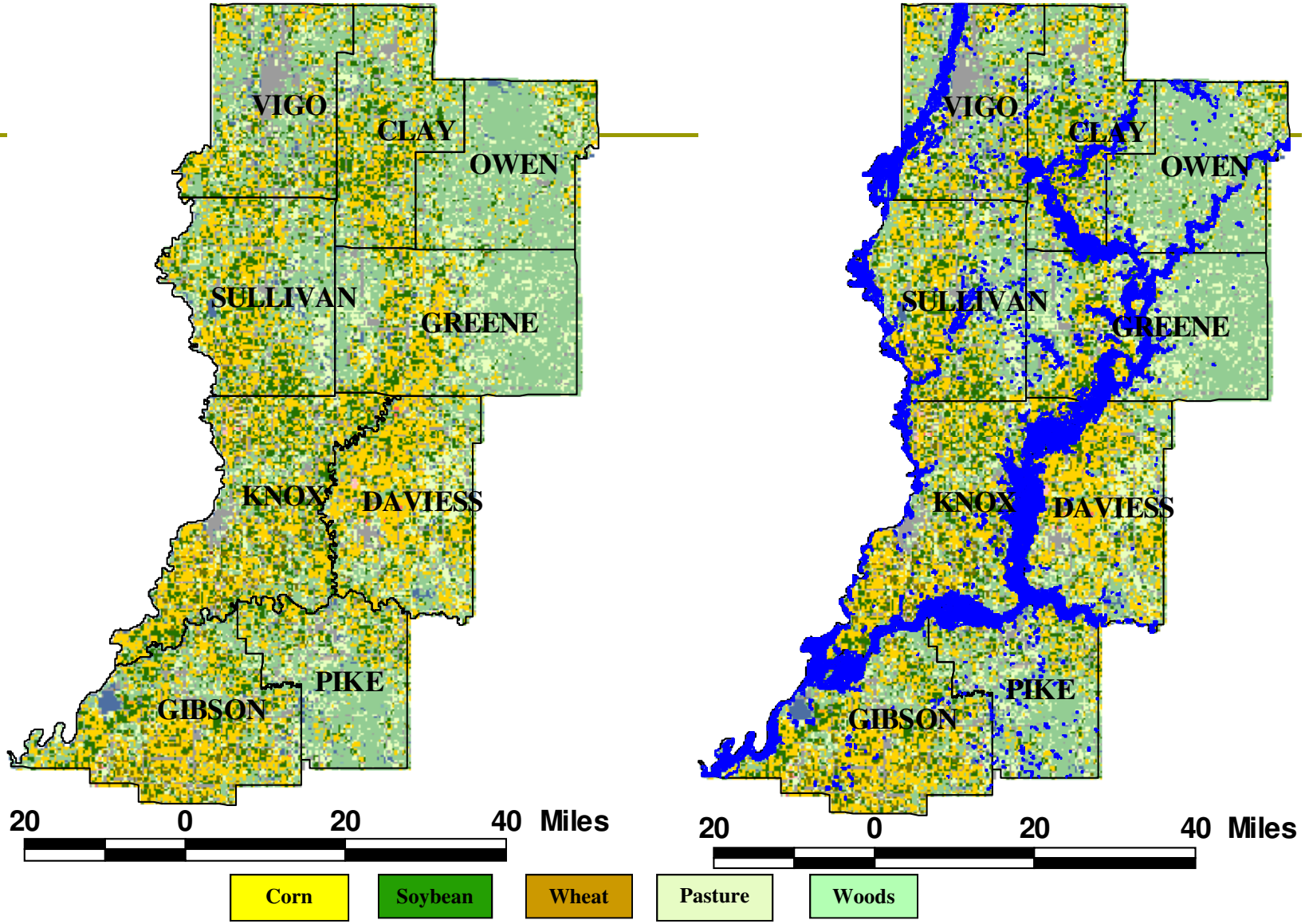
DAMAGE ASSESSMENT

USDA CROPLAND DATA- 2007

- Prepared in collaboration of NASS, Farm Service Agency and participating State's Governments
- Digital categorized geo-referenced data l of major crops acreage
- Focus on Corn, Soybean and Cotton agricultural regions in participating states
- Resource SAT-1 (AWiFS) Indian Remote Sensing Satellite
- Resolution-56 m, 4 bands



USDA CROPS DATA-2007

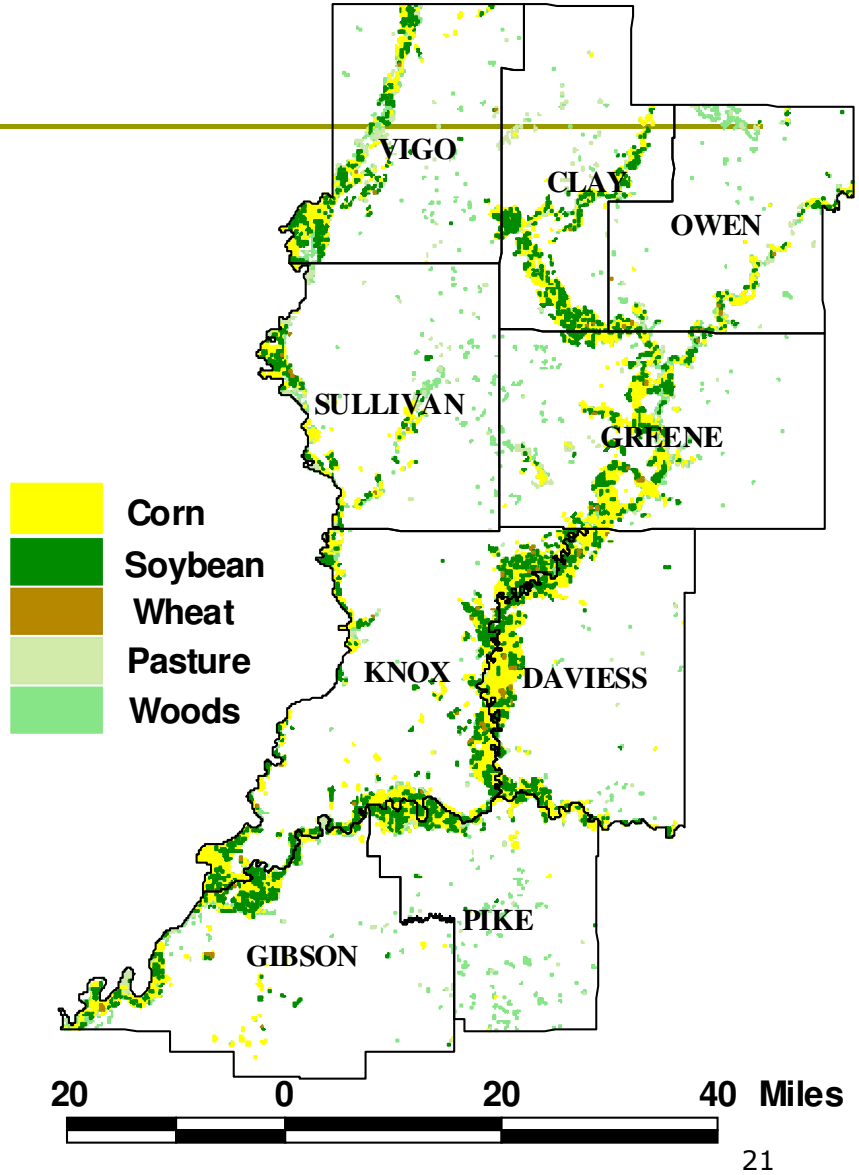


USDA Crops 2007

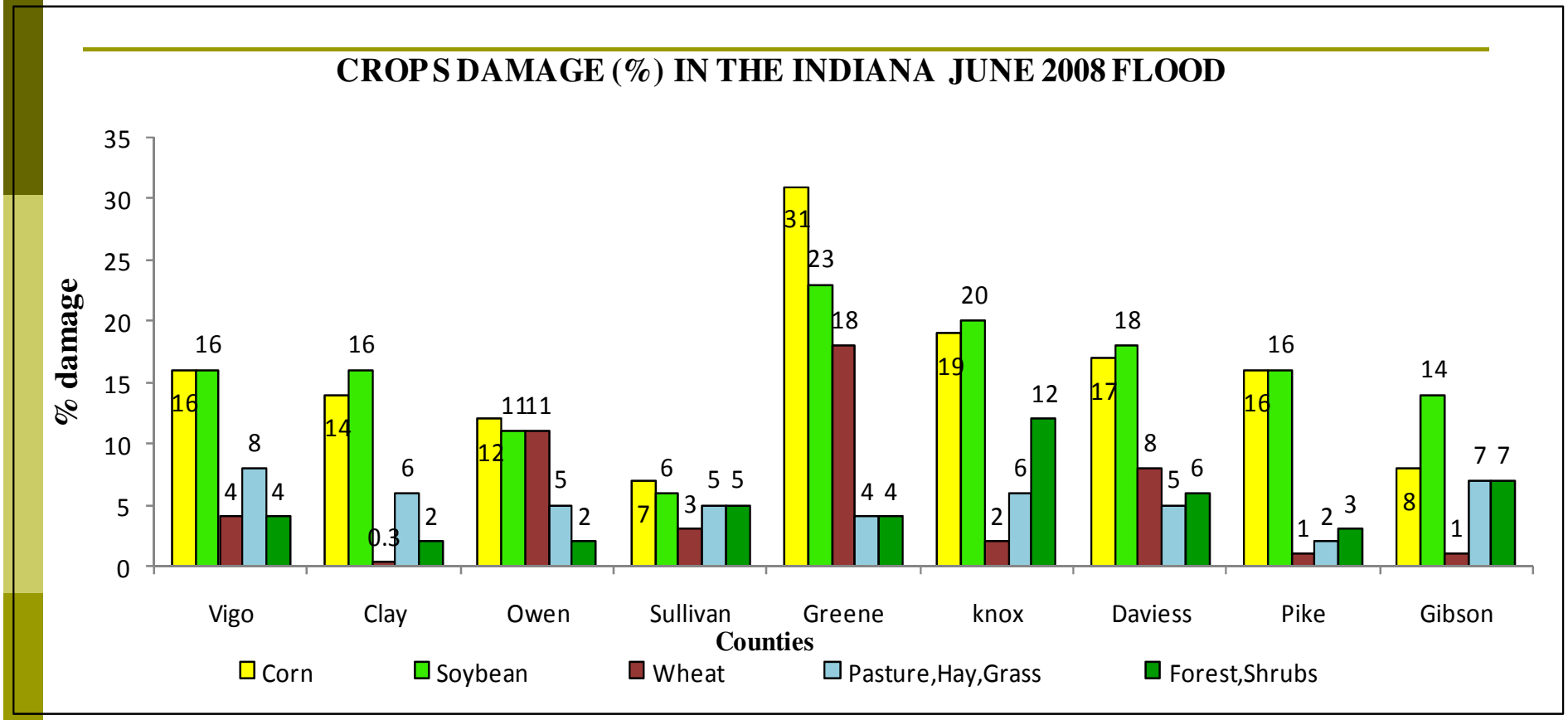
USDA Crops With_2008 Water Layer

CROP DAMAGE ESTIMATE

- Only some crops are assessed
- Assumed the areas under same crops as in year 2007 and 100% planted before flood occurrence
- Results based on flood affected crop areas, not a measure of real damage; some of these may recover .
- Degree of real damages /recovery of crops will depend upon, Ponding time, Erosion, Partial or total submerge, Saturation period of soils/fields, Formation of dense surface crust, Deposition of mud on plants



CROP DAMAGE SUMMARY-NINE COUNTIES

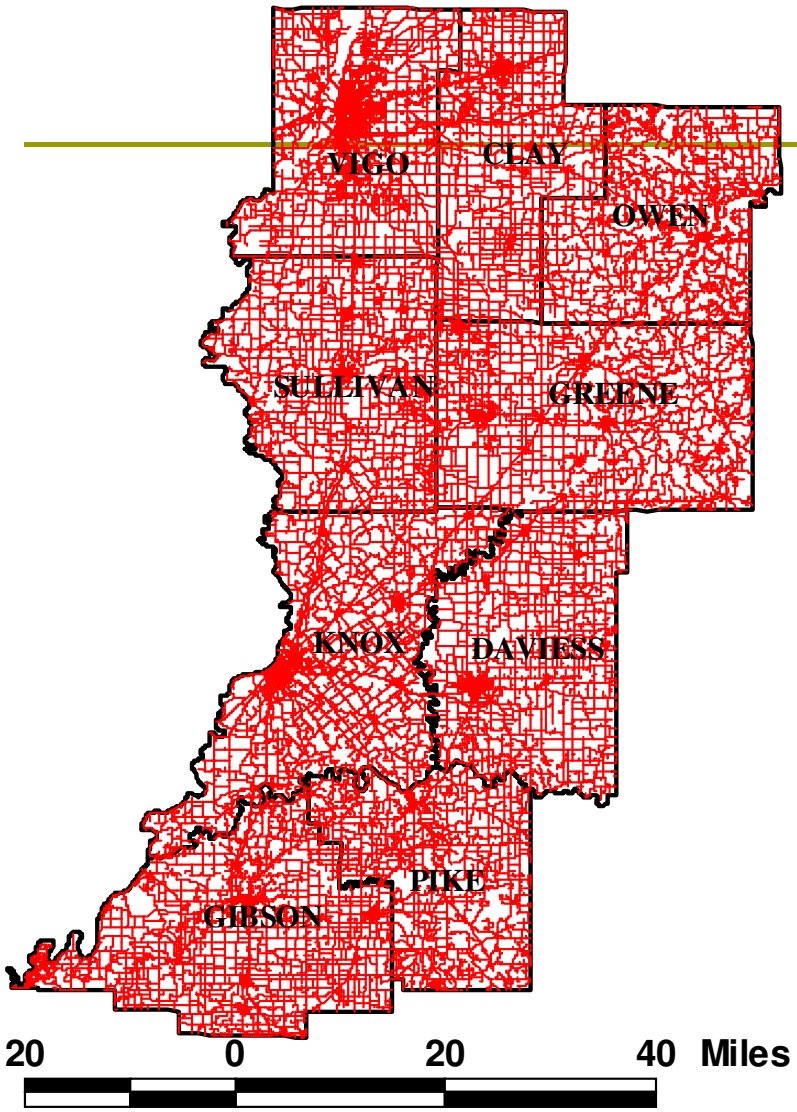


An average of about 15% of corn and soybeans areas affected by floods

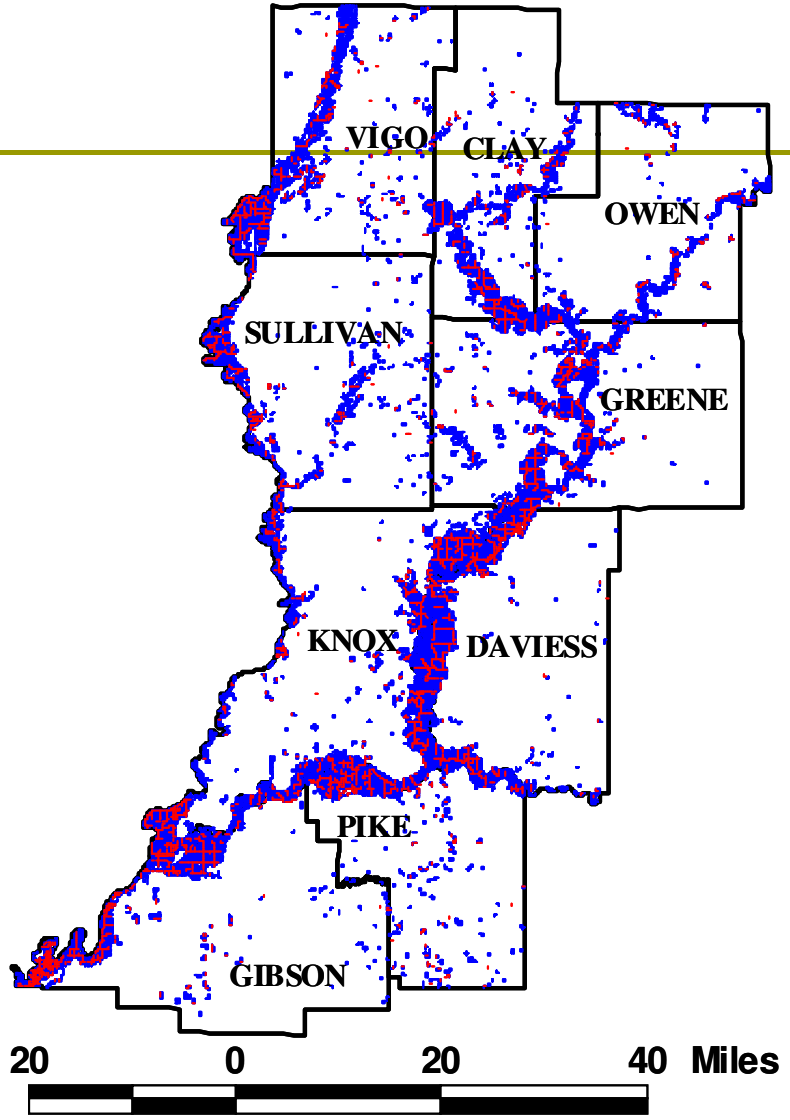
FLOOD AFFECTED ROADS

- **INDOT 2005 roads and streets data**
- **Roads passing through floodplains are mostly affected**
- **Flood affected roads include**
  - **State Roads (SR 42, SR 246, SR 57, SR 157, SR 59)**
  - **US Highway (US 231)**
  - **County Roads and City streets**

FLOOD AFFECTED ROADS

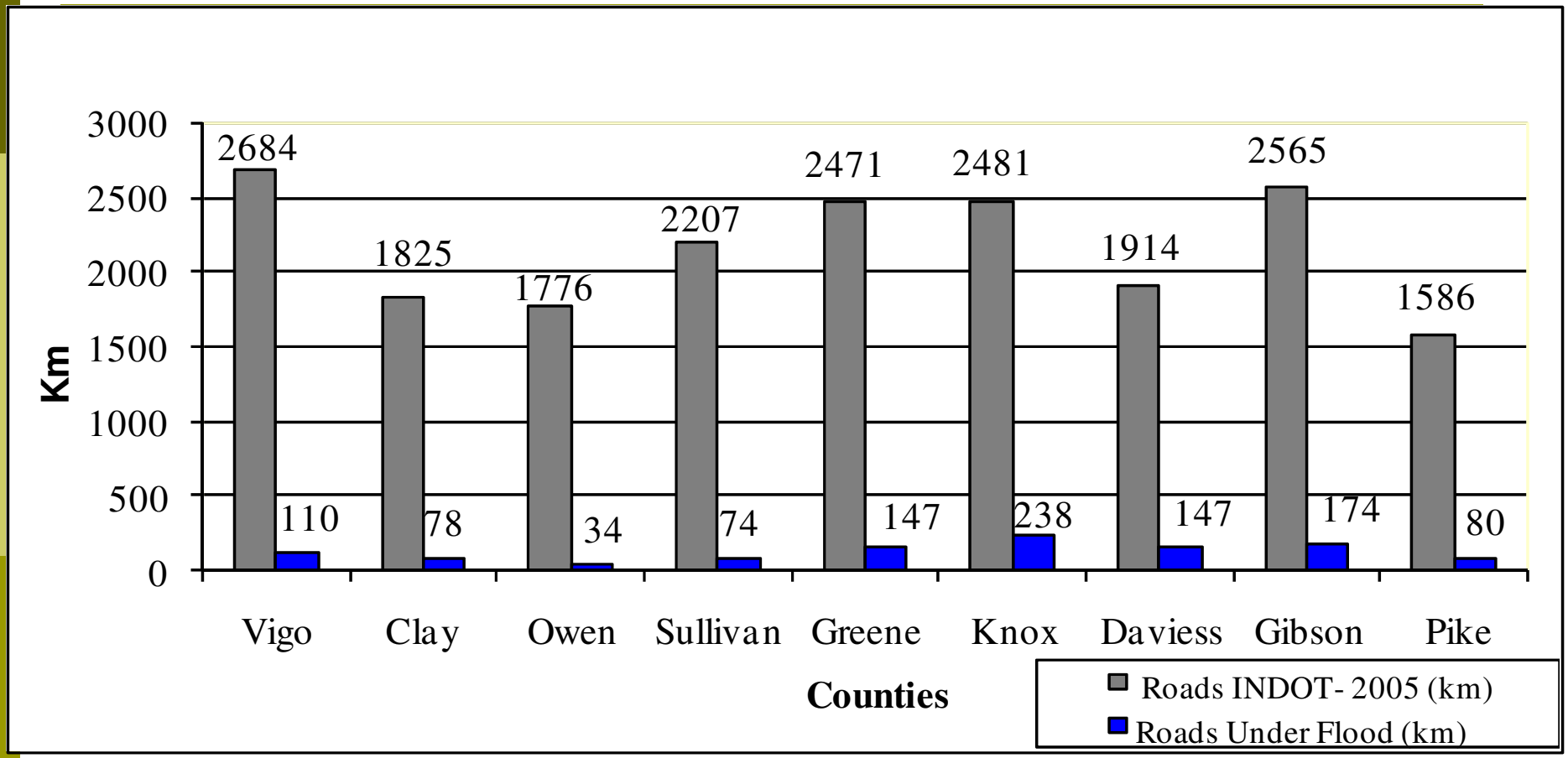


INDOT ROADS 2005

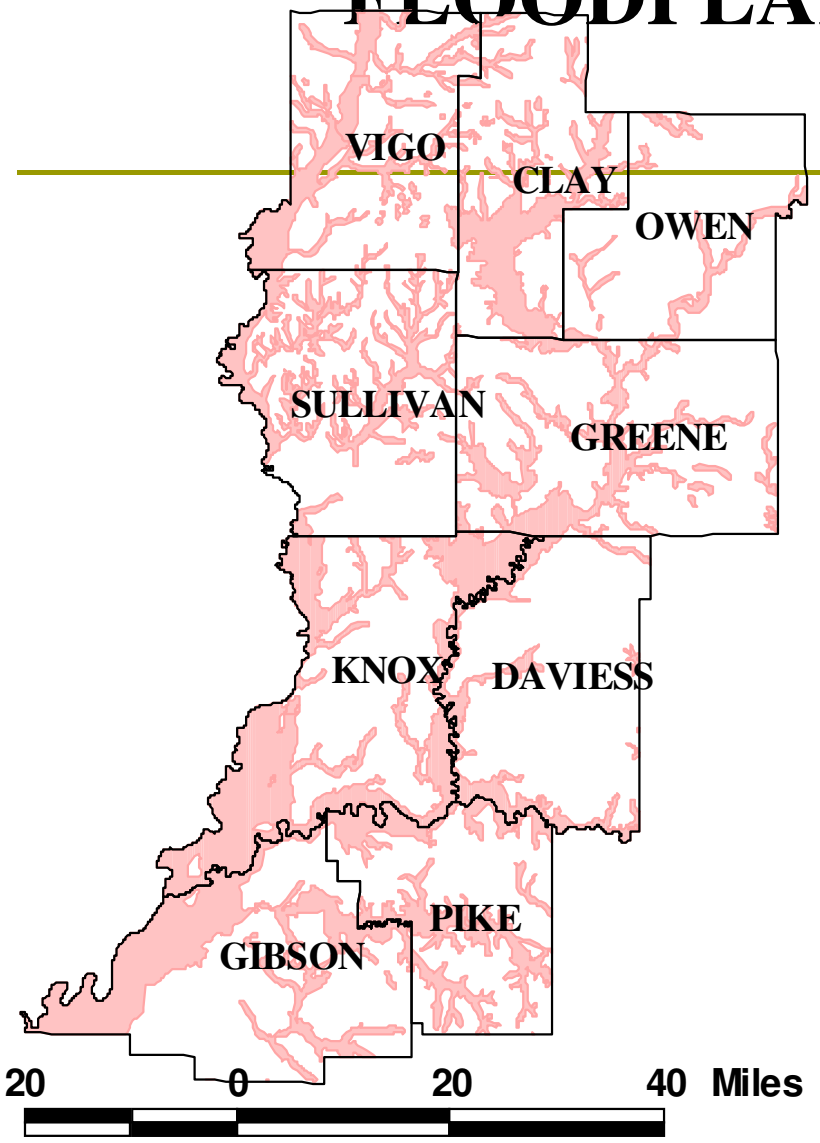


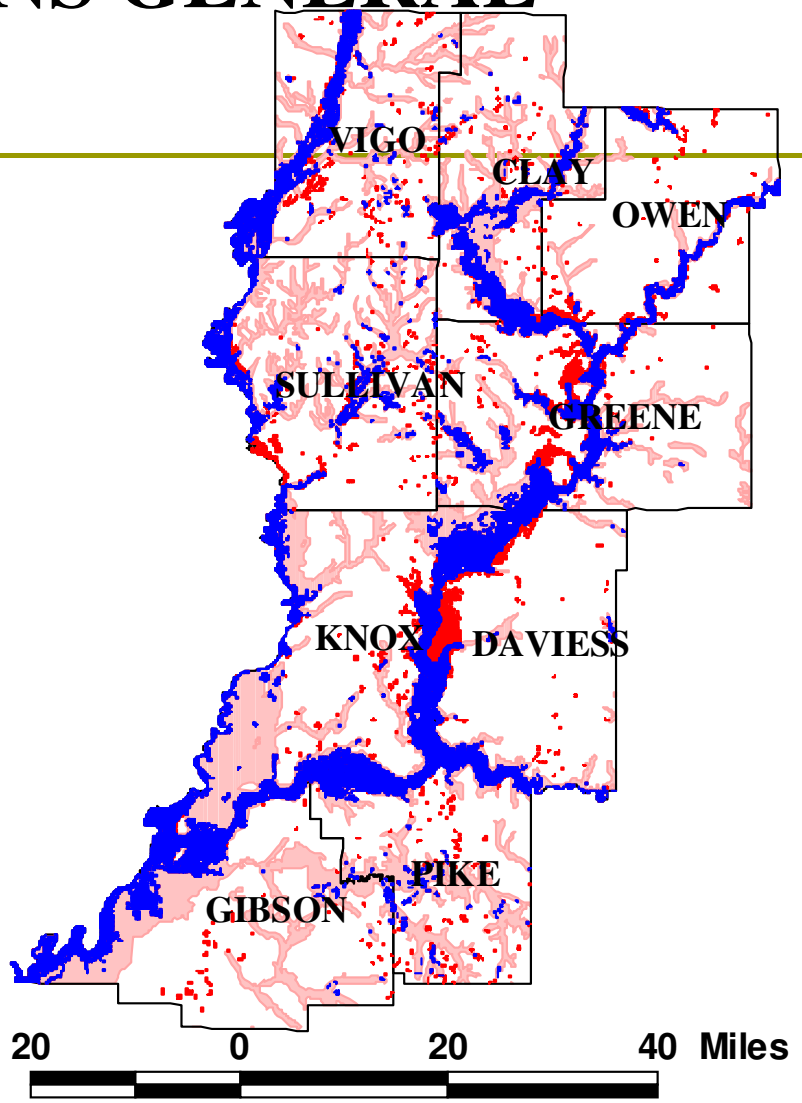
FLOOD AFFECTED ROADS

FLOOD AFFECTED ROADS



FLOODPLAINS GENERAL





FLOODPLAINS

FLOOD WATER IN FLOODPLAINS

93000 Hectares

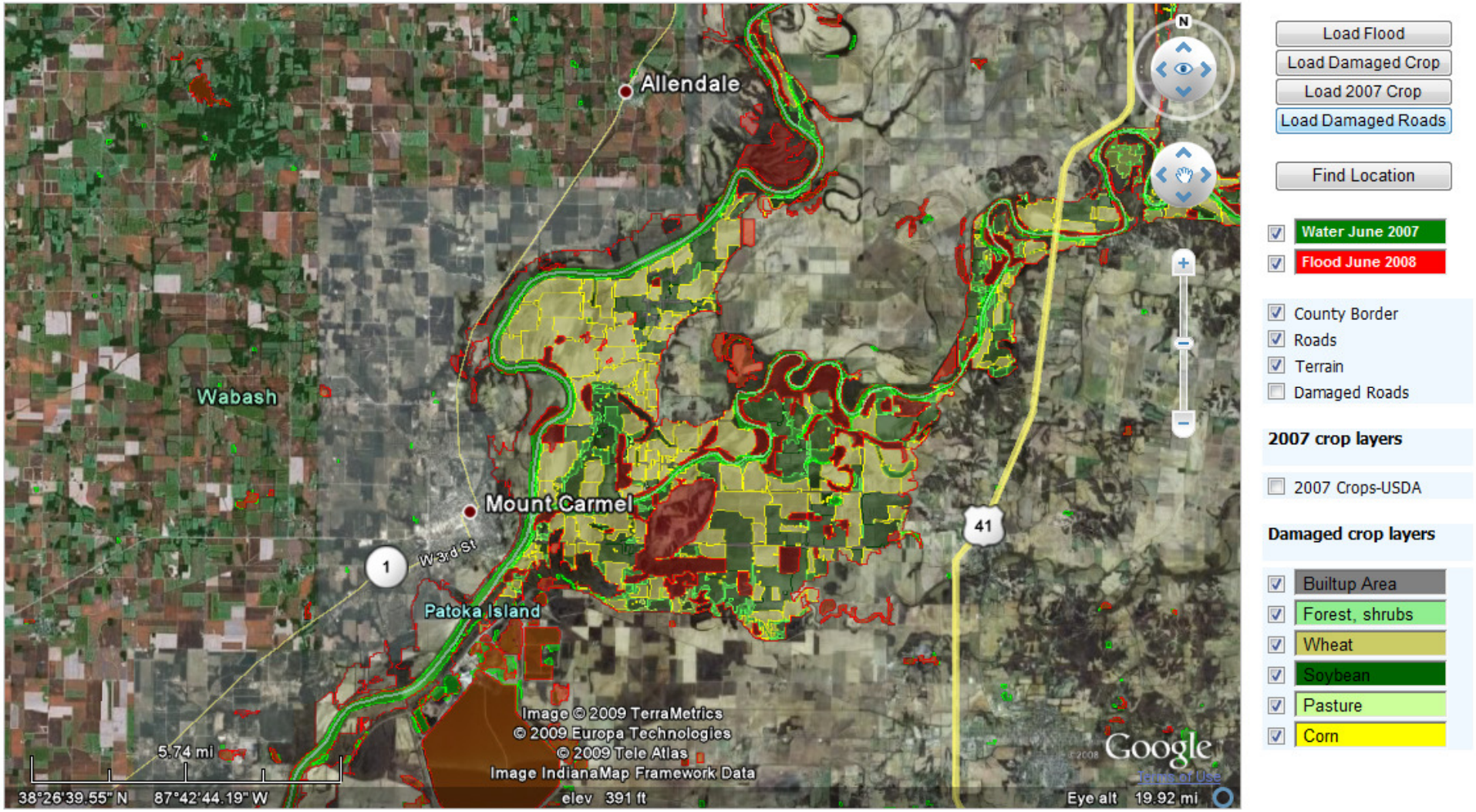
FLOOD WATER OUT OF FLOODPLAINS

6000 Hectares

Web Mapping Service

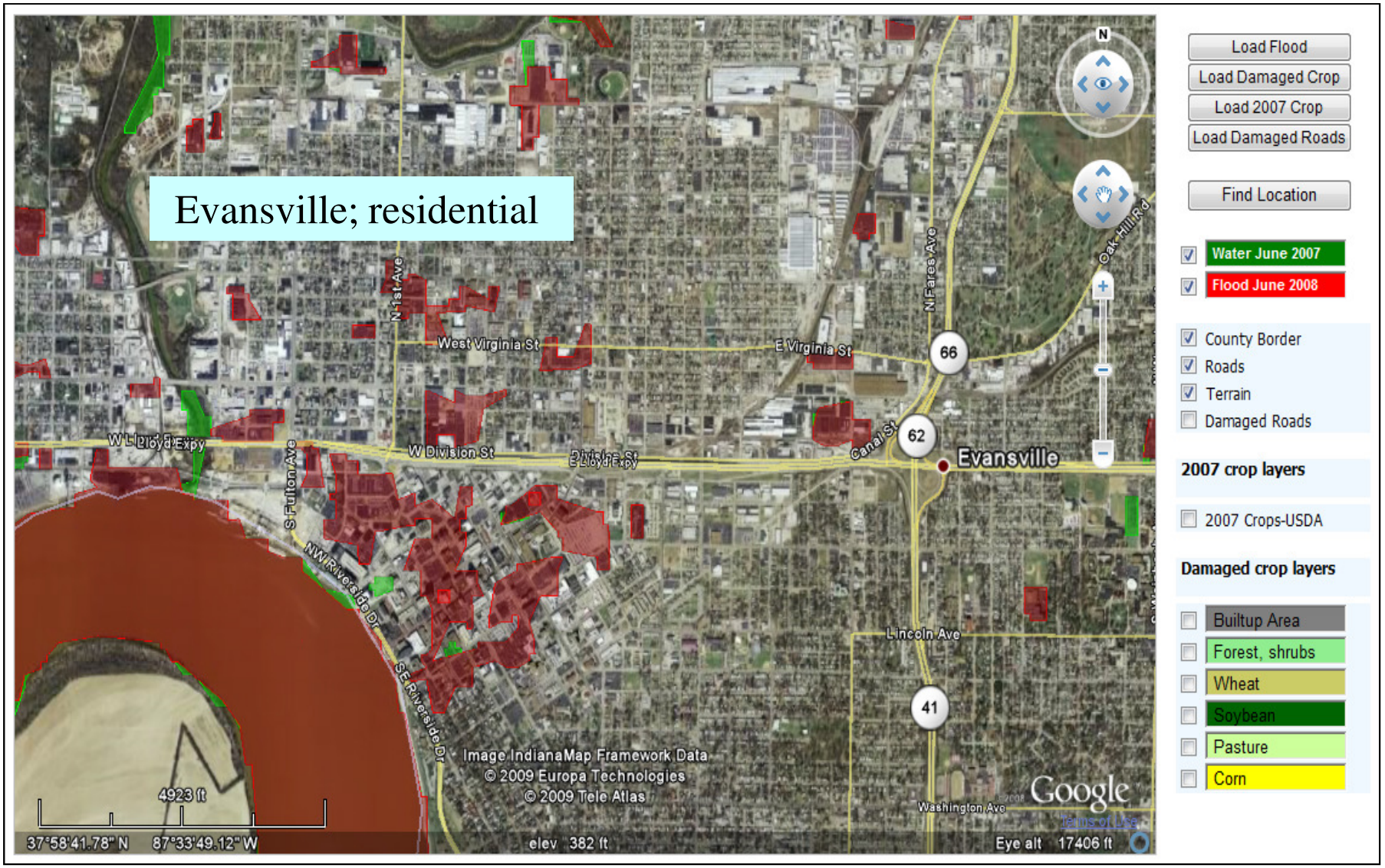
- Uncountable information is being produced by government, universities, companies and individuals.
- These data can be shared and published to the public very effectively with web-GIS technologies.
- Google Earth plug-in (web version of Google Earth) was used because of its powerful visualization functionalities, easiness and cost-effectiveness.

Web interface



https://**engineering.purdue.edu/CE/Academics/Groups/Geomatics/floodmaps**

Web interface



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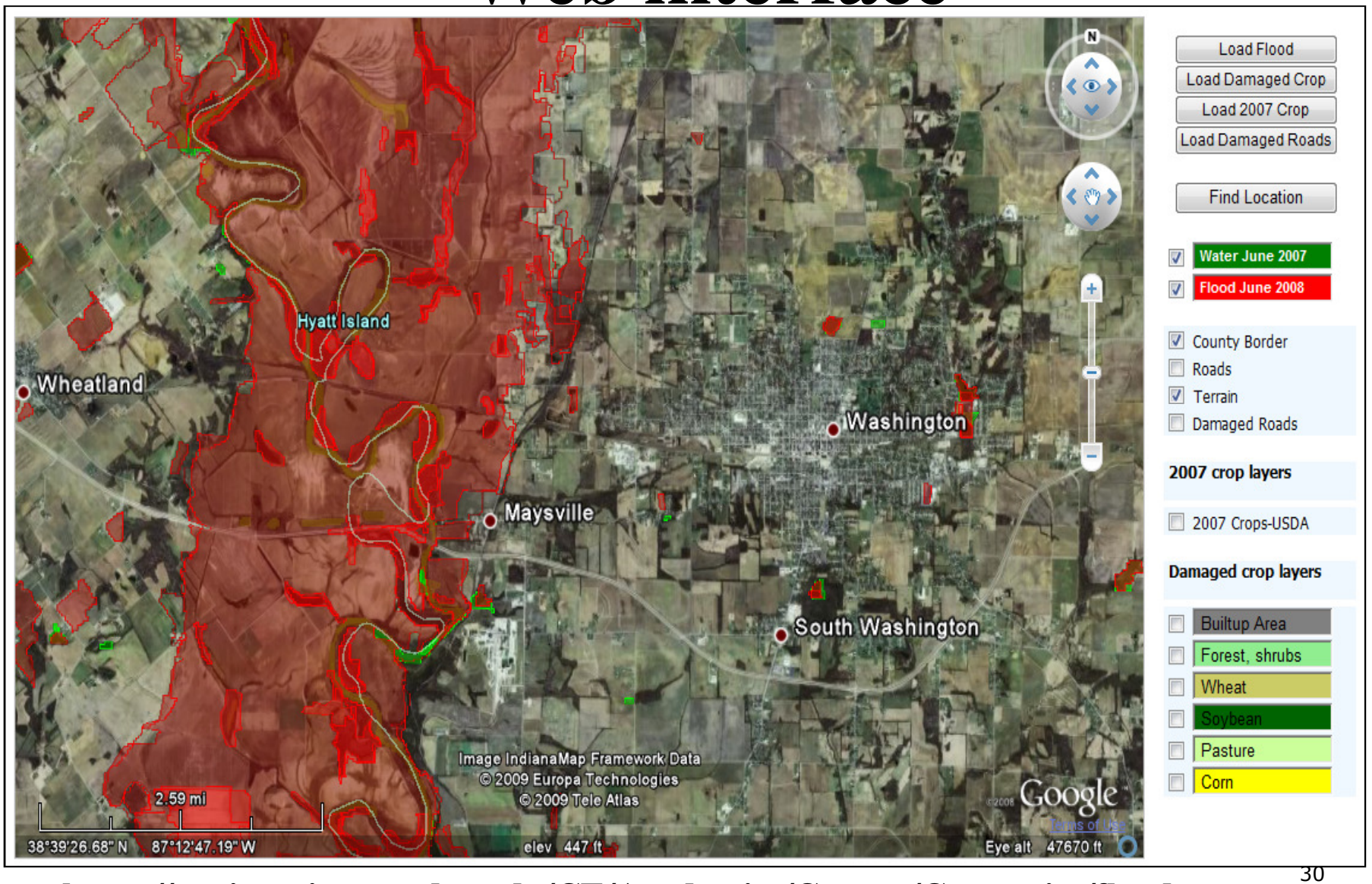
Web interface



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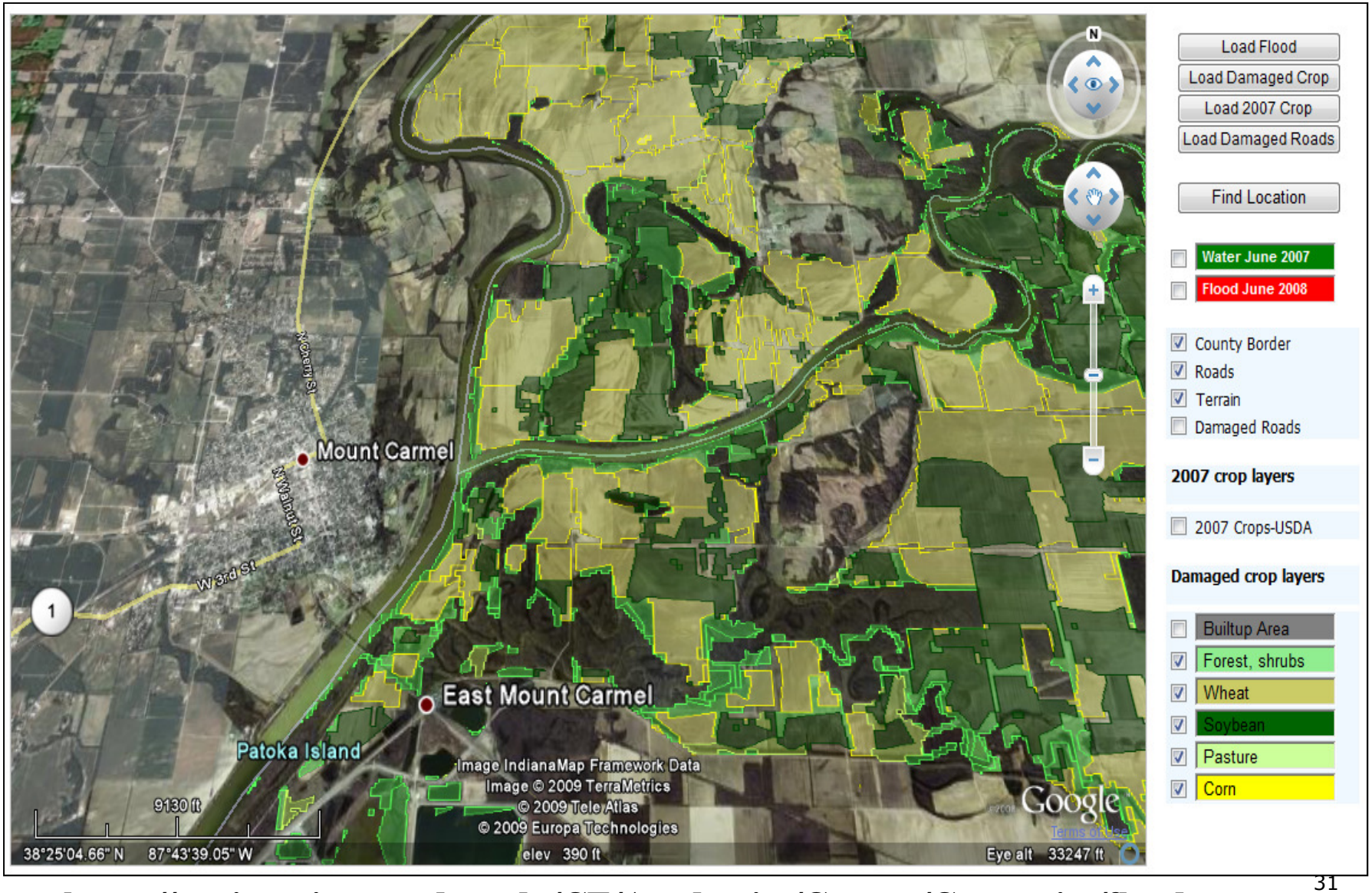
Web interface



https://engineering.purdue.edu/CE/Academics/Groups/Geomatics/floodmaps

Web interface

https://engineering.purdue.edu/CE/Academics/Groups/Geomatics/floodmaps

FINDINGS

- **Damages**
  - An average of 15 % damage to both Corn and Soybeans
  - 1080 km of roads segments affected by/under water, mostly the county roads
  - Knox, Greene and Daviess are worst hit, both in flood affected area and roads damage
  - 6,000 hectares of additional flood affected area beyond the floodplain
- **Data and maps**
  - Timely availability on internet (flood maps) helps to quickly assess the disaster impact,
  - one can view and assess the flooding and damages on line

Northern Indiana flood

March 2009

Northern Indiana

March 2009 N. Indiana flood

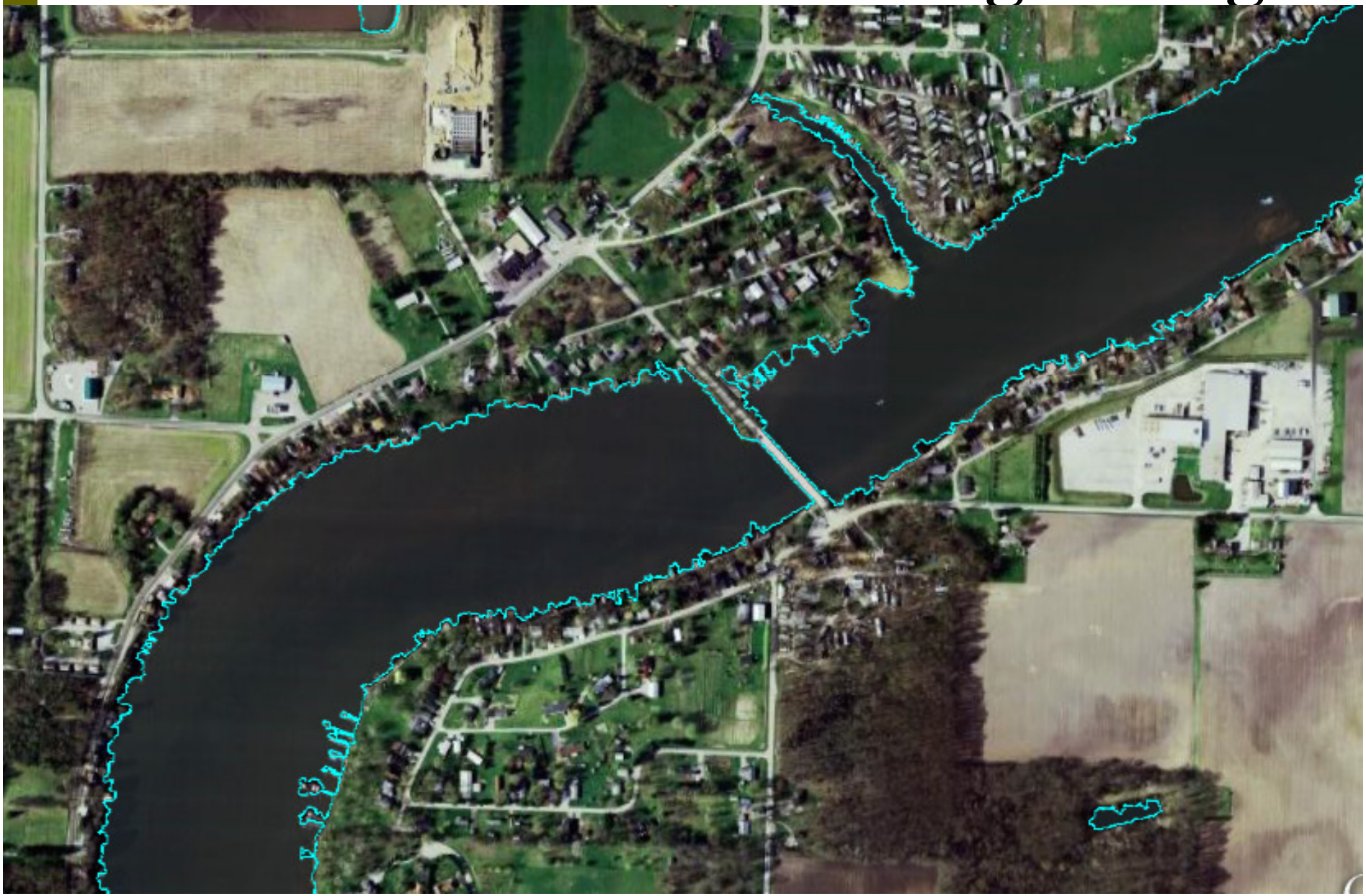
SPOT 4

March 2009 N. Indiana flood

Classified from ALOS

Worldview -3, 0.6m; N. Indiana; March 9, 2009

WV-3 flood extent over Google image



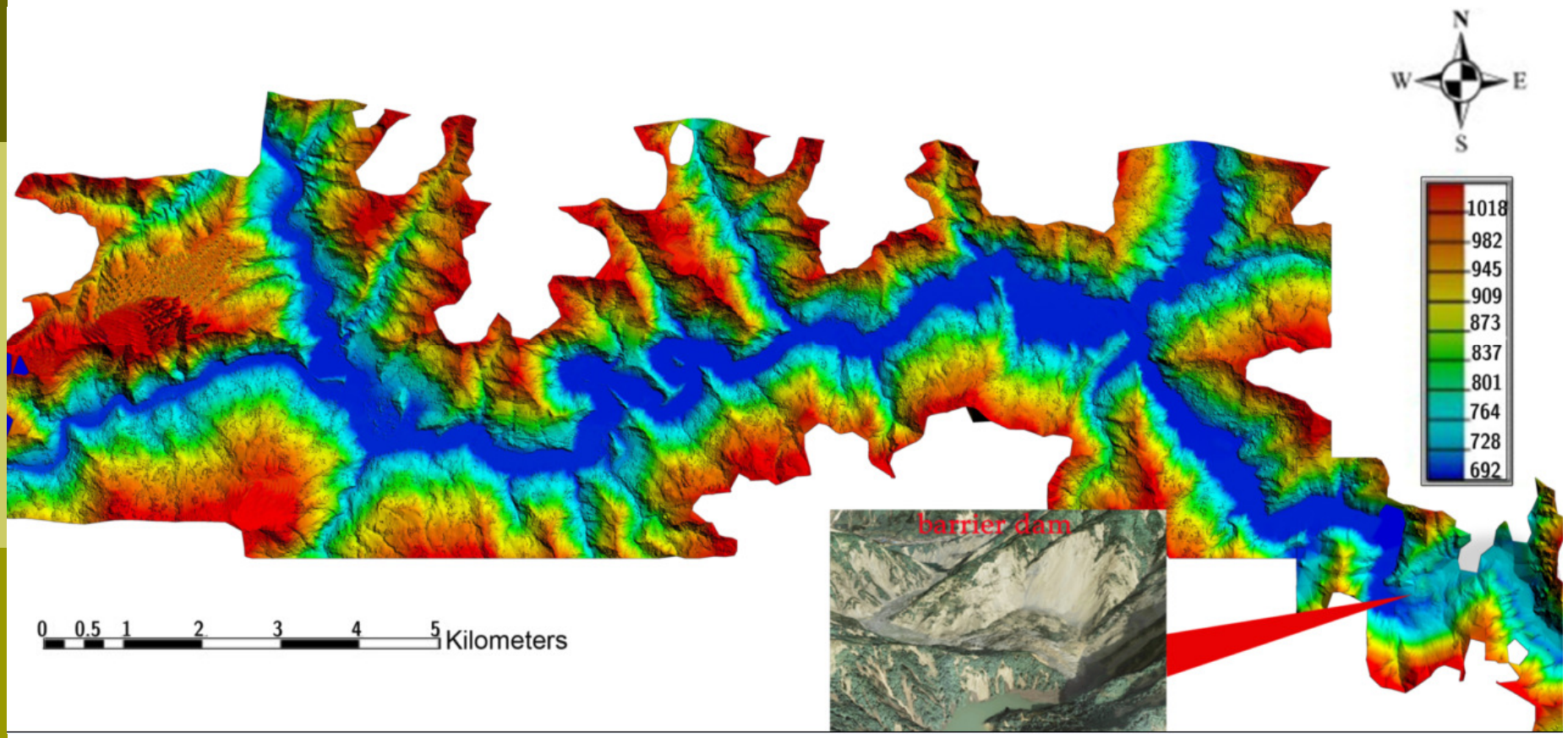
Wenchuan Earthquake

May 12, 2008

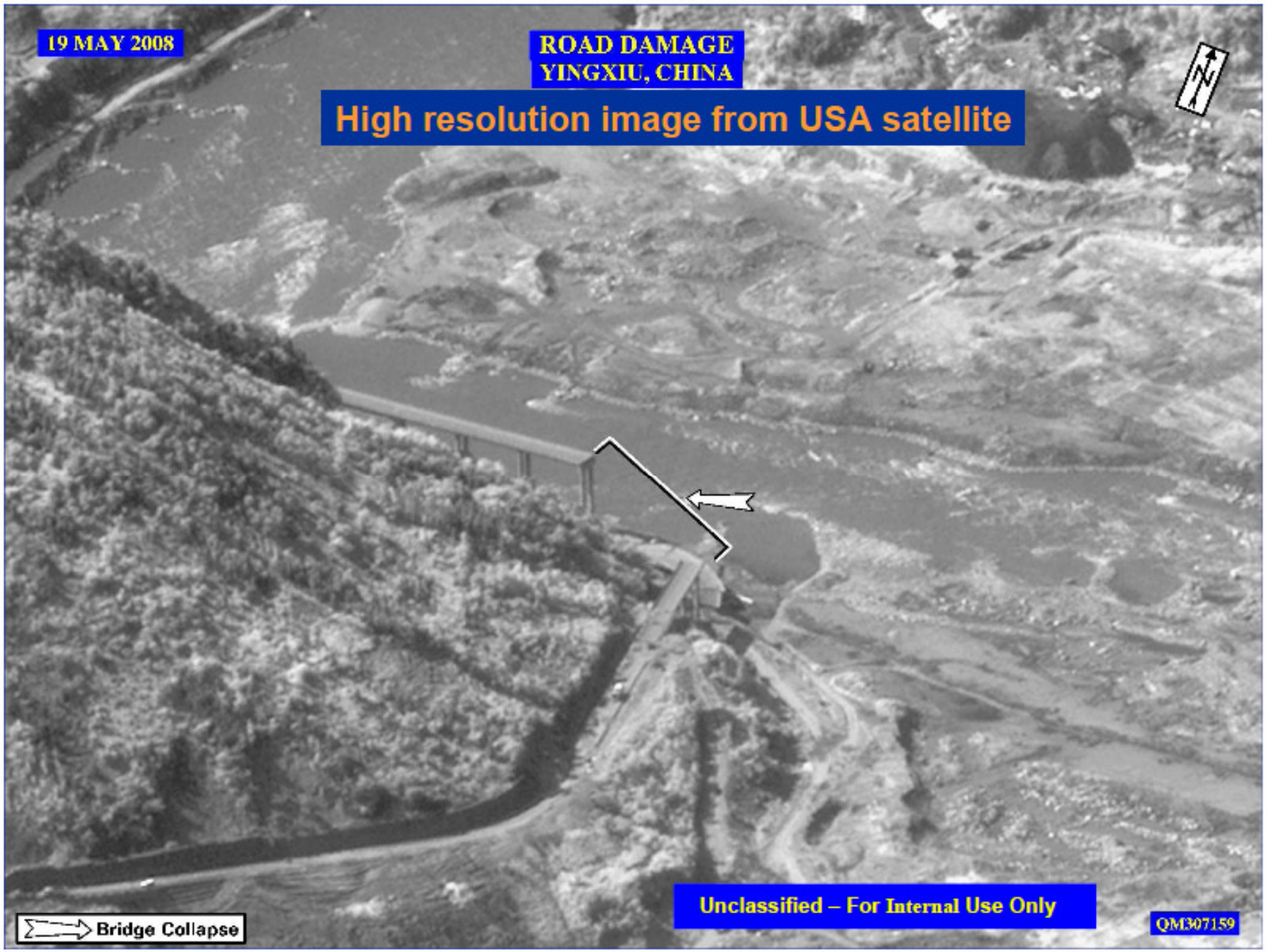
Two Highlight Articles in May of PE&RS Issue

On 14:28, May 12 2008,

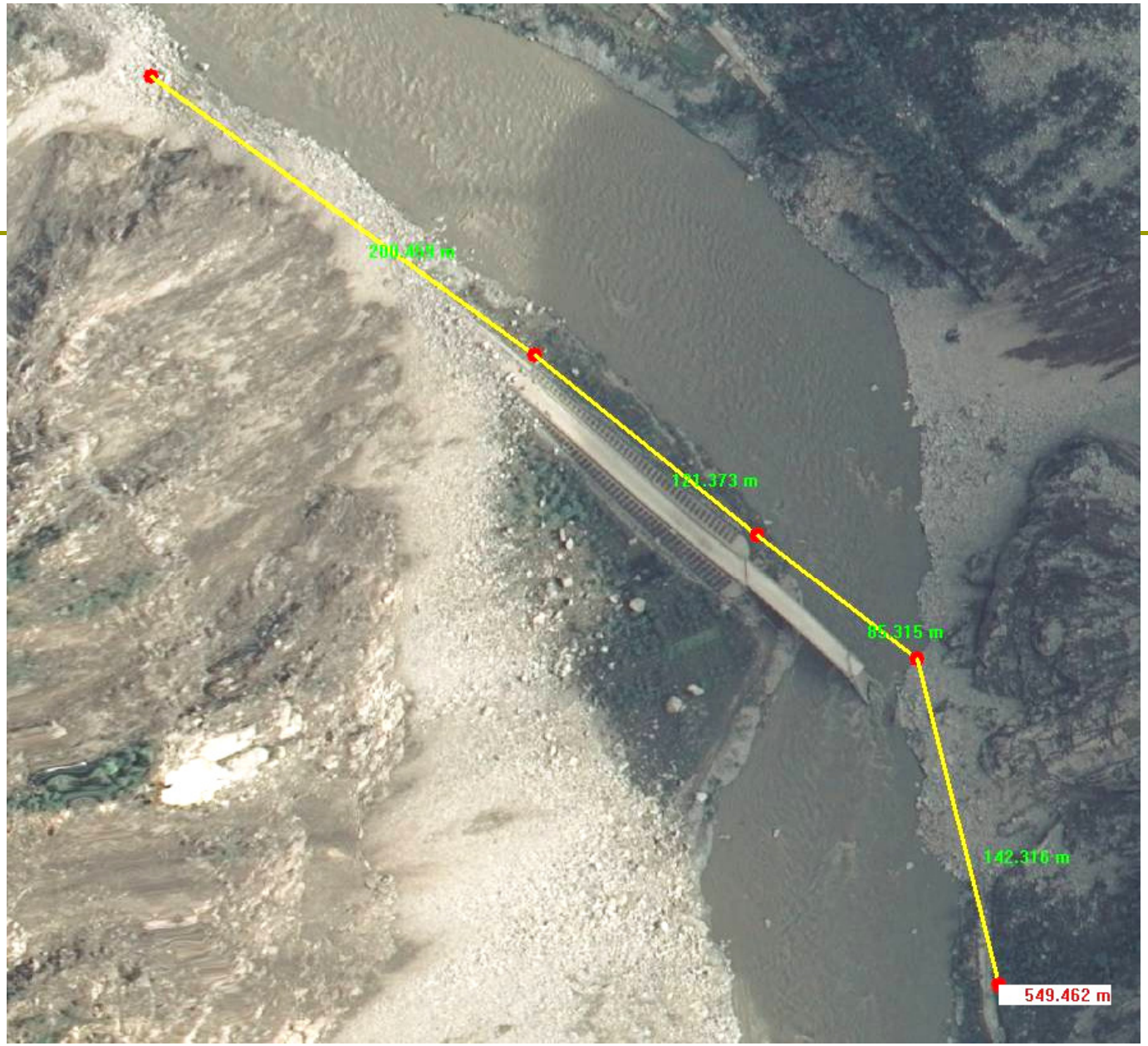
Earthquake with 8.0 grade was happened in Wenchuan County of Sichuan Province


N
W
E
S
1018
982
945
909
873
837
801
764
728
692
barrier dam
0 0.5 1 2 3 4 5 Kilometers

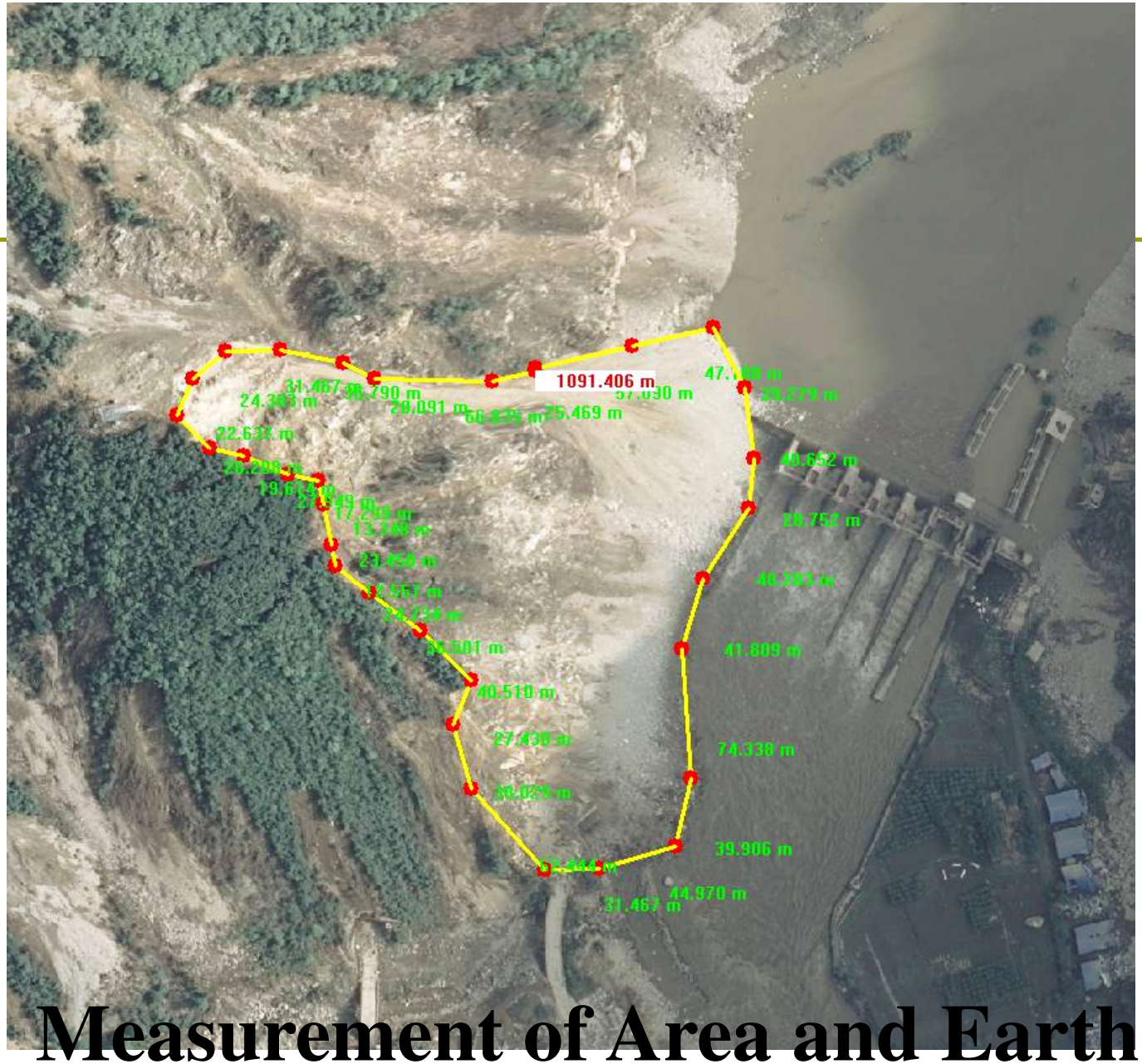
Airborne LiDAR Data


19 MAY 2008
ROAD DAMAGE
YINGXIU, CHINA
High resolution image from USA satellite
N
Bridge Collapse
Unclassified – For Internal Use Only
QM307159

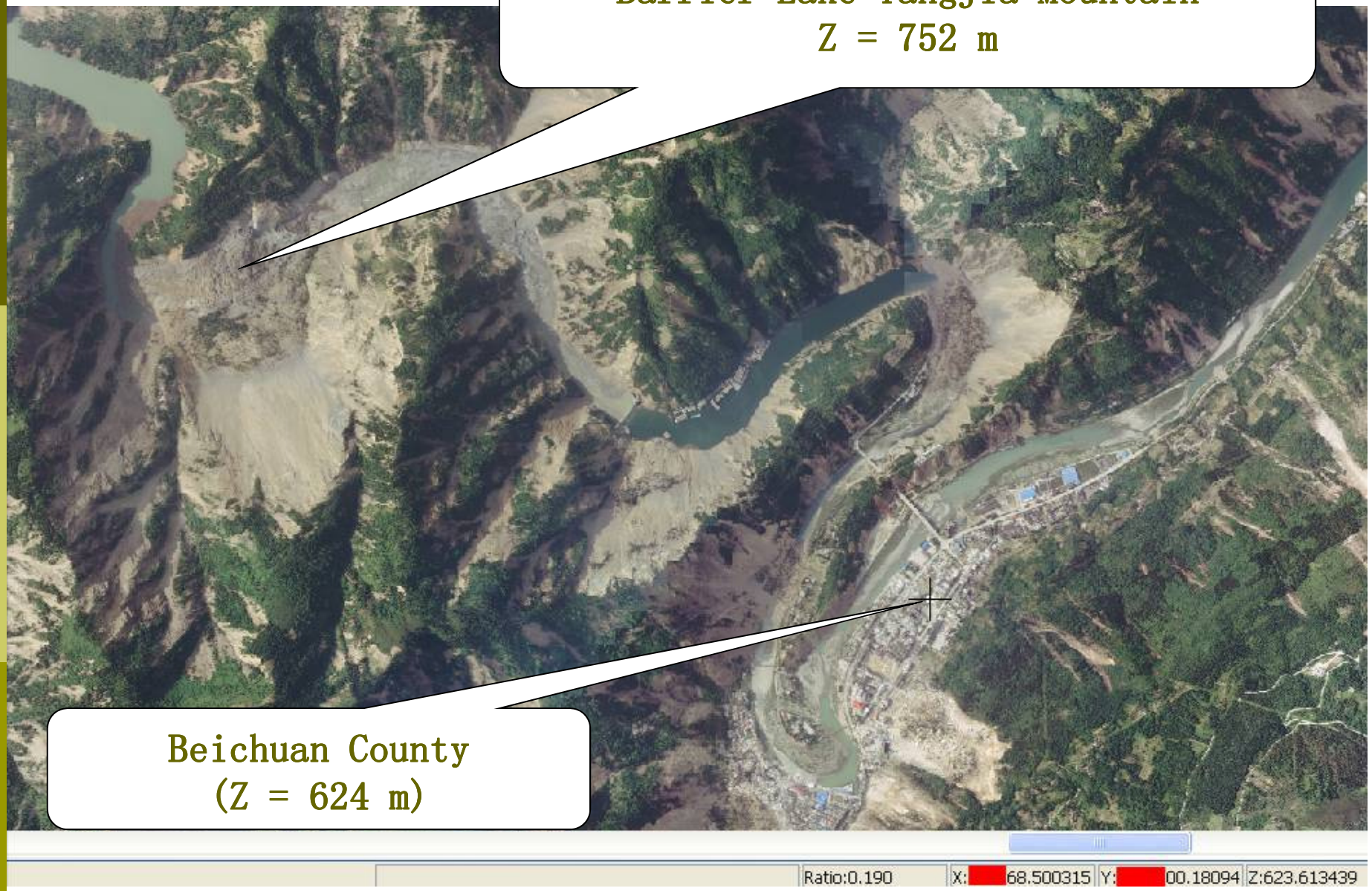

19 MAY 2008
EARTHQUAKE DAMAGE TO ROADWAY ON DAM
ZIPINGPU DAM, CHINA
Concrete barrier on roadway missing
Debris on dam
紫坪铺大坝变形
Unclassified – For Internal Use Only
KN492828



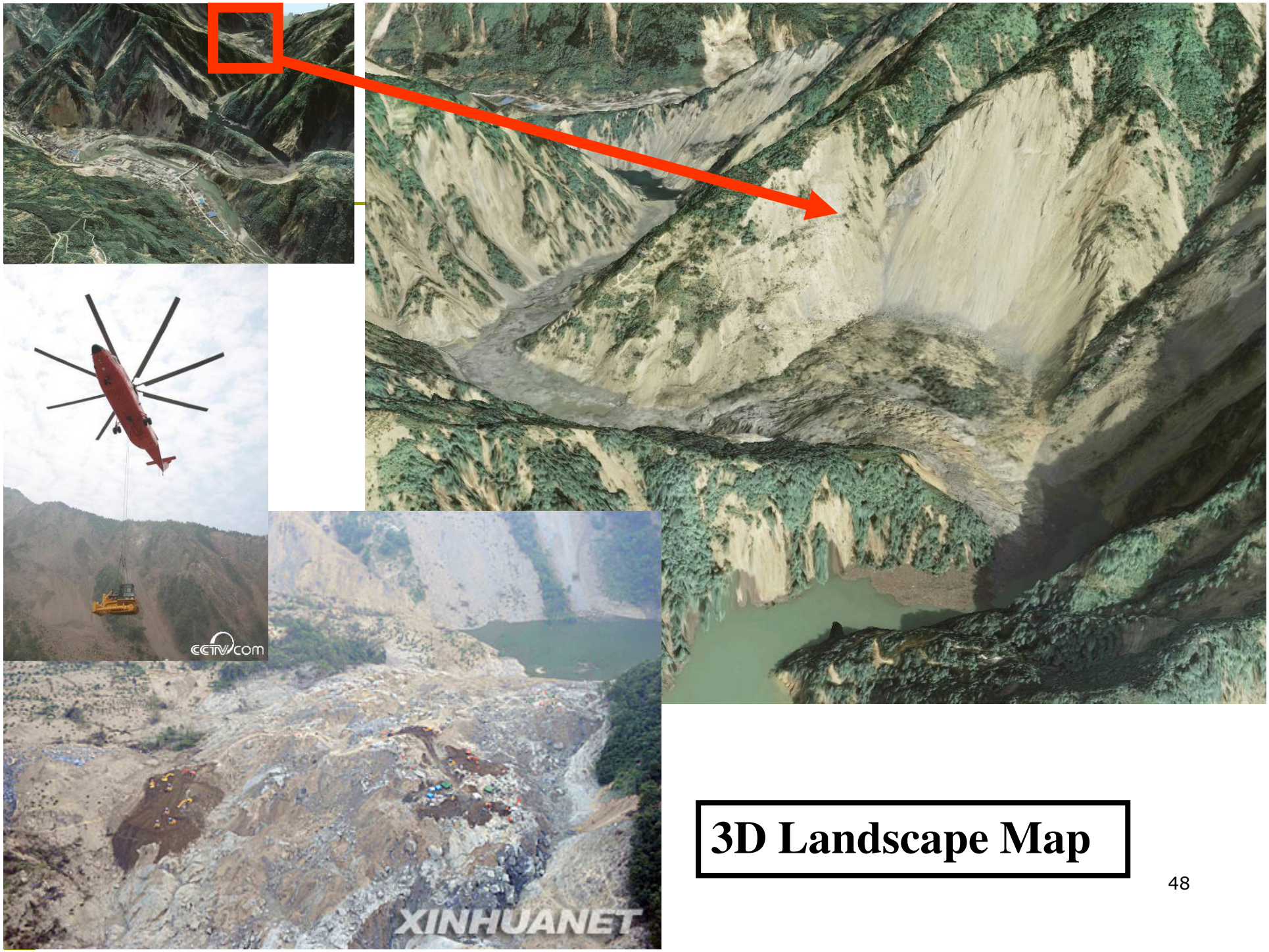
Measurement of Distance on Ortho



Measurement of Area and Earth Volume on Ortho and DEM



Ortho + DEM => 3D Coordinate Measurement

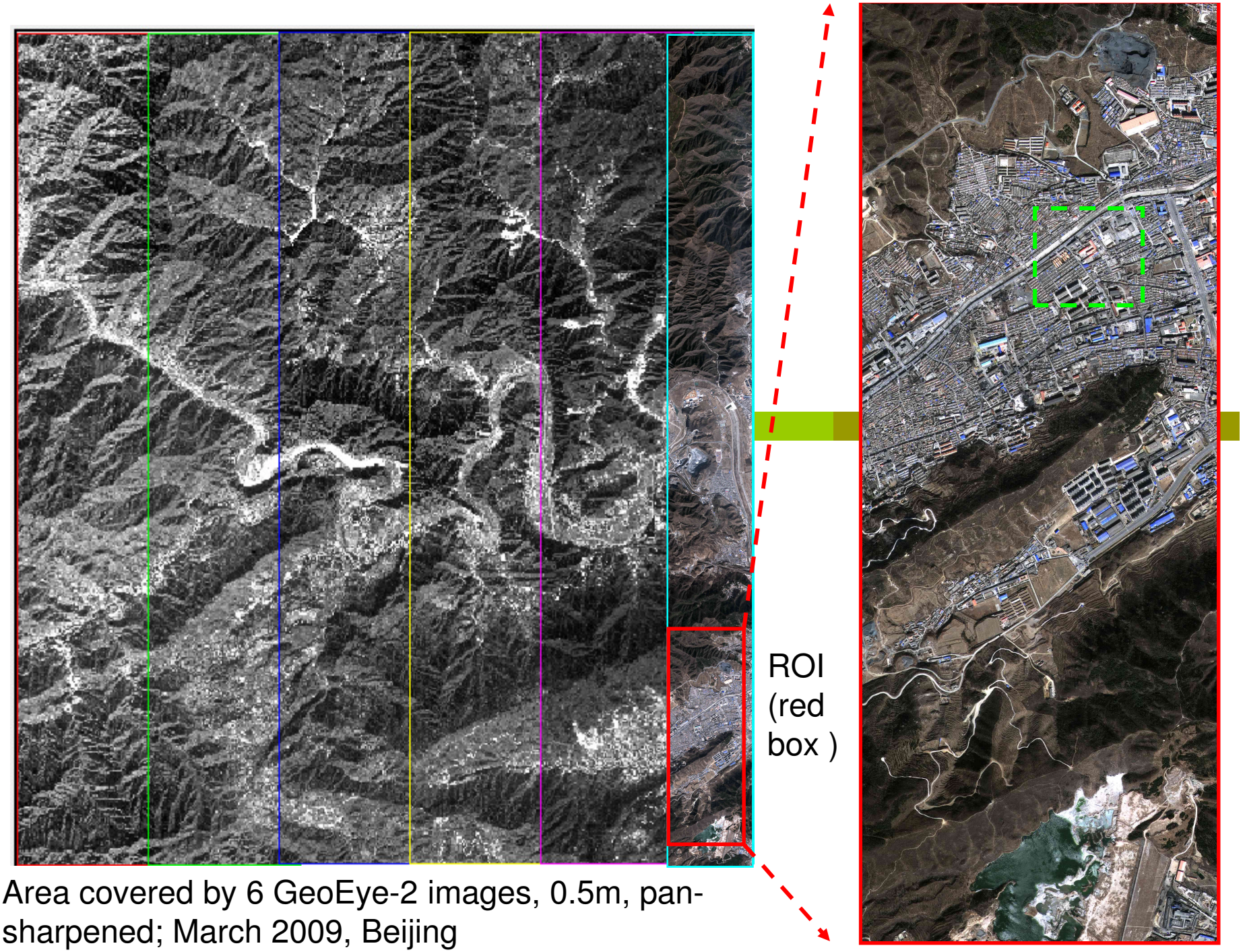


3D Landscape Map

Providing Surveying Data For Rebuilding of Disaster Area

Higher resolution images are available

GeoEye -1



Area covered by 6 GeoEye-2 images, 0.5m, pan-sharpened; March 2009, Beijing

Detail in urban area; GeoEye-1; Beijing

Some experience/lessons

- Timely and proper data acquisition
  - Delayed; cloud; SAR vs optical; resolution; georeferencing; access; communication; etc..
- Sensor web and network
  - Data collection and info service/sharing
- Rapid processing
  - Large volume, multiple sensors, 3-D
- Coordination
  - Top-down, plan ahead
  - Multi institutions
  - High resolution data ?
  - Common platform(s) ?
- Inventory – what can we do ? How well, who ?

Contacts

- A Google Earth view is available at

  https://engineering.purdue.edu/CE/floodmaps/main.htm

- Jie Shan, jshan@purdue.edu

- Comments & Questions ?

Backup slides

Damage Assessment – QuickBird

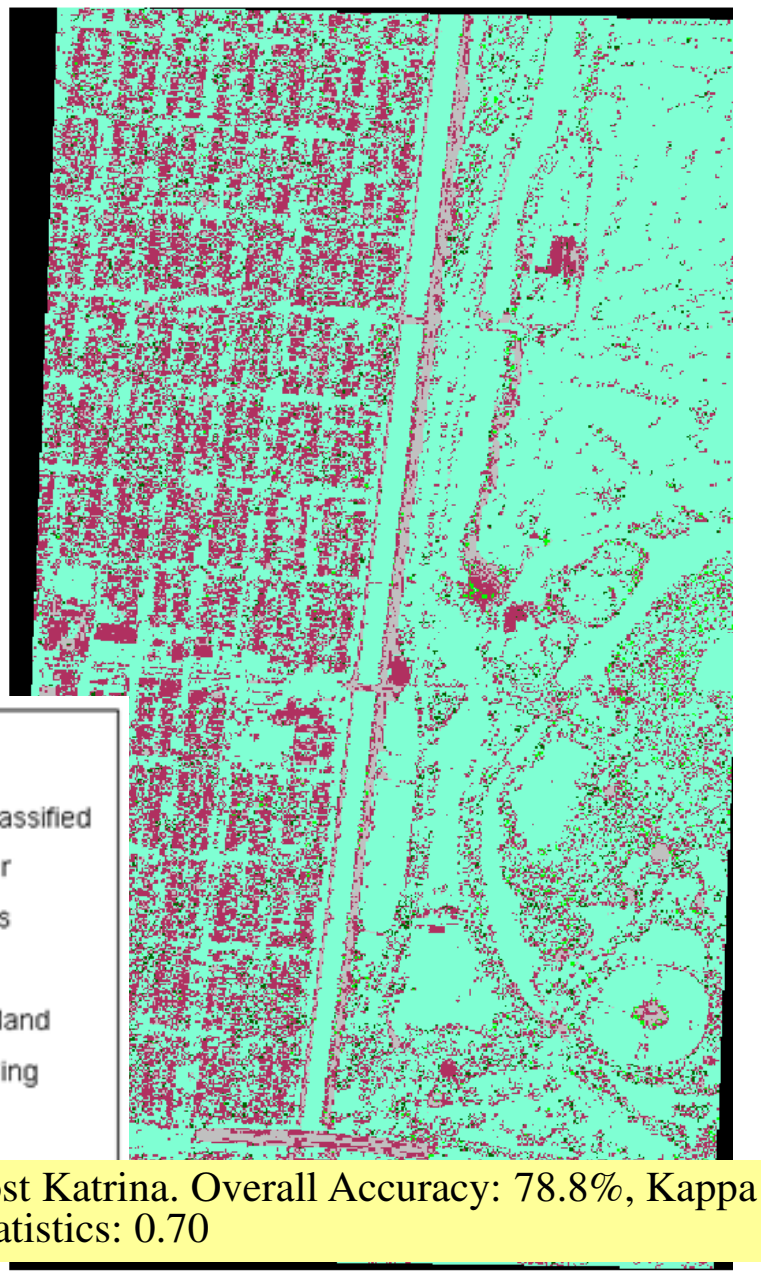
Classes	Pre Katrina (No. of cells)	Post Katrina (No. of cells)	Change (No. of cells)	Area change (km^2)	Change Rate (%)
Building	4,803,261	4,133,656	- 669,605	-3.86	-13.94
Road	3,511,499	1,433,871	-2,077,628	-11.97	-59.17
Bare land	933,339	248,826	-684,513	-3.94	-73.34
Tree	2,735,189	1,167,207	-1,567,982	-9.03	-57.33
Grass	1,607,435	701,376	-906,059	-5.22	-56.37
Water	2,667,168	7,885,543	+5,218,375	30.06	+195.65

Damage Assessment - Ikonos

Input data : Ikonos images (Aug '02 & Sep.02 '05, GSD: 1m)

Damage Assessment - Ikonos

Pre Katrina, Overall Accuracy: 65.8 %, Kappa Statistics: 0.56



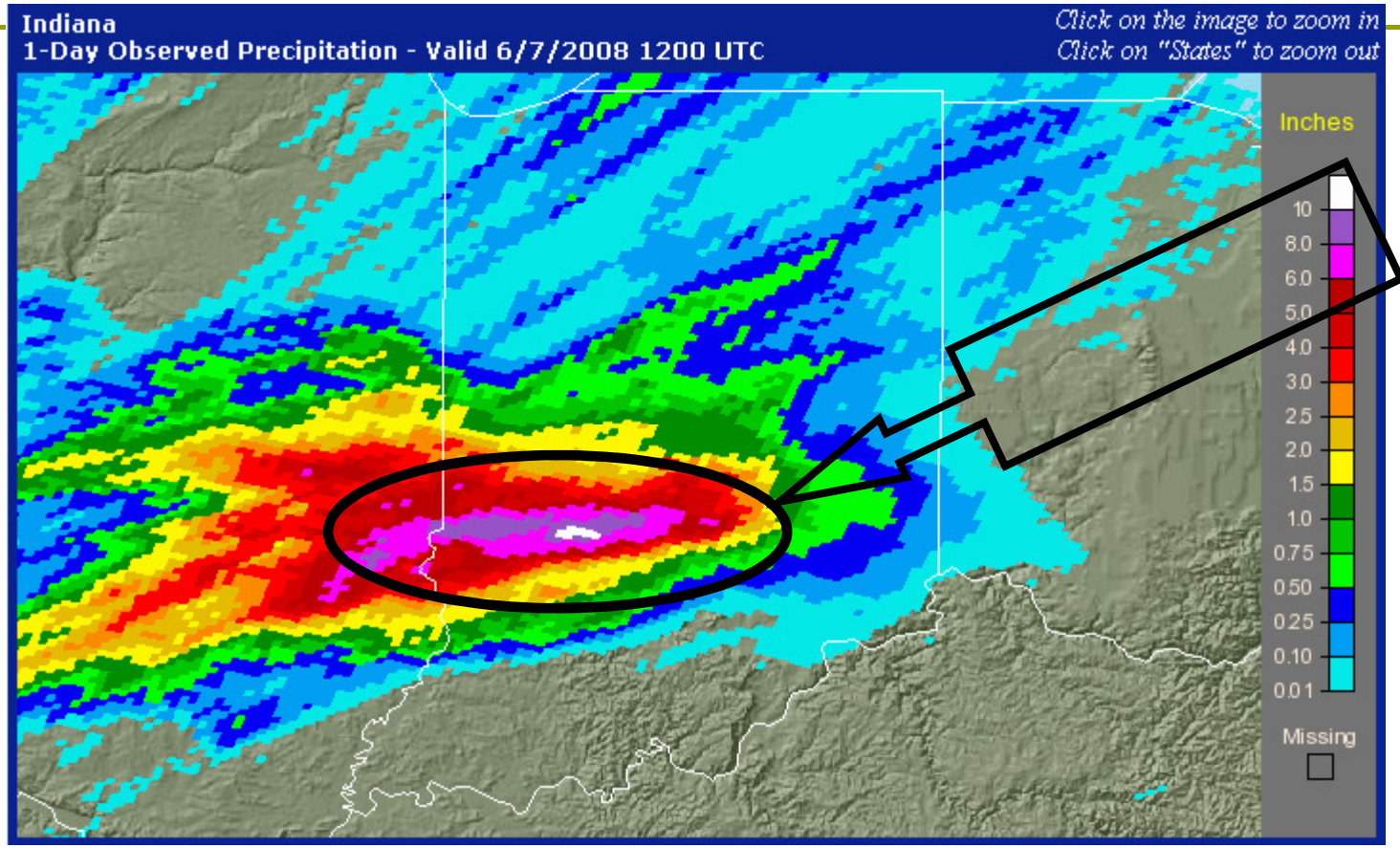
Post Katrina. Overall Accuracy: 78.8%, Kappa Statistics: 0.70

Damage Assessment - Ikonos

- Bare lands are completely disappeared
- Most grasses are submerged.
- The amount of water increased more than 2.8km^2 and this area is severely submerged.

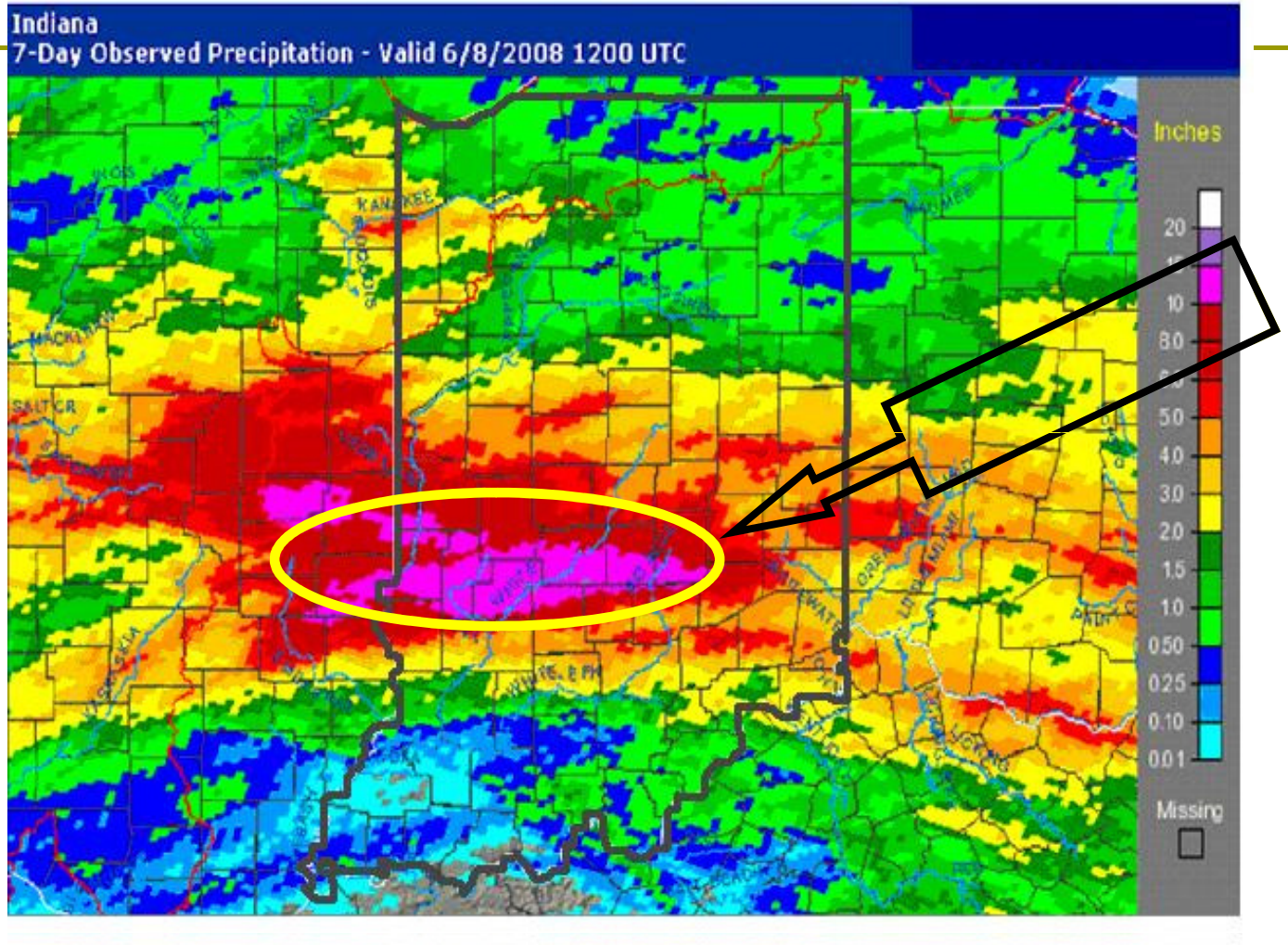
Class	Pre Katrina	Post Katrina	Change (No.of cells)	Area change (km^2)
Building	1,559,902	1,104,244	-455,658	-0.45
Road	852,990	221,400	-631,590	-0.63
Bare land	234,045	0	-234,045	-0.23
Tree	768,315	84,191	-684,124	-0.68
Grass	784,502	23,874	-760,628	-0.76
Water	216,502	2,997,937	2,781,435	2.8

PRECIPITATION ON JUNE 7, 2008



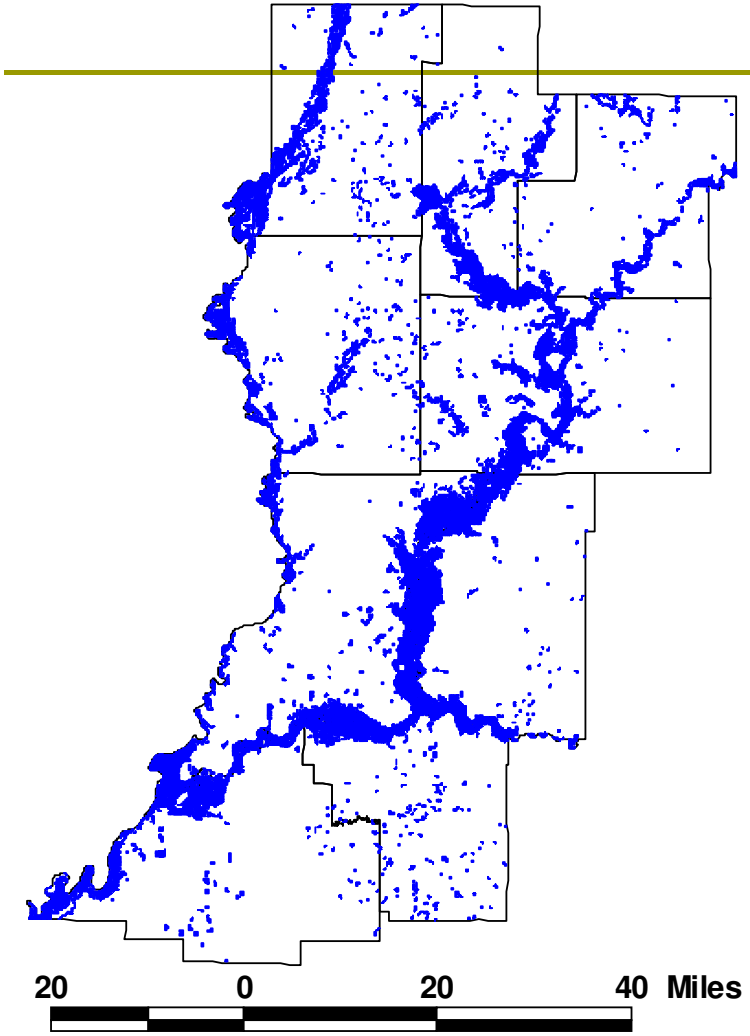
Courtesy National Weather Service

PRECIPITATION ON JUNE 1-7, 2008

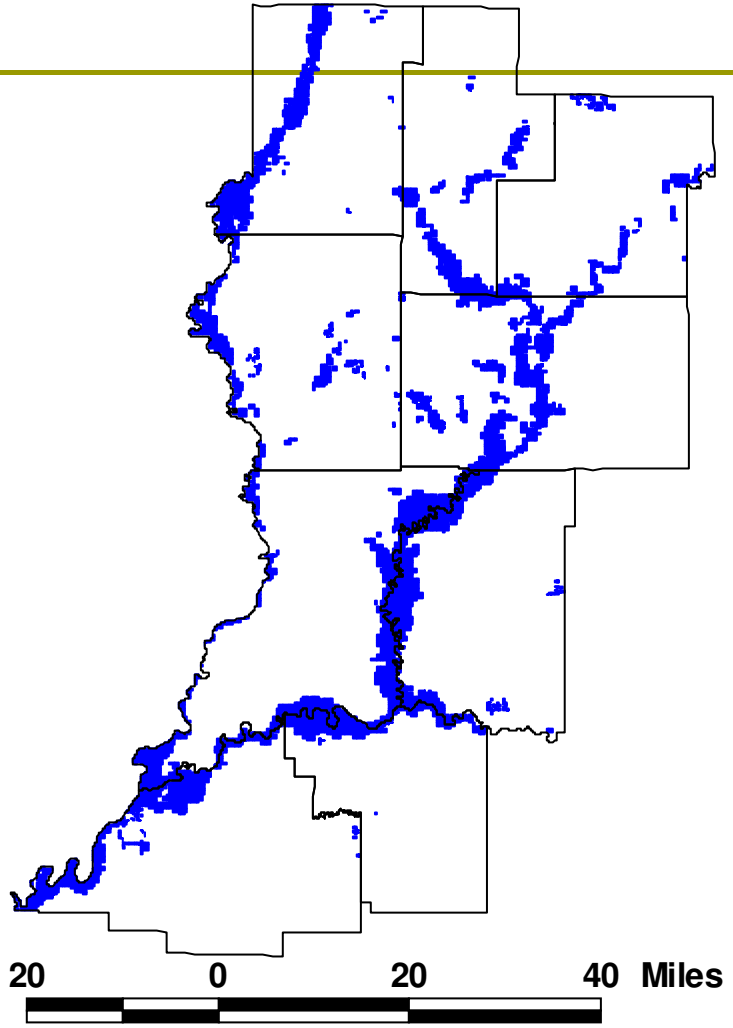


Courtesy National Weather Service

COMPARISON-LANDSAT - MODIS FLOOD EXTENT



LANDSAT FLOOD WATER

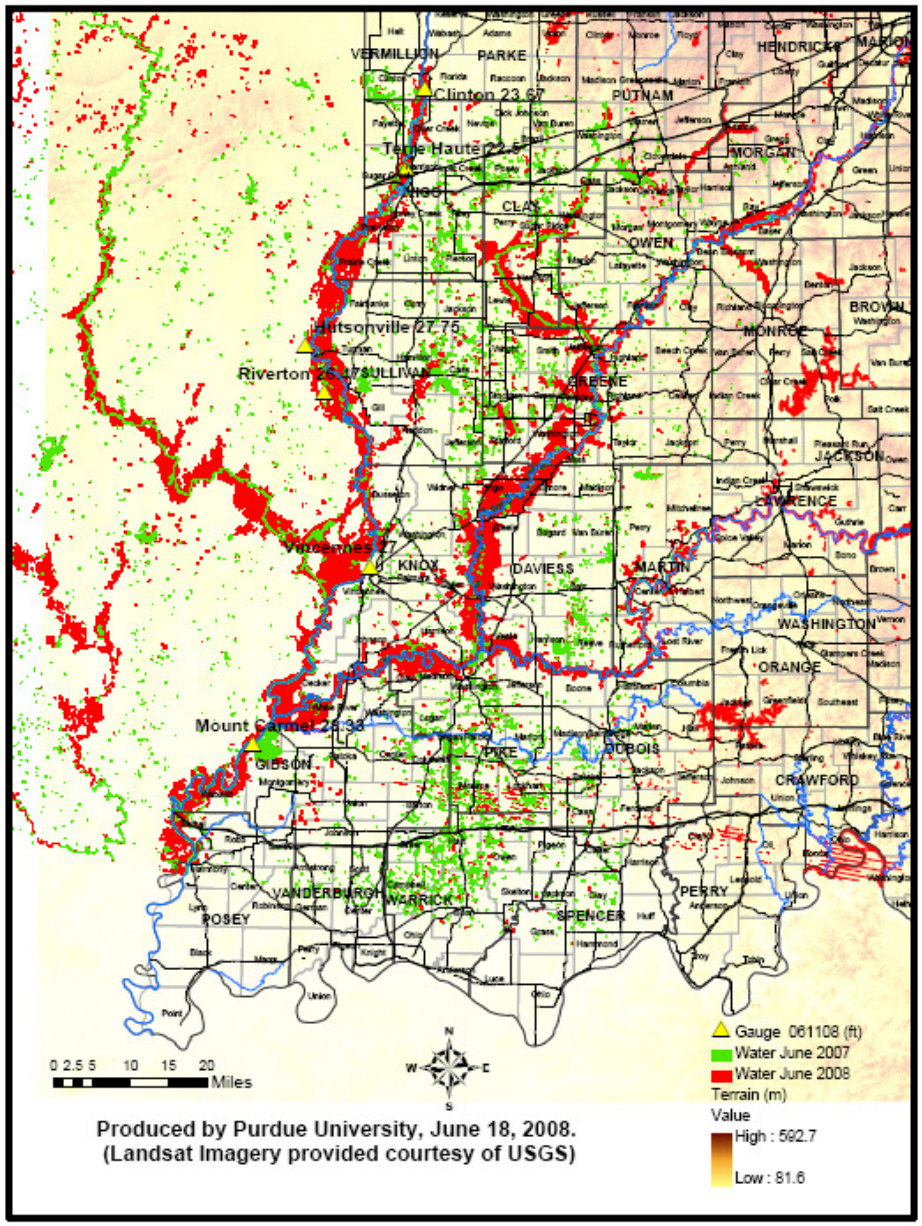


MODIS FLOOD WATER

CROP DAMAGE SUMMARY-NINE COUNTIES

	Crops area under flood (Hectare)				
County	Corn	Soybean	Wheat	Pasture, Hay	Forest, Shrubs
Vigo	3433.91	2480.58	16.57	1005.67	1389.36
Clay	3512.74	2842.43	14.41	843.10	668.00
Owen	1326.77	627.42	49.86	771.43	1375.58
Sullivan	2071.00	1080.13	40.46	789.23	1759.27
Greene	6569.62	2834.42	69.69	1000.63	2487.72
Knox	9234.10	5299.93	132.17	579.29	2406.40
Daviess	6406.31	2646.57	132.18	1118.35	1192.62
Pike	2364.52	1393.75	5.31	228.21	1558.00
Gibson	3498.98	2523.37	68.46	715.55	2161.11
Total Area	38418.00	21728.60	529.12	7051.46	14998.00

Southern Indiana June 11/12 2008 Flood Map

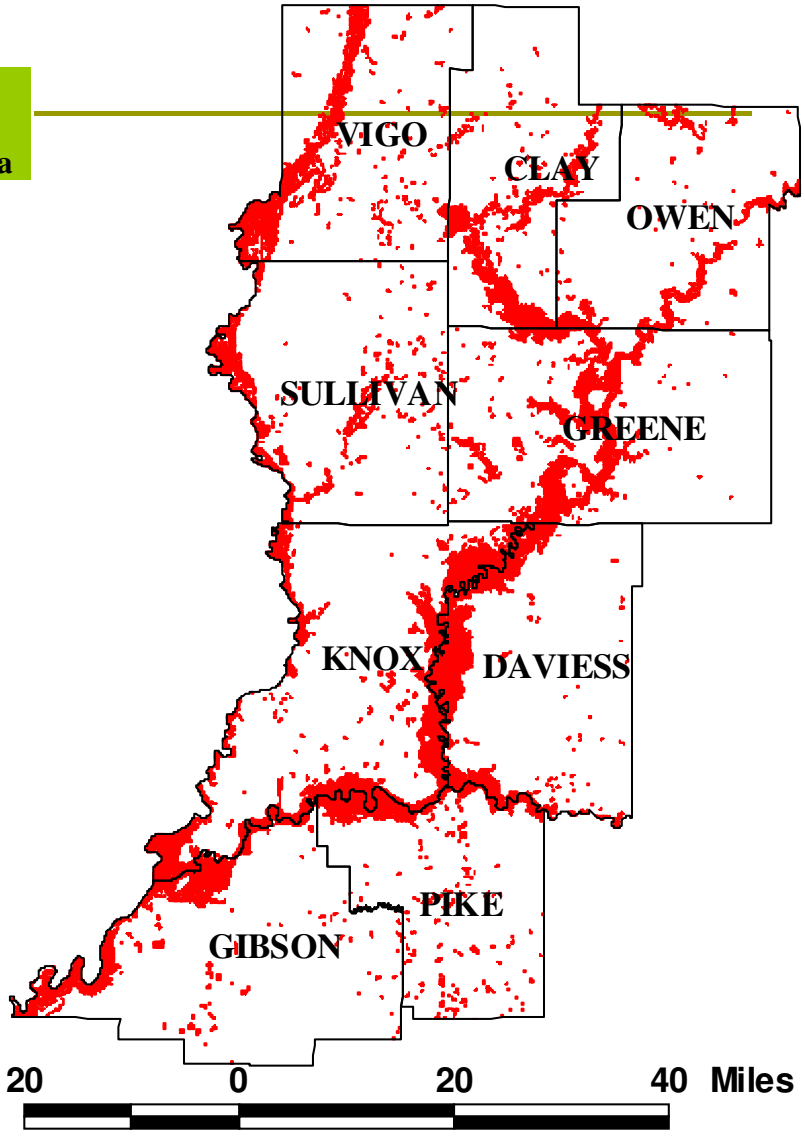


https://engineering.purdue.edu/CE/Academics/Groups/Geomatics/floodmaps

FLOOD EXTENT AND AFFECTED AREAS

County	Area (Hectares)	Flooded area (Hectares)	% Flooded area
Vigo	106223.63	10208.81	9.61
Clay	93237.00	8271.91	8.87
Owen	100316.70	4359.36	4.34
Sullivan	117464.82	6714.66	5.71
Greene	141291.13	14534.00	10.15
Knox	135653.03	20637.82	15.21
Daviess	113003.90	12708.89	11.24
Pike	88302.33	5994.00	6.79

Total Flood area = 93,000 Hectares
Excluding 2007 water



INDOT Road Closures/Restrictions Due to Flooding

July 1 - 8:00 AM

Road	Status	District	County	Direction(s)	Starting Location	Ending Location
SR 42	Closed	Crawfordsville	CLAY	both	Corey Rd	CR 300 W-Clay
SR 246	Closed	Crawfordsville	VIGO	both	All Street	Dickerson St
SR 42	Closed	Crawfordsville	OWEN	both	US 231	SR 59
SR 46	Closed	Seymour	Owen	Both	SR 67	SR 246
SR 144	Closed	Seymour	Morgan	Both	SR 37	SR 67
SR 157	Closed	Vincennes	Greene	Both	SR 54	SR 67
SR 58	Closed	Vincennes	Daviess	Both	SR 67	SR 57
SR 57	Closed	Vincennes	Greene	Both	SR 58	SR 54
SR 257	Closed	Vincennes	Daviess	Both	US 50	SR 356
SR 66	Restricted	Vincennes	Posey	Both	IL Line	SR 69

http://www.in.gov/dot/gis/slo/RoadCloseText.pdf

Brief function list

- Display of background imagery (satellite & aerial) provided by Google Earth
- Display of predefined layers (terrain, borders, roads and 3D models)
- Placement of KML, KMZ and 3D models
- Creation and placement of geometry objects (placemark, line and polygon)
- Mouse and keyboard event management for customization and user interface

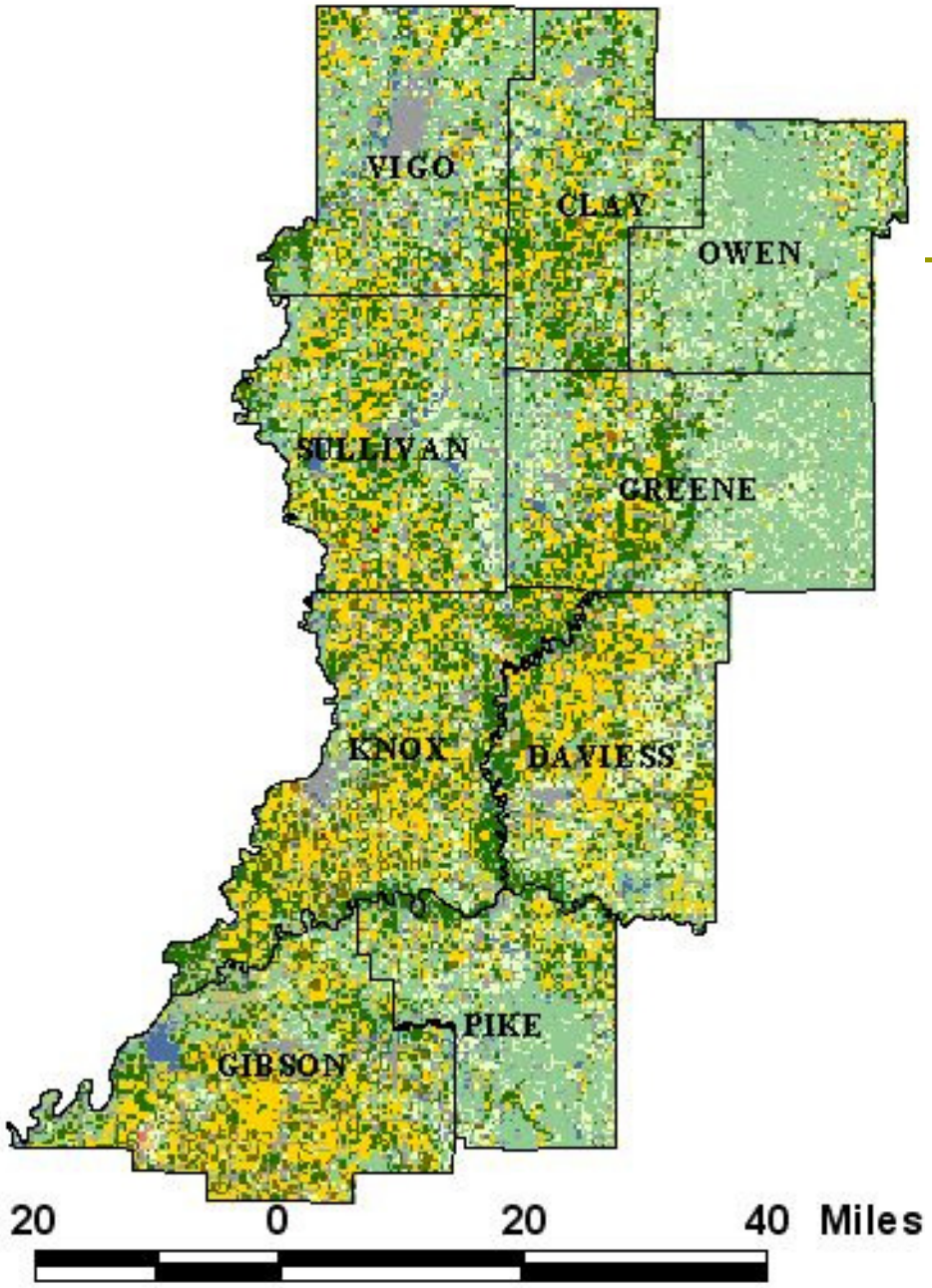
Google Earth plug-in

- Released in the end of May, 2008.
- Most of Google Earth visualization functionalities can be embedded into one's own website.
- Google Earth plug-in add-on is installed on client computer.
- Javascript library (GE-API) is provided for customization.
- Currently support the following OS and browser:

  -Windows 2000, XP, Vista (IE 6.0+,FireFox2.0+ , Flock 1.0+)

  -Apple Mac OS X 10.4 and higher (Safari 3.1+,Firefox 3.0+)
- Data is published in KML or KMZ formats.

2008 CDL Release

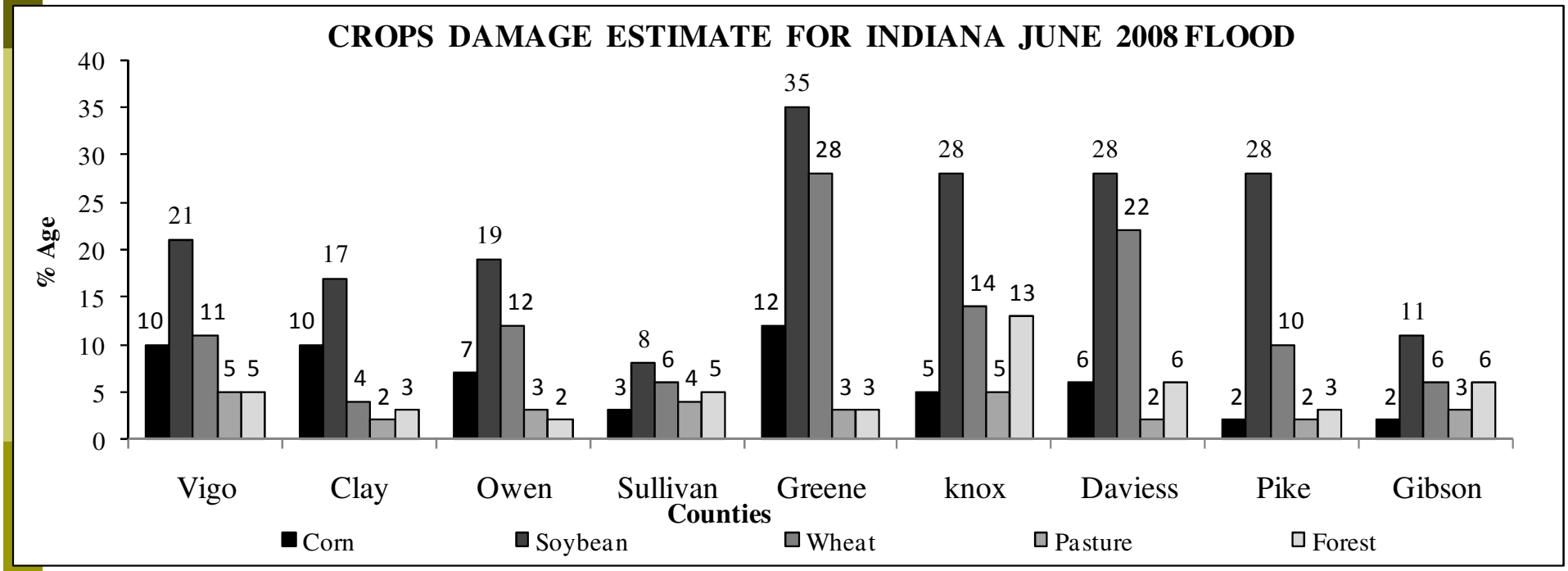


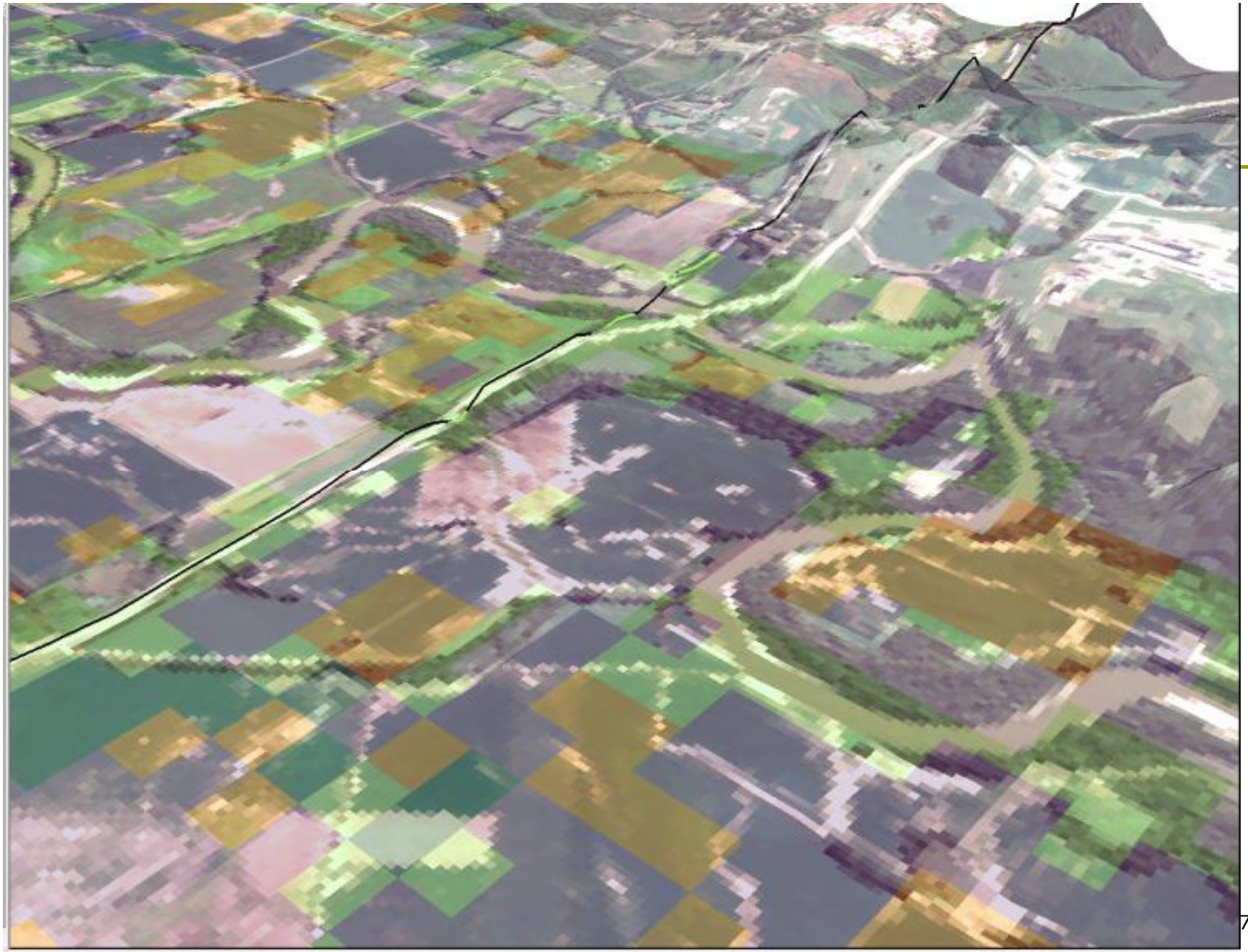
March 1x 2009

Damage from CDL 2008 Data

	Crops area under flood (Hectare)				
County	**Corn**	**Soybean**	**Wheat**	**Pasture, Hay, Grass**	**Forest, Shrub**
Vigo	1823	3911	49	680	1675
Clay	1586	4058	23	208	1025
Owen	393	1336	31	510	1539
Sullivan	752	1994	18	647	1633
Greene	1607	7315	118	652	2061
Knox	1852	10496	63	526	2604
Daviess	1682	6544	38	297	1359
Pike	252	3265	2	249	1071
Gibson	780	2543	5	293	1362
Total Area 08 Total Area 07	10728 38418	41462 21728	347 529	4062 7051	14329 14998

Damage from CDL 2008 Data






Distance: 0.142 Kilometers