

# Addressing Large-Scale Conservation Issues:

## The Impacts of Mountaintop Removal Mining to Rare, Threatened, and Endangered Species

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# What is Mountaintop Removal?

- Box Cut Mining
- Cross-Ridge Mining
- Steep Slope Mining
- Area Mining
- Mountaintop Mining

**Any mining that places overburden into valley fills**

# Blasting



# Dragline





# Valley Fill

# Processing



# Impoundments



# Martin County, KY Sludge Disaster Oct. 2000



Associated Press Photo

# Reclamation



# Reclamation



# Impacts to Communities:

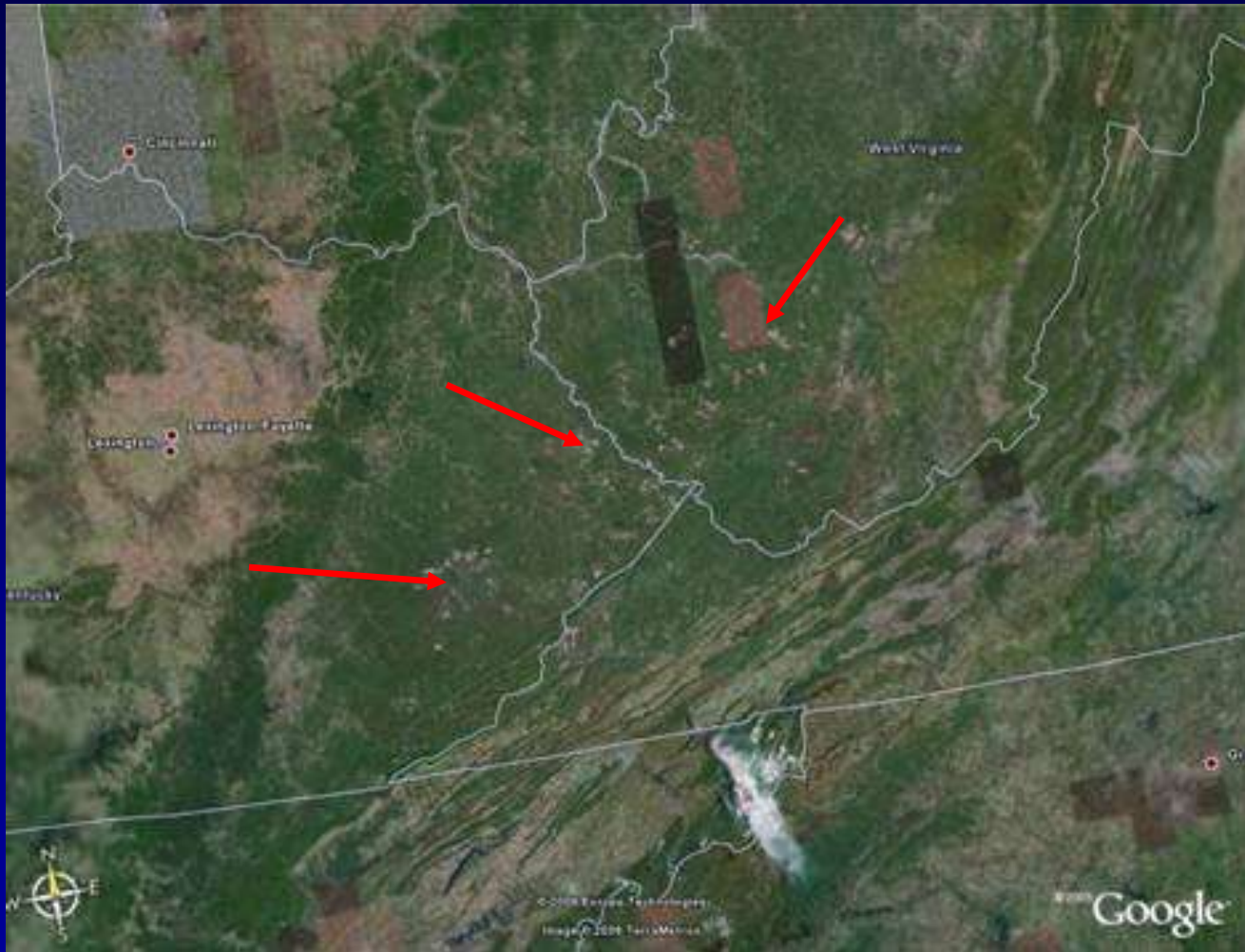
## Polluted Drinking Water



© Melissa Farlow/Nat Geographic

**Mingo County, WV**

# Scale and Current Extent



**Appalachian Surface Mining Activity visible from Space**

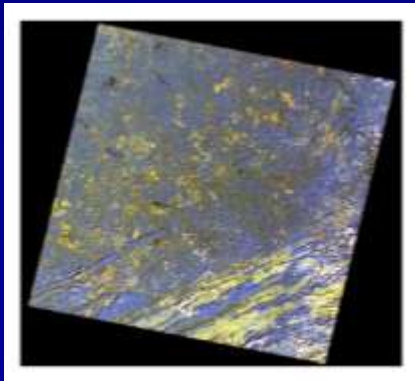
# Methods: Data Used (Geredien 2006)



**2003 Statewide Addressing and Mapping Board (SAMB) Aerial Imagery for West Virginia – 2 ft**



**2004 National Agricultural Imagery Program (NAIP) for Kentucky (1-meter)**



**LANDSAT TM Satellite Imagery, 4 tiles 7-5-4 band combination @ 30 m resolution**



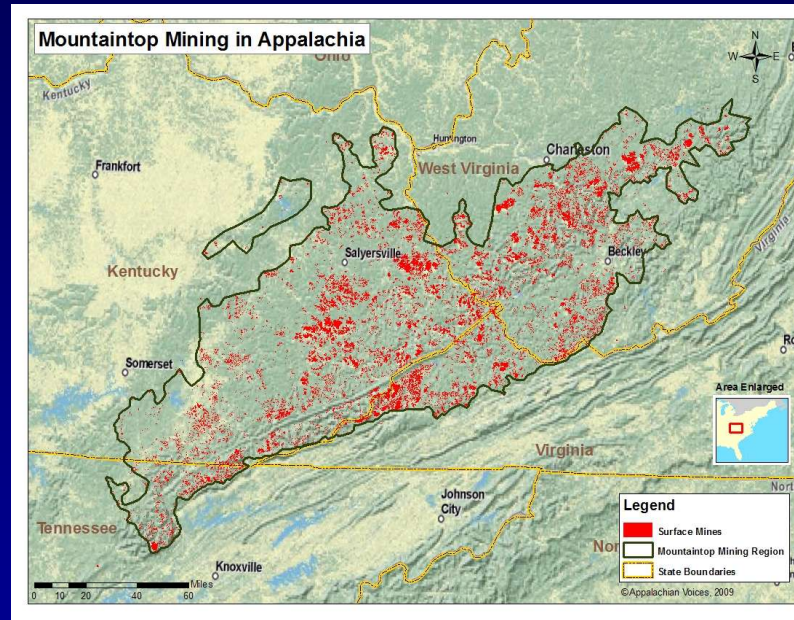
**Additional Info Gleaned from USGS Digital Topo Maps**

# Methods (cont.)

- Digitized Surface Mine Features Using Aerial Imagery and USGS Digital Topographic Maps
- Classified Mine Features into different types of Surface Mining; identified impoundments, processing plants, and other features.
- Performed Inventory using Image index grids as references: worked systematically along rows and columns.
- ~ 500 person-hours

# Results

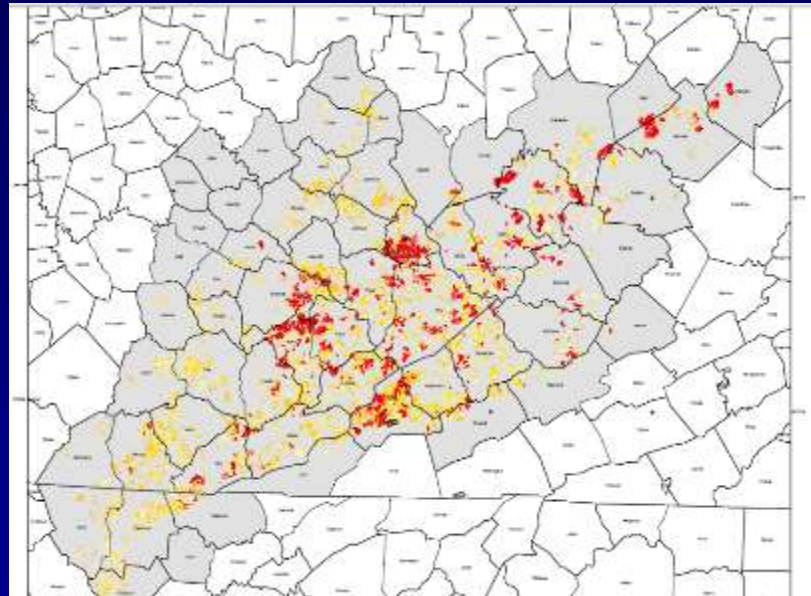
## The First-ever Spatially-explicit vector dataset on MTR (and Appalachian Surface Mining)



Approximately 764,000 acres of Surface mine features documented; Baseline year varies from 1990's thru 2004

# Remote Sensing

Campagna and Amos, 2007  
(Skytruth.org)



Used remote sensing and LANDSAT images (1975-2005) to conduct time change analysis. Spatially-explicit results, but vector features derived from remotely-sensed pixels = 100,000's of features. Classified into "MTR" and "other". Total area: 794,000 acres.

# Ecological Impacts: Rare and Endangered Species



Courtesy J. Pamell

Indiana Bat (*Myotis sodalis*) LE



© Illinois Natural History Survey

Clubshell (*Pleurobema clava*) LE

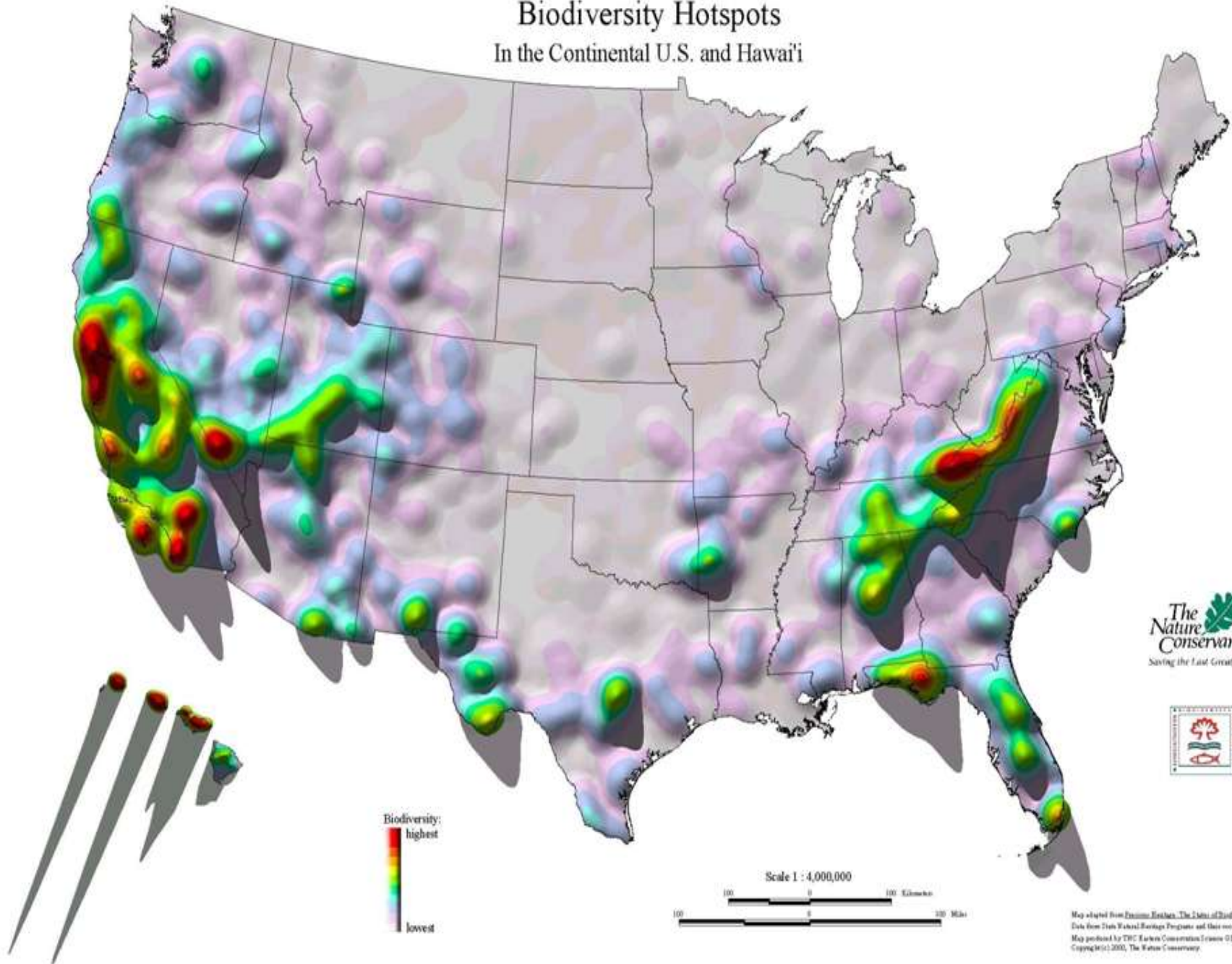


© Krischan Photography

Nodding Trillium (*Trillium flexipes*)

# Biodiversity Hotspots

In the Continental U.S. and Hawai'i



The Nature Conservancy  
Saving the Last Great Places



Map adapted from Eric R. Fausch, "The Status of Biodiversity in the United States,"  
Data from State Natural Heritage Programs and their cooperation.  
Map produced by TNC Eastern Conservation Science GIS, 5/5/00.  
Copyright © 2000, The Nature Conservancy.

# Appalachia: A Biodiversity Hotspot



© Shawn K. Staton / National Water Research Institute

**Northern Riffleshell (Endangered)**

- World's highest diversity of salamanders
- Clinch River: 50+ species of freshwater mollusks
- Dozens of G1-G3 aquatic elements (fish, crayfish, mollusks, etc), a large number of which are federally listed.



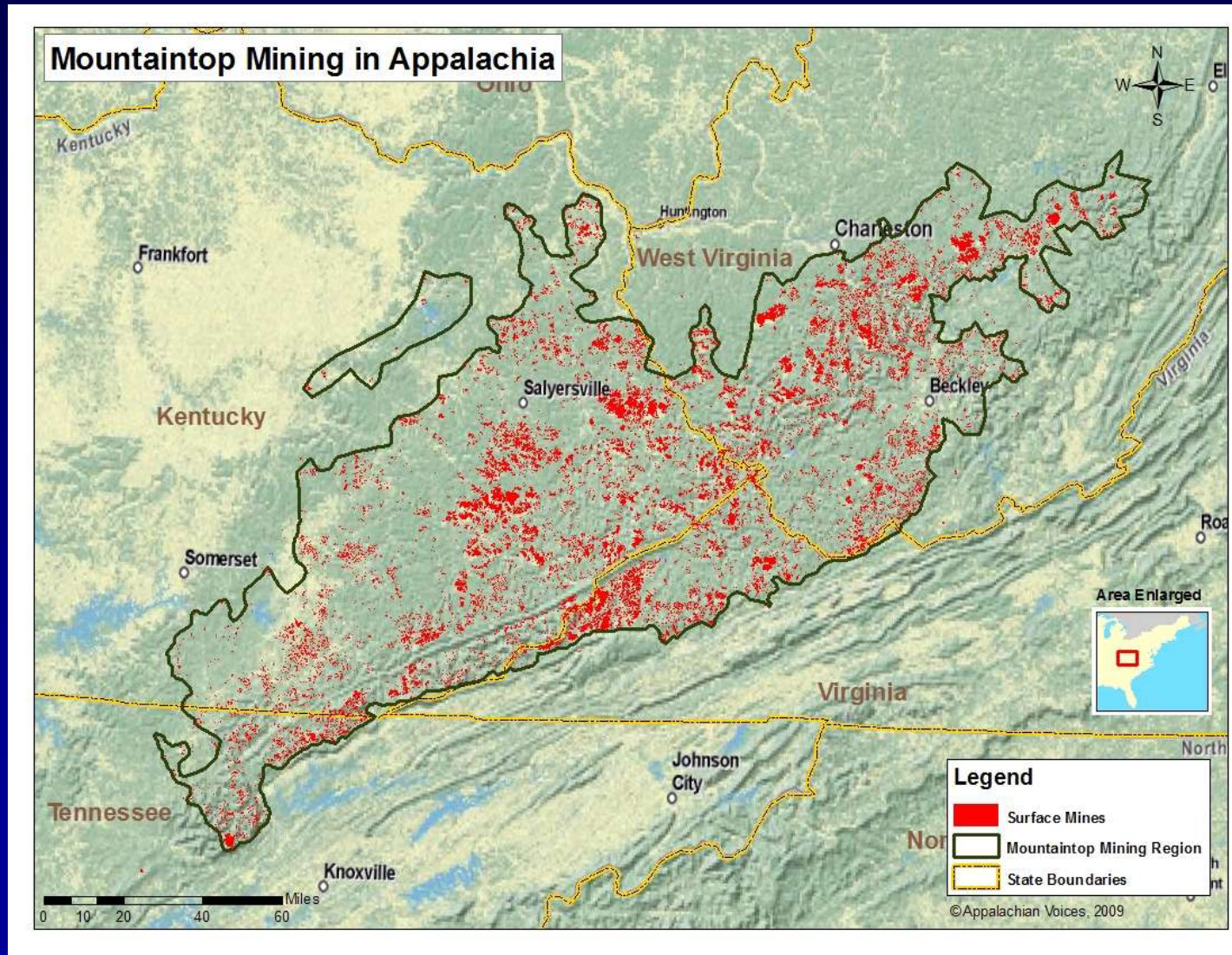
**Cumberland Elktoe (Endangered)**



© USFWS

**Blackside Dace (Threatened)**

# Project Area = > 10 million ac



# Methods

1. Acquired licenses to use Element Occurrence data from the four NHP's in the Region (VA, TN, KY, and WV).
2. Scenario 1: Assumed statistical spatial mean by using the centroid of each Element Occurrence.
3. Performed intersection with mine polygons
4. Scenario 2: Assumed maximum direct impact and included all uncertainty in intersection.
5. Sensitive species for Kentucky were “fuzzed” to quarter quad level.
6. Scenario 3: Proximity analysis to determine how many RTE occurrences are within 100m, 250m, and 500m of surface mine features. Assumption: impacts are not limited to “direct hits” but can also include downstream impacts and impacts from habitat loss and fragmentation, etc.

# Downstream Impacts



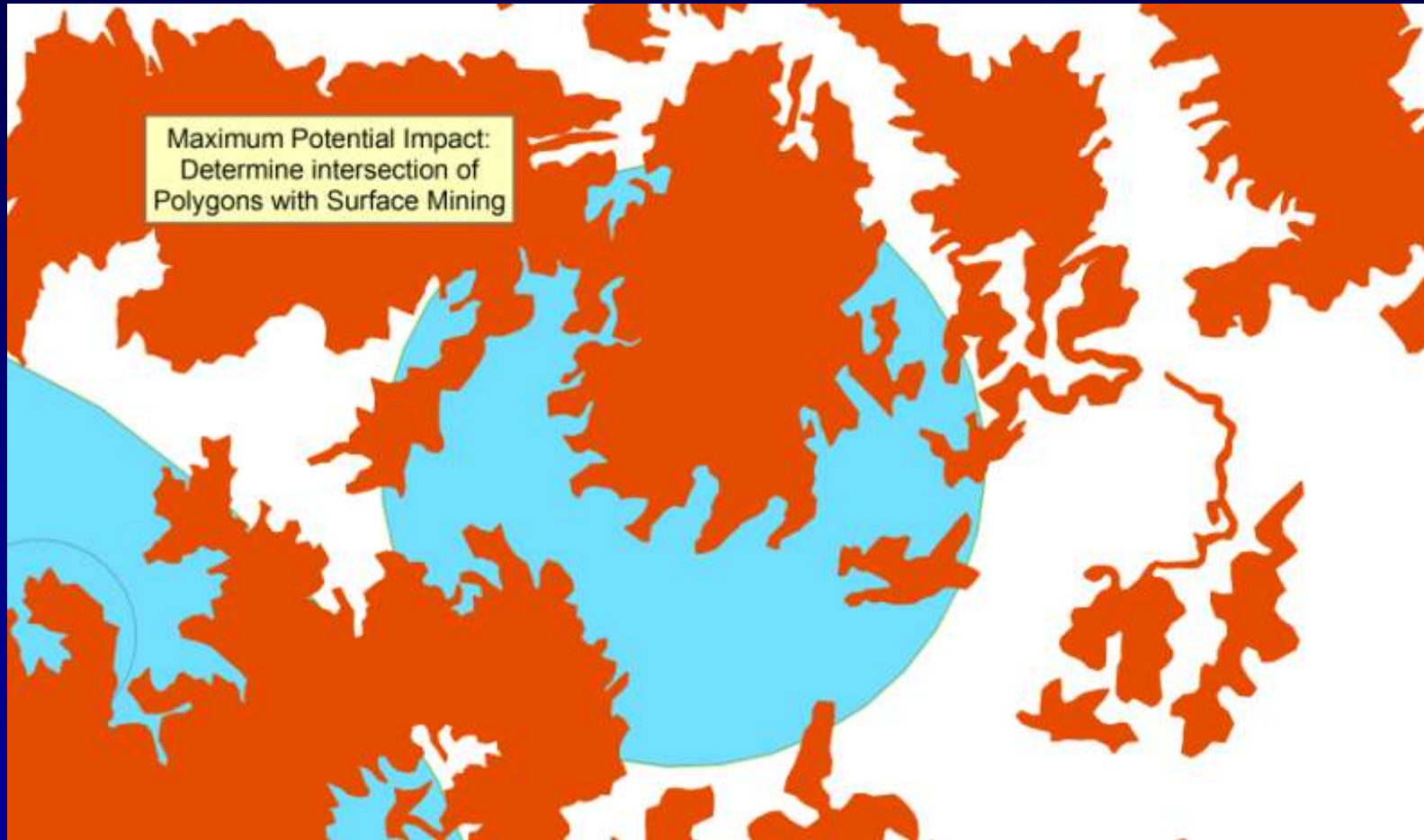
© Matt Wasson

- **Acid Mine Drainage**
- **Conductivity (Palmer et al 2010)**
- **Selenium (Lemly 1999, 2002)**
- **Heavy Metals, Mn, As**

# Methods: Scenario I



# Methods: Scenario II



# Preliminary Results

- ~ 40 RTE species have been directly impacted by surface mining (Mean Scenario) based on 2007 available data.
- As many as 120 RTE species may be suffering direct impacts including incidental take (Maximum Scenario)
- 15-25 additional aquatic species are experiencing significant downstream effects from pollution runoff

# Preliminary Results (Cont.)

## Kentucky

<b>Category</b>	<b>EO's Impacted (Min-Max)</b>	<b>% Impacted**</b>
Critically imperiled (G1):	1-27	2.1-56.2%
Imperiled and Globally rare (G2):	10-47	4.8-22.5%
Globally Vulnerable (G3):	4-64	1.9-31%

## West Virginia

<b>Category</b>	<b>EO's Impacted (Min-Max)</b>	<b>% Impacted**</b>
Critically imperiled (G1):	N/A	N/A
Imperiled and Globally rare (G2):	3-6	6.4-12.8%
Globally Vulnerable (G3):	7-69	2.7-26.5%

# Preliminary Results (Cont.)

## Virginia

<b>Category</b>	<b>EO's Impacted</b>	<b>% Impacted**</b>
Critically imperiled (G1):	1	1.9%
Imperiled and Globally rare (G2):	3	2.4%
Globally Vulnerable (G3):	2	3.0%

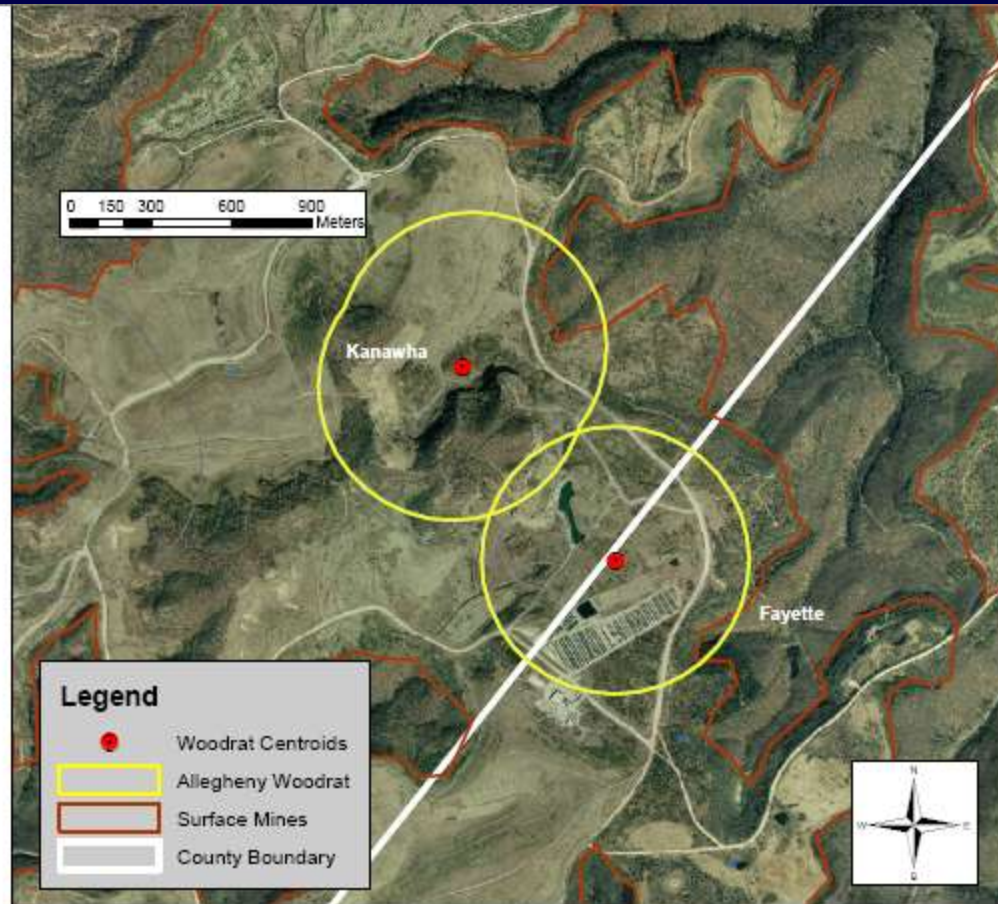
## Tennessee

<b>Category</b>	<b>EO's Impacted (Min-Max)</b>	<b>% Impacted**</b>
Critically imperiled (G1):	0	0%
Imperiled and Globally rare (G2):	0-1	0-0.8%
Globally Vulnerable (G3):	3-5	0.8-1.3%

Complete Species Lists Available Upon Request.



Indiana Bat (*Myotis sodalis*) occurrence wiped out by  
MTR, Letcher County, KY



Allegheny Woodrat  
(*Neotoma magister*)  
And Mountaintop Removal Mine  
Kanawha and Fayette Counties, WV  
Image Date: 2003

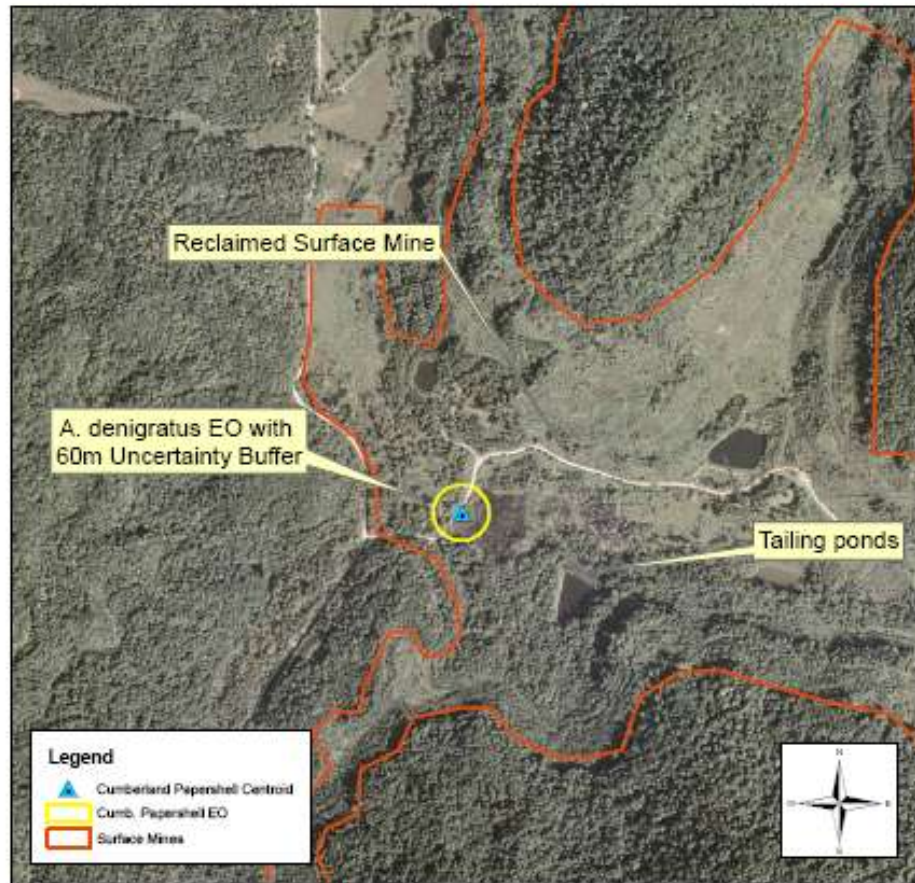


**Blackside Dace**  
*(Phoxinus cumberlandensis)*  
**And Mine Impoundments**

Letcher County, Kentucky

Observed Oct. 25, 1990

Image Date: 2004



Cumberland Papershell  
(*Anodontoides denigratus*)  
And Reclaimed Surface Mine  
Whitley County, Kentucky  
Observed May 22, 1997  
Image Date: 2004

# Draft Report - 2008



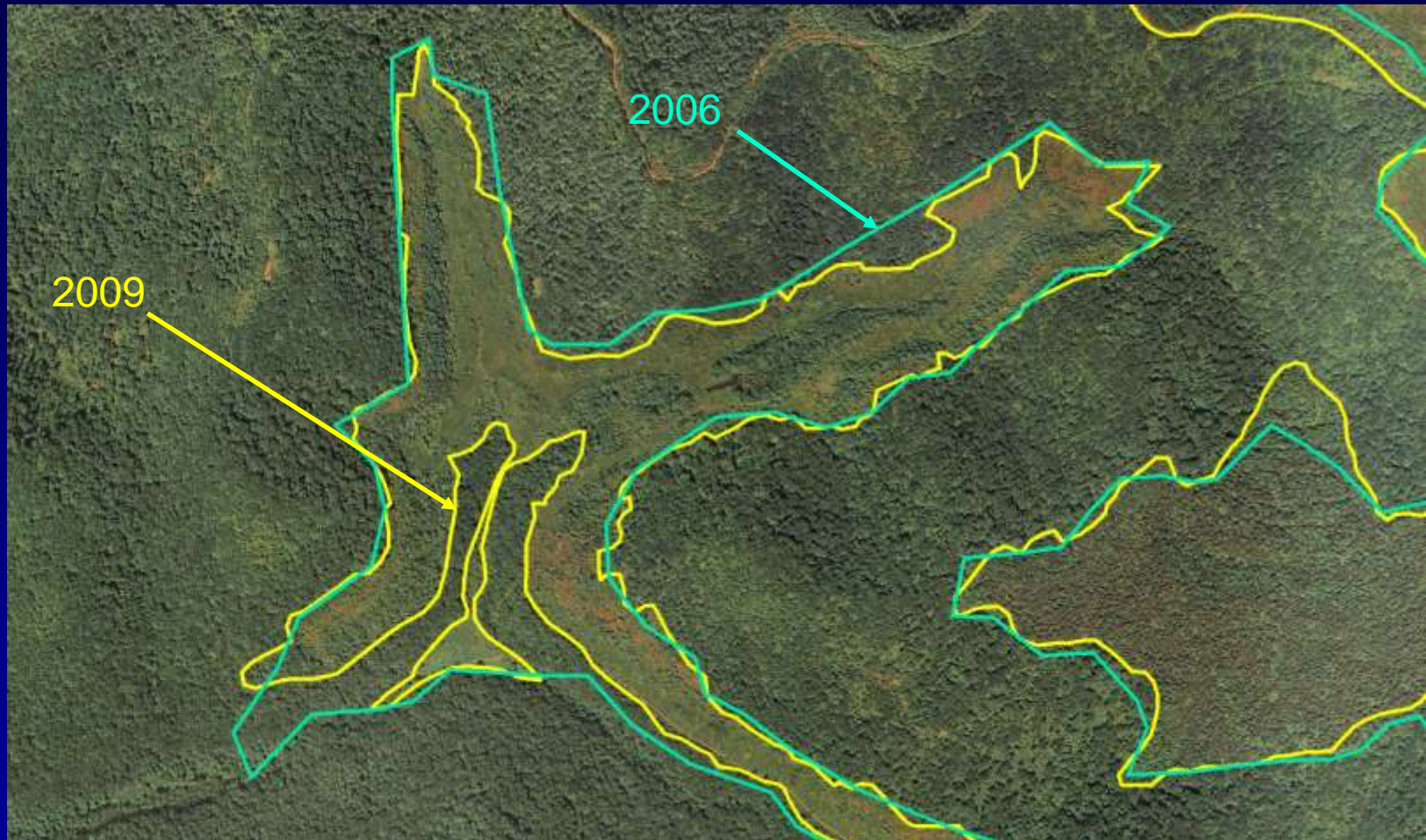
## **A Geospatial Analysis of the Impacts of Mountaintop Removal Coal Mining to Rare, Threatened and Endangered Species in Appalachia**

Technical Report submitted to Appalachian Voices

By Ross Geredien  
Consultant

**Not Submitted for Publication**

# Here's Why



**> 95% Confidence Requires ~>95%  
Spatial Accuracy**

# Accuracy Analysis




- Create a Grid of Uniform Hexagonal Cells
- Select a sample of grid cells to digitize mine features at high resolution (3%, 302,000 acres) using a rules-based technique.
- 5-10-meter edge accuracy was the goal.
- Compare the two data subsets to identify what we got right.
- Used newer, higher quality imagery (NAIP 2006-2008).
- Extrapolated results over entire 10 million-acre project area
- Also analyzed accuracy of Campagna (2007) remote sensing data for comparison.



5-meter Edge

Excluded Tree Island

**Legend**

-  Lowered Mountains
-  Mine Polygons
-  Valley Fills

# Achieving > 95% Spatial Accuracy

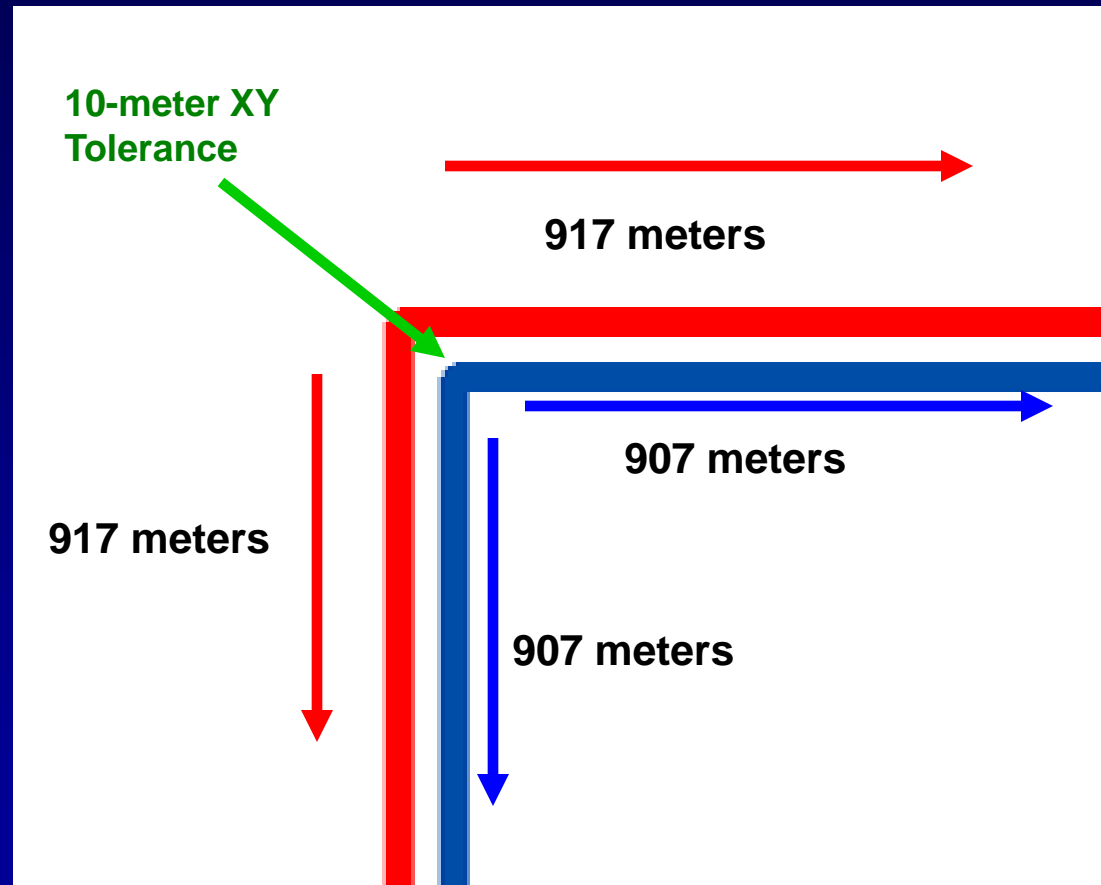
Based on an average mine polygon size of ~ 213 acres

$A_{\text{Red}} = 217$  Acres

$A_{\text{Blue}} = 212.2$  Acres

= 2.3%  $\Delta$  in Area; the larger the mine, the smaller the error.

*Not Only is Feature the correct size, it's in the correct place = Spatially Explicit.*



# Results from the Accuracy Assessment

**Geredien (2006) - 55.5% spatial accuracy, including Type I and Type II Errors**

**Campagna (2007) - 53.7% spatial accuracy**

**Both studies capture about 65% of total area, regardless of spatial accuracy. Some of the Type II error was due to new mining.**

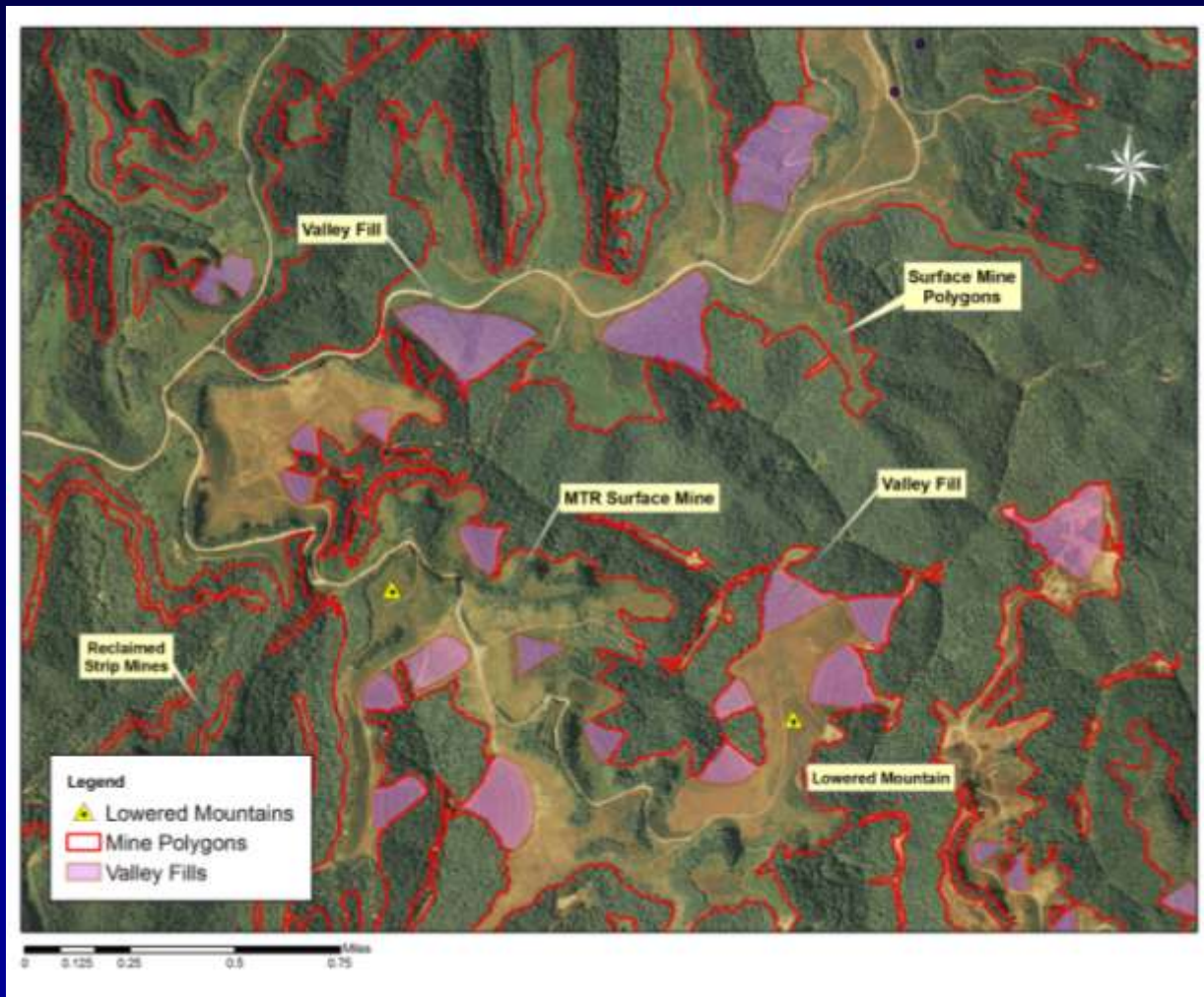
**Bottom Line: Scale Matters!**

# More Results

<b>Total Surface Mining Activity</b>	<b>1,160,000 Acres</b>
<b>Total MTR (summit ridges crossed)</b>	<b>475,000 Acres</b>
<b>Sludge Lakes and Processing Plants</b>	<b>~25,000 Acres</b>

**But Complete Spatially-explicit data is  
still lacking**

# New Directions in Mapping



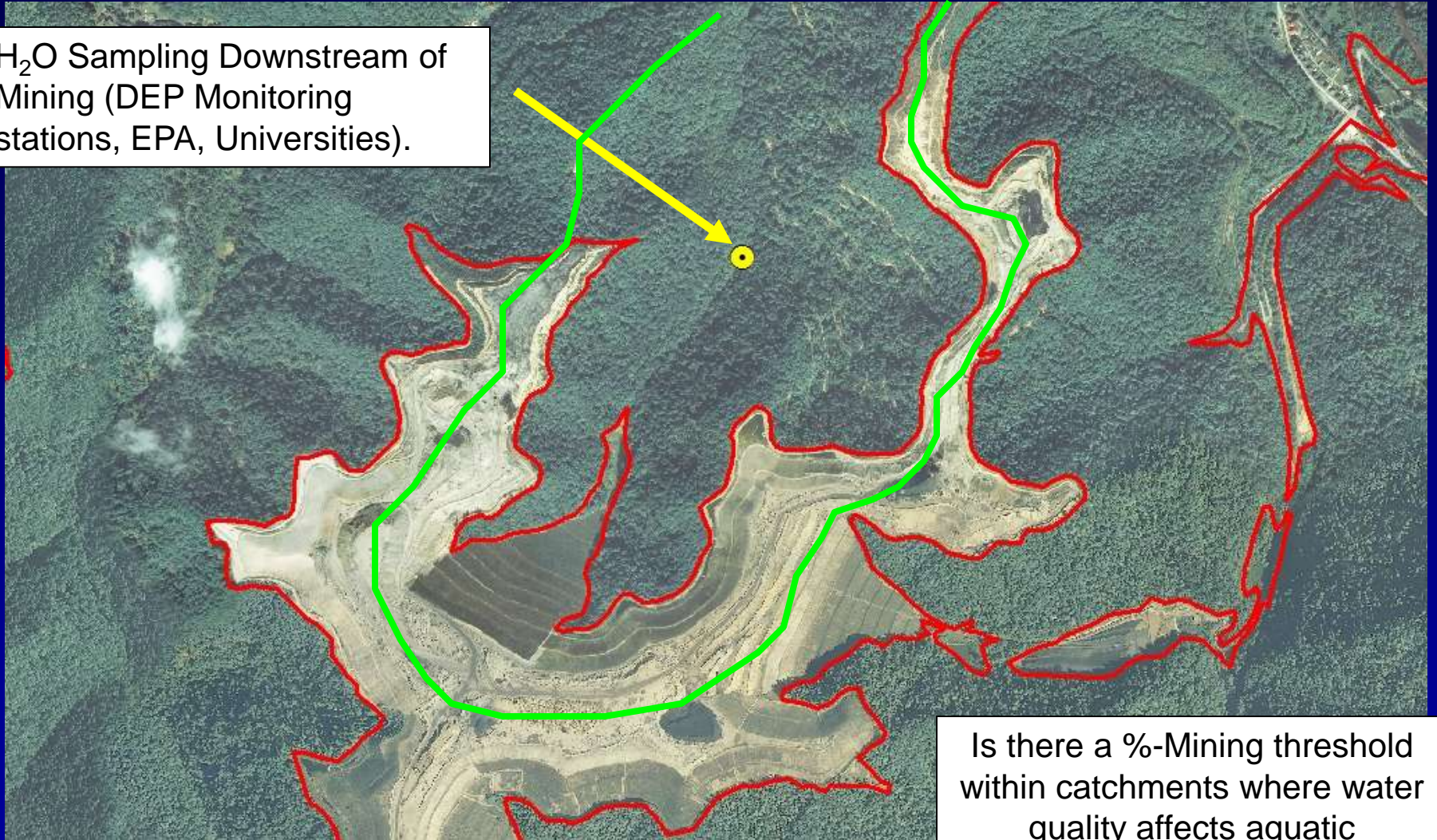
**A High-accuracy GeoSpatial Inventory of Surface Mines and Valley Fills**

# How A High-Resolution Dataset Can Provide the Best Available Data

- Spatially-explicit, not permit-based or modeled data; measures actual mine footprints, active and reclaimed.
- High resolution (1:4000) with high spatial accuracy.
- Complete spatial inventory of all surface mining features, including Impoundments, processing plants, valley fills, abandoned mine lands, etc.
- Information-rich attributes describing vegetation, activity status, valley fill, acreage, location, mining type, etc.
- Vector-based, compatible with common GIS analytical tools and available data; easily converted to raster for spatial analysis.

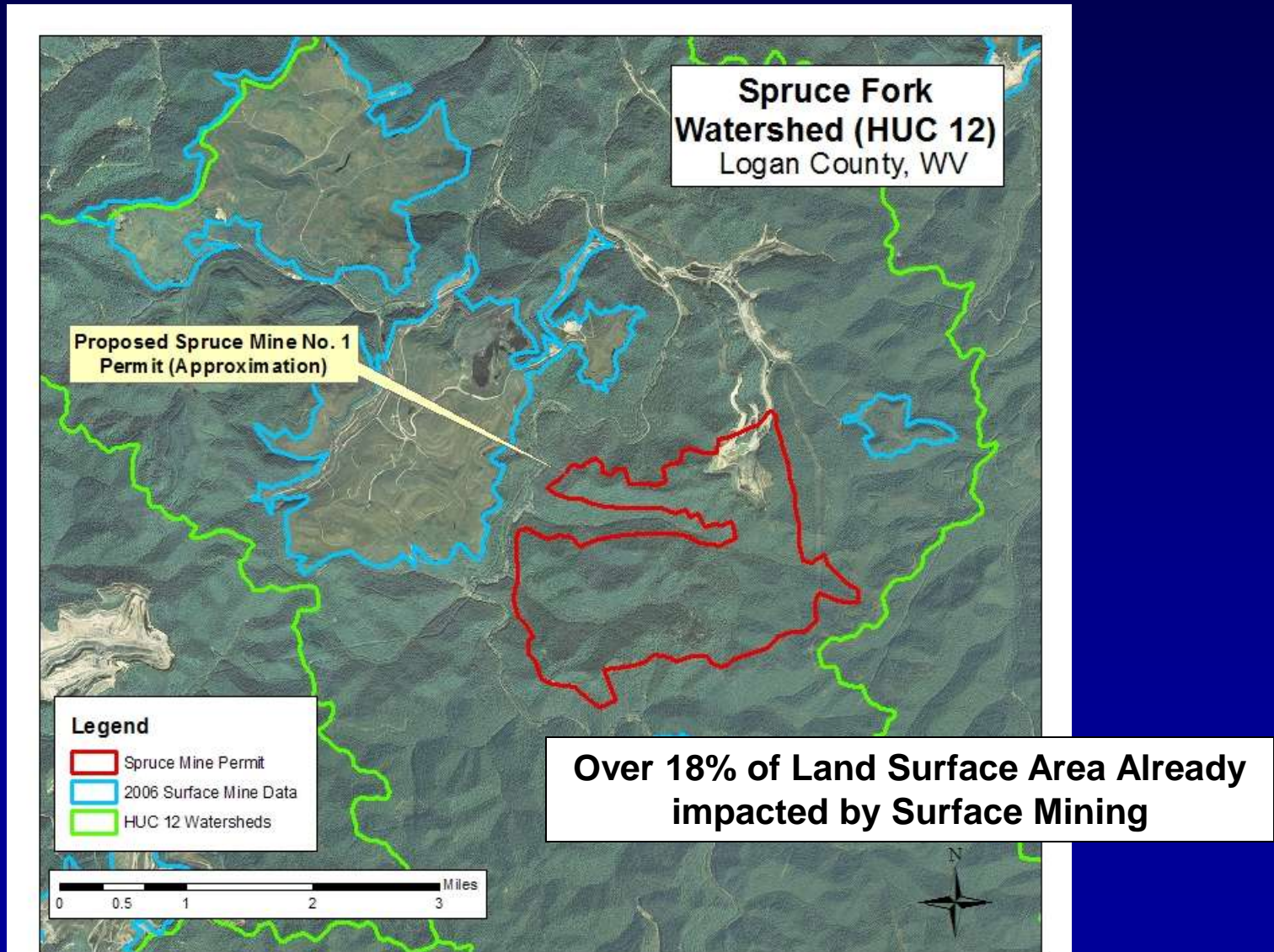
# Correlations with water quality, and macro-invertebrate data

H<sub>2</sub>O Sampling Downstream of Mining (DEP Monitoring stations, EPA, Universities).



Is there a %-Mining threshold within catchments where water quality affects aquatic biodiversity? (Pond et al 2008)

# Applications: 5-S Framework “Stresses” Measuring Cumulative Impacts to Watersheds



# Next Steps: Integrating Science with the Big Picture

1. Work with EPA and other partners to Develop High-Resolution Mining Data
2. Re-run Analyses on Impacts to RTE Species
3. Look at downstream impacts using HUC-Level analysis and “flow analysis”
4. Continued IMR work in the MTR Region, especially on aquatic species, is desperately needed.
5. Opportunity for MJD data to inform EPA and the interagency regulatory process on MTR (OSM, USACE, USFWS).
6. New regulatory climate may yield new opportunities for on-the-ground research.

# Literature Cited

Campagna, David and John Amos. 2007. Mapping Mountaintop Removal Over the Decades. Report to Appalachian Voices, 2007.

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Palmer, M. A., E. S. Bernhardt, W. H. Schlesinger, K. N. Eshleman, E. Foufoula-Georgiou, M. S. Hendryx, A. D. Lemly, G. E. Likens, O. L. Loucks, M. E. Power, P. S. White, P. R. Wilcock. 2010. Mountaintop Mining Consequences. *Science* Vol 327 Jan. 8, 2010, pp. 148-149.

Pond, Gregory J., Margaret E. Passmore, Frank A. Borsuk, Lou Reynolds, and Carol J. Rose. 2008. Downstream Effects of Mountaintop Coal Mining: Comparing Biological Conditions Using Family- and genus-level Macroinvertebrate Bioassessment Tools. *Journal of the North American Benthological Society*, 27, 717-737 (2008).

# Acknowledgements

- Kentucky Natural Heritage Program, KY State Nature Preserves Commission
- West Virginia Natural Heritage Program, WV Dept. of Natural Resources
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- Larry Gibson, the Mountainkeeper, [www.mountainkeeper.org](http://www.mountainkeeper.org)
- Tennessee Natural Heritage Program, TN Dept. of Environment and Conservation
- Tennessee Geographic Information Council
- Virginia Natural Heritage Program, VA Dept. of Conservation and Recreation
- University of Virginia
- Skytruth ([www.skytruth.org](http://www.skytruth.org))
- Appalachian Voices, Boone NC ([www.appvoices.org](http://www.appvoices.org))
- Southwings ([www.southwings.org](http://www.southwings.org))
- Photos courtesy of Ohio Valley Environmental Coalition ([www.ovec.org](http://www.ovec.org))
- Google Earth™