



Remote Sensing as a Tool in the Lake Assessment Program in Idaho

Mary Anne Nelson¹, Clyde Lay¹, Alan Monek²

¹Idaho Department of Environmental Quality

²Twin Falls County Assessor's Office

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History of Lake Assessment in Idaho

- Clean Lakes Studies
- Single lake water quality data collections
- Statewide assessment process
 - Based on stream process methodology
 - Focused on biological communities
 - Used individual water quality parameters
 - Failed due to lack of appropriate data, funding and personnel turnover in the work group
- Most recently, data gathering/analysis effort to review nutrients
 - >8,000 sites with nutrient data
 - Sites with greater than 15 data records that include both “cause” and “effect” monitoring constituents reduced this to 45 key sites

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Current Lake Monitoring/Assessment Strategy

- National limnological studies
 - EPA's Clean Lakes Program
 - Data intensive (Chemical, physical and biological)
 - Assessments require a background in Limnology
 - Often a collaborative effort with Universities and State Agencies
 - Lakewatch Limnology Program
- Trophic State Index (TSI)

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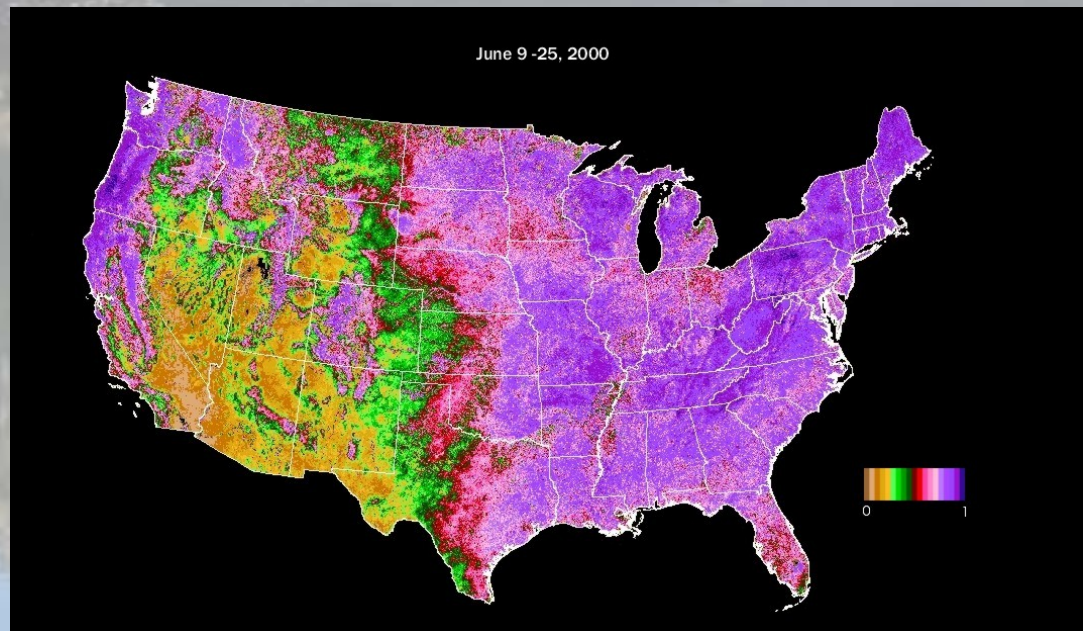
Drawbacks of Current Strategy

- **Field testing requires large investments**
 - \$500 per site
 - Personnel/ Equipment/ Lab costs
- **Personnel lack necessary limnological knowledge/experience**
- **Inflexible monitoring regimes**
- **Sampling variability due to different personnel**
- **Very limited data**
 - Few lakes with historic data
 - Most lakes do not have current data
 - Select points don't necessarily capture intra-lake variability
- **Follow up monitoring seldom performed**
- **No statewide agreement on monitoring methodology**

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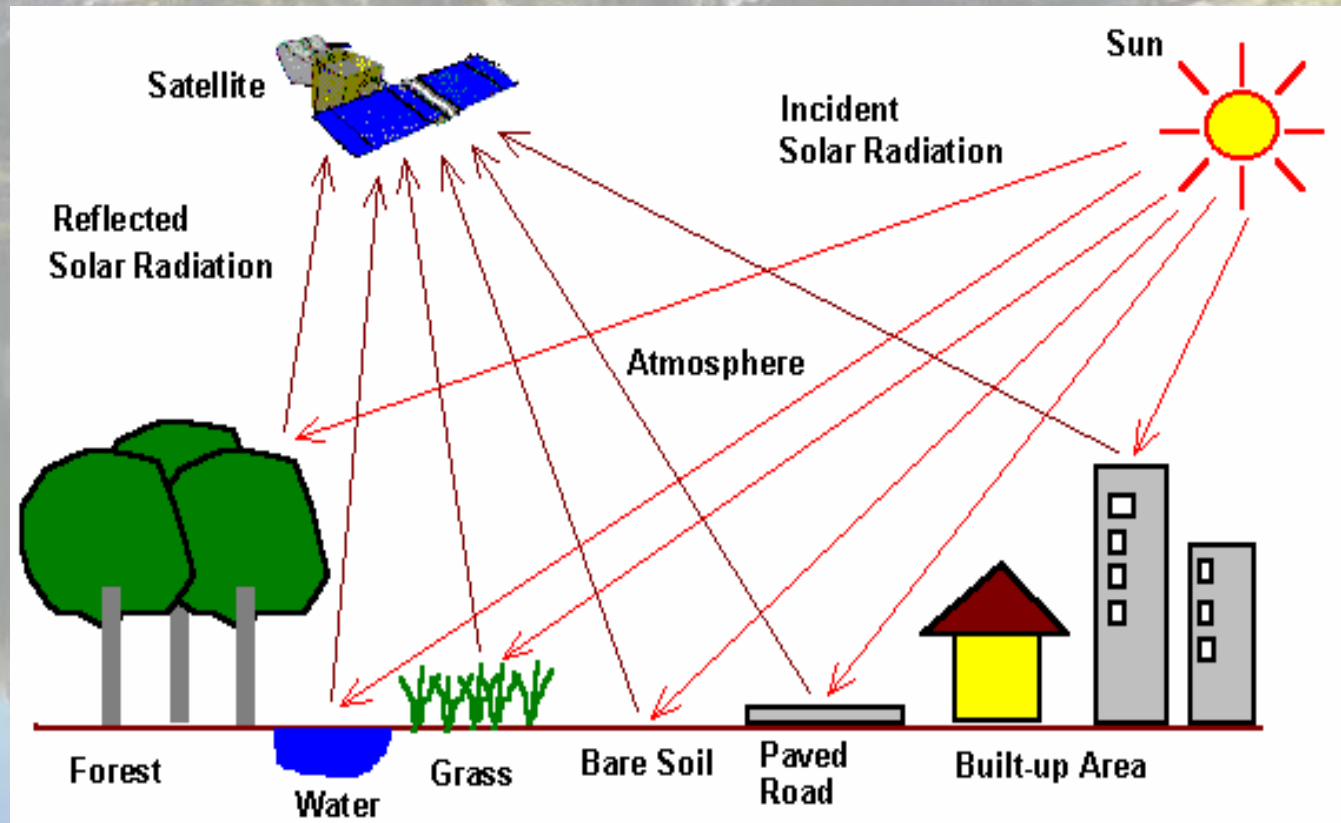
Applications of Remote Sensing: Historic Uses

- Vegetation classification
- Land cover change
- Agricultural uses (USFS, USDA)
- Geologic mapping
- Fire mapping
- Water Quality!

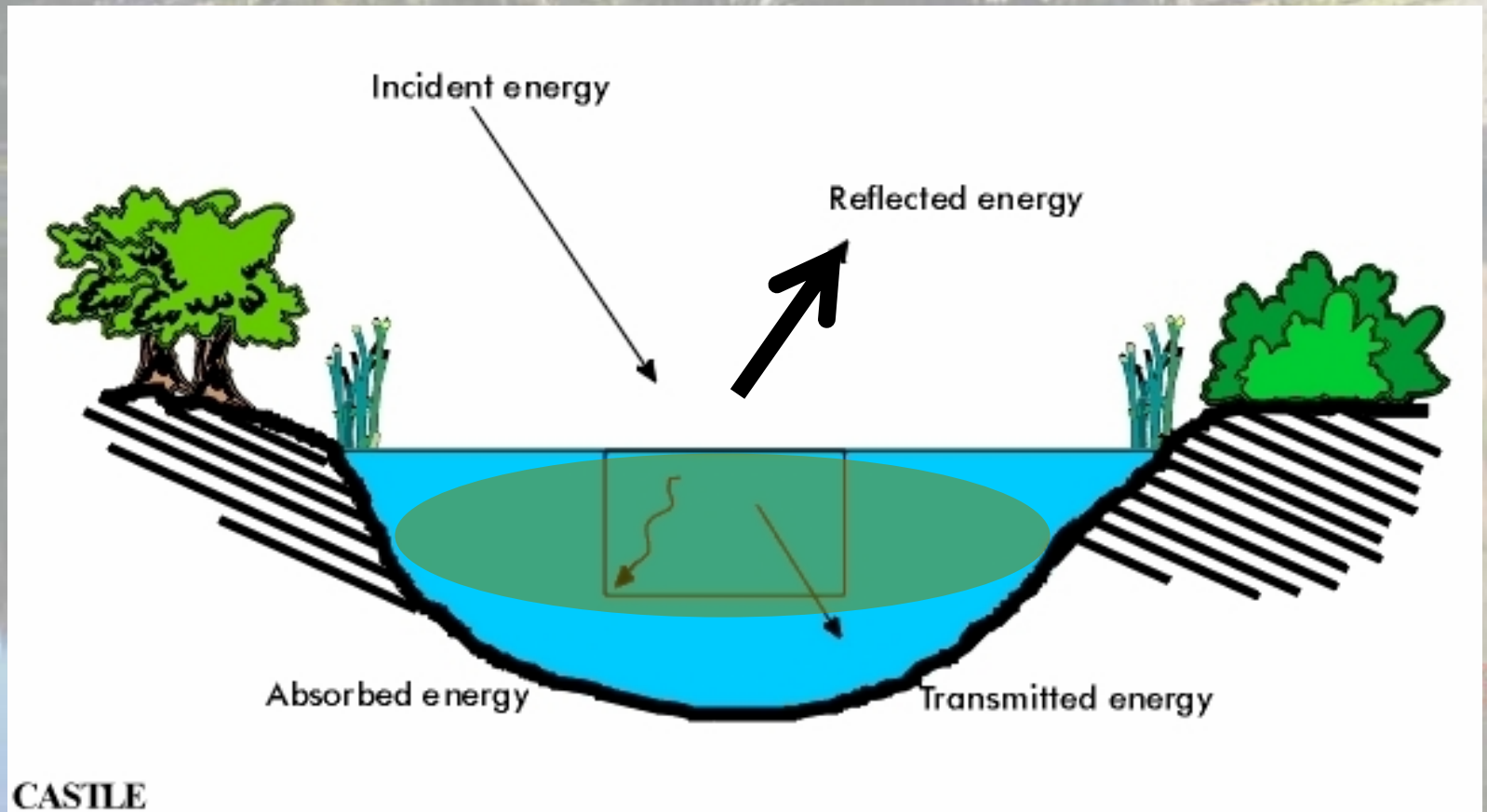


Remote Sensing 101

The Basics: Let's reflect for a moment...



Transmission, Absorption, and Reflection



The Landsat Program

- Studies have historically used Landsat data
 - 1972-8 Landsat 1,2, and 3
 - 1980's Landsat 4 TM and Landsat 5 TM
 - 1999 Landsat 7 ETM+
 - Others: ASTER, AVHRR, MODIS, SPOT, Quickbird
- Why has Landsat data been the standard?
 - Appropriate spectral bands for land use applications
 - 30-meter resolution
 - 16-day temporal resolution
 - Cost and availability

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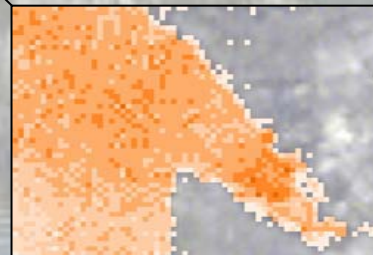
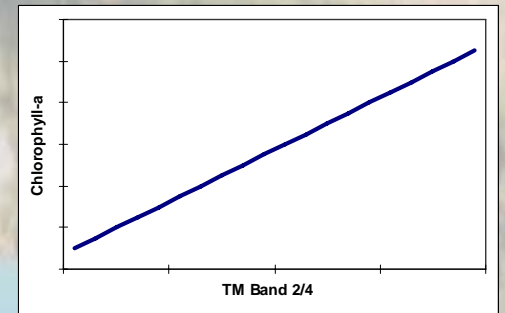
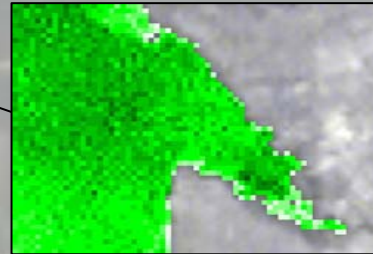
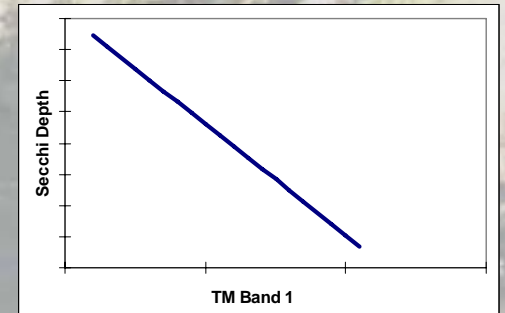
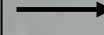
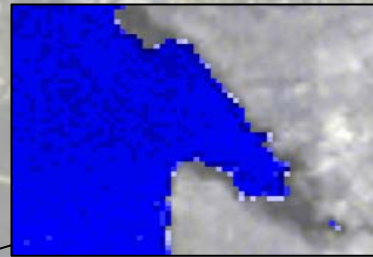
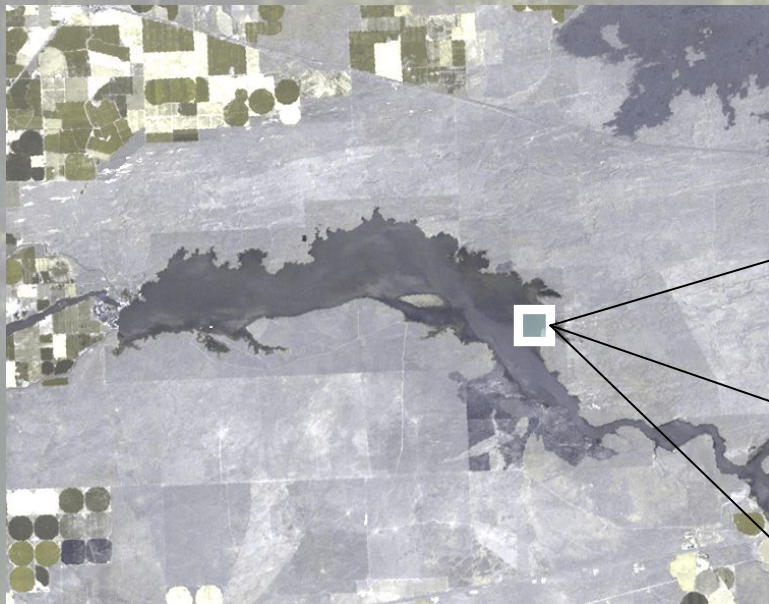
Application of Remote Sensing: Landsat

Water quality studies have traditionally used Landsat bands 1 (blue), 2 (green), and 4 (near IR)

- **Band 1** (Turbidity): Is absorbed by clear water and reflected by suspended solid in water
- **Band 2** (Photosynthesis): Is highly reflected by plant matter
- **Band 4** (Photosynthesis): Is also a good at determining the level of plant material

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Application of Remote Sensing: Graphic Relationships



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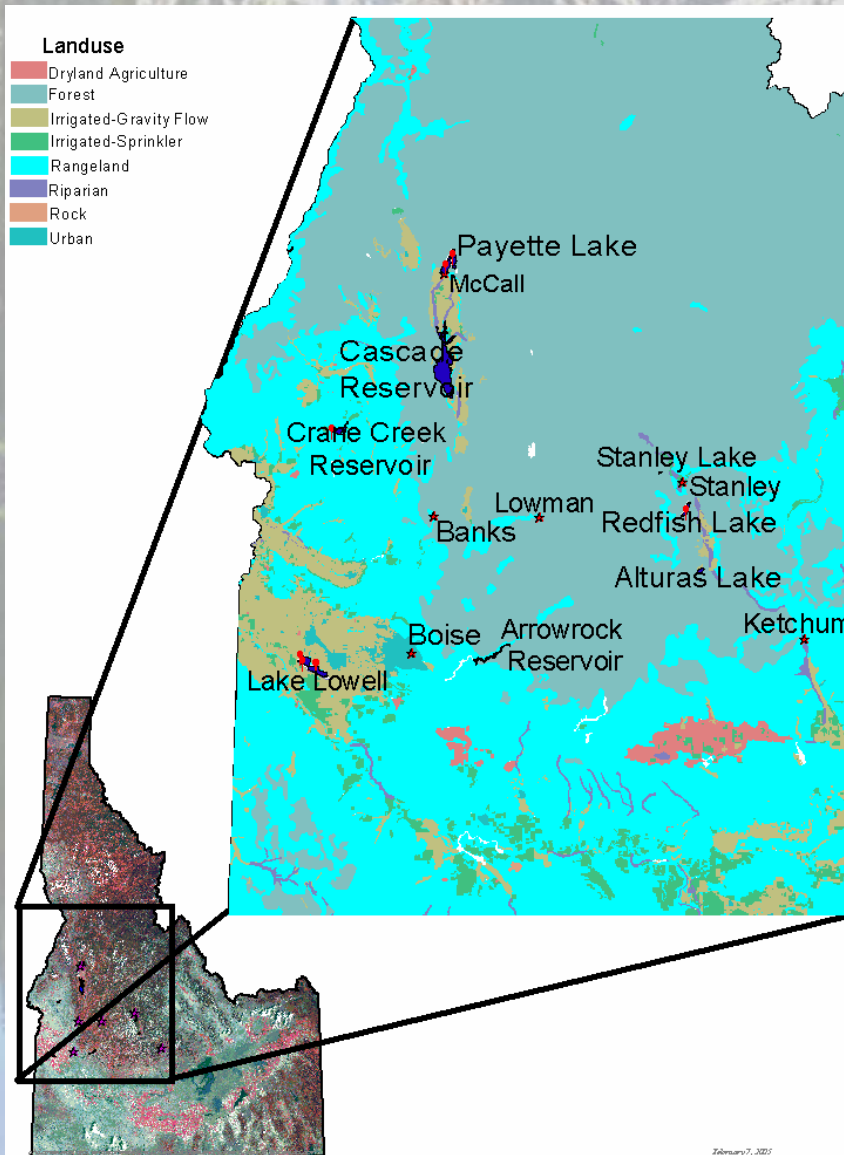
Lakes Survey

Validating remote sensing

- Remote sensing validation
 - 25 sites selected on each of 8 lakes
 - Each site was monitored for chlorophyll a and secchi depth
- Data collection
 - At max depth site, chlorophyll a, dissolved oxygen, temperature, and pH profiles were established
 - Nutrient samples were taken

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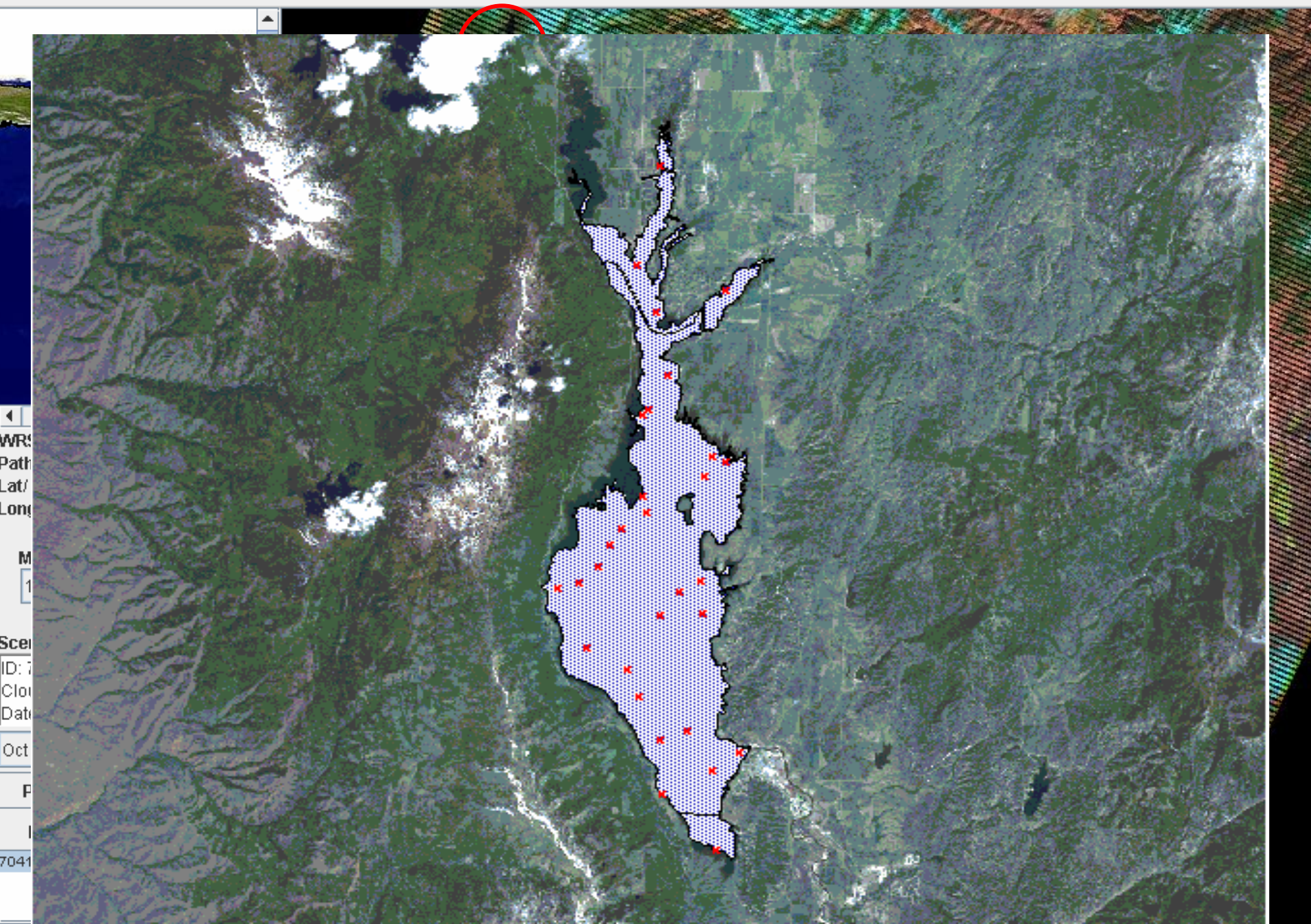
Validation Study



- Selected lakes represent range of clarity, impacts
- Monitored monthly in conjunction with satellite passes

Cascade Reservoir

Sensor Resolution Map Layers Tools File Help



WRS:
Path:
Lat/
Long:

M
1

Scen

ID: 7

Clo

Date

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I

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Water Quality Model Diagram

Processed
Grids

Band 1

Band 2

Band 4

Model

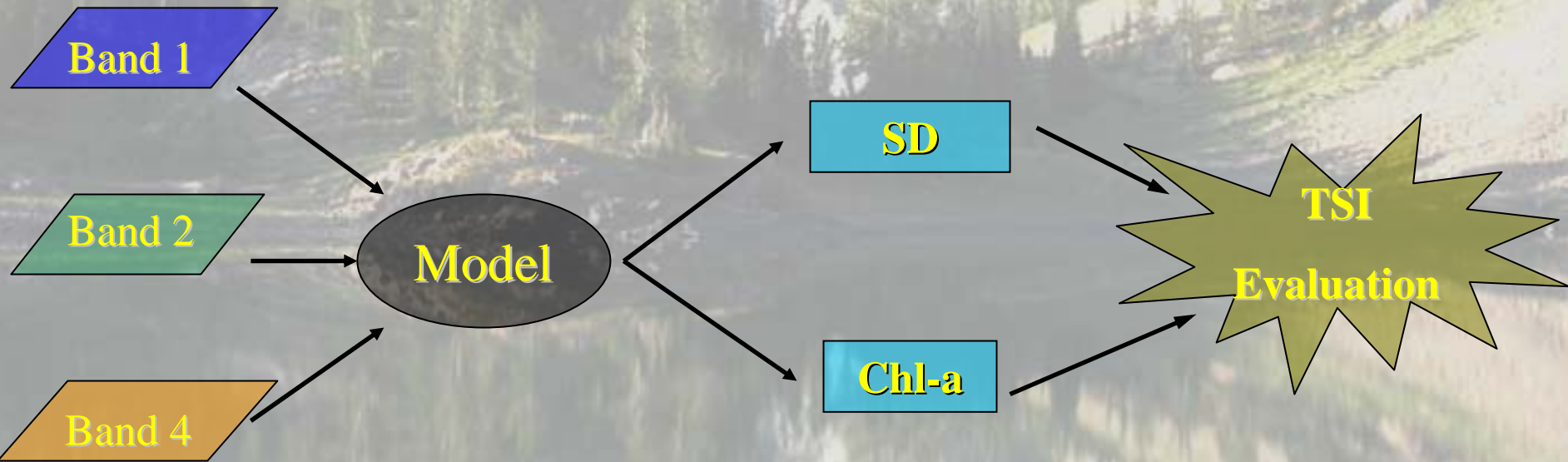
Output
Grids

SD

Chl-a

TSI
Evaluation

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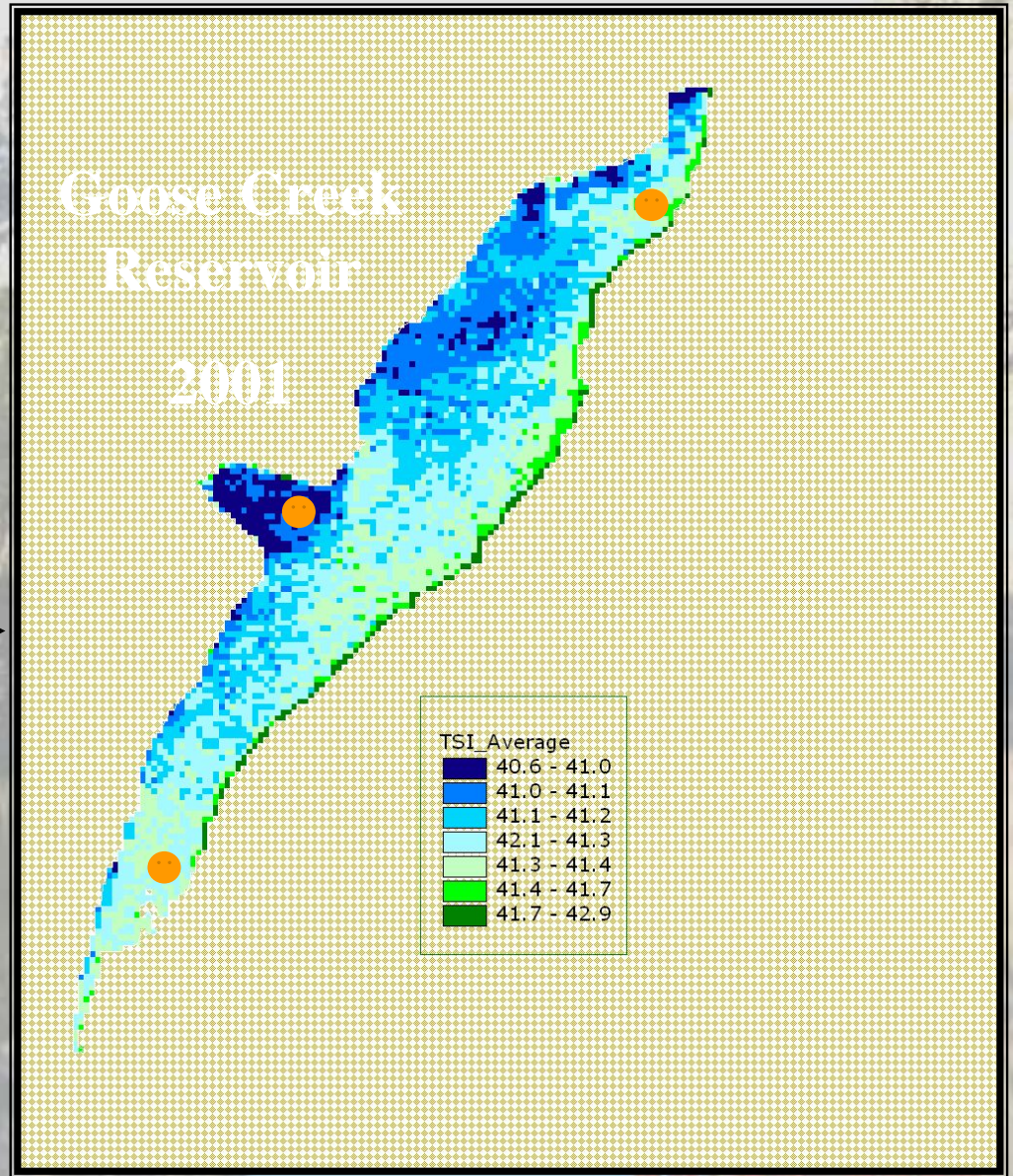
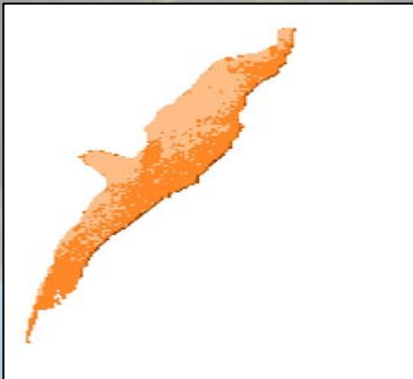
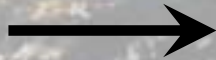
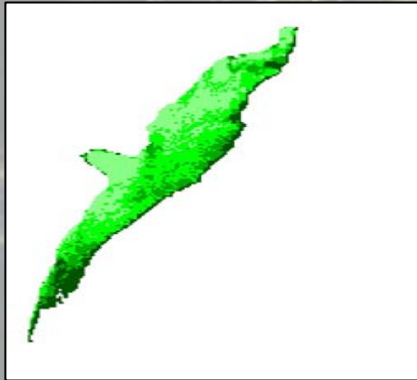
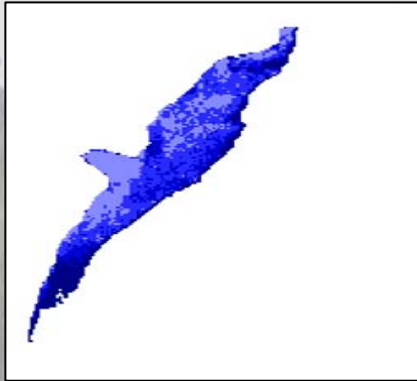
Model Development:

- Acquire data for time period in question
- Import satellite data into GIS
- Convert all Landsat TM bands into individual grids
- Adjust grid values of all bands (time of year, sensor calibration, etc)
- Mask out lakes of interest
- Develop relationships between field and satellite values to create a working predictive model
- Run and evaluate model for southern Idaho
- Develop, automate, and further refine statistical relationships
- Apply the model regionwide / statewide

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Gathering Usable Data





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Incorporating Remote Sensing into Lakes Assessment Strategy

- **Tier 1A (Remote Sensing)**
 - Secchi Disk Depth
 - Chlorophyll a concentration
- **Tier 1B**
 - Measure Secchi Disk Depth
 - Gather pH, Temp, Dissolved Oxygen profiles
 - Determine if lake is stratified
 - Collect water sample for nutrients
 - Collect water sample for chlorophyll a concentration
 - Visually estimate percent macrophyte cover

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Incorporating Remote Sensing into Lakes Assessment Strategy

- **Tier 2A**
 - Measure Secchi Disk Depth
 - Gather pH, Temp, Dissolved Oxygen profiles
 - Determine if lake is stratified
 - Collect water sample for nutrients
 - Collect water sample for chlor a concentration
 - Collect macroinvertebrate sample
 - Collect zooplankton sample
 - Collect phytoplankton sample
 - Collect macrophytes

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Advantages of Proposed Model

- Quick visualization of problem areas (1st cut)
- Continuous and dependable data
- Large historic dataset available for trend analysis
- Robust statistics (intra-lake variability)
- Cost effective (\$300 for multiple lakes)
- Statewide applicability and standardization
- Data applicable to other program areas

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Limitations of Proposed Model

- Not all constituents are measured (temperature, DO)
- Not a 'silver bullet' - field measurements still required
- Areas must be cloud free at time of acquisition
- 4-6 opportunities per month
- Initial cost
 - Required software and extensions
 - \$300/scene (Landsat 7 L1G) : \$275/scene (Landsat 4/5)
 - 15-20 scenes need to cover entire state

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Conclusion

- Provide useful tool to supplement existing monitoring regimens
 - Supplies managers with a 'First Cut' at lake quality
 - Better utilization of department resources
 - Intra-lake variability
 - Historic analysis
- Establish a quantitative baseline for lake health
- Creation of a statewide standard for all regions
- Automation of technical aspects of the process

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