Not Your Grandfather's Map

A Brief Discussion of the History, Driving Forces, Impediments, Opportunities and Future Directions of GIS Technology's Evolution/Revolution

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Estes Park, Colorado

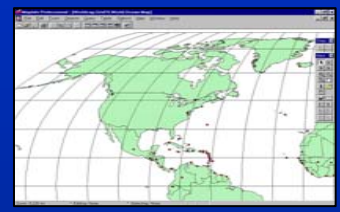
Historical Setting and GIS Evolution

Manual Mapping for 8,000 years

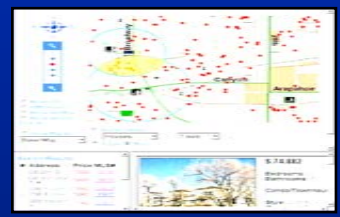
Geotechnology (GPS, GIS, RS)

DIGITAL **ANALOG**

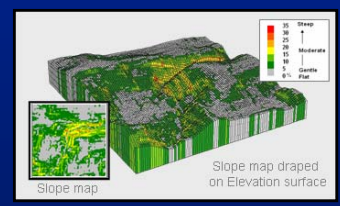
Computer Mapping *automates the cartographic process (70s)*



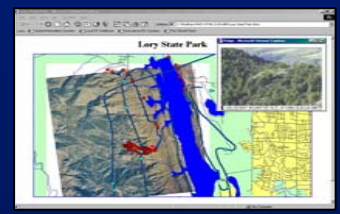
Spatial Database Management *links computer mapping techniques with traditional database capabilities (80s)*



Map Analysis *representation of relationships within and among mapped data (90s)*



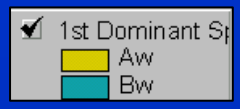
Multimedia Mapping *full integration of GIS, Internet and visualization technologies (00s)*



(Berry)

Desktop Mapping Framework (Vector, Discrete)

Click on…



Select Theme

Zoom Pan

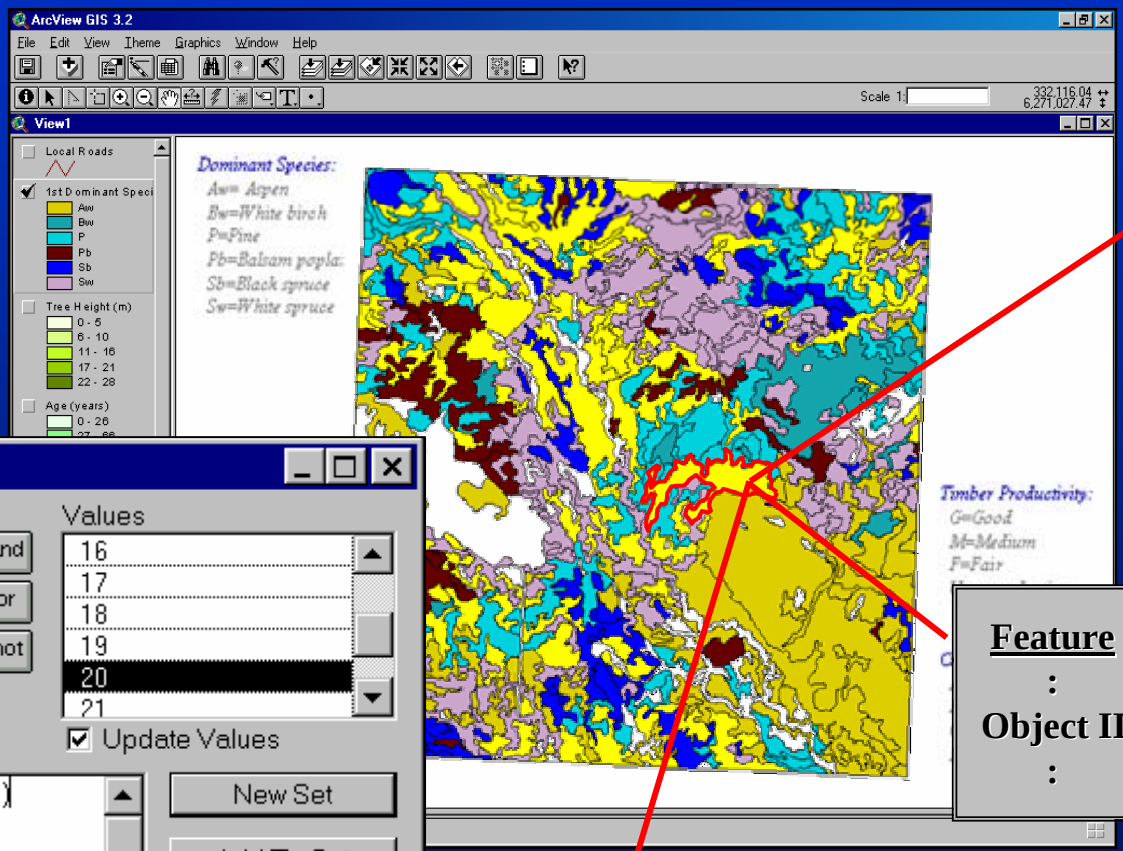
Info Tool

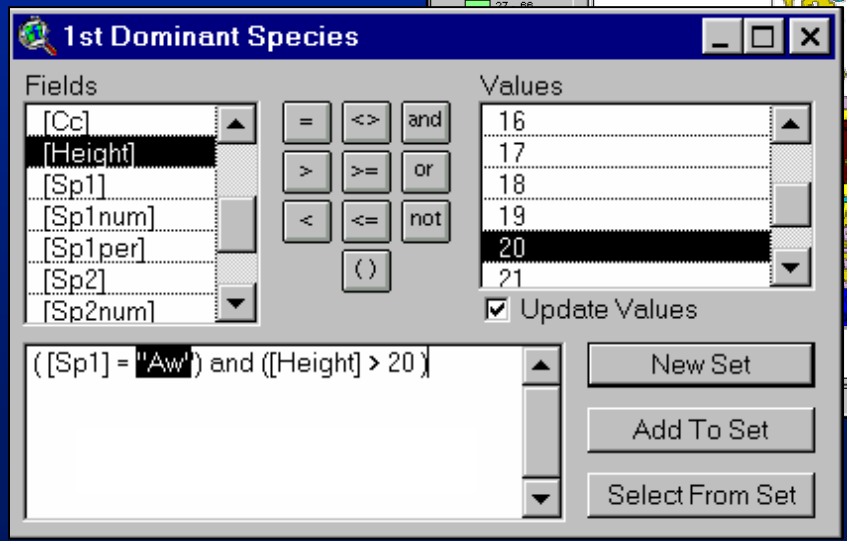
Theme Table

Distance

Query Builder

…identify tall aspen stands





Spatial Table

:
Object ID
X,Y
X,Y
X,Y
:

Attribute Table

Feature	Species	etc.
:	:	
Object ID	Aw	
:	:	

Discrete, irregular map features (objects)

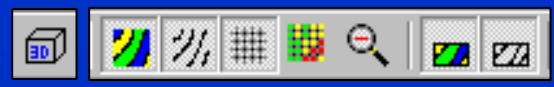
Points, Lines and Polygons

(Berry)

MAP Analysis Framework (Raster, Continuous)

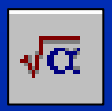
Click on…

Zoom Pan Rotate



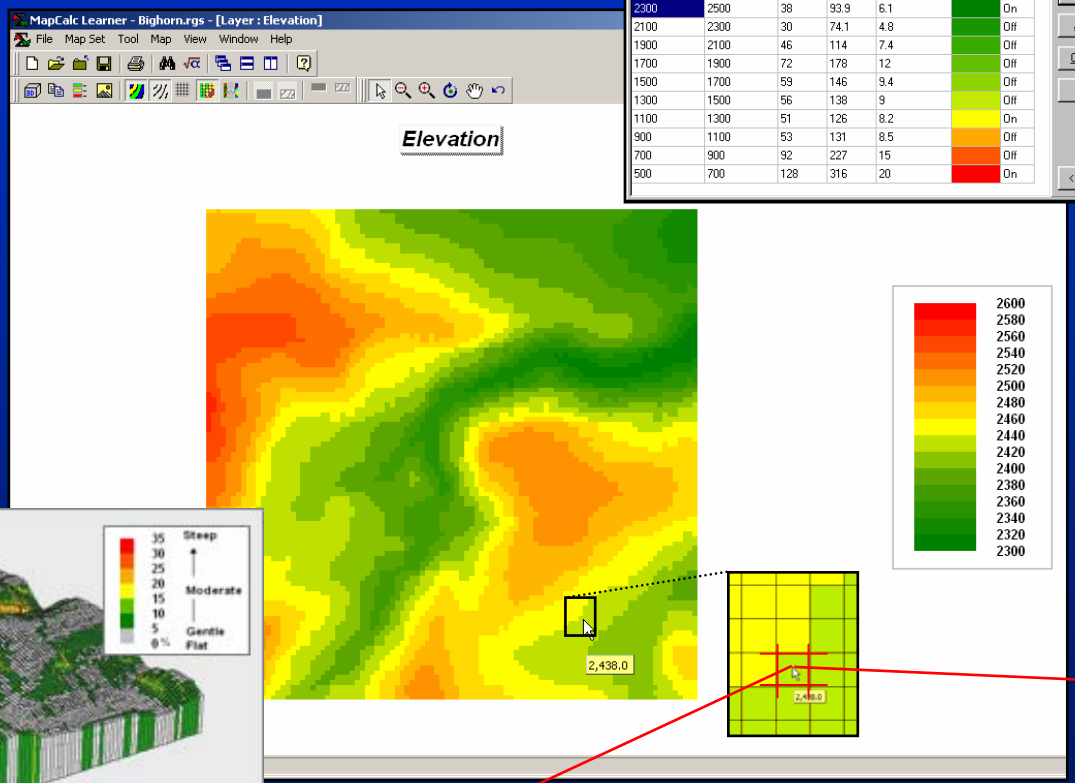
Display

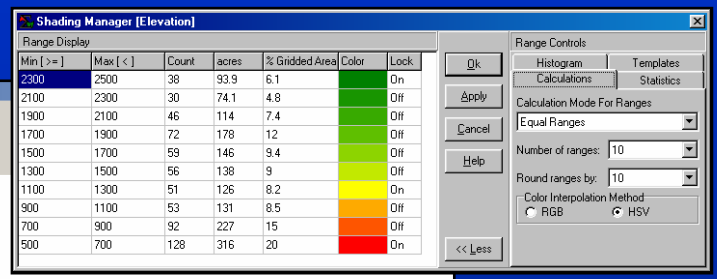
Shading Manager

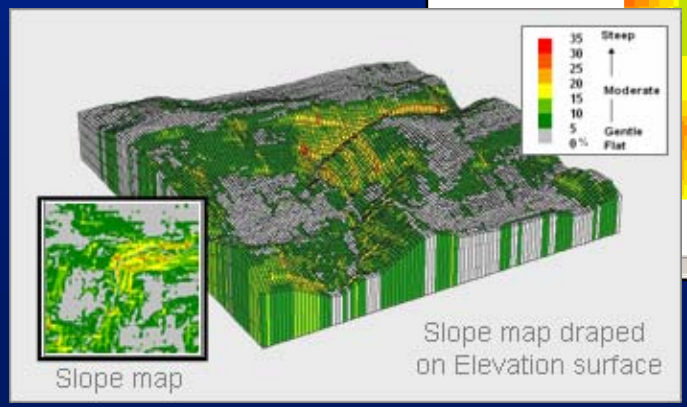


Grid Analysis

…calculate a slope map and drape on the elevation surface







Grid Table

:				
--,	--,	--,	--,	
--,	--,	--,	--,	
--,	--,	--,	--,	
--,	2438,	--,		
--,	--,	--,	--,	
:				

Continuous, regular grid cells (objects)

Points, Lines, Polygons and Surfaces

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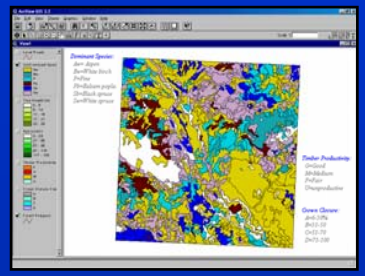
Map Analysis Evolution *(90s, Revolution)*

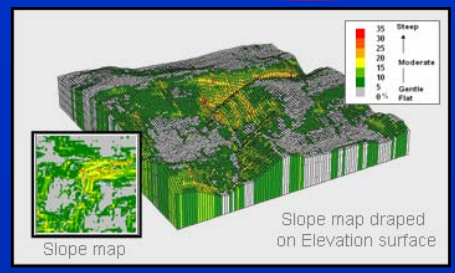
Traditional GIS



Forest Inventory Map

- Points, Lines, Polygons
- Discrete Objects
- Mapping and Geo-query

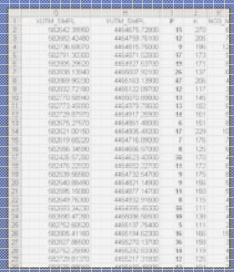
Spatial Analysis

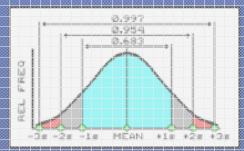


Slope Map Surface

- Cells, Surfaces
- Continuous Geographic Space
- Contextual Spatial Relationships

Traditional Statistics

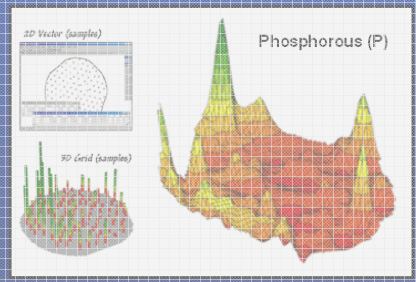




Minimum= 5.4 ppm
Maximum= 103.0 ppm
Mean= 22.4 ppm
StDEV= 15.5

- Mean, StDev (Normal Curve)
- Central Tendency
- Typical Response (scalar)

Spatial Statistics



Spatial Distribution (Surface)

- Map of Variance (gradient)
- Spatial Distribution
- Numerical Spatial Relationships

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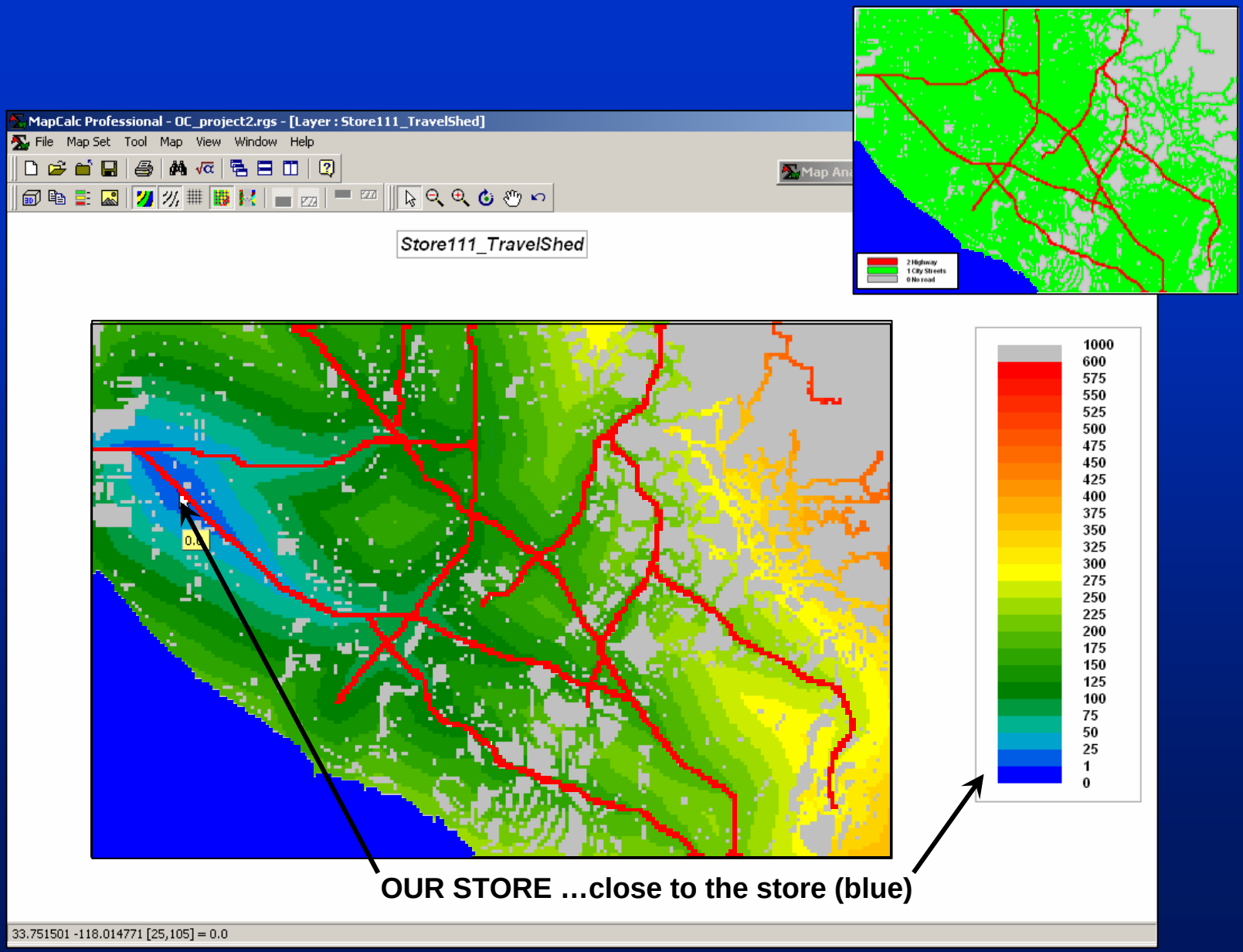
Travel-Time for Our Store to Everywhere



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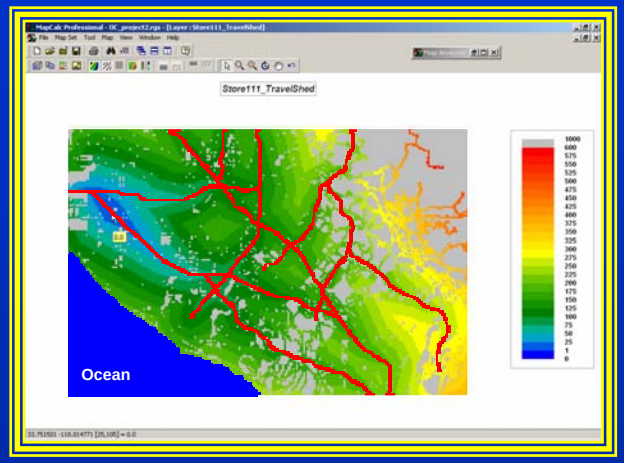
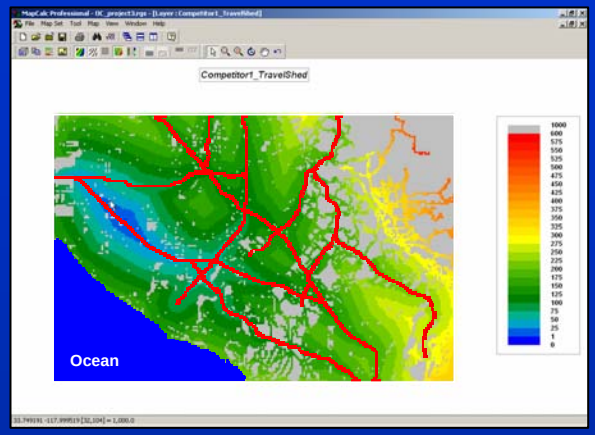
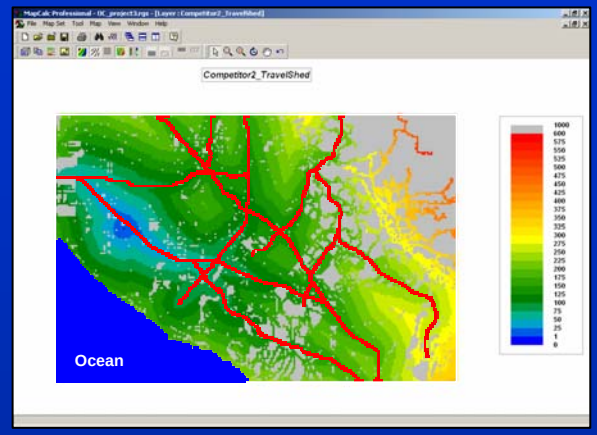
Travel-Time for Competitor Stores



Our Store (#111)

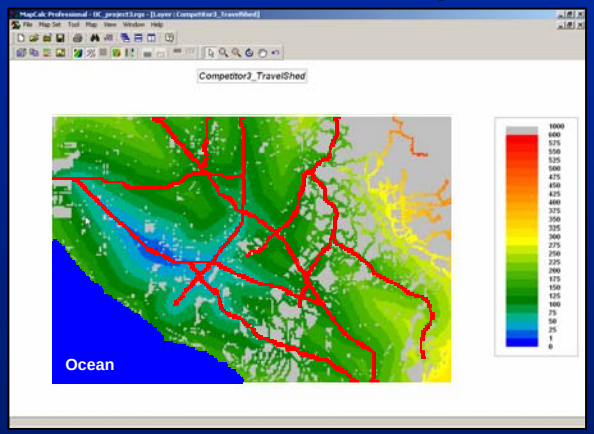


Competitor 1

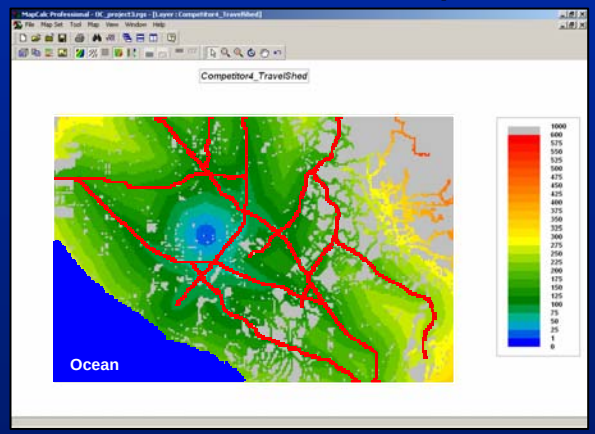


Competitor 2

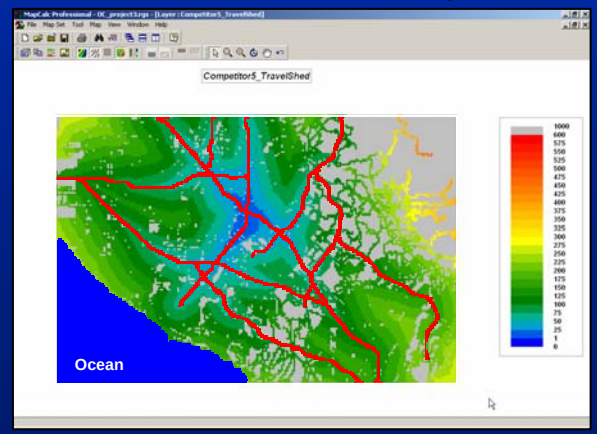
Competitor 3



Competitor 4



Competitor 5



Travel-Time maps from several stores treating highway travel as four times faster than city streets.

Blue tones indicate locations that are close to a store (estimated twelve minute drive or less). Customer data can be appended with travel-time distances and analyzed for spatial relationships in sales and demographic factors.

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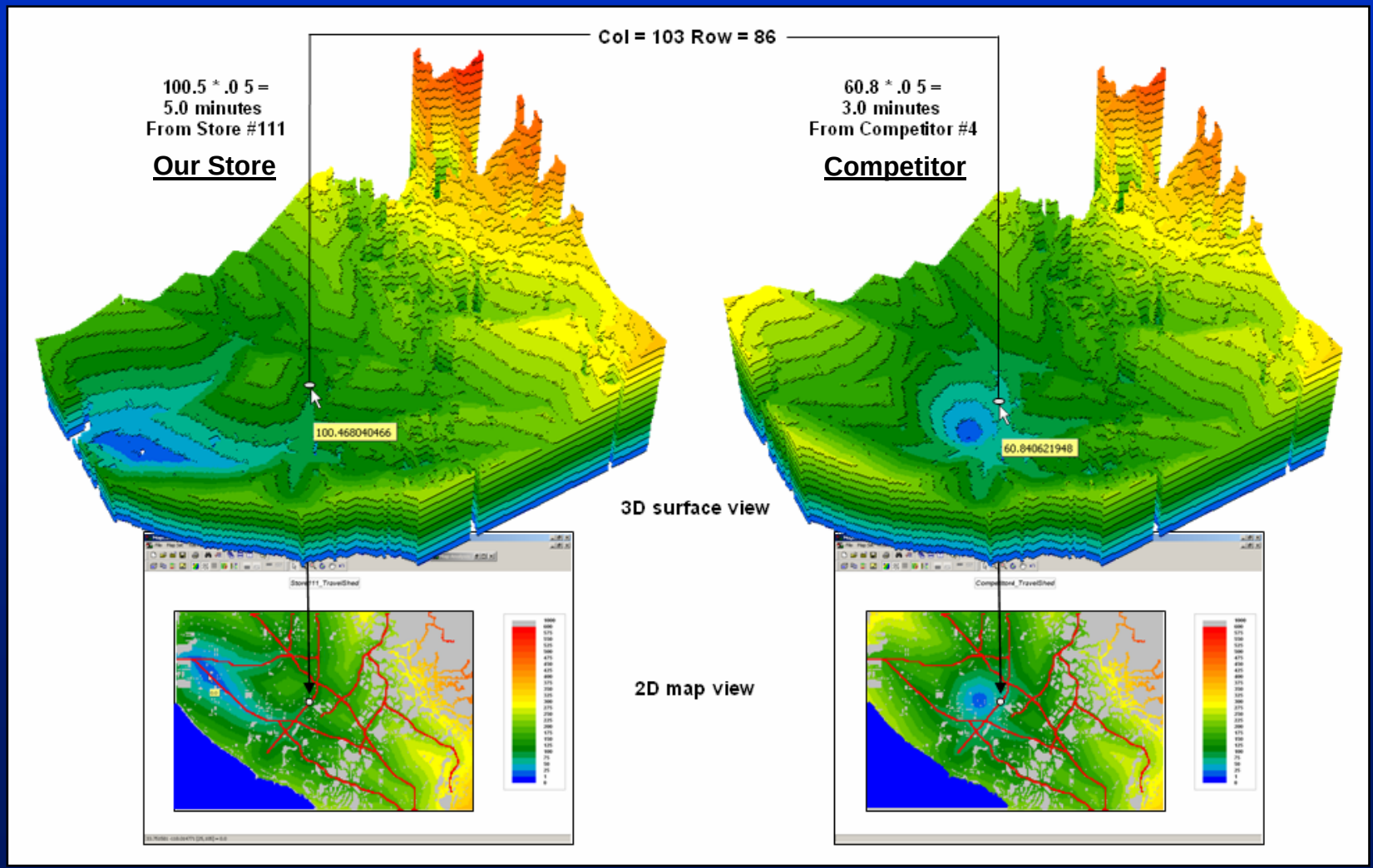
Travel-Time Surfaces (Our Store & Competitor #4)

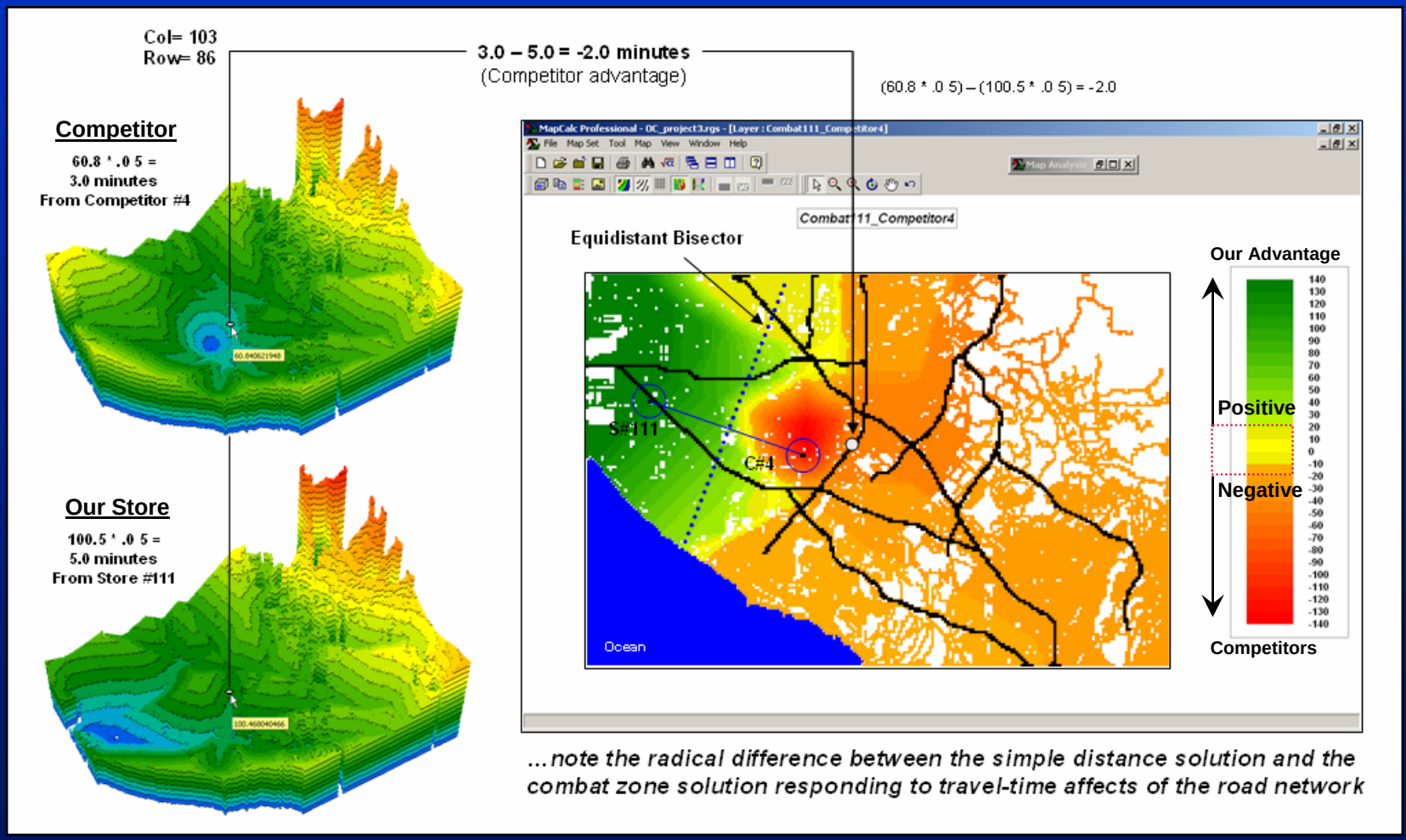
Blue tones indicate locations that are close to a store (estimated twelve minute drive or less). The green through red tones form a bowl-like surface with larger travel-time values identifying locations that are farther away.



Competition Map *(Store #111 & Competitor #4)*

The travel-time surfaces for two stores can be compared (subtracted) to identify the relative access advantages throughout the project area.

Zero values indicate the same travel-time to both stores (equidistant travel-time)
…yellow tones identifying the Combat Zone ; green Store #111 advantage; red Competitor #4 advantage



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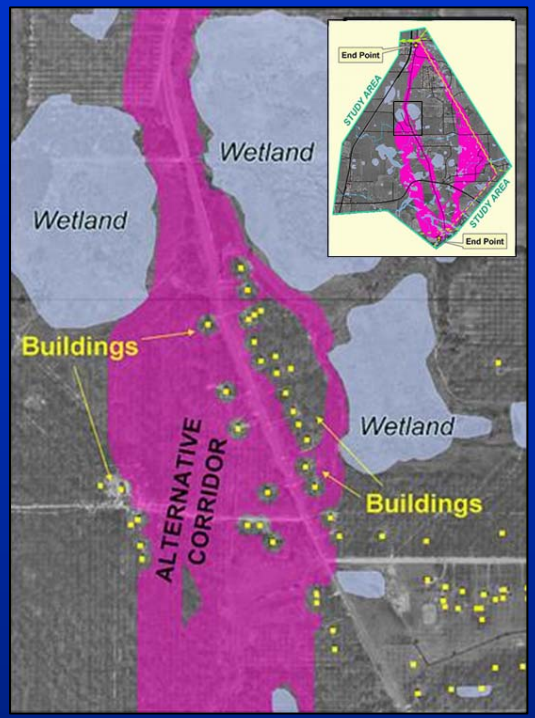
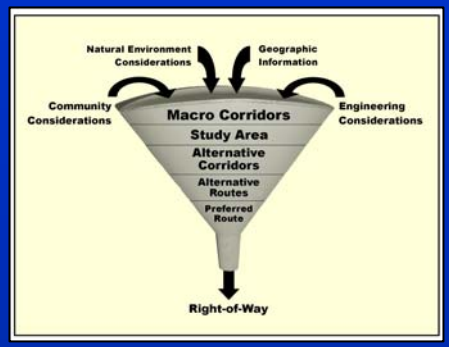
Power and Pipeline Routing *(Least cost path)*

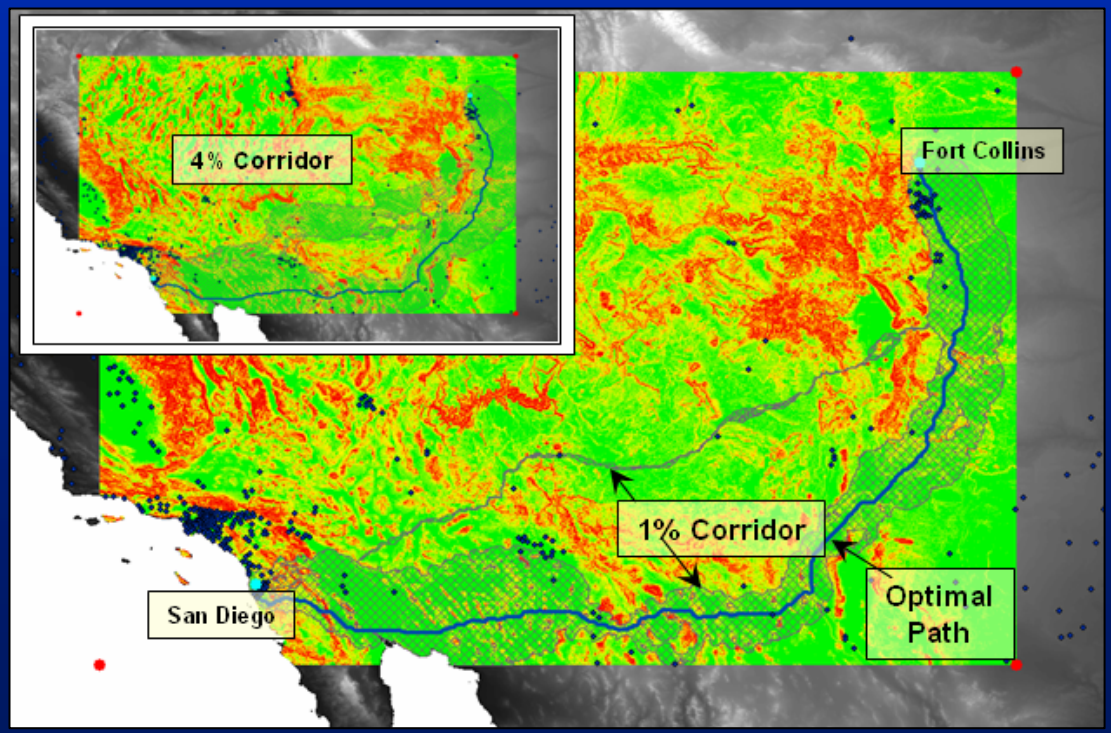
…see www.innovativegis.com Online Papers, "A Consensus Method Finds Preferred Routing"





Infusing stakeholder perspectives into Calibration and Weighting

…Engineering considerations, Natural Environment consequences and Built Environment impacts



Global routing solution identifying…

Optimal Route
Optimal Corridor

…see www.innovativegis.com Online Papers, "Identifying and Evaluating Alternative Pipeline Routes and Corridors "

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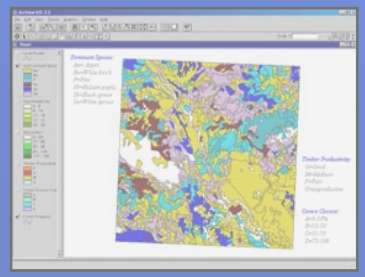
Map Analysis Evolution *(Revolution)*

Traditional GIS



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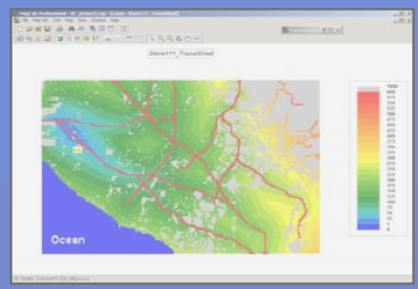
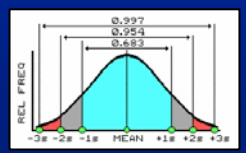
Spatial Analysis



Store Travel-Time (Surface)

- Cells, Surfaces
- Continuous Geographic Space
- Contextual Spatial Relationships

Traditional Statistics



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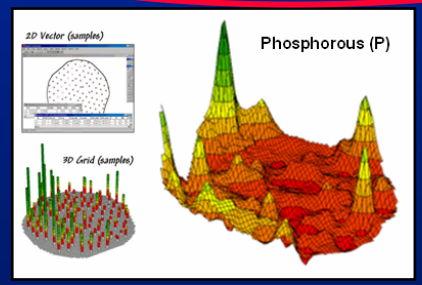
Spatial Statistics



Spatial Distribution (Surface)

- Map of Variance (gradient)
- Spatial Distribution
- Numerical Spatial Relationships

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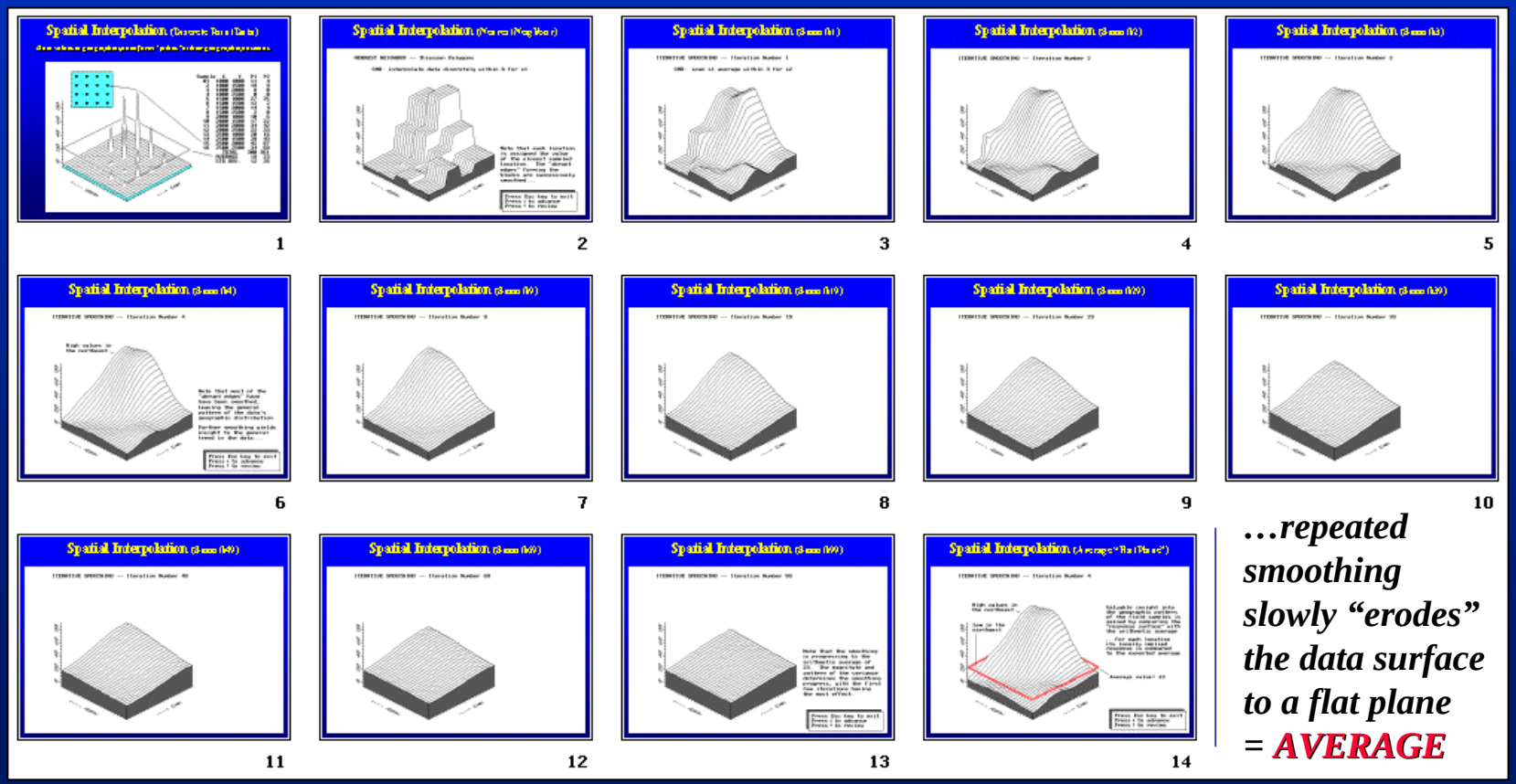
Spatial Interpolation *(Spatial Distribution)*

The "iterative smoothing" process is similar to slapping a big chunk of modeler's clay over the "data spikes," then taking a knife and cutting away the excess to leave a continuous surface that encapsulates the peaks and valleys implied in the original field samples …mapping the Variance



…repeated smoothing slowly "erodes" the data surface to a flat plane = AVERAGE

(digital slide show SSTAT)

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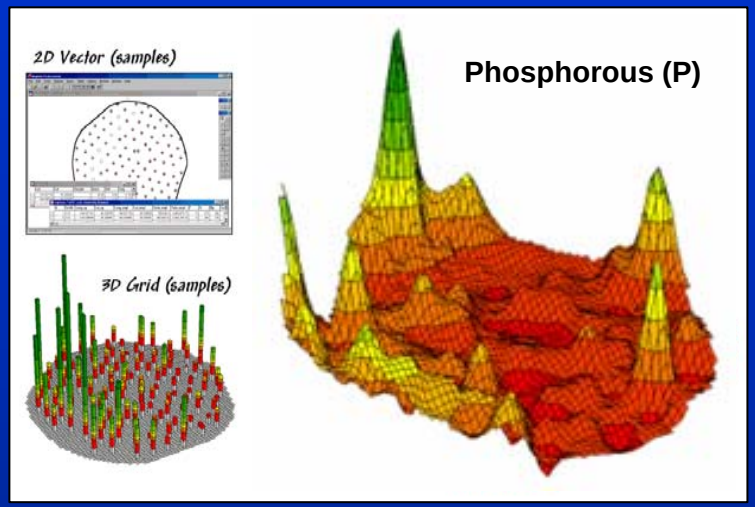
Visualizing Spatial Relationships



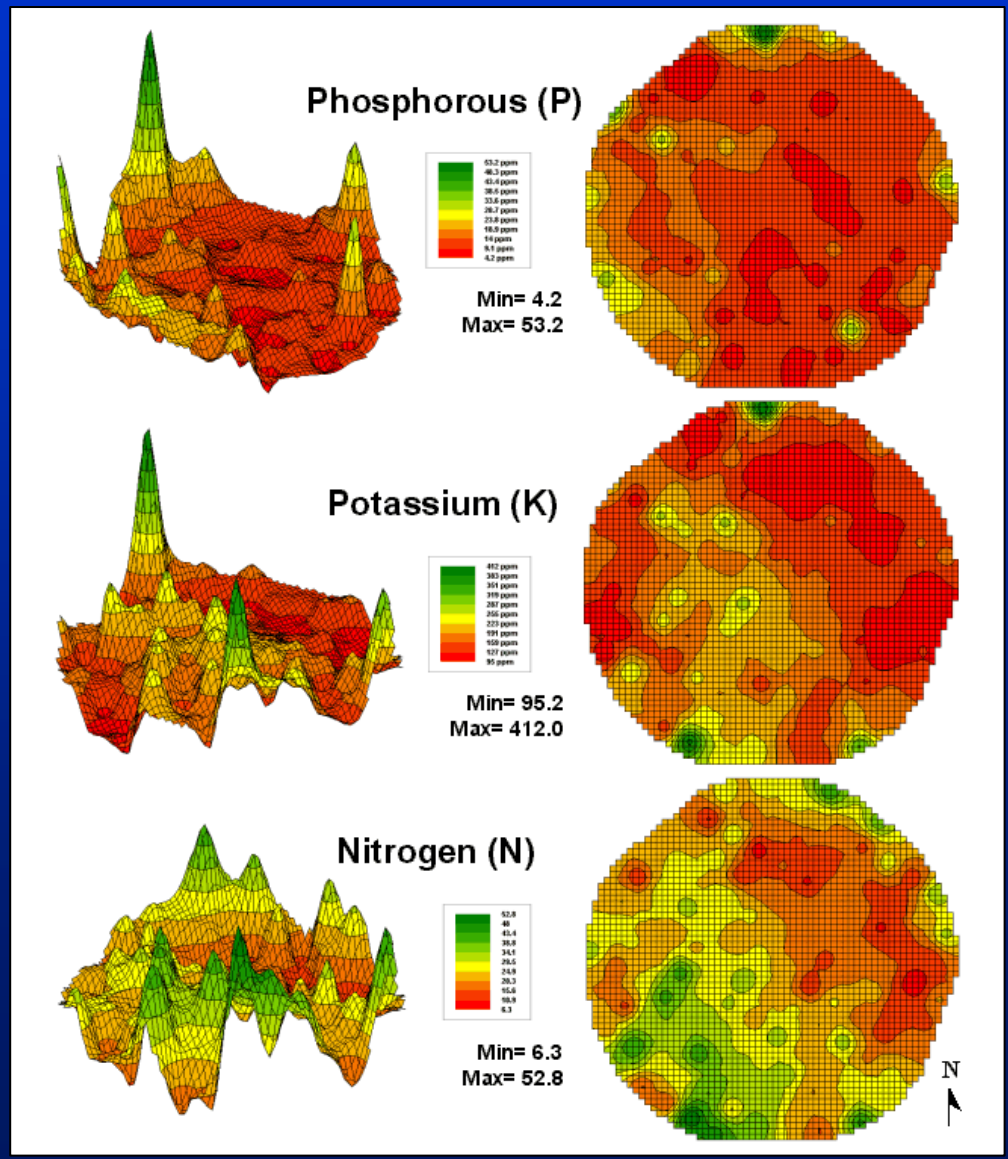
What spatial relationships do you SEE?

…do relatively high levels of P often occur with high levels of K and N?

…how often?

…where?

Multivariate Analysis



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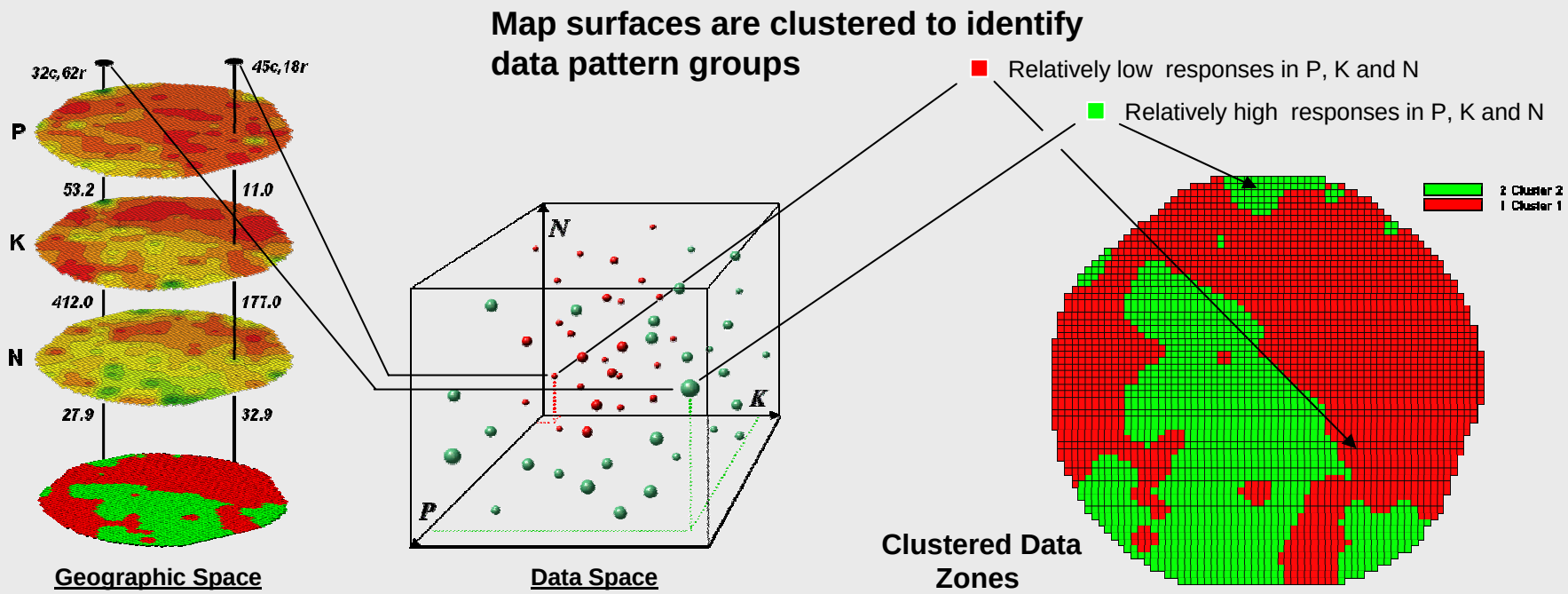
Clustering Maps

…groups of "floating balls" in data space identify locations in the field with similar data patterns– data zones

Spatial Data Mining



…other techniques, such as Level Slicing, Similarity and Map Regression, can be used to discover relationships among map layers

…map-ematics/statistics

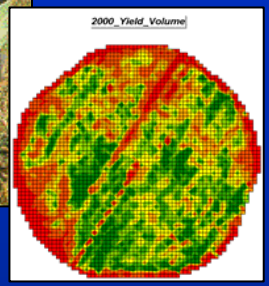
(Berry)

The Precision Ag Process *(Fertility example)*

As a combine moves through a field it 1) uses GPS to check its location then 2) checks the yield at that location to 3) create a continuous map of the yield variation every few feet. This map is 4) combined with soil, terrain and other maps to derive 5) a "Prescription Map" that is used to 6) adjust fertilization levels every few feet in the field (variable rate application).

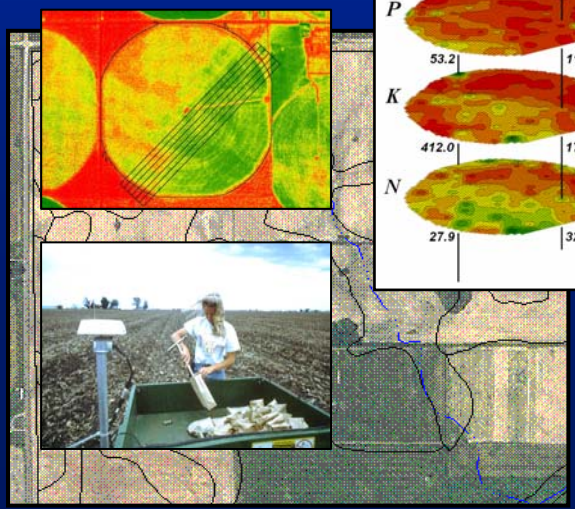
On-the-Fly Yield Map

Steps 1) – 3)

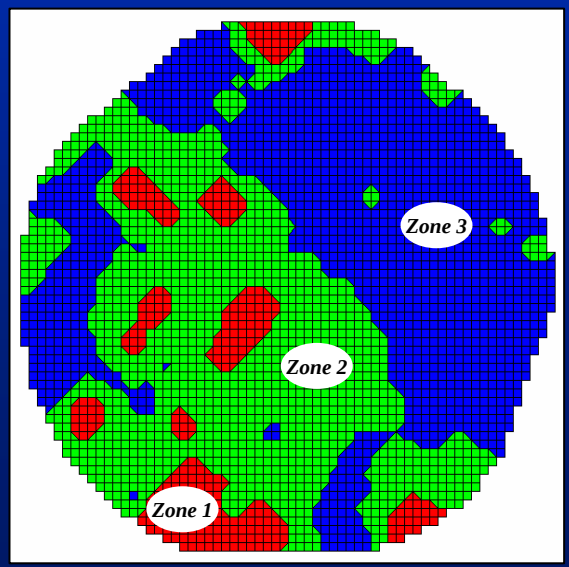


Step 4)

Farm dB



Map Analysis



Prescription Map

Step 5)

Variable Rate Application

Step 6)

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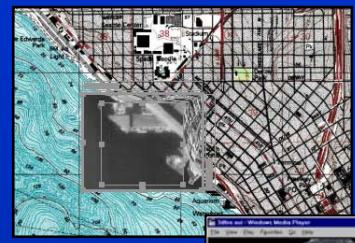
Part 2 Multimedia Mapping (00s,)

1) Map Delivery/Devices

GPS/GIS Enabled Devices and Internet Mapping

2) Map Display

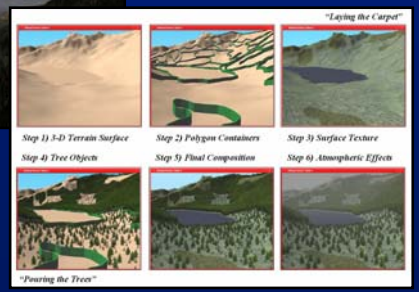


Interactive Maps

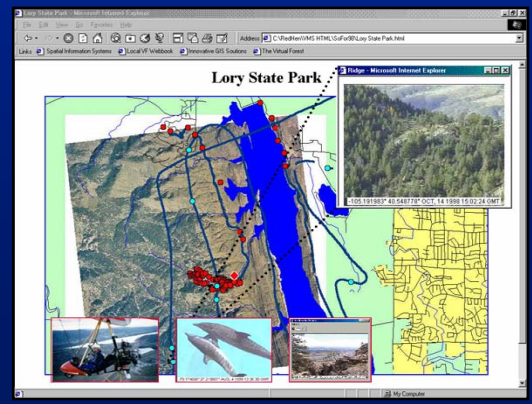
Animated Maps

3) Visualization

Rendered Scenes



4) Geospatial Multimedia



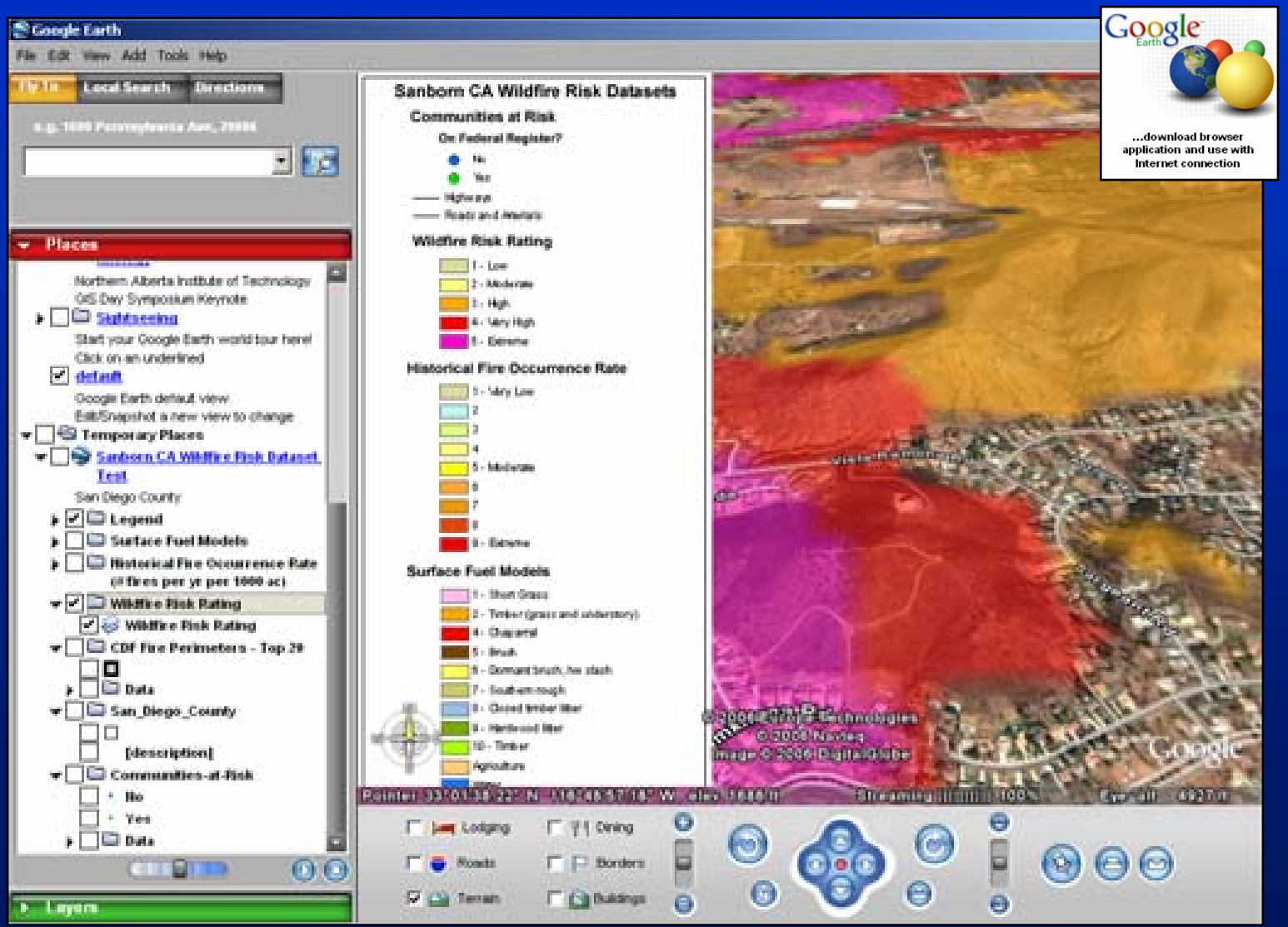
Maps with Integrated

- Photos
- Video
- Audio
- Text
- Data

(Berry)

Google Earth *(Killer App of 2005)*

***Vessel for Mapped Data*— has brought geotechnology to the masses; not a GIS but digests map data for 3D display with satellite imagery of the globe as backdrop**

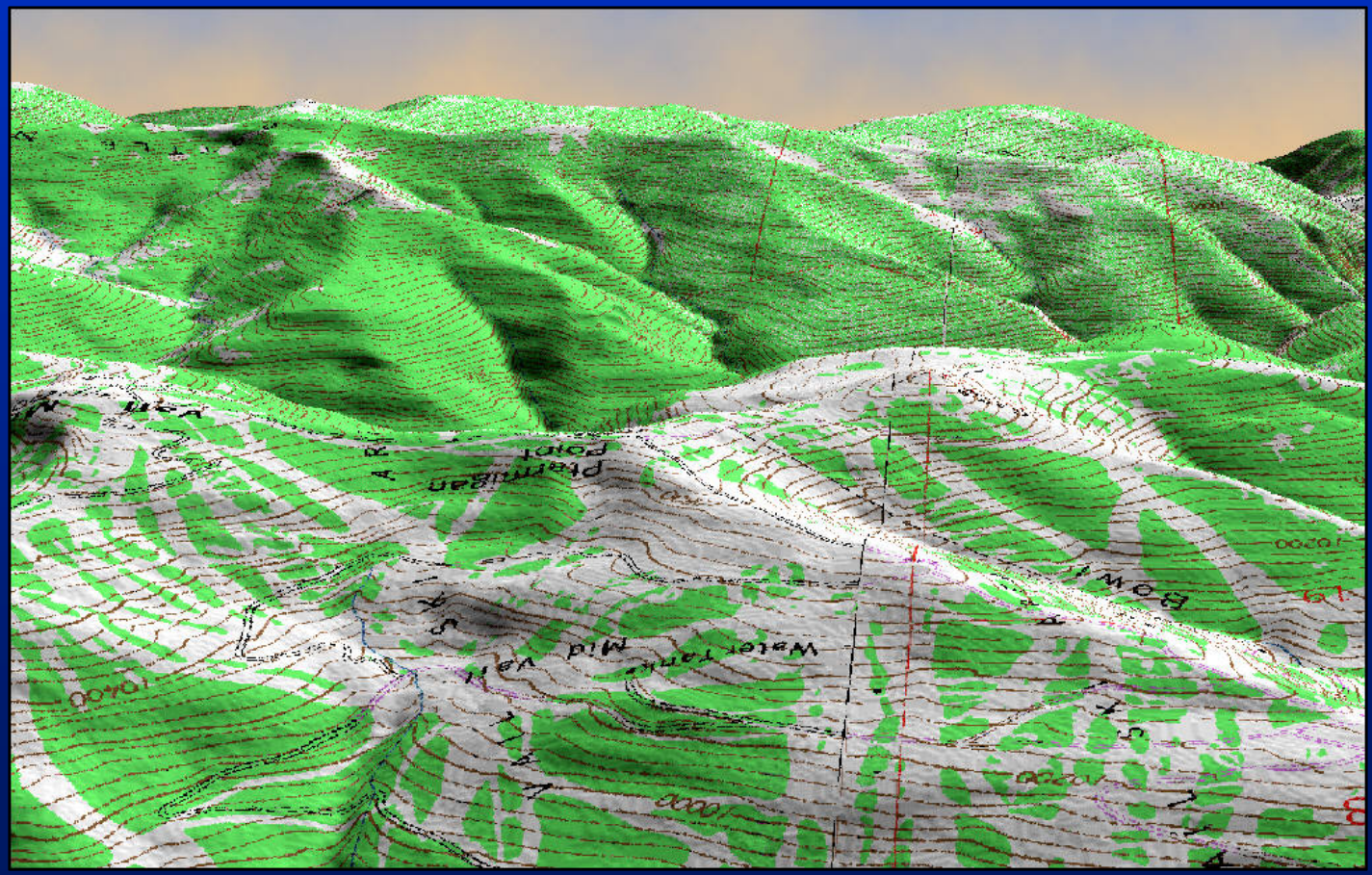


(Berry)

3-D Visualization Approaches *(Mega-Trend #2)*

Image Draping *-- is an established technique in GIS. Draping a topographic or thematic map onto a 3-D terrain surface is effective but relies on abstract colors, shading and symbols.*

"Map Abstraction"



SportsTracker (MapTrek, 9/98)

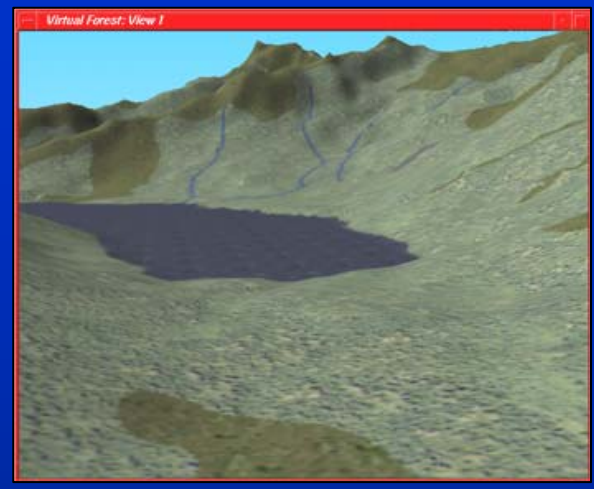
(Berry)

Landscape Visualization (Rendering Technique)

"Laying the Carpet"

Step 1) 3-D Terrain Surface

Step 2) Polygon Containers



Step 3) Surface Texture

Step 4) Tree Objects

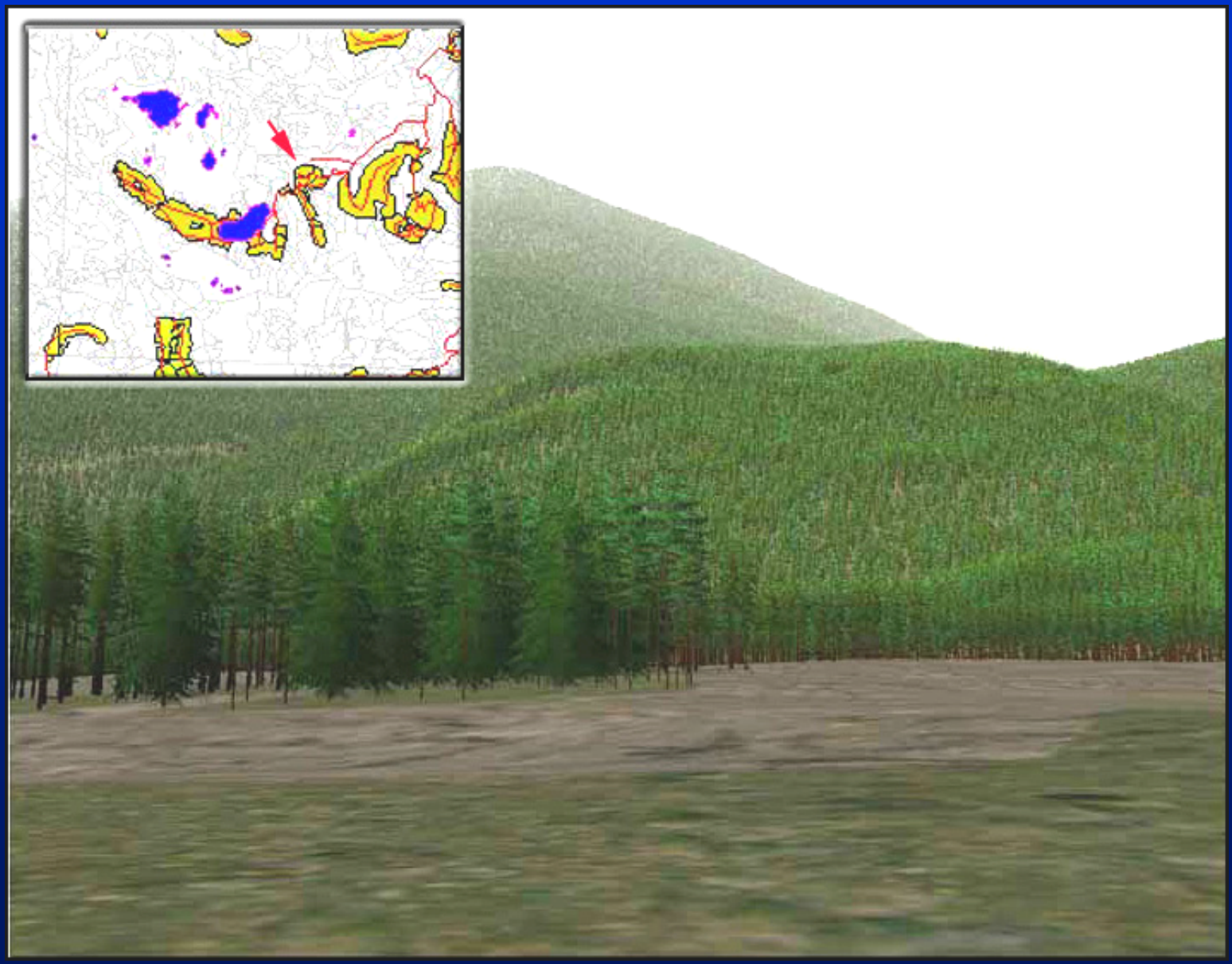
Step 5) Final Composition

Step 6) Atmospheric Effects

"Pouring the Trees"

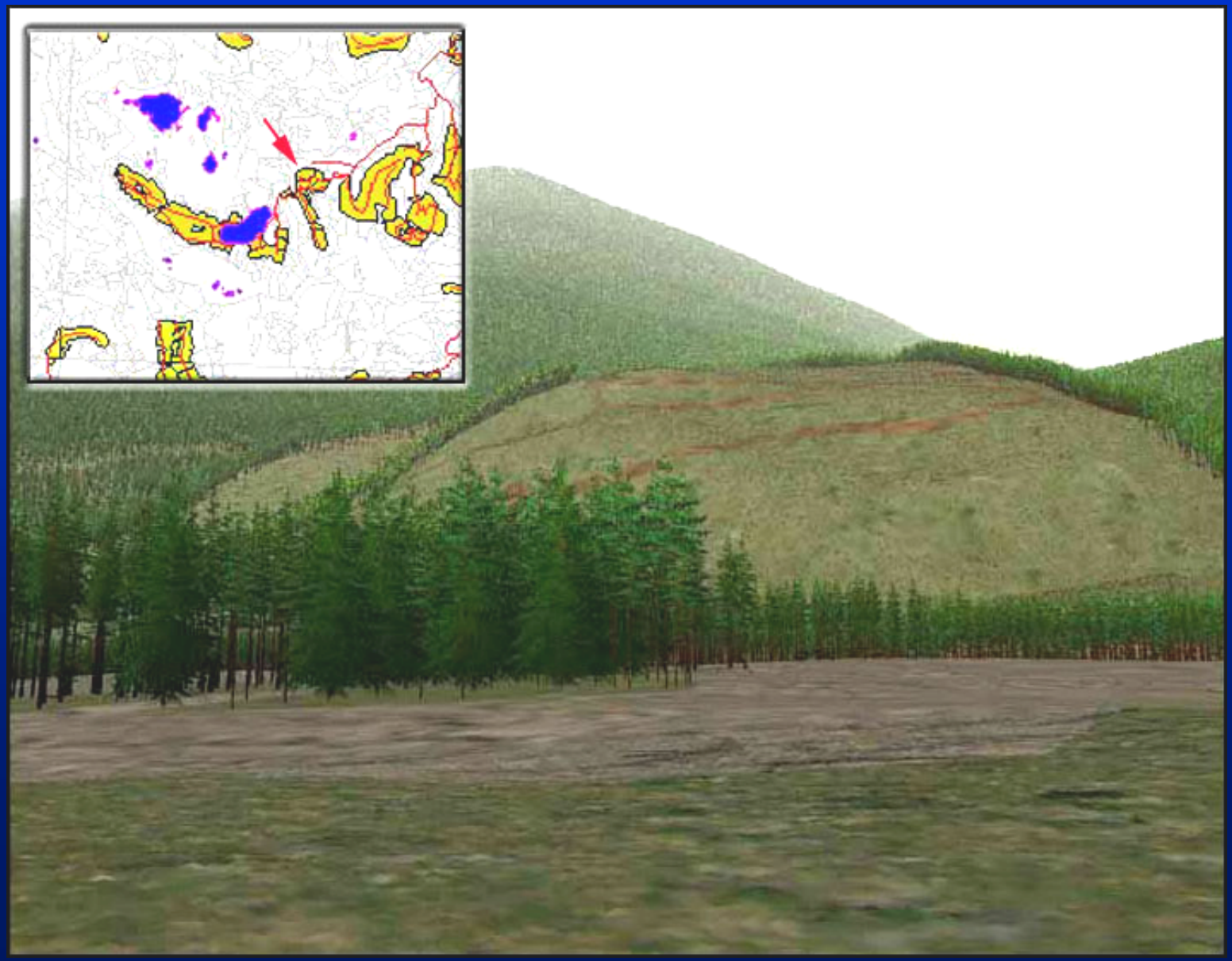
(Berry)

Visualizing Landscape Impacts (GIS Rendering)



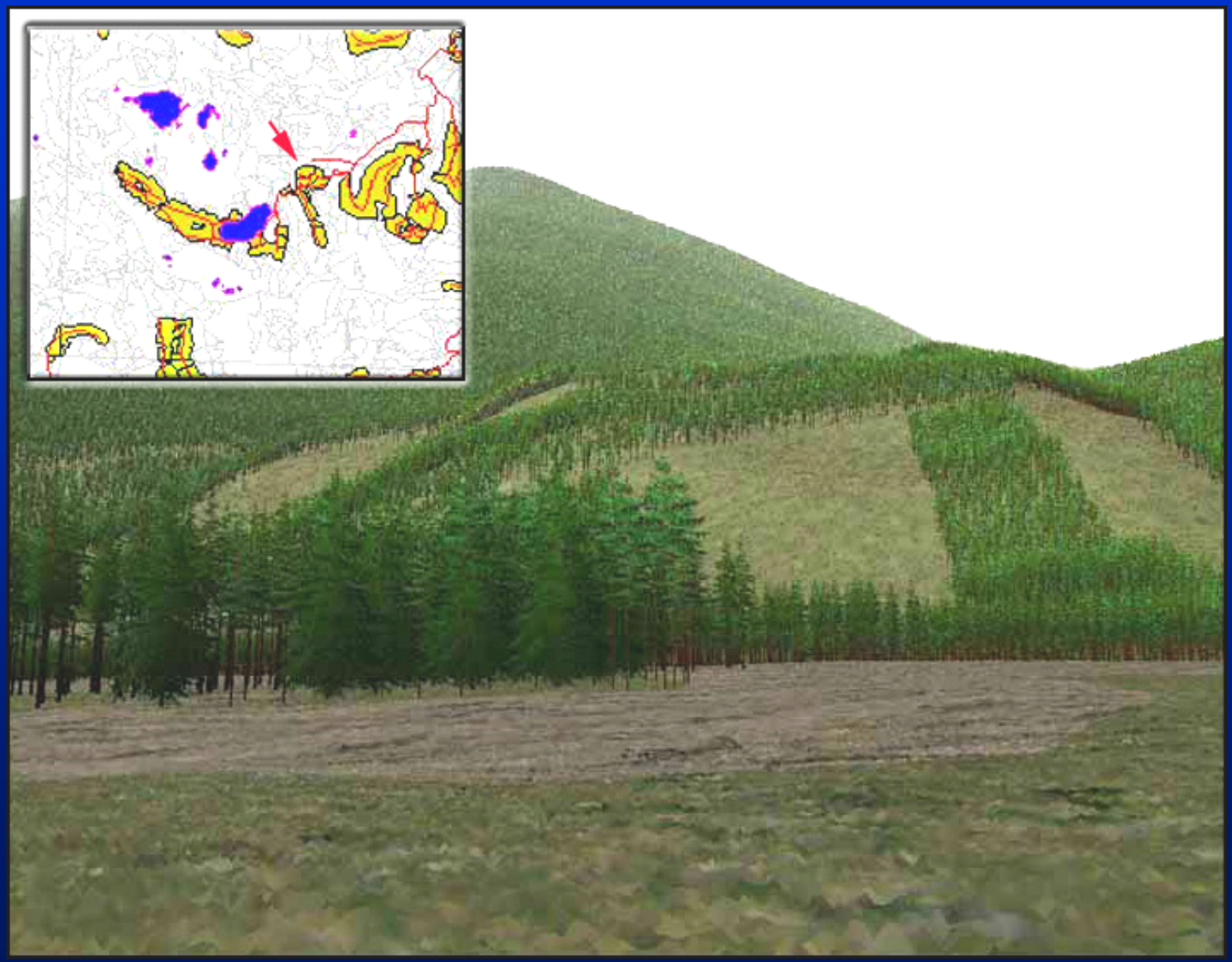
(Berry)

Visualizing Landscape Impacts (Clear cut)



(Berry)

Visualizing Landscape Impacts (Water retention cut)



(Berry)

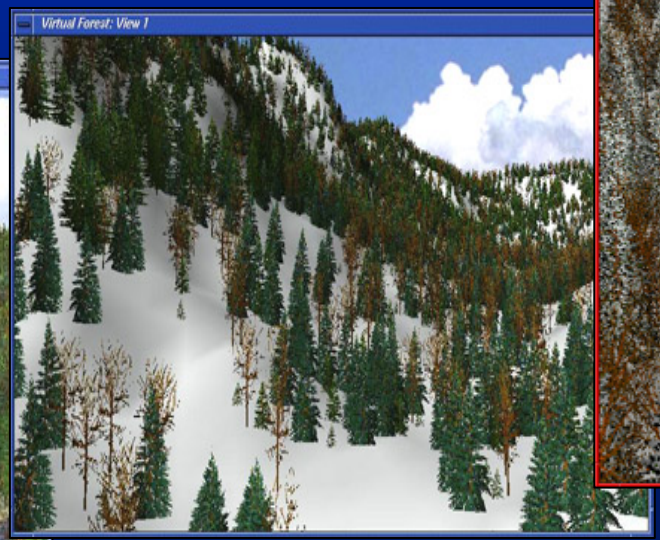
Visualizing Landscape Conditions

…changing the landscape's carpet and objects to simulate different conditions

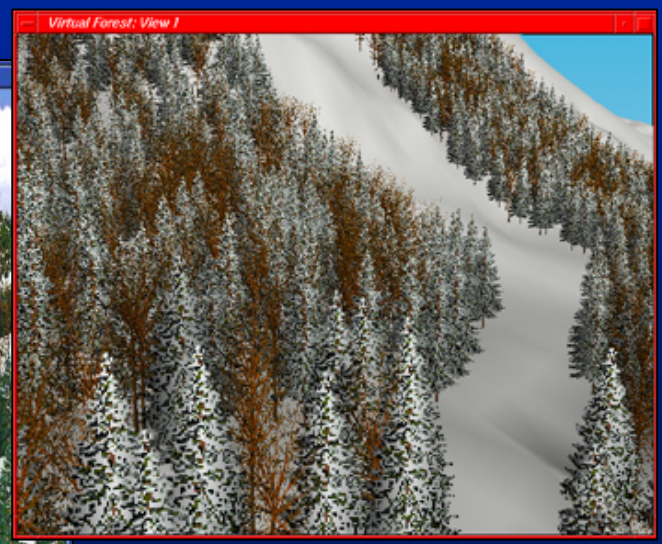
Before Fire

After Fire

Summer



Winter



After Snowfall

(Berry)

Geospatial Multimedia *(Mega-Trend #4)*

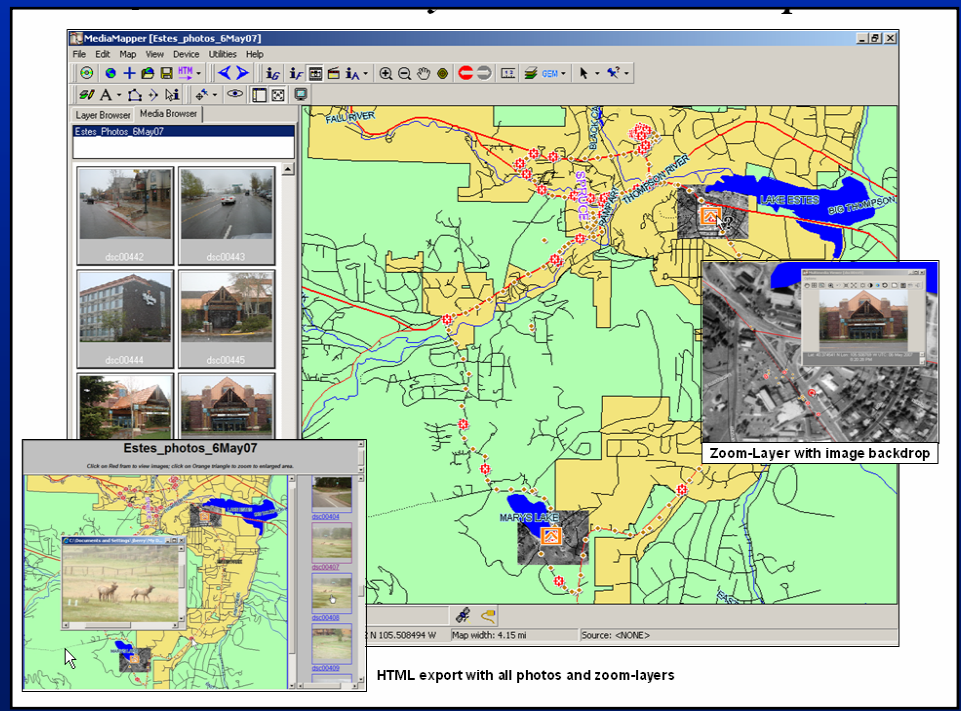
Digital Camera

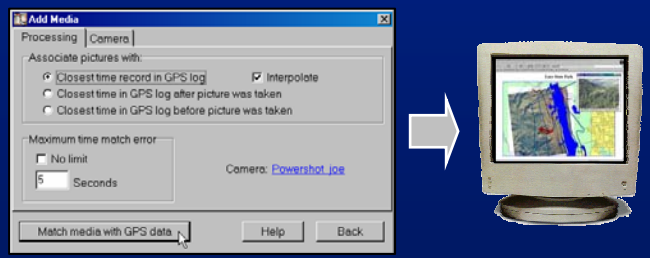
…take pictures with a digital camera or video recorder while carrying a GPS with 'track logging' then link the Lat/Lon with each picture.

- ✓ *What (picture)*
- ✓ *When (time)*
- ✓ *When (time)*
- ✓ *Where (X,Y)*

GPS Unit

Pictures are "posted and linked" to a map





MediaMapper GeoVideo Software

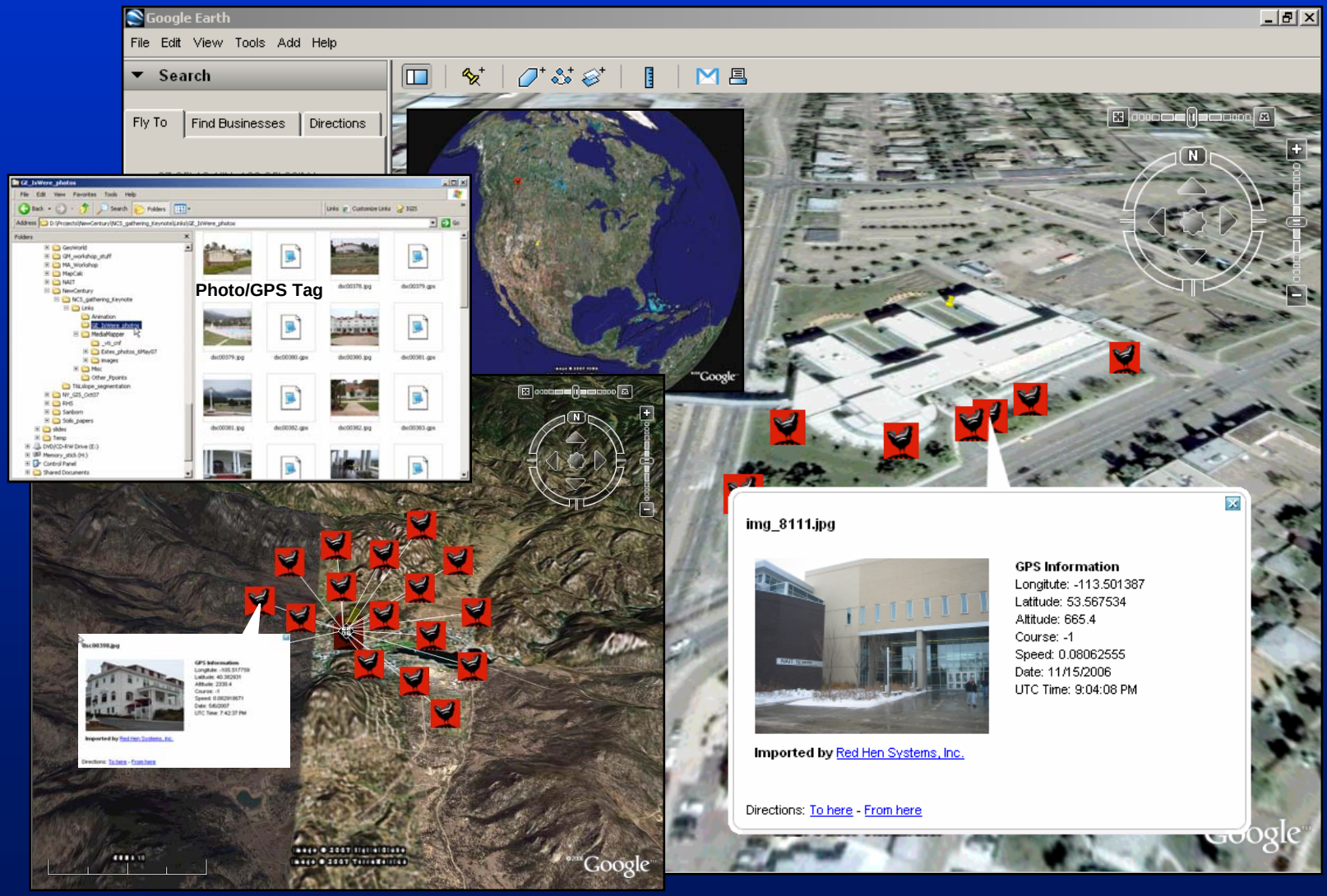
Red Hen Systems, http://www.redhensystems.com/

(See http://www.geoplace.com/gw/2001/0501/0501map.asp for more information)

(Berry)

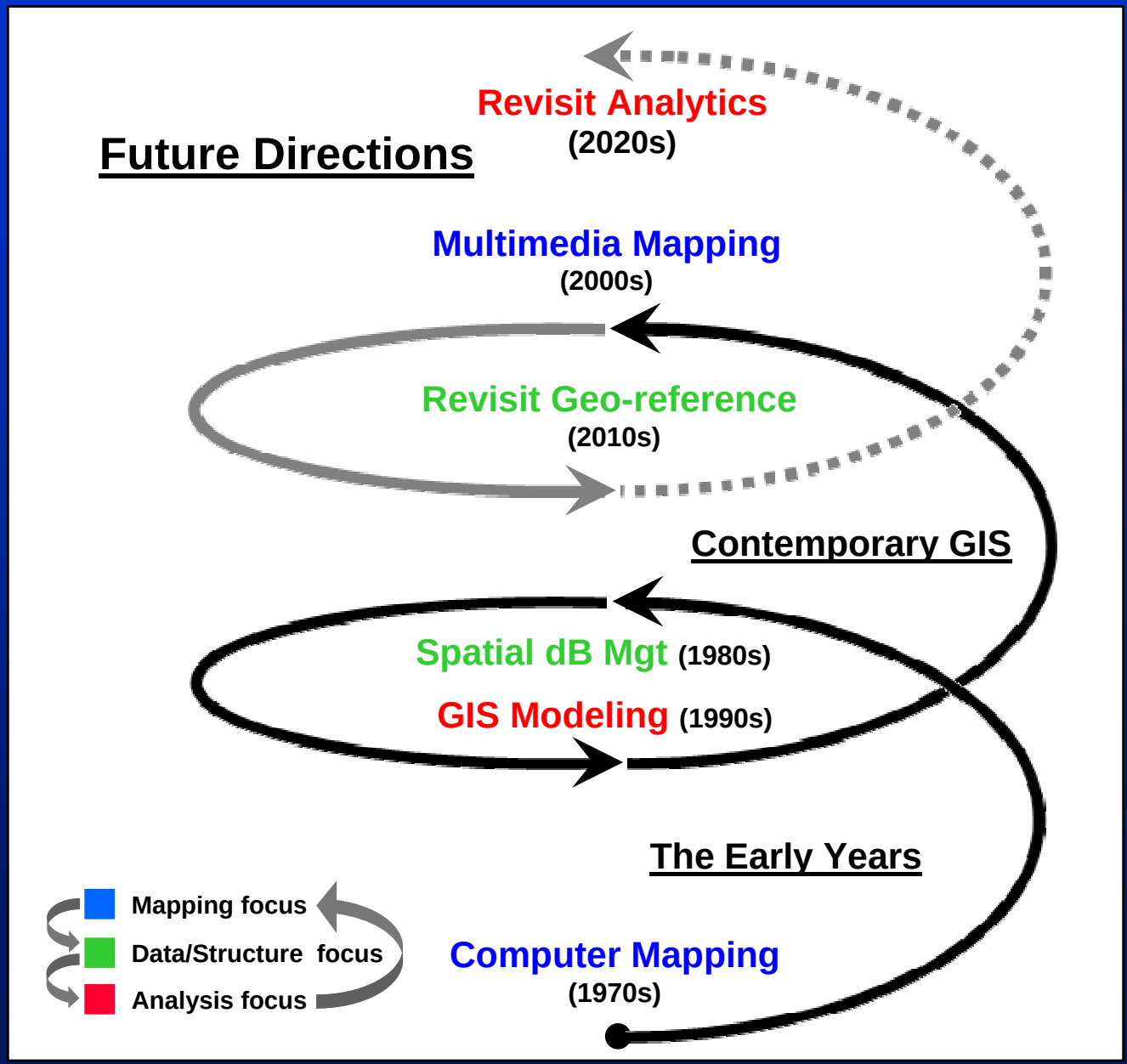
Google Earth *(Killer App of 2005)*

***Vessel for Mapped Data*— has brought geotechnology to the masses; not a GIS but digests map data for 3D display with satellite imagery of the globe as backdrop**



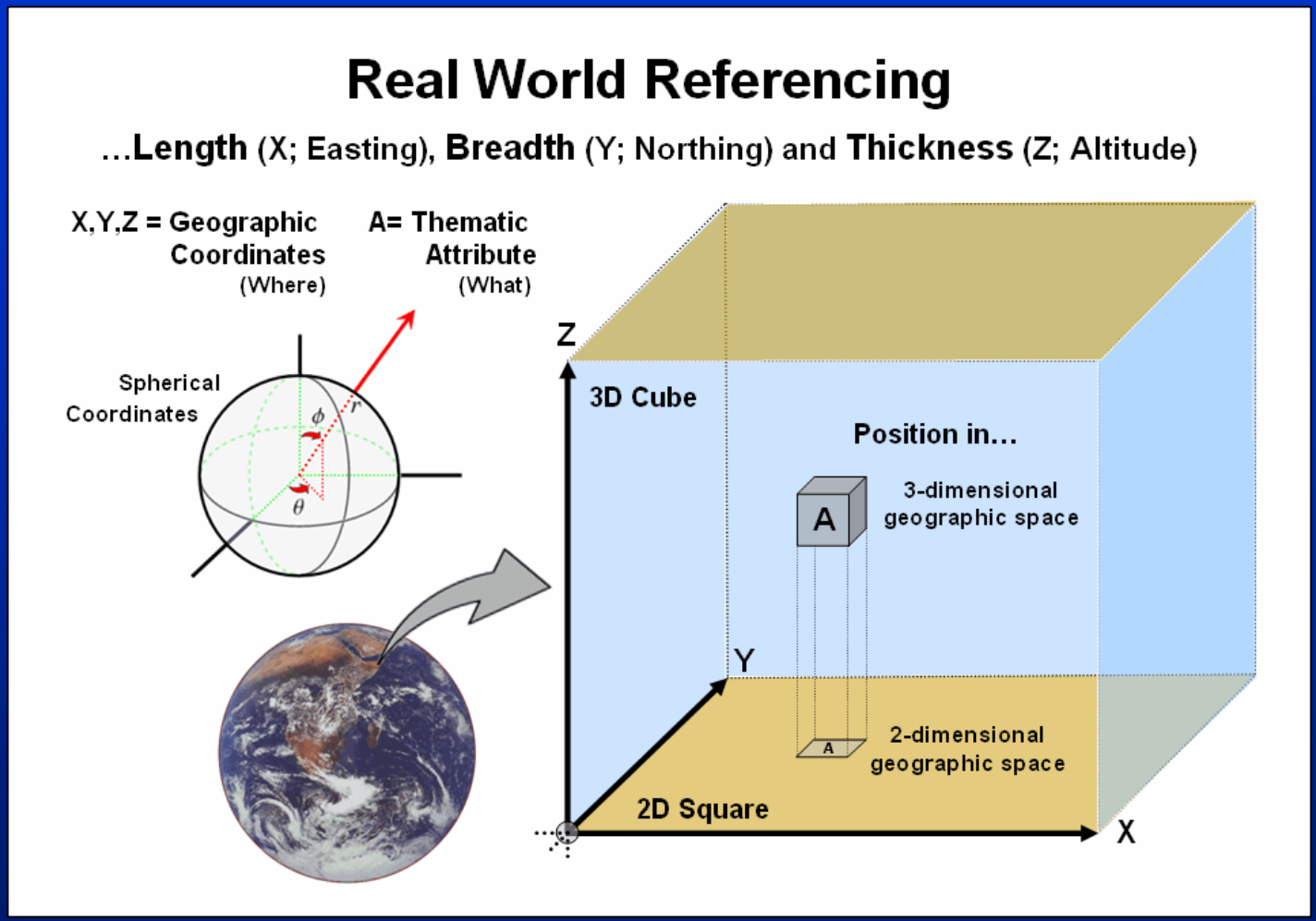
(Berry)

A Peek at the Bleeding Edge *(2010 and beyond)*



(Berry)

Traditional Geographic Referencing *(Cartesian)*



Cartesian Coordinate System (X, Y, and Z)

- **Discrete Spatial Objects** (vector) — *Point (X,Y) as fundamental unit*
- **Continuous Surfaces** (grid) — *Cell (Col,Row) as fundamental unit*

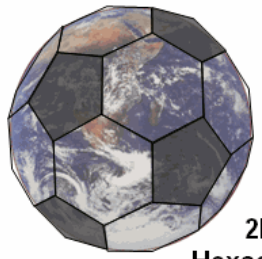
(Berry)

Alternative Geographic Referencing

Geographic Space

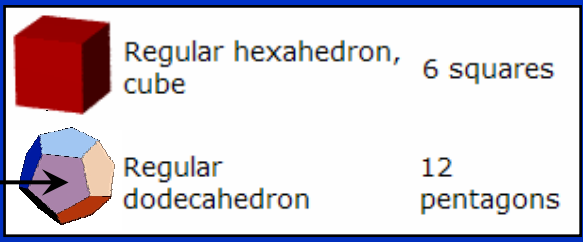
…Nested Hexagons as alternative to Traditional Square Grid (Cartesian)

Hexagon



2D
Hexagon Grid

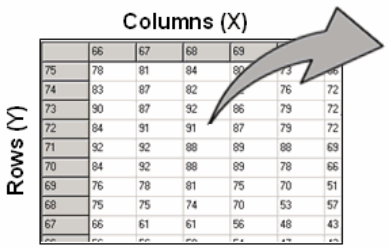
3D
Polyhedron

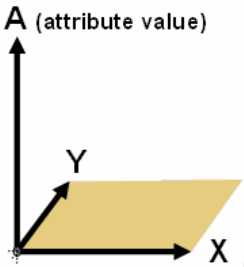


Abstract Space

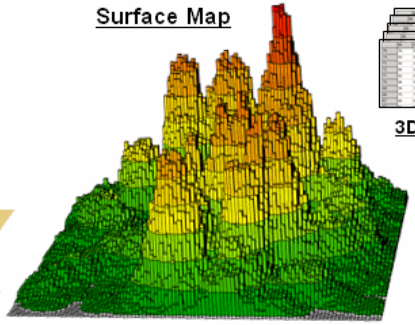
…Attribute Value (A) replacing Z Geographic Coordinate

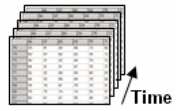
2D Data Matrix





Surface Map

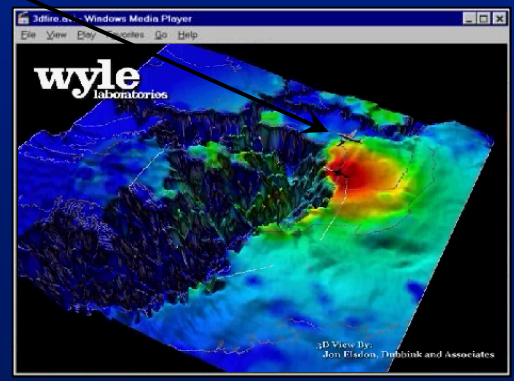




3D Data Matrix

Geo-referencing *(2010)*

- **Nested Hexagons**
  (2D hexagon grid)
- **Continuous Surfaces**
  (3D polyhedral grid)
- **Space/Time Continuum**
  (4D ????)



Animated Maps

Re-tooling Analytics *(and beyond)*

...the new geo-referencing and data structures will spawn new analytic algorithms *(e.g., 3D flows)*

(Berry)

Where Have We Been…

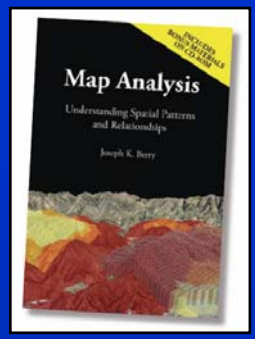
The US Department of labor identifies Geotechnology as one of the "three most important emerging and evolving fields"

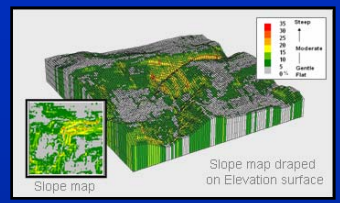
(along with Biotechnology and Nanotechnology)

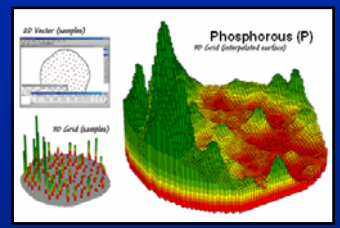
Computer Mapping (70s) — Spatial Database Management (80s)

Map Analysis *representation of relationships within and among mapped data (1990s)*

- ***Spatial Analysis*** *— "contextual" relationships*
- ***Spatial Statistics*** *— "numerical" relationships*

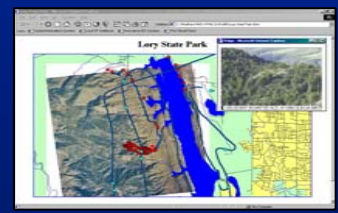






Multimedia Mapping *full integration of GIS, Internet and visualization technologies (2000s)*

- ***Map Delivery/Devices*** *— Internet & Devices*
- ***3D Visualization*** *— Draping & Virtual Reality*
- ***Map Display*** *— Interactive & Animated Maps*
- ***Multimedia Mapping*** *— GPS/Photos & Video*
- ***Google Earth*** *— New Vessel for Mapped Data*



Geo-referencing (2010s) — Re-tooling Analytics (2020s)