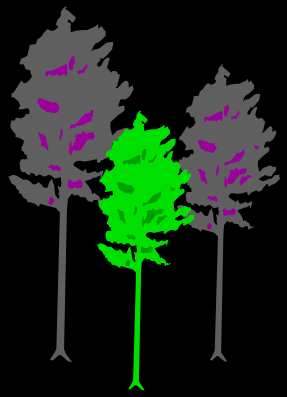

REMOTE SENSING NEEDS FOR STATE FORESTRY AGENCIES: A VIRGINIA PERSPECTIVE

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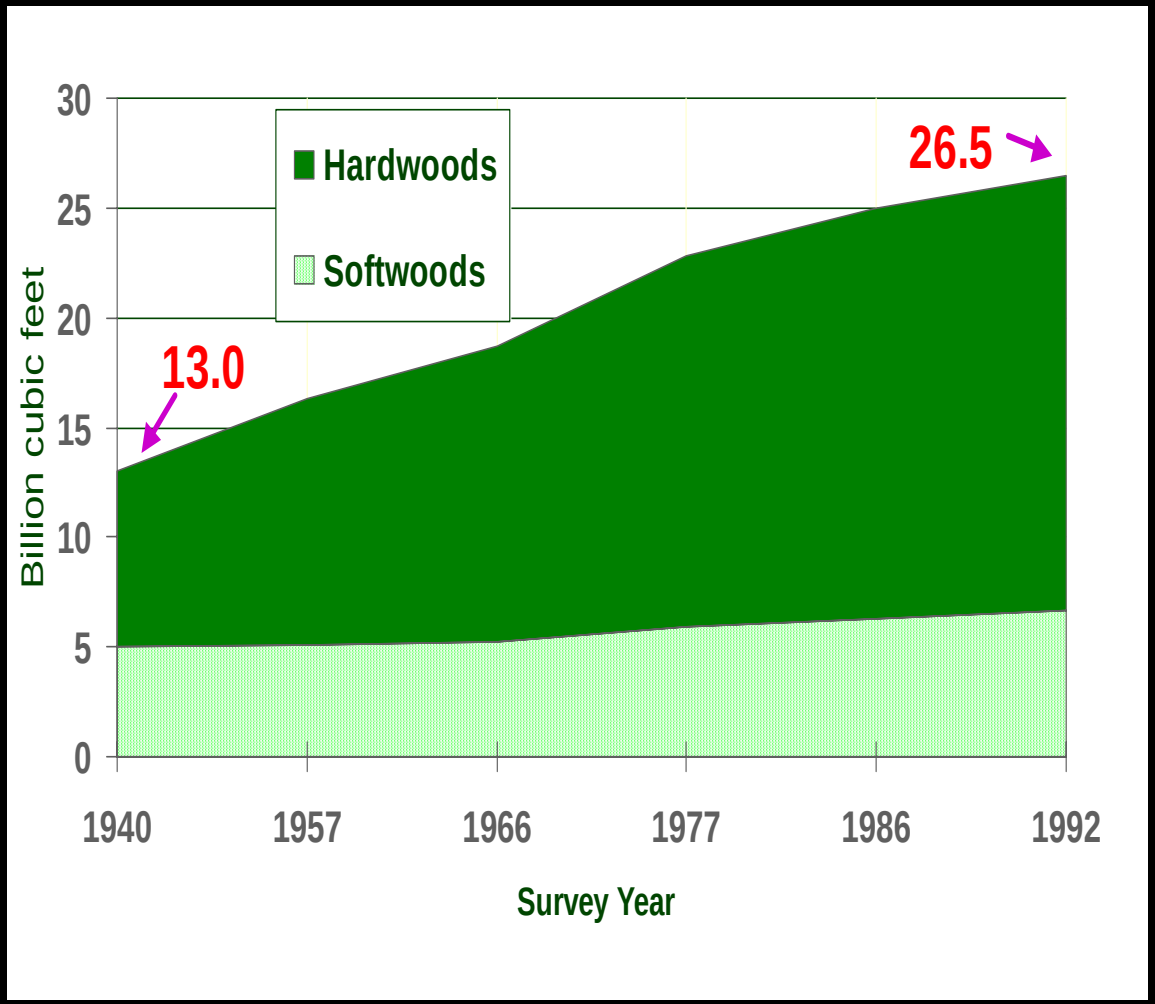
Presented at the LCLUC Science Team Meeting on GOFC and Disturbance, September 20-22, Rockville, Maryland, USA

Virginia Forests

- 16 million acres (6.3 million ha)
- 63% of total land
- 77 % non-industrial private land ownership
- More than 300,000 private landowners

Growing Stock Inventory 1940-1992



Softwood

1940 5.03

1992 6.65

+32.2%

Hardwood

1940 7.97

1992 19.84

+148.9%

Virginia Department of Forestry

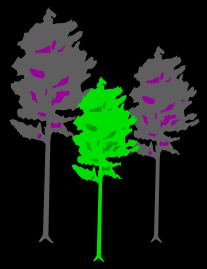
Our Mission:

Protect and develop healthy, sustainable forest resources.

Traditional Roles

- Fire protection and prevention
- Reforestation: nursery production, site preparation burning, planting, competition control
- Management planning assistance

VIRGINIA DEPARTMENT OF FORESTRY



Sustainability: Strategic Goals

- Maintain and, as appropriate, expand the area covered by forests
- Promote long-term investment in forests
- Recognize and respect a mixed public-private system of ownership
- Encourage multiple forest uses consistent with long-term integrity of forest ecosystems
- Promote citizen participation in determining the care and management of forest resources
- Maintain the productivity of forest ecosystems for a full range of values, functions and services

New Roles

- Forest resource assessment, economic, social and ecological sustainability
- Forest land conservation
- Water quality protection via
  - forest conservation,
  - riparian buffers, and
  - best management practices for harvesting

New Role - Annual Forest Inventory and Monitoring

- In fourth year of annual inventory system, cooperative with USFS
- 1000+ field plots per year
- Investigating the use of satellite remote sensing to:
  - provide forest area estimates
  - estimate levels of forest harvesting and disturbances
  - provide better local estimates of volume, growth, removals & health
  - provide landscape analysis

CHESAPEAKE 2000
Federal and Multi-State Agreement

FORESTS

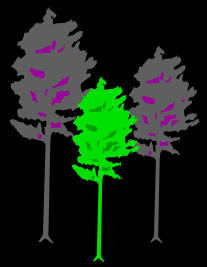
- By 2002, ensure that measures are in place to meet our riparian forest buffer restoration goal of 2,010 miles by 2010. By 2003, establish a new goal to expand buffer mileage.

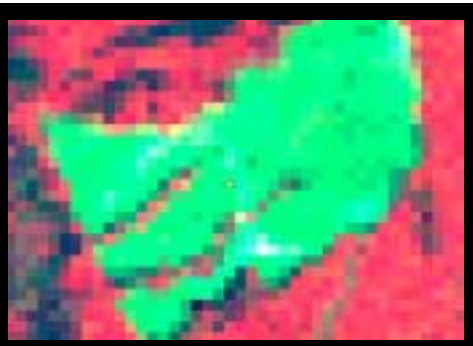
Conserve existing forests along all streams and shorelines.

- Promote the expansion and connection of contiguous forests through conservation easements, greenways, purchase and other land conservation mechanisms

New Role - Riparian Forest Buffer Monitoring

- New state law provides tax credit to forest landowners leaving riparian buffers in timber harvests
- Requires 15 year monitoring of buffers
- Up to 2,000 buffers added each year
- Remote sensing only practical way to monitor

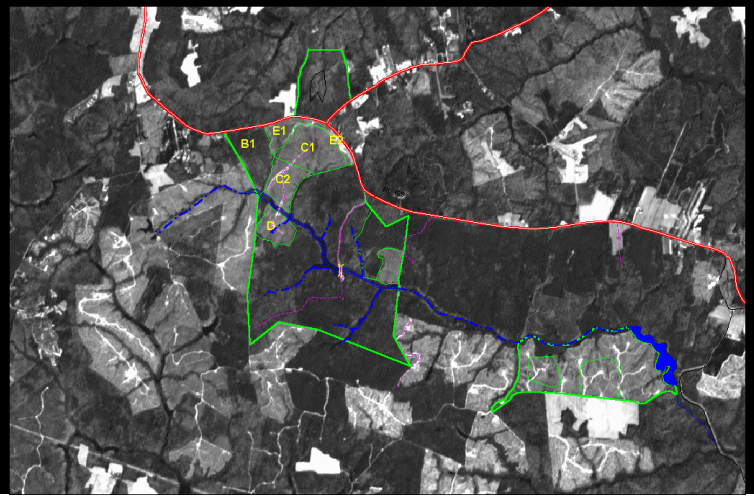




Products Needed From RS

- Forest area maps and estimates (5 yr basis)
- Harvest and disturbance detection (1-2 yr)
- Monitoring of riparian buffers (1 yr)
- Improved local forest type, volume, growth & removal estimates (1-5 yr)
- Landscape level analysis of fragmentation and broader issues of sustainability (5 yr)

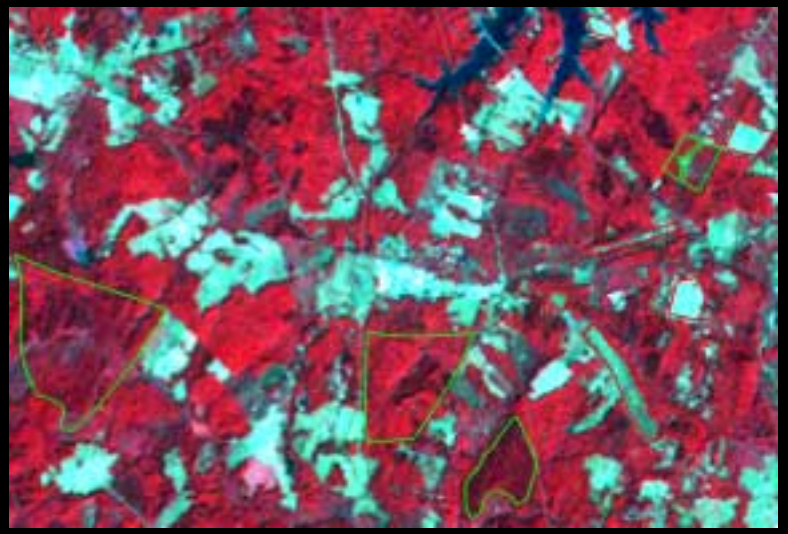
State Forestry Agencies - Cornucopia of Ground Truth

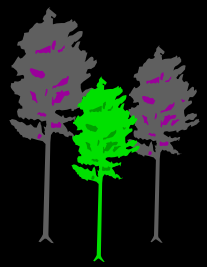


- Currently using GPS to map tracts for reforestation, release and management projects
- Most timber harvests are visited on the ground for BMP compliance
- Riparian forest buffers receiving tax credit must be accurately mapped (GPS)
- Stewardship plans produce maps of forest cover
- Forest inventory plots are GPS'd

Work to Date

- Phase I Forest Area Estimation Using Landsat TM and Iterative Guided Spectral Class Rejection (IGSCR)
- Change detection using TM and reference data





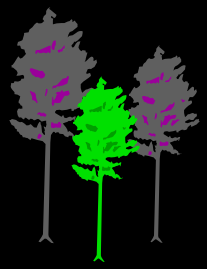
Criteria for Forest Area Estimation Methodology

- Objective and repeatable
  - across operators, regions and time
- Quick and low-cost
  - repeatable at 3-5 years
- Provides a binary forest/non-forest *landcover/landuse* classification
- Usable to estimate Phase 1 *forest land use*
  - adjusting map marginals with ground truth

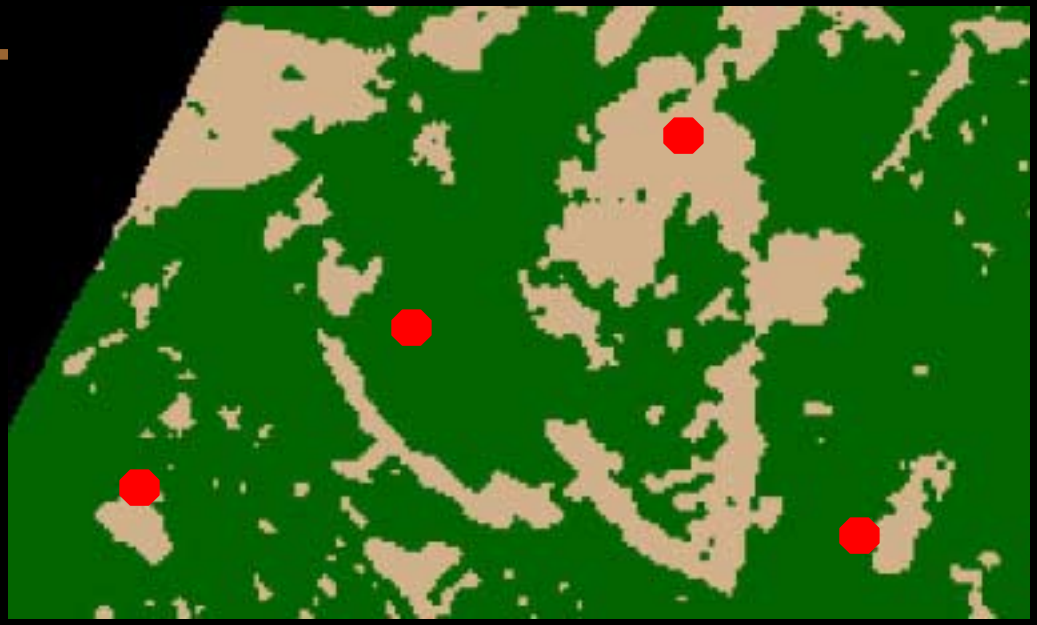
Traditional PI Method

- Operational SAFIS program used for comparison
- Phase 1 PI
  - 1994 NAPP photography (1991-96)
  - ground truth performed late 1997-2000
- Estimates via Li, Schreuder, Van Hooser & Brink (1992)

Phase I Estimates from Image Classifications



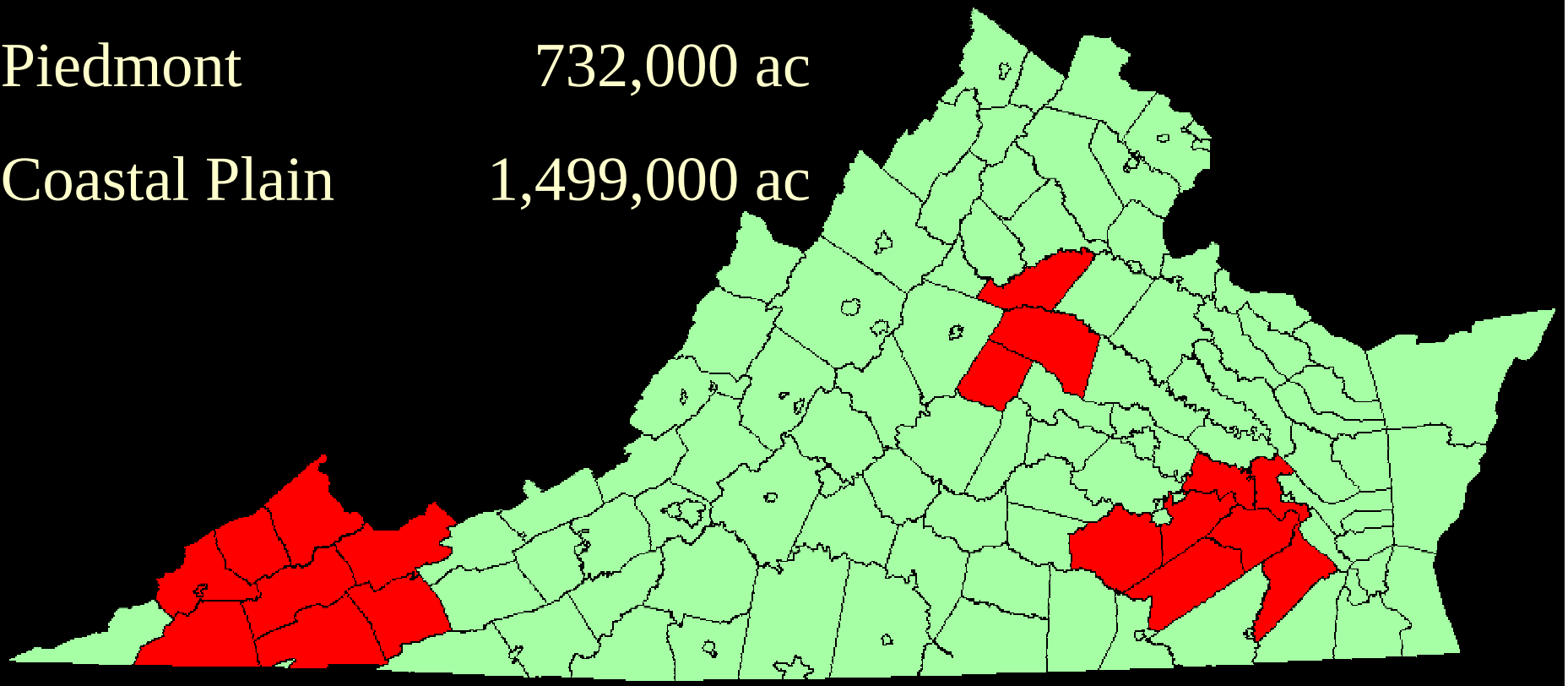
- Map marginal proportions from classification used as large "sample"

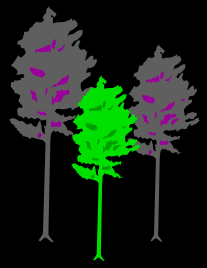


- Phase II (and III) FIA ground plots and intensification points used as "small sample", or ground truth, to adjust map marginal proportions
- Standard errors estimated via Card (1982) formulae

Study Areas

Mountains	2,435,000 ac
Piedmont	732,000 ac
Coastal Plain	1,499,000 ac





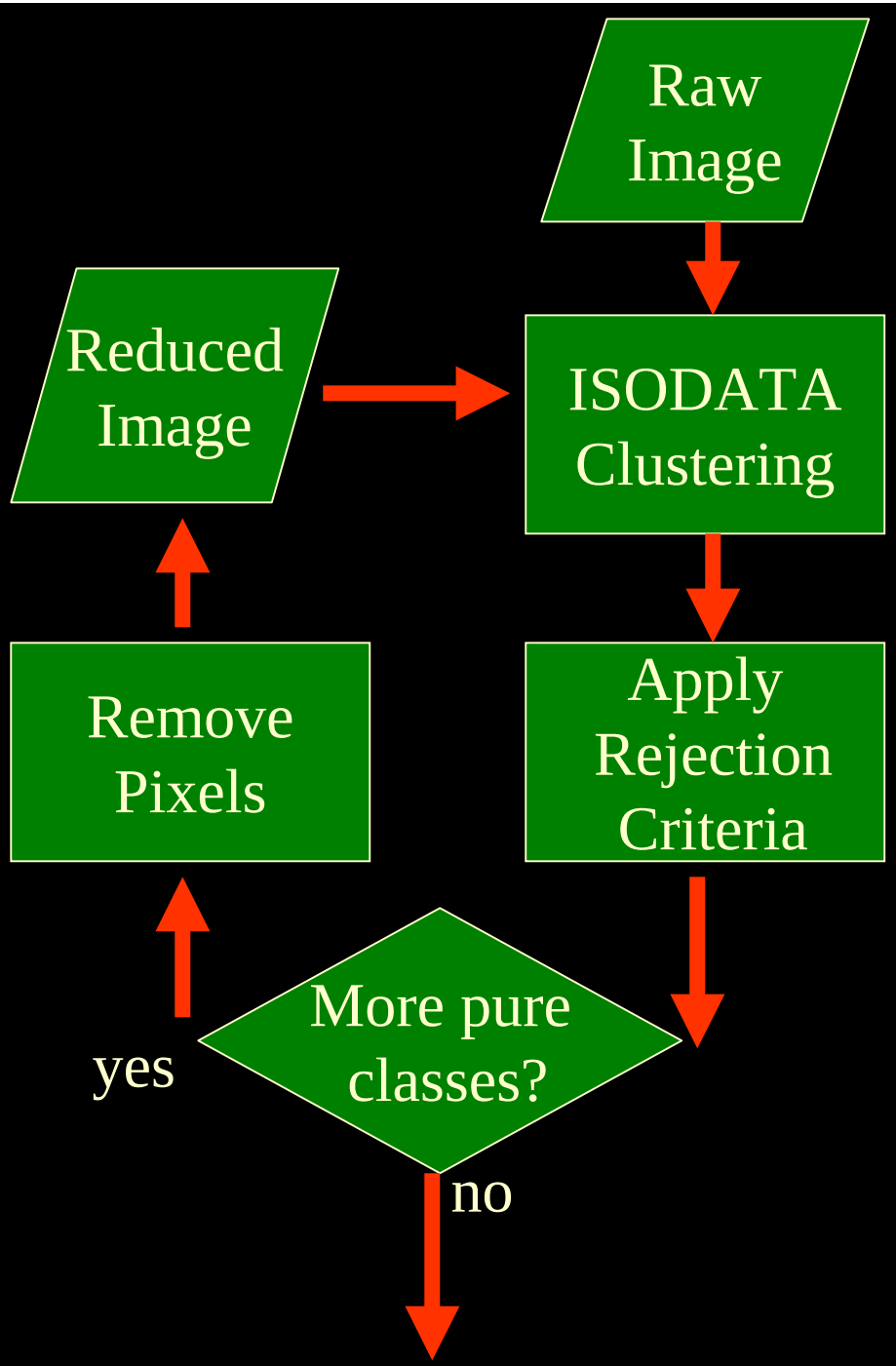
Reference Data for IGSCR

- Any source of know forest and non-forest can be used
- Need to sample range of spectral variability
- Need to sample “confused” spectral classes
- Need to sample proportionally within confused classes

Physiographic Region	Buffered Points	Heads-up Digitizing	Harvest Polys	Helopolys
Coastal Plain	X		X	X
Piedmont		X	X	X
Ridge and Valley	X	X		

Iterative Guided Spectral Class Rejection

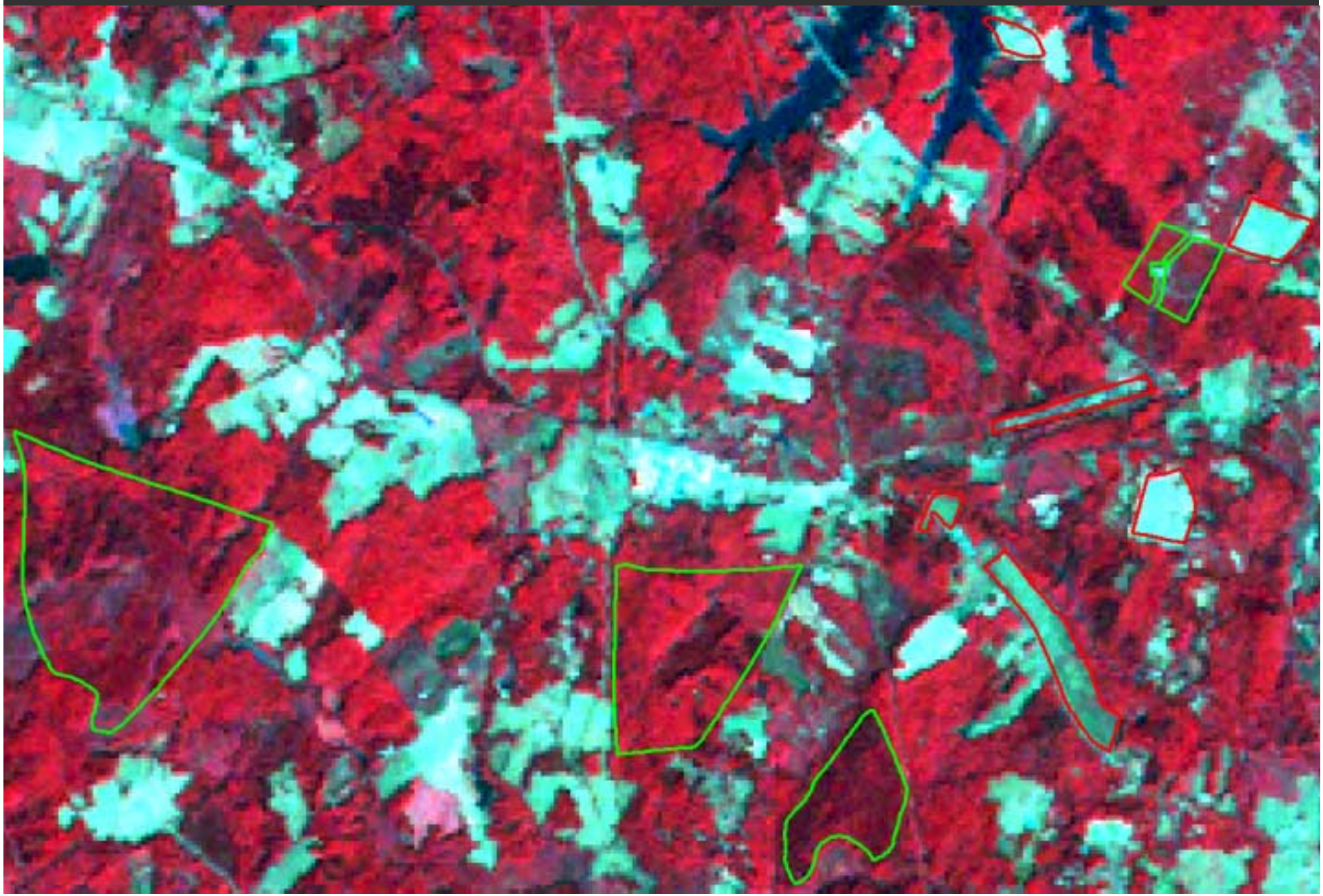
- unsupervised ISODATA clustering into 100-500 spectral classes
- reference data used to "reject" relatively "pure" spectral classes (e.g. 90% pure)
- "pure" classes removed from image and remaining pixels enter into next iteration



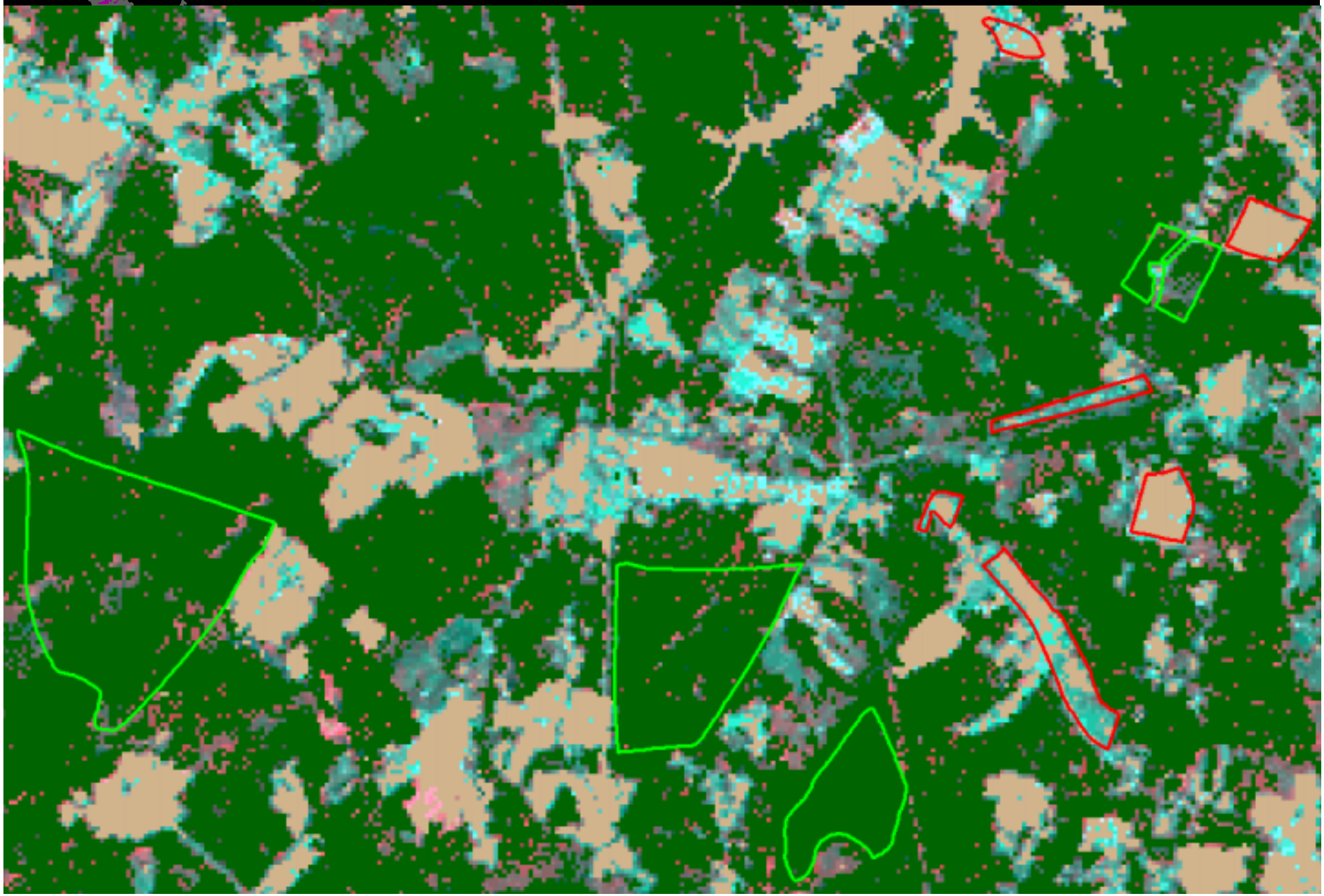
Iterative Guided Spectral Class Rejection

- Iterations continue until no further pure spectral classes are extracted
- Identified “pure” spectral classes used as signatures for a ML classification
- 3x3 scan majority filter used to assign final pixel classification

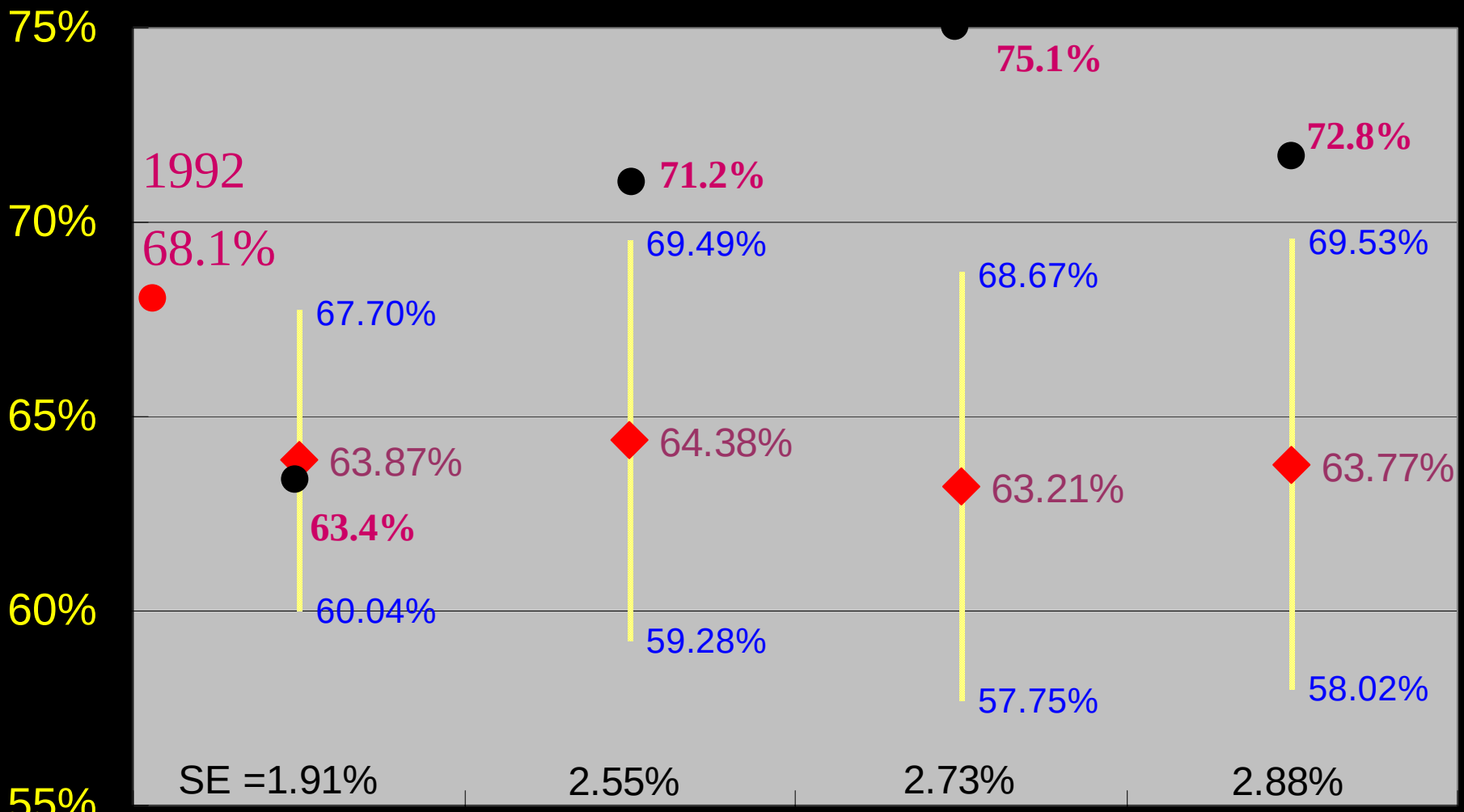
Raw TM Image

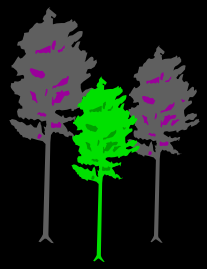


After First Iteration



Phase I Estimates - Piedmont



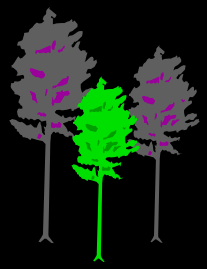


Results Summary

Method	Unadjusted % Forest	Adjusted % Forest	Std Error	n	1992 Estimate
Coastal					
Traditional FIA PI	67.27%	66.06%	1.08%	260	69.99%
IGSCR (3x3 filter)	68.38%	67.14%	3.07%	121	
MRLC-15for	68.40%	69.84%	3.15%	121	
MRLC-15non	66.70%	72.14%	3.36%	121	
Mountain					
Traditional FIA PI	65.75%	69.74%	1.22%	493	67.17%
IGSCR (3x3 filter)	76.87%	69.68%	2.44%	241	
MRLC-15for	77.28%	70.53%	2.52%	240	
MRLC-15non	77.17%	70.70%	2.50%	240	

Accuracy Statistics - Piedmont

	IGSCR	MRLC-15f	MRLC-15n
Overall Acc.	85.4	82.8	80.7
Kappa	.676	.605	.565
Users - For	85.0	80.5	80.4
Users - Non	86.4	89.6	81.5
Producers - For	93.4	95.9	91.7
Producers -Non	71.8	60.6	62.0



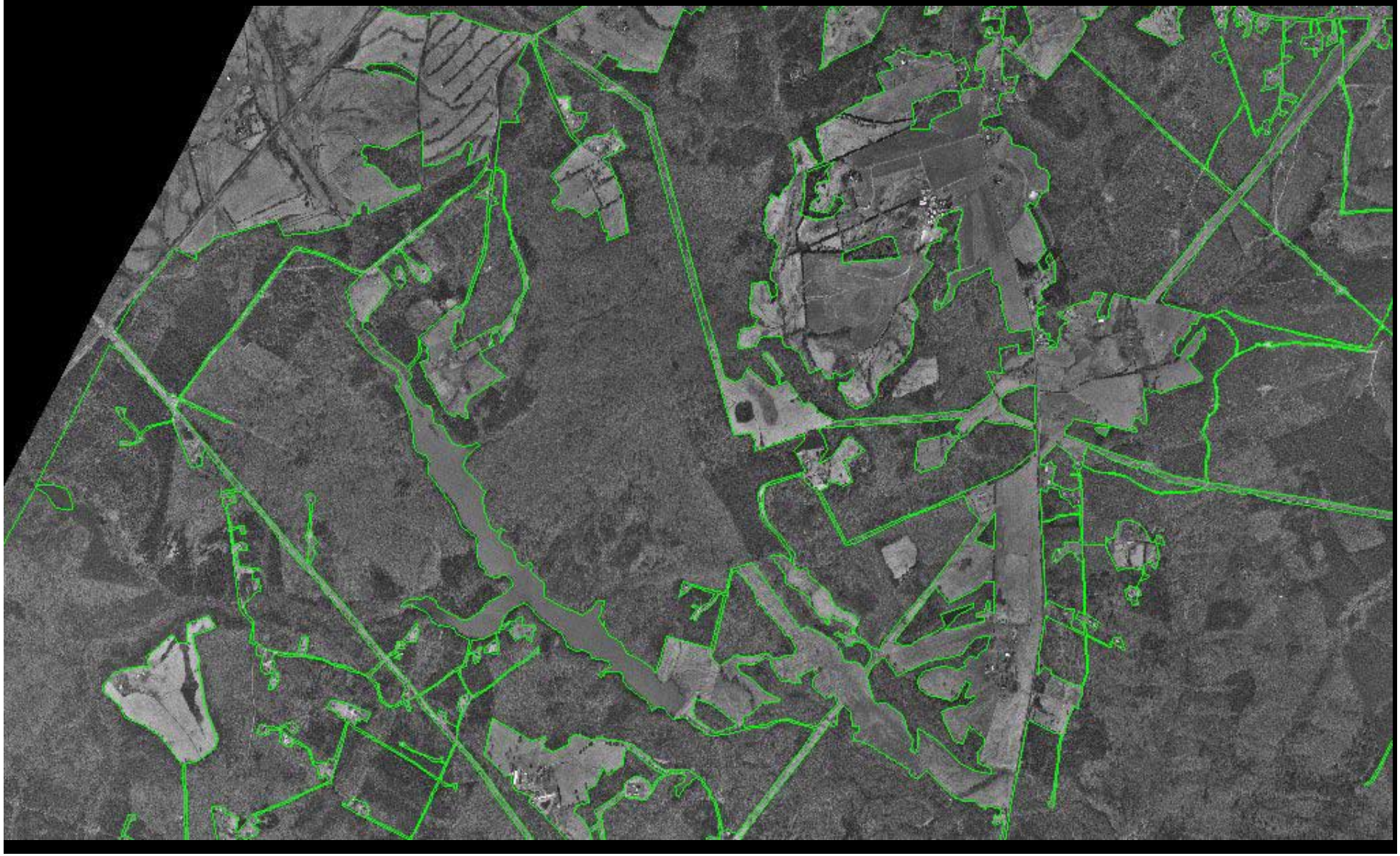
Accuracy Statistics - Coastal

	IGSCR	MRLC-15f	MRLC-15n
Overall Acc.	94.8	86.8	81.8
Kappa	.855	.667	.566
Users - For	94.7	90.9	90.2
Users - Non	95.2	75.8	64.1
Producers - For	98.6	90.9	84.1
Producers -Non	83.3	75.8	75.7

Accuracy Statistics - Mountains

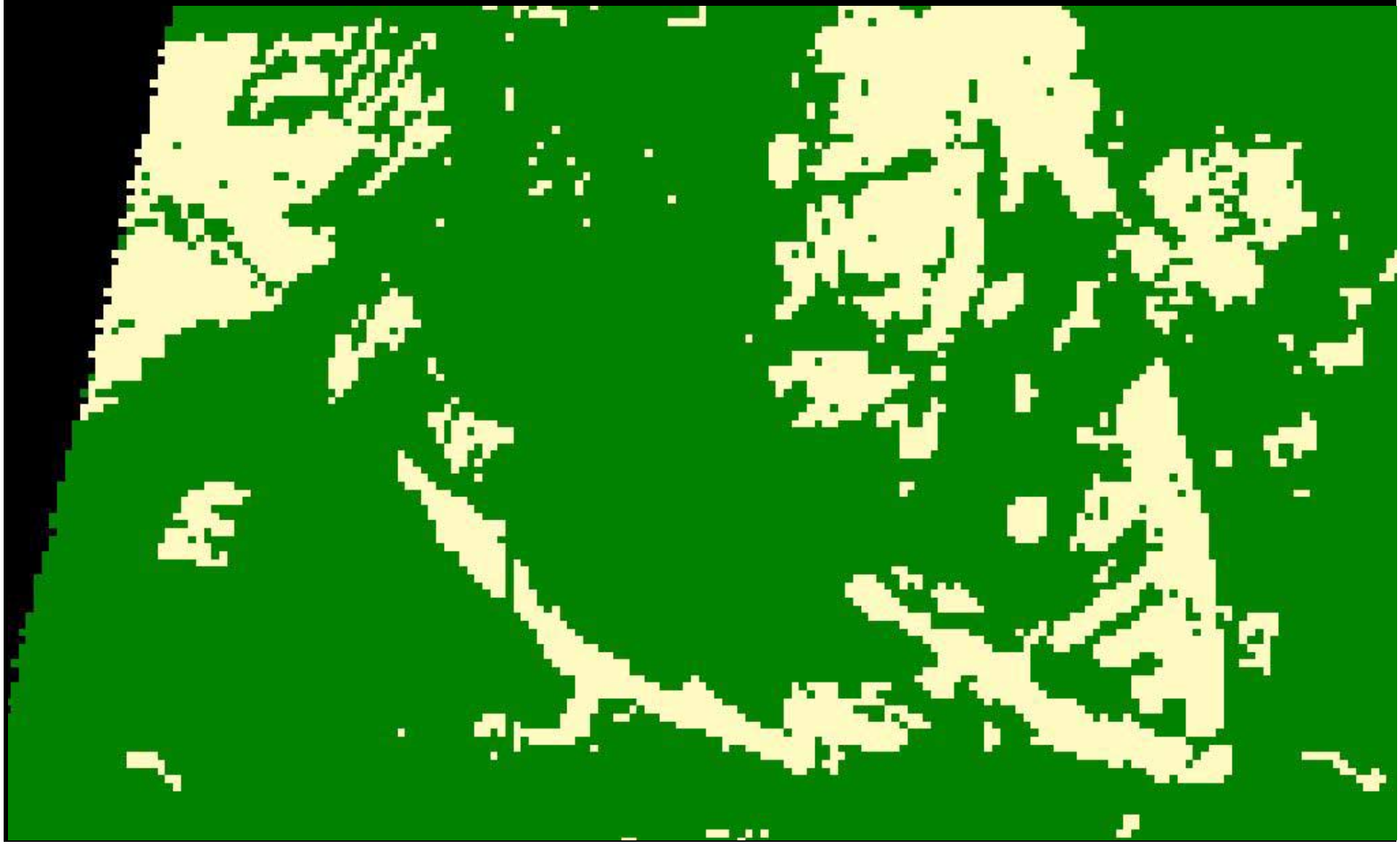
	IGSCR	MRLC-15f	MRLC-15n
Overall Acc.	82.6	80.8	81.2
Kappa	.552	.508	.521
Users - For	84.0	83.2	83.7
Users - Non	77.78	72.7	73.2
Producers - For	92.9	91.1	91.1
Producers -Non	58.3	56.3	57.7

Forest From 2-ft Orthophotography

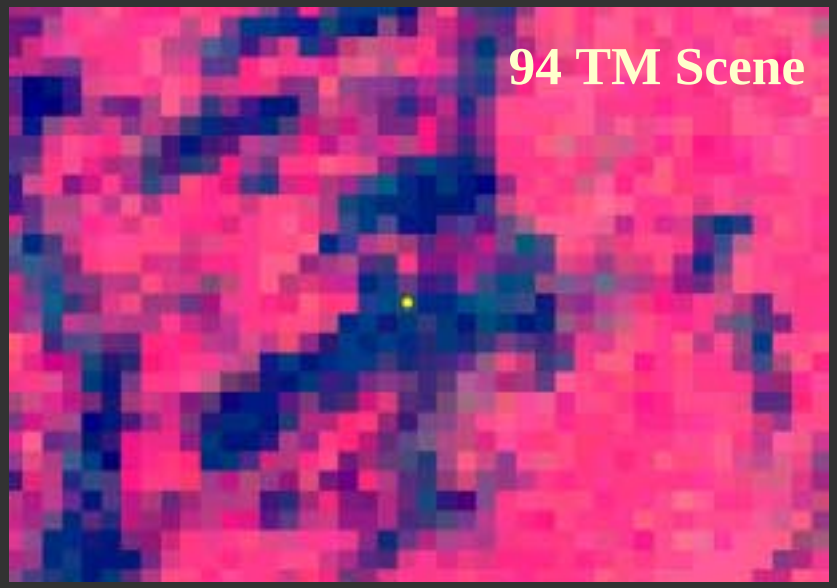


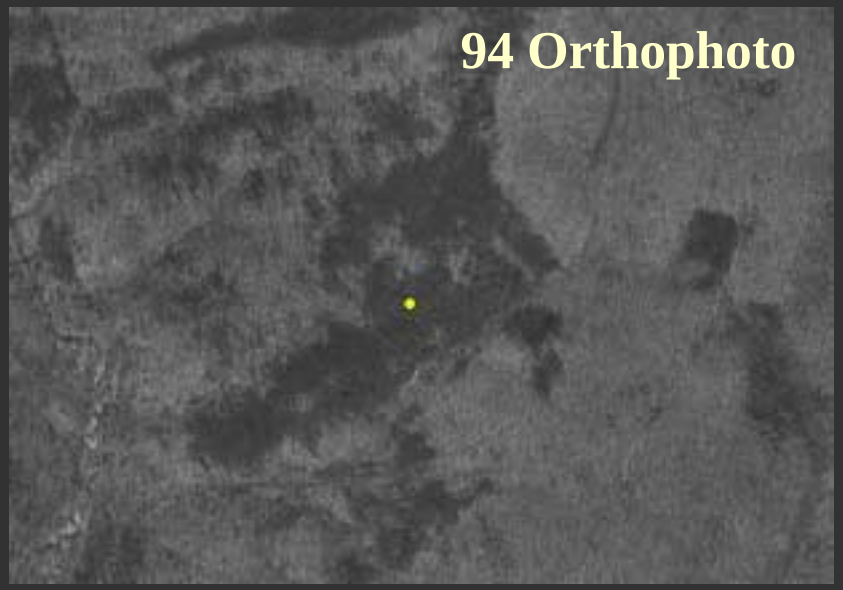
IGSCR Classification

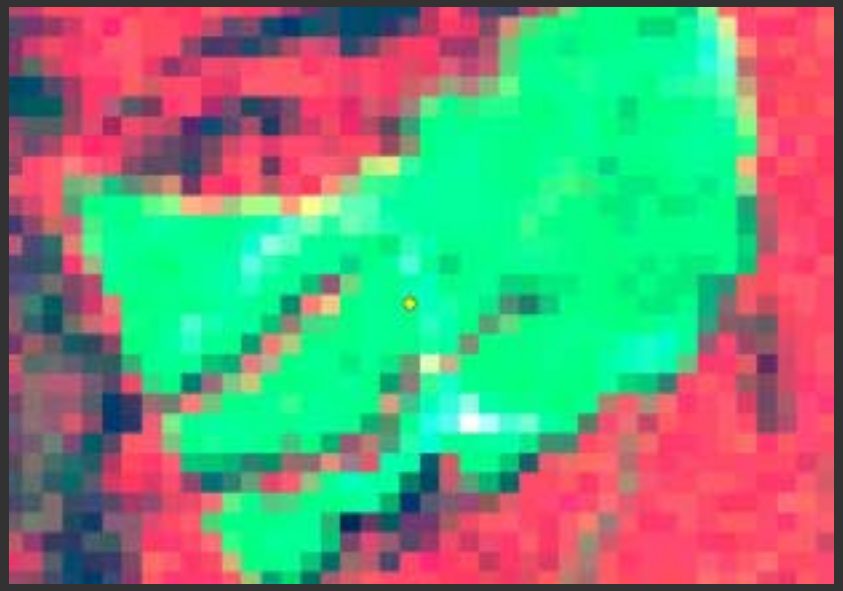
Recoded MRLC Classification



Change Detection Studies

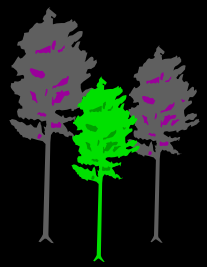






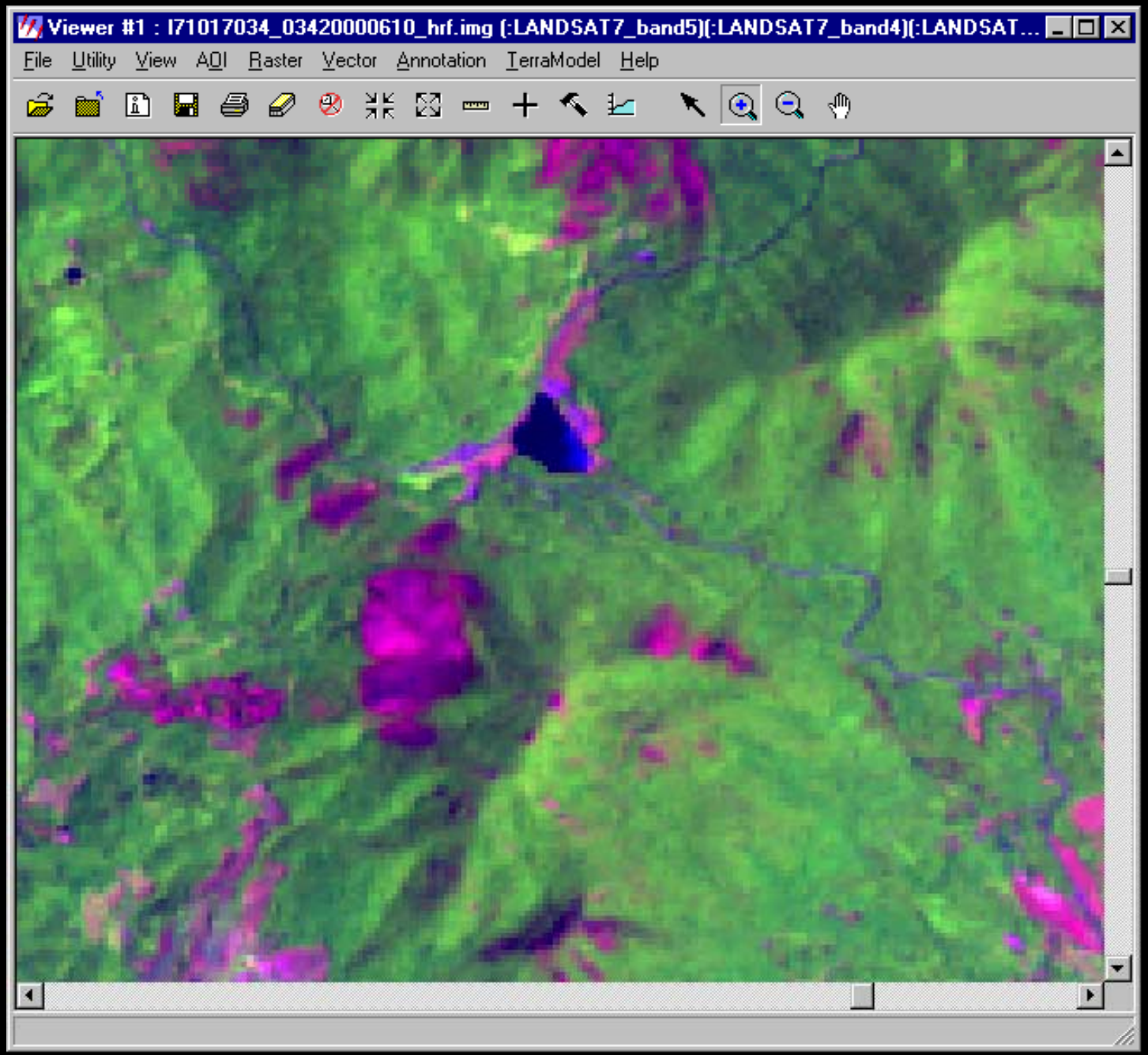
Change Detection Techniques Under Investigation

- raw bands 3 and 5 differences
- raw bands 3,4, and 5 differences
- selected principal components bands differences
- “change” band(s) in a multi-temporal PCA image
- tasseled cap “brightness differences
- NDVI differences
- change vector analysis using bands 3 and 5
- Multi-temporal IGSCR



Uses for Change Detection

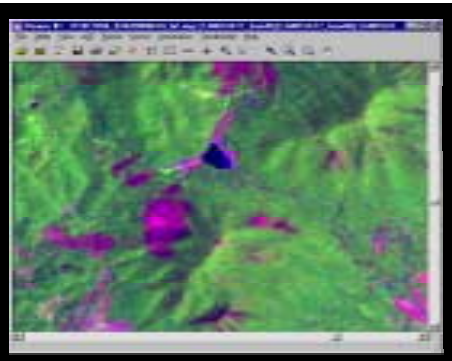
- Harvest monitoring, BMP compliance
- Riparian buffer compliance
- Improved estimates or harvest, removals and disturbance rates
- Monitoring of land conversion and rural residential development
- Forest health monitoring



Forest Health Monitoring

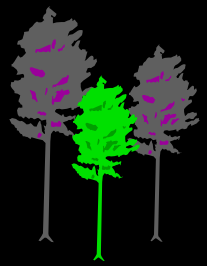
L7 Image of Gypsy Moth Defoliation

Peaks of Otter, VA, June ,2000



Future Work

- Refinement of Phase I forest estimation into an operational program (5 yr cycle)
- Refinement of change detection for harvest and disturbance monitoring (1 yr cycle)
- Investigate methods to improve local volume estimates using imagery and other geospatial data (e.g. DEM's) (5 yr cycle)



Conclusions

- New roles of state forestry agencies create a need for timely geo-spatial information about forest resources
- Issues of forest land conservation and sustainability require improved methods for estimation of forest ecosystem parameters, with improved spatial dimensions.
- Monitoring needs are increasing and can be best met with remote sensing
- Satellite image analysis techniques need to become operational, i.e. repeatable and low-cost

Thank you, Questions?

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