Building a GEO Forest Carbon Tracking Database

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U.S. Geological Survey
U.S. Department of Interior

National Demonstrator Annual Products

a. Forest and land cover maps
b. Biomass estimations
c. Carbon stock estimates
d. Future carbon stock scenarios

What will it take to get there?

Steps to Comprehensive FCT

1. Creation of a CEOS Virtual Technical Center (VTC) for Forest Cover and Carbon Assessment, Monitoring and Verification
2. Data Outreach and Training: Methods, Tools, and Capacity
3. Sampling and Sampling Frames
4. Earth Observation Data Provision, Pre-processing and Distribution
5. *In situ* Data Management and Protocols
6. Classification and Mapping Support

1. A Virtual Technical Center (VTC) for Forest Cover and Carbon Assessment, Monitoring and Verification

Action 1:
Create a “virtual” center of specialists to provide training, to provide expert advice on mapping procedures, and to support carbon accounting and verification methods.

Undertake the following actions:

2. Data Outreach and Training: Methods, Tools, and Capacity

USGS and GOFC-GOLD have been holding training sessions at the EROS Data Center, training international users and providing them with data from the EROS archive.

Action 2:

This program should be **continued and expanded** and it should include **more specific training on forest and land cover mapping** as well as the **provisioning of hardware and software as well as data**.

3. Sampling and Sampling Frames

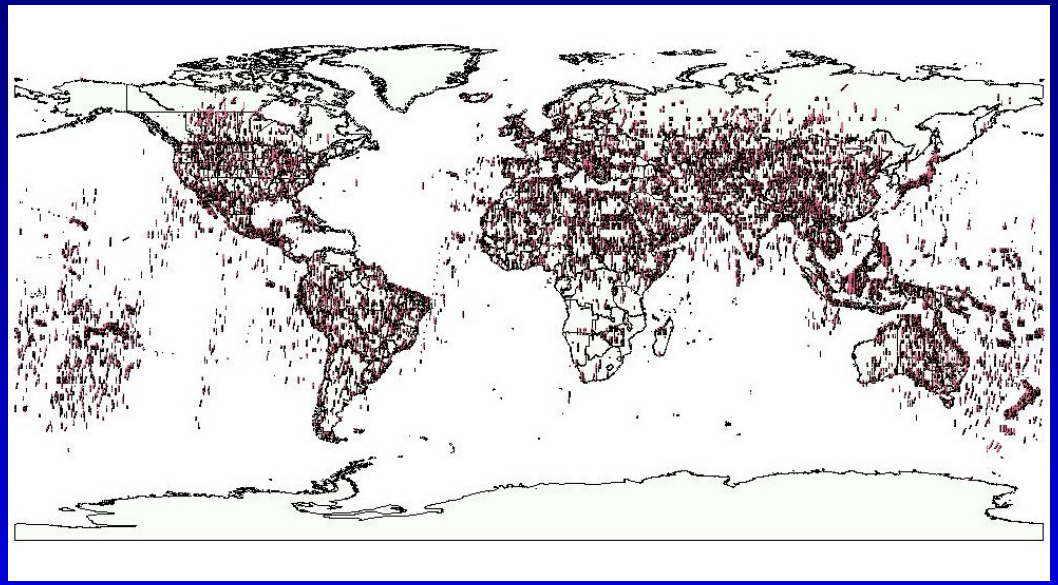
Action 3:

Conduct a study on the distribution of current field sites and field campaigns; develop a global multi-stage and multi-scale sampling frame along with a database of global sites and *in situ* data to better coordinate field data collection, aerial surveys, and satellite acquisitions with existing research sites.

Test Site Analysis Datasets – Satellite

- OrbView-3 Footprints
- Hyperion
- Optical and Radar Assets (Table below)

OrbView-3 Data Archive



- Spatial Area
  - The collection occupies much of the land masses of the world
- Temporal Range
  - The images were acquired between 2003 and 2007.
  - The collection is being offered in its entirety of 530,424 records.

Test Site Analysis Datasets – Aerial

- Lidar
- Radar
- Hyperspectral
- Photography / Videography

Test Site Analysis Datasets – In situ

- ILTER
- TEAM
- FluxNet
- Smithsonian
- American Cordillero
- Other

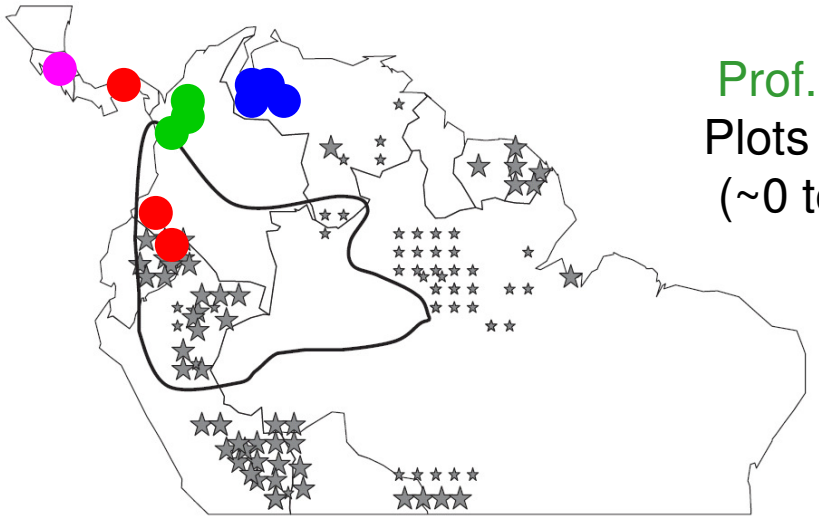
Build on Existing in situ Networks

Some examples from South America

The CTFS plot network
http://www.ctfs.si.edu/
(130 to 1780 m elevation; mean = 715 m)

Prof. J. P. Veillon *et al.*
Plots measured 1961 to 1985?
(<180 to >2450 m elevation)

Dr. D. Lieberman *et al.*
Plots measured
1969 to 1985?
(32 to 71 m elevation)



Prof. A. J. Duque M. *et al.*
Plots are being established
(~0 to ~3000 m elevation)

The RAINFOR plot network
http://www.geog.leeds.ac.uk/projects/rainfor/
(35 to 800 m elevation; mean = 250 m)

Let’s not forget aerial ….

especially, a resource for identifying upcoming missions for sharing….

4. Earth Observation Data Provision, Pre-processing and Distribution

Action 4a:

- Development of robust, spatially integrated primary datasets for the FCT National Demonstrators (ND). These data would include an appropriate array of Essential Climate Variables (ECVs) as defined by CEOS, as well as supporting documentation, and would be distributed to National FCT/UN REDD lead institutions on hard disks considering the data volume.

Action 4b:

- Process MODIS 250m time series vegetation index data on 16-day intervals, and generate temporal metrics (length of growing season, start of growing season etc.) which will be included as part of the national data bundles.

Core Data Resources

1. Satellite
2. Digital Terrain Data: slope, aspect, elevation
3. Landforms
4. Land cover
5. Land use/Land cover change
6. Hydrology / Hydrography
7. Geology
8. Ecosystems Maps (GEO Ecosystems)
9. Soils
10. Climate Data
11. Protected Area Data (WDPA)
12. Plot-based Measurements

FCT National Demonstrator Metadata

Data	Source	Pre-processing Institution	Product(s)	Product Type / Name	Product Processing Institution	Spatial Resolution (m)	Timestep	Date(s)	File Format	Projection	Datum	Spheroid	Projection Parameters	Atmospheric Correction	Terrain Correction
Terrain Model															
ALOS-PALSAR	JAXA					10, 50									
ASAR															
ASTER	JAXA					30									
AVHRR						1000									
CBERS 2B CCD	Brazil/China	INPE		Level 1T		20			GEO-TIFF	UTM	WGS84			?	SRTM
COSMO-SkyMed															
ENVISAT ASAR	ESA														
IRS	India														
Landsat INPE	Brazil/China	INPE		Level 1G		30			GEO-TIFF	UTM	WGS84			?	
Landsat USGS	USGS	USGS	Forest cover and change	Landsat TM/ETM Level 1T	TBD	15, 30, 60			GEO-TIFF	UTM	WGS84			yes	SRTM (GTOPO-30)
LIDAR - aerial															
Meris	ESA					300									
MODIS	NASA/USGS	USGS	Phenology		USGS	250	8/16-day composites		HDF-EOS	ISG					
Radarsat-2															
SPOT-4 TPM	SPOT														
SPOT-4/5	SPOT Image														
SPOT-VGT	SPOT					10000									
TerraSAR-X															
Terrain Model															
ASTER DEM	JAXA		derivatives			30									
SRTM	NGA		derivatives			30									
SRTM	NGA		derivatives			90									
Ancillary Data															
GEO Ecosystems	USGS	N/A	Ecosystems		USGS			2010							
Soils															
Geology															
Lithology															
Climate			T, Precip.				monthly	term							

National Data Standards

Country	Lead National Insitution	FCT Lead (s)	File Format	Projection	Datum	Spheroid	Projection Parameters	Atmospheric Correction	Terrain Correction	Resampling	National Demonstrator	UN-REDD
Africa												
Cameroon		ESA									yes	
Democratic Republic of Congo		Congo Basin Forest Fund (Norway + UK)										yes
Ghana		Australia TBC										
Tanzania	Div. of Forestry and Beekeeping	Norway, Australia?		UTM	ARC1960						yes	yes
Zambia												yes
Asia and Pacific												
Australia (Tasmania)		Australia									yes	
Cambodia		Australia, Japan, USA (TBC)		UTM	Indian 1954	Everest Adjustment 1937						
China		China, Australia										
Indonesia (Borneo)	TBD	Australia, Japan, Indonesia									yes	yes
Papua New Guinea		Australia										
Vietnam												yes
North and Central America												
Mexico											yes	
Panama												yes
South America												
Bolivia		EU, ESA										
Brazil		Brazil, Norway, USA									yes	
Brazil - Xingu		Brazil, Norway, USA										
Colombia	Colombia	TBD										
Guyana	Guyana Forestry Commission	Norway									yes	
Paraguay												yes
Peru												

Test Site Analysis Datasets – Sites

- FAO FRA Remote Sensing Survey
- Confluences
- Protected Areas (WDPA)
- KBAs, IBAs

5. *In situ* Data Management and Protocols

Action 5:

Develop a best practices set of guidelines for field sampling, and produce a field methods manual with accompanying forms, hand-helds, and databases.

Why a plot model and database?

- Calibration and validation of remote sensing models
- Direct parameterization: the ability to directly predict plot variables rather than map categorical classification systems
- Direct mapping and cross-walking of multiple classification systems
- Mixture modeling: allows understanding the relationship of plot composition and structure to remote sensing parameters
- Permanent and standardized to permit monitoring and continuity of descriptions across plots, sites and regions

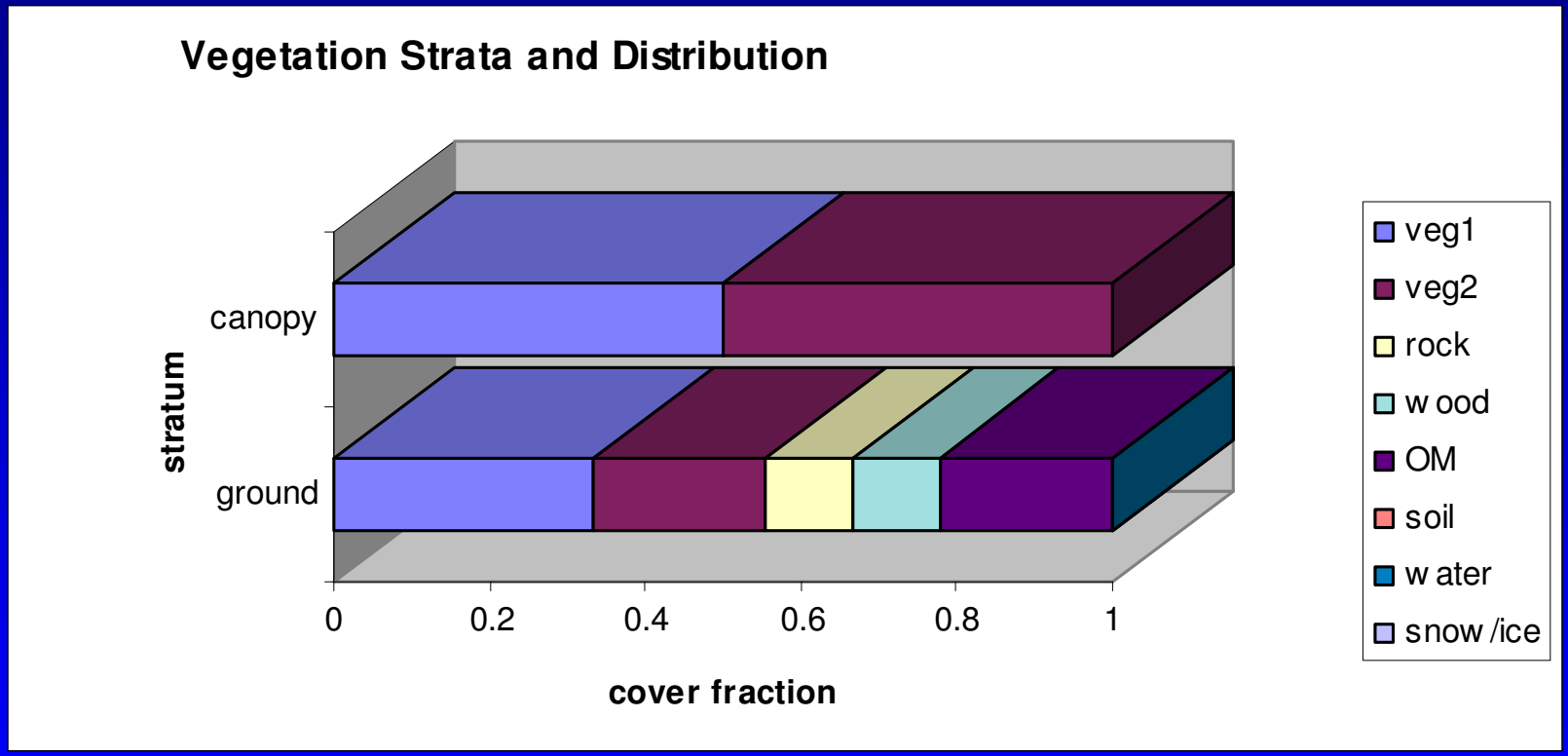
Site/Environmental Data Variables

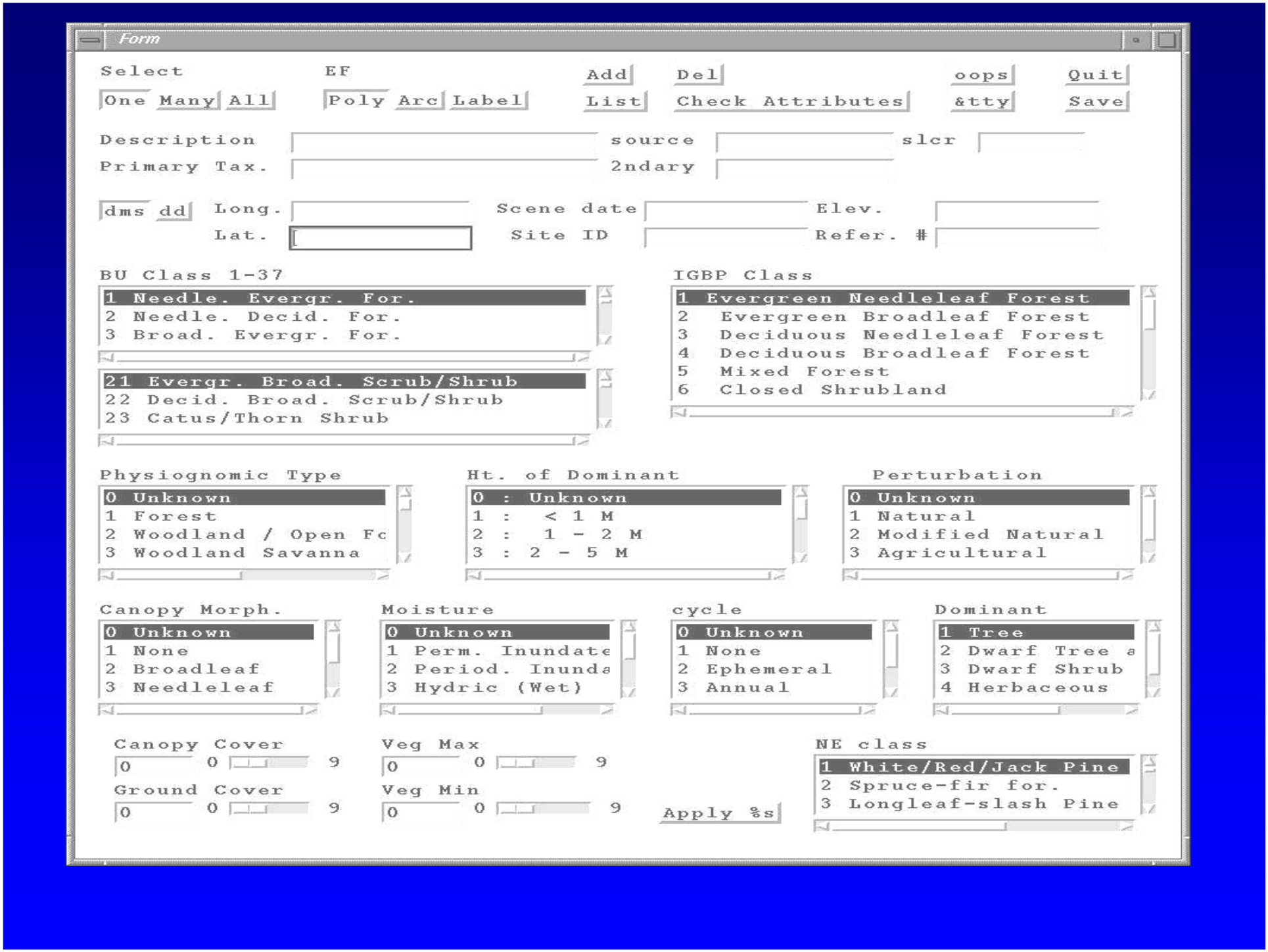
feature	variable name	data type	data range	data units
latitude	X	ratio	71.35-91.56	dec. degrees
longitude	Y	ratio	8.01-19.52	dec. degrees
moisture	MOIST	categorical	1-8	class
disturbance	PERT	categorical	0-4	class
physiognomic formation	PHYS	categorical	1-13	class
IGBP	IGBP	categorical	1-17	class
STEP-Vegetation	VEGCLASS	categorical	1-37	class
polygon site ID	SITEID	categorical	1-300	class
canopy cover fraction (%)	CCOV	ordinal	0-9	percent class
canopy cover leaf morphology	CMORPH	categorical	0-6	class
canopy cover phenology	CPHEN	categorical	0-6	class
vegetation cycle (periodicity)	CYCLE	categorical	0-6	class
vegetation distribution	DIST	categorical	1-4	class
dominant lifeform	DOM	categorical	0-4	class
cover of dominant lifeform	DOMCOV	ordinal	0-9	percent class
height of dominant lifeform	DOMHT	ordinal	0-8	height class
groundcover leaf morphology	GCMORPH	categorical	0-7	class
groundcover phenology	GCPHEN	categorical	0-7	class
vegetated ground fraction (%)	GCVEG	ordinal	0-9	percent class
leaf type	LTYPE	categorical	0-8	class
percent max. vegetation cover	VEGMAX	ordinal	0-9	percent class
percent min. vegetation cover	VEGMIN	ordinal	0-9	percent class
month of max. vegetation	MONTHMAX	categorical	1-12	month
month of min. vegetation	MONTHMIN	categorical	1-12	month

Remote Sensing / Environmental Variables

feature class	feature	variable name	data type	data range	data units	source
VI	daily NDVI	c1_vi - c365_vi	interval	0-255	index	NDVI
temporal NDVI	max. monthly NDVI	x_max	interval	0-255	index	NDVI
	min. monthly NDVI	x_min	interval	0-255	index	NDVI
	month of max. NDVI	mo_max	categorical	1-12	month	NDVI
	month of min. NDVI	mo_min	categorical	1-12	month	NDVI
	mean annual NDVI	xndvi	interval	0-255	index	NDVI
	NDVI range	x_range	interval	0-100	index	NDVI
	NDVI prinicpal components	PCA_1-6	interval	0-255	index	DEM
topography	slope	SLOPE	ratio	0-25	degrees	DEM
	aspect	ASP	interval	0-255	degrees	DEM
	elevation	ELEV	ratio	0-255	meters	DEM
temperature	12 monthly temp.means	t1_x - t12_x	interval	0-255	degrees K	AVHRR
temporal Temp.	max. monthly temperature	tmax	interval	0-255	index	AVHRR
	min. monthly temperature	tmin	interval	0-255	index	AVHRR
	month of max. temperature	mtmax	categorical	1-12	month	AVHRR
	month of min.temperature	mtmin	categorical	1-12	month	AVHRR

Vegetation Structure and Distribution




Form
Select
One Many All
EF
Poly Arc Label
Add
Del
List
Check Attributes
oops
&tty
Quit
Save
Description
source
slcr
Primary Tax.
2ndary
dms dd
Long.
Lat.
Scene date
Site ID
Elev.
Refer. #
BU Class 1-37
1 Needle. Evergr. For.
2 Needle. Decid. For.
3 Broad. Evergr. For.
21 Evergr. Broad. Scrub/Shrub
22 Decid. Broad. Scrub/Shrub
23 Catus/Thorn Shrub
IGBP Class
1 Evergreen Needleleaf Forest
2 Evergreen Broadleaf Forest
3 Deciduous Needleleaf Forest
4 Deciduous Broadleaf Forest
5 Mixed Forest
6 Closed Shrubland
Physiognomic Type
0 Unknown
1 Forest
2 Woodland / Open Fc
3 Woodland Savanna
Ht. of Dominant
0 : Unknown
1 : < 1 M
2 : 1 - 2 M
3 : 2 - 5 M
Perturbation
0 Unknown
1 Natural
2 Modified Natural
3 Agricultural
Canopy Morph.
0 Unknown
1 None
2 Broadleaf
3 Needleleaf
Moisture
0 Unknown
1 Perm. Inundate
2 Period. Inunda
3 Hydric (Wet)
cycle
0 Unknown
1 None
2 Ephemeral
3 Annual
Dominant
1 Tree
2 Dwarf Tree a
3 Dwarf Shrub
4 Herbaceous
Canopy Cover
0 0 9
Ground Cover
0 0 9
Veg Max
0 0 9
Veg Min
0 0 9
Apply %s
NE class
1 White/Red/Jack Pine
2 Spruce-fir for.
3 Longleaf-slash Pine

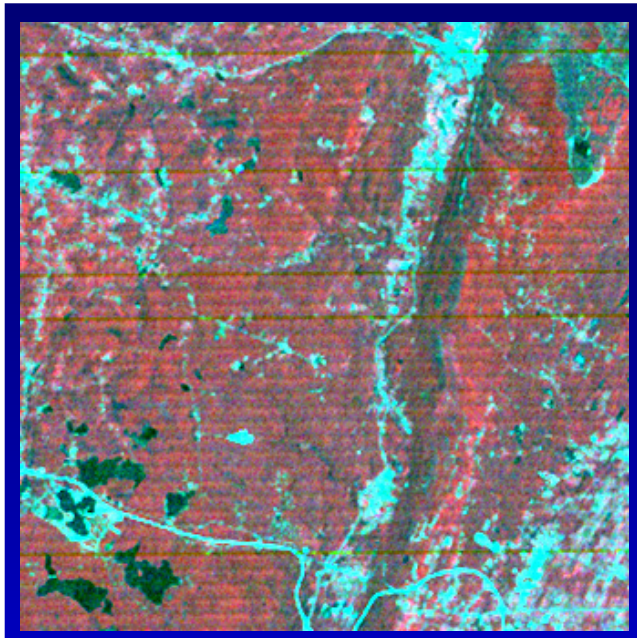
6. Classification and Mapping Support

Action 6a:

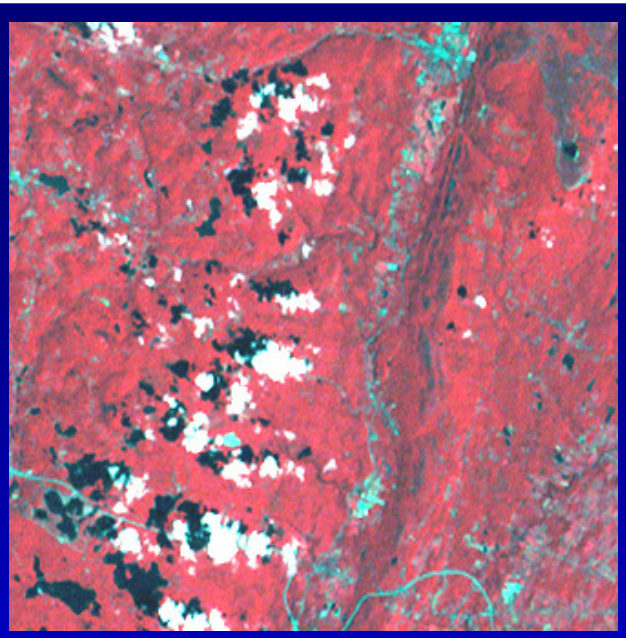
- Provide best practice methods and training on MRV and FCT dataset development, and mapping methods.

Action 6B:

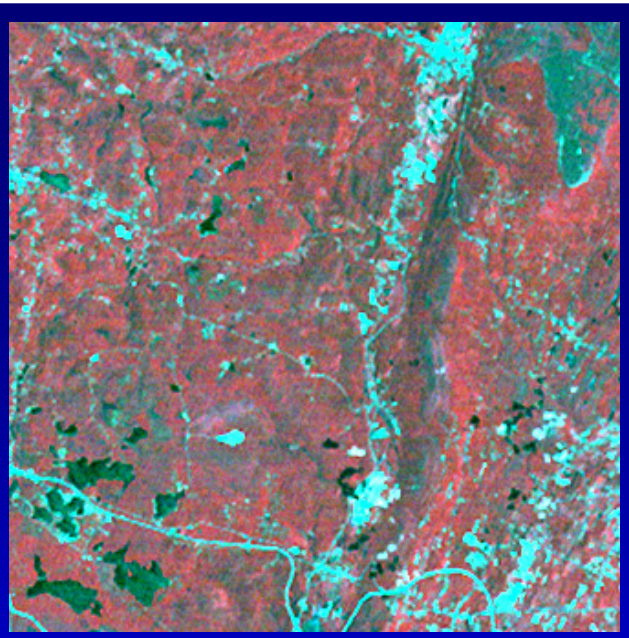
- Derive a global 30 m forest and land cover map using the GLS data.



Landsat MSS 1972

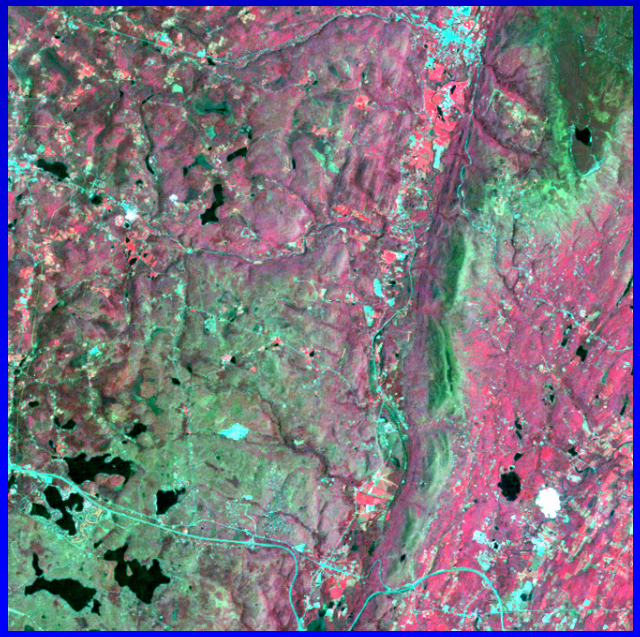


Landsat MSS 1980

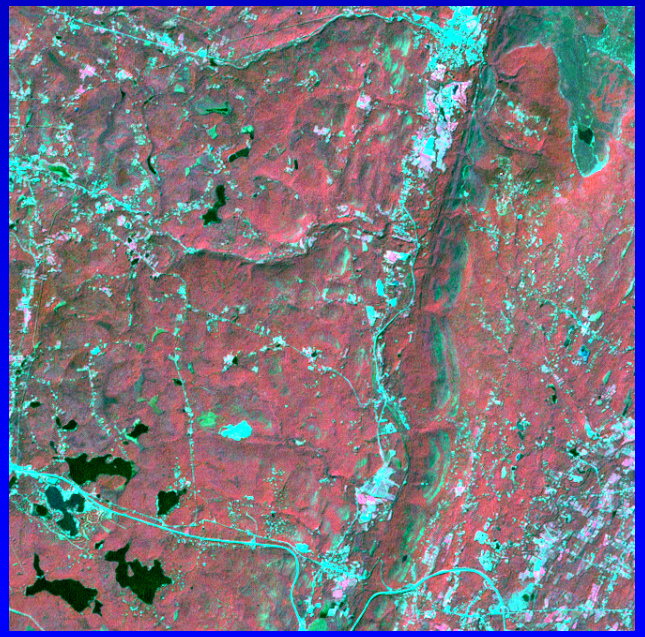


Landsat MSS 1986

Landsat Time Series

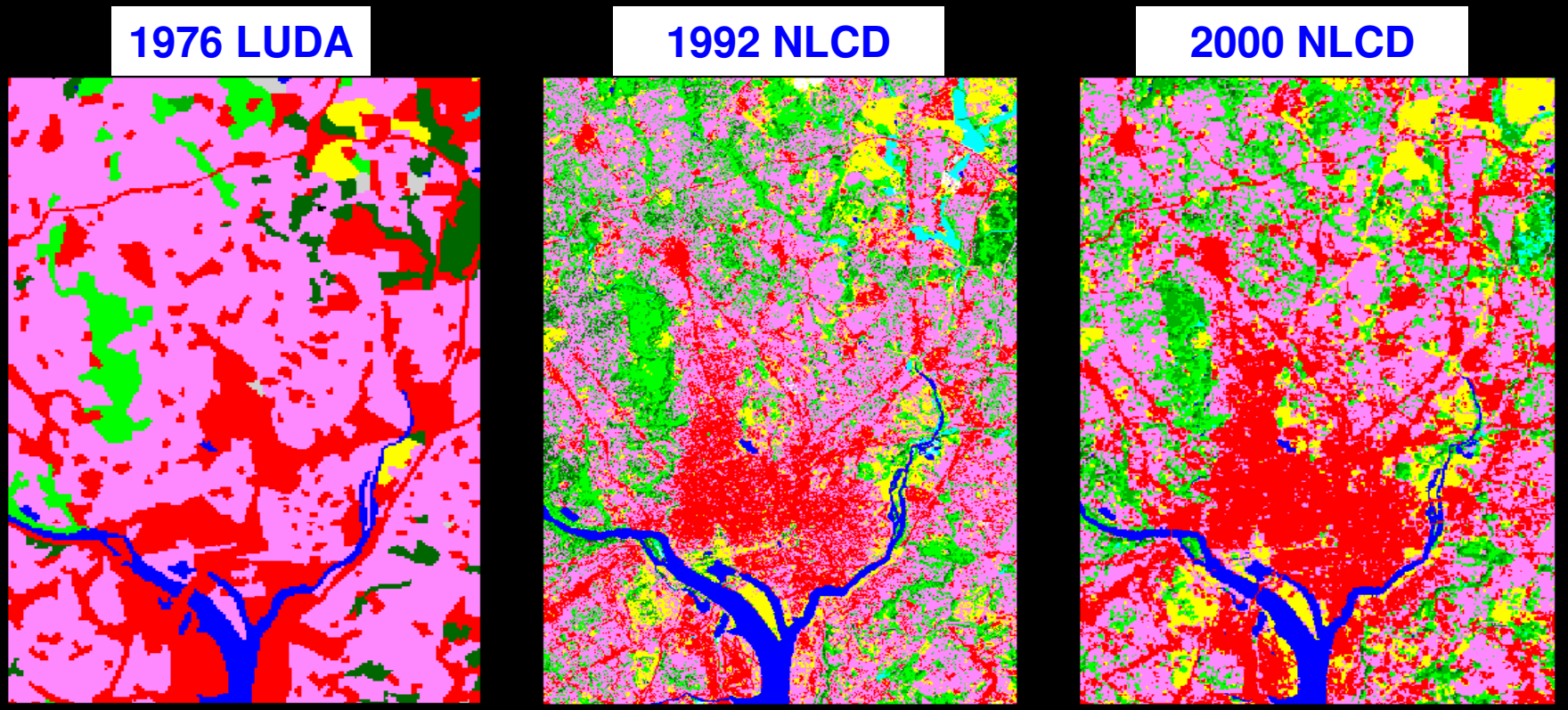


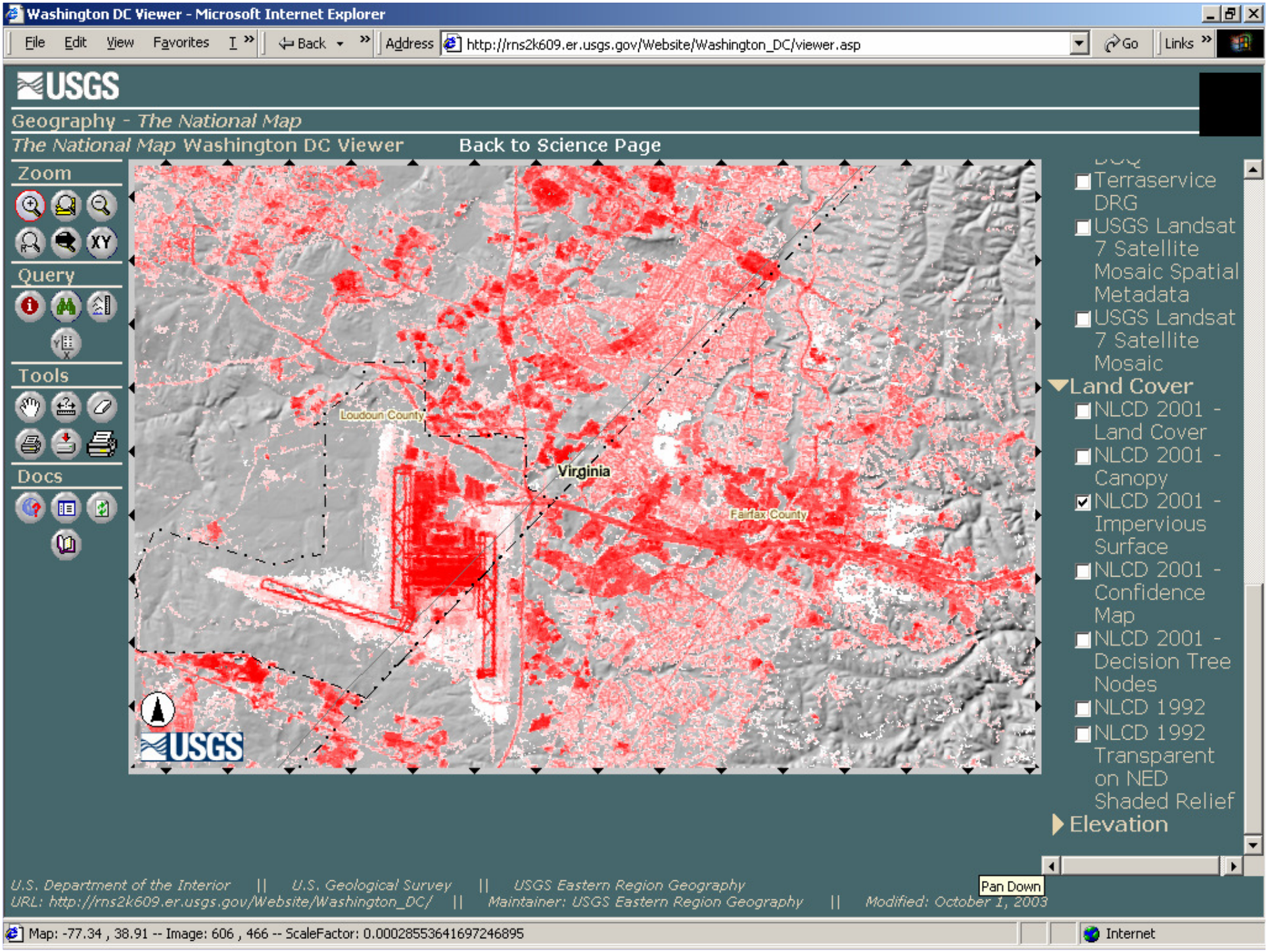
Landsat TM 1992



Landsat ETM+ 2000

Land Cover


1976 LUDA
1992 NLCD
2000 NLCD
CLASSIFICATIONS SIMPLIFIED FOR COMPARISON PURPOSES
Open Water
Ag/Grass
Deciduous
Barren
Low-Int. Urban
Evergreen
Woody Wetland
High-Int. Urban
Mixed Forest
Herbaceous Wetland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Terraservice DRG
USGS Landsat 7 Satellite Mosaic Spatial Metadata
USGS Landsat 7 Satellite Mosaic
Land Cover
NLCD 2001 - Land Cover
NLCD 2001 - Canopy
NLCD 2001 - Impervious Surface
NLCD 2001 - Confidence Map
NLCD 2001 - Decision Tree Nodes
NLCD 1992
NLCD 1992 Transparent on NED Shaded Relief
Elevation
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URL: http://rns2k609.er.usgs.gov/Website/Washington_DC/ || Maintainer: USGS Eastern Region Geography || Modified: October 1, 2003
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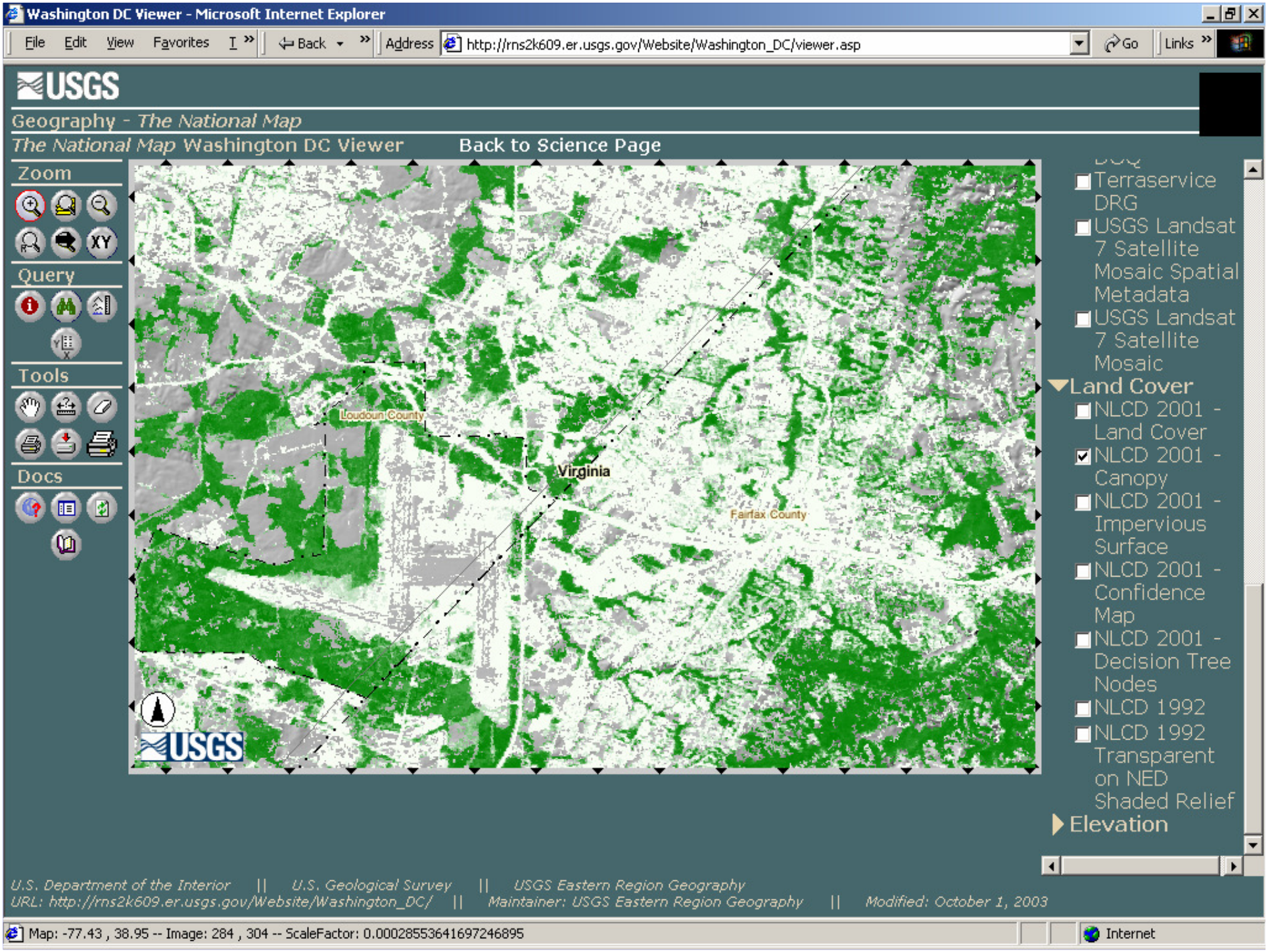
Internet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Virginia
Fairfax County
USGS
Terraservice DRG
USGS Landsat 7 Satellite Mosaic Spatial Metadata
USGS Landsat 7 Satellite Mosaic
Land Cover
NLCD 2001 - Land Cover
NLCD 2001 - Canopy
NLCD 2001 - Impervious Surface
NLCD 2001 - Confidence Map
NLCD 2001 - Decision Tree Nodes
NLCD 1992
NLCD 1992 Transparent on NED Shaded Relief
Elevation
U.S. Department of the Interior || U.S. Geological Survey || USGS Eastern Region Geography
URL: http://rns2k609.er.usgs.gov/Website/Washington_DC/ || Maintainer: USGS Eastern Region Geography || Modified: October 1, 2003
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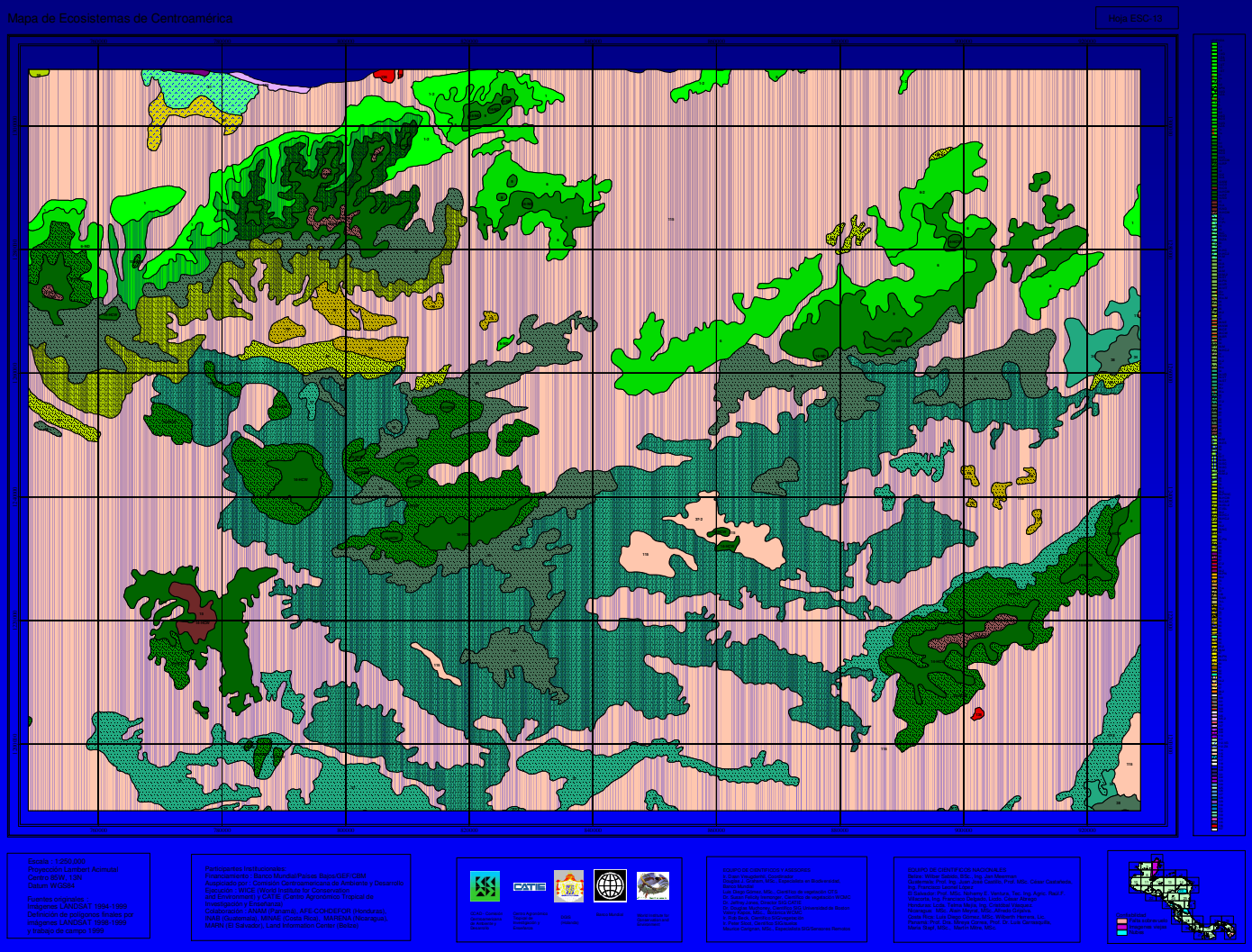
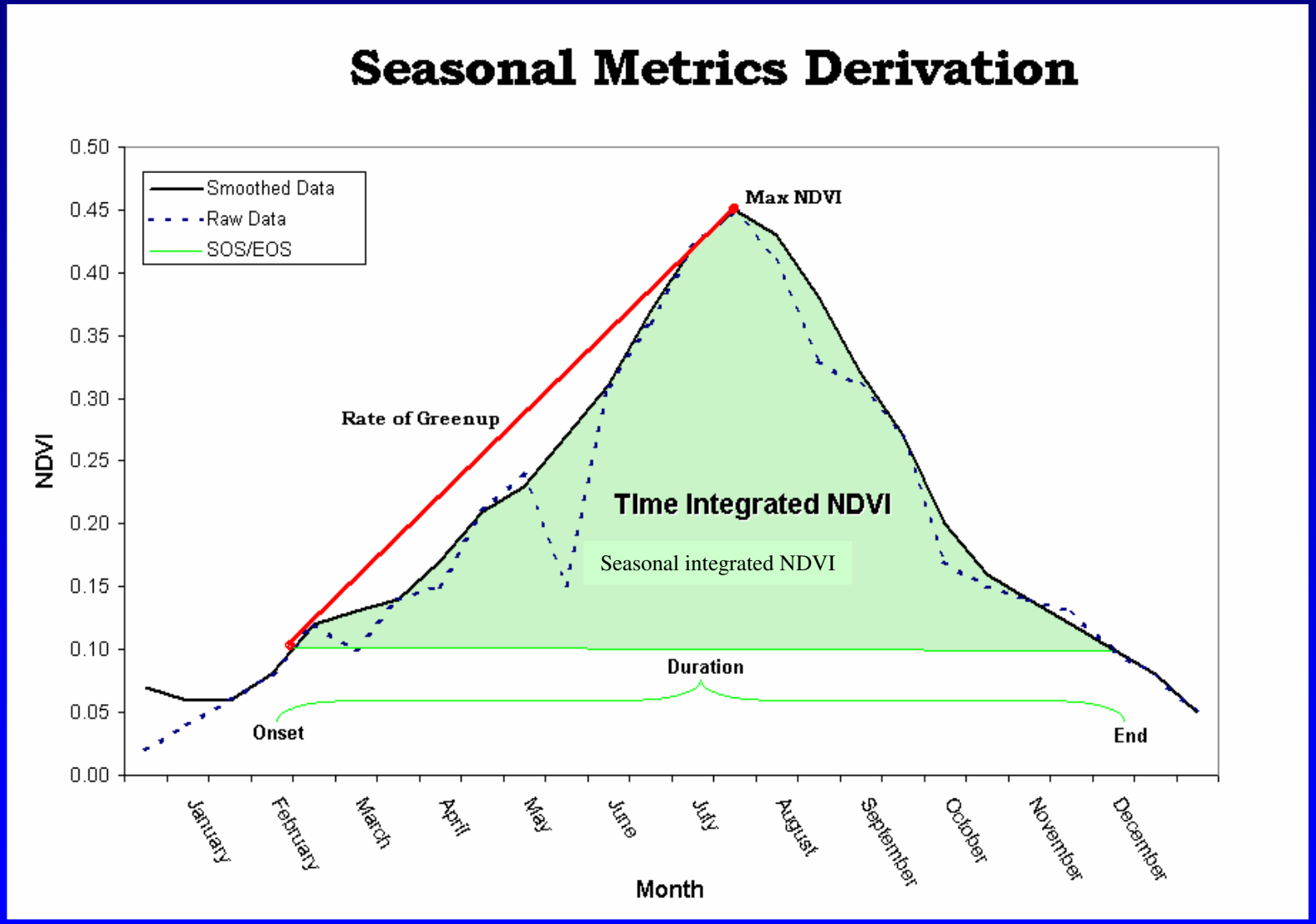
Internet

Central American Ecosystems



Temporal / Phenologic Vegetation Metrics



Scientific and operational challenges

- Optical data acquisition in the tropics
- Data Integration: in situ, optical, radar and lidar
- Database management
- Accurately estimating forest cover, volume, biomass, and carbon stocks and flows
- Land cover change modeling for future scenarios
- Long-term operations in developing countries
- Accuracy requirements traded against costs and benefits
- Accuracy assessments
- Requirements for verification

30-Month Timeline

Task	Duration (Months)	Month																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
VTC Logistical Support	**30**																													
Training	**24**																													
Sampling Design and Protocols	**12**																													
STEP Manual																														
Data Collection																														
Cartographic	**24**																													
In Situ	**24**																													
Remote Sensing	**12**																													
Landsat	**12**																													
MODIS	**12**																													
Radar																														
Aerial Photography																														
LiDAR																														
Database Development	**12**																													
Database Management	**22**																													
Algorithm Development																														
Forest and Land Cover	**10**																													
Biomass	**12**																													
Phenology	**3**																													
Disturbance History	**12**																													
Data Processing																														
Forest and Land Cover	**24**																													
Carbon Estimates	**24**																													
Disturbances	**12**																													
Land Cover Change	**12**																													
Carbon Verification	**6**																													
Transition to Operations	**8**																													
Reporting	**6**																													

Thank you

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